The relevance of the anatomical basis of fracture for the subsequent treatment of the anterior humeral circumflex artery and the axillary nerve

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Abstract

Purpose The purpose of this study was to determine the location of the anterior humeral circumflex artery and axillary nerve based on bony landmarks, and to provide anatomical information that enables a safe approach when treating a proximal humeral fractures.

Methods Thirty cadavers were included. The distances of both the anterior humeral circumflex artery and the axillary nerve from body landmarks were measured using Vernier calipers.

Results The mean distance between the inferior border of the medial acromion and the superior border of the anterior humeral circumflex artery was 5.1 ± 0.2 cm (range, 4.6–5.5 cm); the mean distance between the prominence of the lesser tuberosity and the superior border of the anterior humeral circumflex artery was 2.5 ± 0.2 cm (range, 2.0–3.0 cm); the mean distance between the anterior-inferior

border of the acromion and the superior border of the axillary nerve was 6.3 ± 0.5 cm (range, 5.2–7.0 cm).

Conclusions The artery is located approximately 5.1 cm below the inferior border of the medial acromion and 2.5 cm below the prominence of the lesser tuberosity, and the nerve was located approximately 6.3 cm below the anterior-inferior border of the acromion and 3.5 cm below the prominence of the greater tuberosity. The reduction manoeuvres should be conducted with extreme care in this region.

Introduction

Traditionally, the transdeltoid lateral and the deltopectoral approach are used in reduction and internal fixation of proximal humeral fractures, depending on the fracture type and the experience of the surgeon [1]. The priority is to preserve the anterior humeral circumflex artery and the axillary nerve, which are both commonly injured during this type of operation [2, 3]. Disruption of the arterial supply from the humeral circumflex artery often leads to avascular necrosis of the head fragments [4]. Axillary nerve injury, along with shoulder dislocation and rotator cuff tear, is called the “unhappy triad” of the shoulder joint [5]. Therefore, it is extremely important for the surgeon to locate the artery and nerve on the basis of bony landmarks.

Previous cadaver studies of the arterial anatomy of the humeral head have focused on the arterial supply to the humeral head [6, 7] but have not established the location of the humeral circumflex arteries with respect to bony landmarks. The path of the axillary nerve has been described [8], and findings from the present investigation will be compared to these results.

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The aim of the study was to analyse the relationship between the humeral circumflex arteries and the bony landmarks and the relationship between the axillary nerve and the bony landmarks, and to provide a more anatomical basis for the safe zone to treat fractures of the proximal humerus.

Materials and methods

There were ten females and 20 males (30 cadavers in total), with an age range of 27–73 years. In each case, the skin and the attached subcutaneous tissue around the shoulder was removed. After cutting the pectoralis major muscle from its insertion on the humeral shaft, the origin of the conjoint tendon was separated from its attachment to expose the anterior humeral circumflex artery. The deltoid muscle was retracted laterally and the lesser tuberosity was exposed. The border of the medial acromion, the prominence of the lesser tuberosity and the point where the anterior humeral circumflex artery crossed the humeral shaft were marked with k-wires (Yuanchang Company, Yiwu) running perpendicular to the humeral shaft.

The deltoid was carefully split using a transdeltoid lateral approach from the anterior-inferior border of the acromion, until the axillary nerve and greater tuberosity were exposed. The nerve was carefully separated from the soft tissues and the humerus kept in a neutral position. The prominence of the greater tuberosity, the anterior-inferior border of the acromion and the point where the axillary nerve crossed the humeral shaft were marked with K-wires running perpendicular to the humeral shaft. The incision was then extended until it was 8–10 cm from the anterior-inferior border of the acromion.

The following distances were measured using Vernier calipers: from the inferior border of the medial acromion to the superior border of the anterior humeral circumflex artery, from the prominence of the lesser tuberosity to the superior border of the anterior humeral circumflex artery, from the anterior-inferior border of the acromion to the superior border of the axillary nerve, from the prominence of the greater tuberosity to the superior border of the axillary nerve, and the width of the axillary nerve at the line between the anterior and lateral third of the deltoid muscle.

The angle formed by the axillary nerve with the vertical of the humerus was measured using a protractor (Figs. 1, 2, 3, 4, 5).

Results

In all cases, the anterior humeral circumflex artery and the axillary nerve were successfully separated from the

Fig. 1 The location where extreme care should be taken to protect the anterior humeral circumflex artery (point 1). Point 2 shows the prominence of the lesser tuberosity

surrounding soft tissues and could be clearly identified. The artery followed a mostly horizontal course, except for when it crossed the humeral shaft on an oblique path. Similarly, there was an angle between the axillary nerve and the humeral shaft. We did not find any branches leading from the anterior trunk of the axillary nerve between the anterior and lateral third of the deltoid muscle (Table 1).

Discussion

The anterior circumflex artery arises from the third part of the axillary artery at the lower border with the subscapularis [2], and follows a horizontal course behind the coracobrachialis muscle to the bicipital groove. The artery gives off one principal branch, the arcuate artery, which ascends on the lateral border of the groove and enters the proximal humerus at the level of the greater tuberosity [9]. Previous studies have shown that this artery is the dominant blood supply to the humeral head [2].

Fig. 2 Point 1 shows the distance between the inferior border of the medial acromion and the superior border of the anterior humeral circumflex artery; Point 2 is the anterior humeral circumflex artery; Point 3 is the inferior border of the medial acromion

Fig. 3 The location of the safe zone between the prominence of the greater tuberosity (1) and the superior border of the axillary nerve (2)

Injury to this artery, along with the axillary nerve, is common during surgical procedures to the shoulder and poses a risk to the rich network of anastomoses in the posteromedial humeral epiphysis [6, 7, 9]. Therefore, the objective of this study was to investigate the anatomy of these structures to improve understanding of “safe zones” during operations.

This study set out to determine the distance between the inferior border of the medial acromion and the superior border of the anterior humeral circumflex artery, and between the prominence of the lesser tuberosity to the superior border of the anterior humeral circumflex artery. These were found to be 5.1 ± 0.2 cm and 2.5 ± 0.2 cm, respectively.

When the deltopectoral approach is performed, the location of the prominence of the lesser tuberosity is first identified. The anterior humeral circumflex artery is located 2–3 cm below this, where it crosses the lateral border of the conjoint tendon to the bicipital groove. Therefore, reduction manoeuvres should be conducted on the lateral side of the proximal humerus, with the upper arm rotated internally. Extreme care should be taken in order to preserve the soft tissues and bone arteries adhering to the medial side, particularly

Fig. 4 The location of the safe zone between the superior border of the axillary nerve (1) and the anterior-inferior border of the acromion (2)

Fig. 5 Point 1 represents the angle between the axillary nerve (2) and the vertical line (3) of the humerus (4). Point 5 is the anterior-inferior border of the acromion

the area around the anterior humeral circumflex artery (Figs. 1 and 6).

However, if the lesser tuberosity is displaced in a fracture, the course of the anterior humeral circumflex is difficult to determine. In this case, the course of the artery can be estimated as running 5.0–5.2 cm below the inferior border of the medial acromion. The standard deviation of the inferior border of the medial acromion next to the clavicle as bony landmark is larger than that of the lesser tuberosity, specifically, 2.42 cm versus 1.87 cm.

The probability of avascular necrosis after a fracture depends on the pattern of injury to the arterial anatomy of the humeral head [9] and circulation of fragments, which therefore influence the choice of fracture treatment. The fracture pattern and the distribution of the fragments in complex fractures can be visualised in three-dimensional CT scans. By comparing these scans with photographs of the proximal humerus, the surgeon can plan reduction manoeuvres to ensure that blood supply to the fragments is maintained.

The axillary nerve is commonly injured during surgery, especially in plate fixation of the proximal humerus, which requires significant retraction of the deltoid muscle [3]. The position of the nerve relative to the incision and bony landmarks was investigated and

Table 1 Measurements of anatomic index of the anterior humeral circumflex artery and the axillary nerve

Items	Mean $\pm$ SD	Range	99% confidence interval
Distance between the inferior border of the medial acromion and the superior border of the anterior humeral circumflex artery (cm)	5.1 $\pm$ 0.2	4.6–5.5	5.0–5.2
Distance between the prominence of the greater tuberosity and the superior border of the axillary nerve (cm)	3.5 $\pm$ 0.2	3.2–4.1	3.4–3.6
Angle between the axillary nerve and the vertical of the humerus ($^{\circ}$)	22 $\pm$ 7	8–37	18–26
Width of the axillary nerve at the line between the anterior and lateral third of the deltoid (mm)	4.2 $\pm$ 0.8	3.7–5.5	4.0–5.0

compared with current data. The mean distance from the superior border of the axillary nerve to the anterior-inferior border of the acromion was 6.3 $\pm$ 0.5 cm, which was identical to the 6.3 cm reported by Vathana et al. [10]. However, Burkhead et al. [11] reported this distance to be 5.7 cm (4.1–7.1 cm). This discrepancy could be attributed to the oblique course of the nerve or because the distance was measured from a different point of the acromion. In conclusion, the safe zone for hardware placement is up to 4 cm distal from the anterior-inferior border of the acromion, and the deltoid may be safely split again with minimal risk of injuring the axillary nerve distal to 8 cm (Figs. 4 and 6).

We found that the distance from the superior border of the axillary nerve to the prominence of the greater tuberosity was 3.5 $\pm$ 0.2 cm smaller than the mean of 4.6 cm reported by Lin et al. [12]. This discrepancy could also be because the distance was measured from a different point of the greater tuberosity. Rough handling and strenuous retraction of the deltoid muscle should be avoided to minimise risk of injury to the axillary nerve (Fig. 3). When the greater tuberosity was directly exposed during open surgical procedures, the prominence could be used as a proper bony landmark to estimate the location of

the axillary nerve, rather than the acromion. However, as with the lesser tuberosity, the greater tuberosity may be displaced after a fracture. In this case, the course of the axillary nerve can be estimated from the acromion.

The axillary nerve runs on an oblique course at the line between the anterior and lateral third of the deltoid muscle, where the mean angle between the axillary nerve and the vertical line of the humerus is 22 $^{\circ}$ $\pm$ 7 $^{\circ}$. The distance between the anterior-inferior border of the acromion to the superior border of the axillary nerve, and the distance from the prominence of the greater tuberosity to the superior border of the axillary nerve are not always constant. Since its course is irregular, surgical instruments such as drag hooks and interlocking screws should not be placed too deeply to avoid damage.

The anterior humeral circumflex artery is located approximately 5.1 cm inferior to the inferior border of the medial acromion and 2.5 cm below the prominence of the lesser tuberosity. The axillary nerve is located approximately 6.3 cm below the antero-inferior border of the acromion and 3.5 cm below the prominence of the greater tuberosity. Therefore, operative manoeuvres in these regions should be conducted with extreme care to prevent neurovascular injuries.

Fig. 6 The general boundaries of the safe zone on the medial and lateral side of humerus

Conflict of interest Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. Robinson CM, Page RS (2003) Severely impacted valgus proximal humeral fractures. Results of operative treatment. *J Bone Joint Surg Am* 85:1647–1655
2. Gerber C, Schneeberger AG, Vinh TS (1990) The arterial vascularization of the humeral head. An anatomical study. *J Bone Joint Surg Am* 72:1486–1494
3. Tubbs RS, Oakes WJ, Blount JP, Elton S, Salter G, Grabb PA (2001) Surgical landmarks for the proximal portion of the axillary nerve. *J Neurosurg* 95:998–1000
4. Gerber C, Hersche O, Berberat C (1998) The clinical relevance of posttraumatic avascular necrosis of the humeral head. *J Shoulder Elbow Surg* 7(6):586–590
5. Gonzalez D, Lopez R (1991) Concurrent rotator-cuff tear and brachial plexus palsy associated with anterior dislocation of the shoulder. A report of two cases. *J Bone Jt Surg* 73(4):620–621
6. Duparc F, Muller J, Fréger P (2001) Arterial blood supply of the proximal humeral epiphysis. *Surg Radiol Anat* 23(3):185–190
7. Meyer C, Alt V, Hassanin H, Heiss C, Stahl JP, Giebel G, Koebeke J, Schnettler R (2005) The arteries of the humeral head and their relevance in fracture treatment. *Surg Radiol Anat* 27(3):232–237
8. Apaydin N, Tubbs R, Loukas M, Duparc F (2010) Review of the surgical anatomy of the axillary nerve and the anatomic basis of its iatrogenic and traumatic injury. *Surg Radiol Anat* 32(3):193–201
9. Brooks CH, Revell WJ, Heatley FW (1993) Vascularity of the humeral head after proximal humeral fractures. An anatomical cadaver study. *J Bone Joint Surg Br* 75:132–136
10. Vathana P, Chiarapattanakom P, Ratanalaka R, Vorasatit P (1998) The relationship of the axillary nerve and the acromion. *J Med Assoc Thai* 81:953–957
11. Burkhead WZ, Scheinberg RR, Box G (1992) Surgical anatomy of the axillary nerve. *J Shoulder Elbow Surg* 1:131–136
12. Lin J, Hou SM, Inoue N, Chao EY, Hang YS (1999) Anatomic considerations of locked humeral nailing. *Clin Orthop* 368:247–254