THE COURSE OF THE AXILLARY NERVE AMONG ADULT KENYAN CADAVERS

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ABSTRACT

Background: The axillary nerve is one of the terminal branches from the posterior cord of the brachial plexus and is closely related to the surgical neck of the humerus where it may be injured.
Objective: This study set out to describe the course of the anterior and posterior branches of the axillary nerve in an adult Kenyan population.
Methods: This was a cross-sectional study conducted at the Department of Human Anatomy Laboratory, Moi University. Dissections were done on 51 formalin prefixed left adult upper limbs.
Results: The nerve originated from the posterior cord of the brachial plexus and divided within the quadrangular space into anterior and posterior branches. The main trunk supplied teres minor (35.3%), teres major (15.7%) and subscapularis (3.9%) muscles. The anterior branch supplied the anterior (100%) and middle (92.1%) parts of the deltoid. The posterior branch innervated the posterior part of deltoid in all specimens. The middle part of deltoid received dual innervation in 7.8%. The shoulder joint was innervated by both the main trunk (80.4%) and anterior branch (19.6%). The upper lateral cutaneous nerve of the arm arose from the posterior branch in all specimens.
Conclusions: The nerve has an anterior branch distributed over and consistently innervates the anterior and middle parts of deltoid muscle, while the posterior branch supplies the posterior part.

Key words: Deltoid muscle, Fracture of proximal humerus

INTRODUCTION

The axillary nerve is one of the branches of the posterior cord of the brachial plexus. It originates at the lower border of the subscapularis muscle (1). From this origin, the nerve passes through the quadrangular space or interval.

The axillary nerve is in intimate contact with the surgical neck of the humerus and the capsule of the shoulder joint within the quadrangular space. It gives off a branch to the shoulder joint before dividing into its main terminal branches. The anterior branch which is accompanied by the posterior circumflex humeral vessels curves around the surgical neck of the humerus to supply the deltoid muscle. The posterior branch originates medially adjacent to the inferior edge of the glenoid rim. It supplies the teres minor muscle and the skin over the lateral part of the proximal part of the arm (1).

Anatomical variations of the axillary nerve have been described within the deltoid muscle. In 65% of cases, the nerve divided within the quadrangular space into anterior and posterior branches while in 35% of cases, the nerve split within the deltoid muscle. In addition, posterior branch of the axillary nerve gave a branch to the teres minor muscle and a superior lateral brachial cutaneous branch in all the specimens studied. Furthermore, the anterior branch of the axillary nerve provided a branch to the joint capsule, anterior and middle parts of the deltoid muscle in 100% of the cases and a branch to the posterior part of the deltoid muscle in 18% of the cases. Both the middle and posterior parts of the deltoid received dual nerve supply from both branches in 38% and 8% of cases respectively (2).

Such variations have been described in the Chinese and Caucasian populations(3). This study set out to describe the course of the axillary nerve and to document any variant anatomy of this nerve among cadaveric adult specimens in the Department of Human Anatomy Laboratory, Moi University.

MATERIALS AND METHODS

This was a descriptive dissection study on fifty-one formalin prefixed left adult upper limbs (of either sex) disarticulated at the scapulothoracic junction. It was conducted in the Human Anatomy Laboratories of Moi University, School of Medicine. All non-mutilated, non-decomposed cadavers whose anatomy of the upper limb region was intact were dissected. Only the left limbs were used since these were the majority. Dissections were done using the deltopectoral approach to demonstrate the origin, course and distribution of the axillary nerve beneath the deltoid muscle. Data obtained was entered into a Microsoft® Excel® database and exported to SPSS® version 21(SPSS Inc., Chicago, III) for analysis and presented in tables, figures and photographs. Permission and clearance to conduct the study was sought from Institutional Research and Ethics Committee (I.R.E.C) of Moi University, and the Department of Human Anatomy, Moi University, School of Medicine. Data collection tools were shredded upon completion of the study and disposed of in the most appropriate way.

RESULTS

The axillary nerve originated from the posterior cord of the brachial plexus as one of the large terminal branches of the posterior cord of the brachial plexus in all the 51 specimens.

It descended posterior to the third part of the axillary artery, lateral to the radial nerve and obliquely on the surface of the subscapularis muscle. In this proximal course, the nerve was located in an imaginary triangle bounded laterally by the tip of the acromion process and the medial border of the coracobrachialis muscle, medially by the upper lateral part of the pectoralis minor muscle, and inferiorly by the axillary artery.

It then curved posterolaterally on the inferior border of the subscapularis muscle to enter/end in the quadrangular space whose boundaries included the surgical neck of the humerus laterally, teres minor muscle superiorly, proximal part of the long head of triceps brachii medially and teres major muscle inferiorly.

The main trunk of the axillary nerve innervated the shoulder joint in a total of 41 cases (80.4%) with the anterior division supplying the remainder. No articular branch arose from the posterior division of the axillary nerve. The main trunk of the axillary nerve innervated the teres major (28.57%, n=28, Figures 1a & b), teres minor (64.29%, n=28) and subscapularis (7.14%, n=28) muscles. The anterior branch of the axillary nerve was the main/larger terminal branch of the axillary nerve which began within the quadrangular space in 100% of cases studied (n = 51) and was always accompanied by the posterior circumflex humeral vessels. The anterior branch then curved posterolaterally in close contact with the surgical neck of the humerus to enter a subfascial plane under the cover of the deltoid muscle. It terminated by dividing into intermuscular twigs which innervated the various parts of the deltoid muscle into articular branches supplying the glenohumeral joint in 19.6% of the specimens. The nerve divided into two main parts to supply the anterior and middle parts of the deltoid muscle in 51 (100%) and 47 (92.1%) of specimens respectively (Table 1). There was no branch to the posterior part of the deltoid muscle from the anterior division of the axillary nerve. In addition, one specimen received dual innervation to the middle part of the deltoid from both the anterior and posterior divisions of the axillary nerve. In 8 specimens, the nerve to teres major arose directly from the main trunk of the axillary nerve as shown in Figures 1a and 1b.

Figures 1a and 1b

Photograph and illustration showing the terminal branches from the posterior cord of the brachial plexus. PC- posterior cord of brachial plexus, RN- radial nerve, USN- upper subscapular nerve, LSN- lower subscapular nerve, AN- axillary nerve

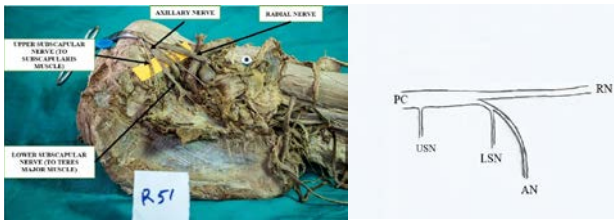

Table 1

Pattern of innervation to the deltoid muscle

Axillary nerve division	Anterior part of deltoid muscle	Middle part of deltoid muscle	Posterior part of deltoid muscle
Anterior	51 (100%)	47 (92.1%)	0
Posterior	0	4 (7.8%)	51 (100%)

The anterior part of the deltoid muscle was innervated by the anterior division, while the posterior part by the posterior division in all specimens (n=51).

The posterior branch of the axillary nerve was the smaller terminal branch of the axillary nerve. It separated from the anterior branch of the axillary nerve inferior to the glenoid at around six o'clock position within the quadrangular space in 51 (100%) of cases and curved posteromedially. The posterior branch terminated into muscular branches which supplied the teres minor muscle. The nerve to teres minor muscle arose from the posterior branch of the axillary nerve in 33 (64.7%) of cases. From its origin within the quadrangular space, it curved posteromedially to enter teres minor on its inferior surface. The posterior part of the deltoid muscle was innervated by the posterior branch of the axillary nerve in 51 (100%) of cases. In addition, the middle part of the deltoid was innervated by the posterior branch of the axillary nerve in 4 (7.8%) of cases. There was no muscular branch to the anterior part of the deltoid muscle from the posterior branch of the axillary nerve observed (Table 1).The superior lateral cutaneous nerve of the arm originated from the posterior branch of the axillary nerve in all the cases studied. This branch curved posterolaterally and deep to the posterior part of the deltoid muscle to end within the subcutaneous tissue. It did not pierce the muscle in any of the specimens studied.

DISCUSSION

The axillary nerve (C5, 6) is one of the two large terminal branches of the posterior cord of the brachial plexus. The radial nerve (C5-C8, T1) is the other branch (1, 4). In this study of 51 adult cadaveric specimens, the axillary nerve originated from the posterior cord of the brachial plexus in all specimens. This is the conventional and consistent origin of this nerve (1, 4-6).

However, variations in the classical branching pattern of the posterior cord of the brachial plexus have been shown to exist in different populations. In this study, the upper and lower subscapular nerves which usually innervate the subscapularis and teres major muscles respectively originated directly from the axillary nerve in 8 (15.7%) and 2 (3.9%) cases respectively instead of the posterior cord. This is in agreement with a cadaveric study on 75 brachial plexuses from 68 human cadavers done in Kenya which reported that only 8 (10.7%) showed the classical pattern of division of the posterior cord of the brachial plexus (7). This high individual and population variation has been attributed to the unusual embryological development of the roots, trunks and divisions of the brachial plexus (8).

This has major clinical implications during surgical procedures of the axilla and root of the neck, and during infraclavicular anaesthetic blocks of the posterior cord. Such unusual branching can lead to iatrogenic injury and peripheral nerve impingement syndromes. In addition, injury to axillary nerves that give origin to the upper, middle or lower subscapular nerves can lead to catastrophic and extensive functional impairment of the arm (7).

From its origin, the main trunk of the axillary nerve descended on the anterior surface of the subscapularis muscle and curved inferolaterally to end by dividing into its terminal branches within the quadrangular space in all of the specimens studied. The anterior branch was always located deeper than the posterior branch. Our results are comparable to both Cetik *et al.* (9) and Leechavengvongs *et al.* (9).

In contrast, Loukas *et al.* (2), reported that the axillary nerve divided within the quadrangular space in 65% and within the deltoid muscle in 35% of cases respectively in a study of 50 cadaveric specimens. Likewise, Gurushantappa *et al.* (5), studied 25 adult cadavers and demonstrated that the nerve divided within the quadrangular space and deltoid muscle in 88% and 12% of cases respectively. These differences in the branching of the main trunk of the axillary nerve can be due to the unusual embryological development of the divisions of the brachial plexus (11).

In this present study, the anterior branch of the axillary nerve originated from within the quadrangular space. It then curved posterolaterally (along the surgical neck of the humerus) and was always accompanied by the posterior circumflex humeral vessels in all the specimens with the nerve located superior to the vessels. This is in agreement with Loukas *et al.* (2), and Gurushantappa *et al.* (5). This branch is therefore at risk of injury in shoulder dislocation, fractures involving the proximal humerus and during open reduction and internal fixation of such fractures (12-16).

The posterior branch of the axillary nerve also originated from within the quadrangular space. It had an intimate relation with the inferior rim of the glenoid in all specimens studied. It innervated the posterior part of the deltoid muscle and teres minor muscle in 100% and 64.7% of specimens respectively. Finally, it terminated deep to the posterior part of the deltoid muscle to end as the superior lateral cutaneous nerve of the arm. No articular branch arose from it.

Comparable results were reported in a study of 19 freshly frozen cadavers. It was described that

the posterior branch lay directly on the shoulder joint capsule and the glenoid rim. It gave muscular branches to the posterior part of the deltoid and the teres minor and ended by becoming the superior lateral cutaneous nerve (17).

From an arthroscopic perspective, Price *et al.* (18) reported that the posterior branch of the axillary nerve and its branches to the teres minor and the superior lateral cutaneous nerve lay closest to the glenoid rim at the 6 o'clock position. The branches from the posterior part of the axillary nerve are therefore vulnerable to injury during manipulation of the inferior part of the shoulder joint capsule e.g. arthroscopic thermal shrinkage, anterior shoulder dislocation and quadrilateral space syndrome (19-21).

The teres minor muscle is classically described as part of the rotator cuff group of muscles (1, 4). It is considered as a dynamic stabilizer of the shoulder joint and functions as an external rotator of this joint with the arm in abduction. The present study found that in 64.7% of cases, the nerve to teres minor arose from the posterior branch of axillary nerve while in 35.3% it arose directly from the main trunk of the axillary nerve. In contrast, Loukas *et al.* (2) reported that the branch to teres minor muscle arose from the posterior branch of the axillary nerve in 100% of specimens studied. Both Ball *et al.* (17) and Gurushantappa *et al.* (5) reported that this nerve arose from the posterior branch of the axillary nerve.

Therefore, it can be concluded from this present study that lesions that affect the posterior branch of the axillary nerve which innervates the teres minor muscle can cause functional motor impairment with loss of sensation to the skin over the deltoid in 64.7% of cases. However, in 35.3% of the population from the present study, loss of sensation to the skin over the deltoid muscle is not a reliable indicator of coexistent injury to the nerve to teres minor as this may be supplied by a branch directly from the main trunk of the axillary nerve.

The pattern of innervation to the deltoid muscle has been shown to have individual and population variations. In this study, the axillary nerve had a consistent and predictable location within the sub fascial space deep to the deltoid muscle in all specimens. This finding is in agreement with Rotari *et al.* (22). This consistent and predictable location is clinically important in the identification of the nerve during surgeries involving the deltoid muscle.

The anterior division of the axillary nerve innervated the anterior part of the deltoid muscle in 51 (100%) and middle part of the deltoid in 47 (92.1%) in all specimens studied. While the posterior division innervated the middle part of the deltoid in 4 (7.8%) and the posterior part of the deltoid in 51 (100%) of specimens. In one specimen (1.9%), the middle part of the deltoid muscle received dual innervation from both the anterior and posterior branches of the axillary nerve. The anterior branch did not supply the posterior part of deltoid. Similarly, the posterior branch did not innervate the anterior part of the deltoid. These findings are comparable to those reported by Cetik *et al.* (9).

In contrast, both Ball *et al.* (17) and Leechavengvong *et al.* (10) described a consistent supply to posterior part of the deltoid muscle from the anterior branch of the axillary nerve. Likewise, Gurushantappa *et al.* (5) reported that the anterior branch of the axillary nerve supplied the posterior part of the deltoid muscle in 8% of specimens studied. These variable findings and descriptions on the innervation of the deltoid muscle have clinical implications on the surgical interventions and subsequent motor function upon injury. From the observations in the present study, reconstruction of the axillary nerve should involve both the anterior and posterior branches of the axillary nerve in order to restore full motor function of the deltoid muscle. In contrast, the reconstruction of the anterior branch is more appropriate for the restoration of arm abduction strength since the function of the posterior part of the deltoid (extension of the arm) can be compensated by other muscles acting on the shoulder including latissimus dorsi and teres major (23).

CONCLUSIONS

The axillary nerve has an anterior branch which is distributed over and consistently innervates the anterior and middle parts of deltoid muscle, while the posterior branch is distributed over and supplies the posterior part of deltoid. Both teres major and subscapularis muscles had unusual innervation by the main trunk of the axillary nerve in a selected number of cadaveric specimens.

CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interests regarding the publication of this paper.

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