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Objective: To investigate the relationship between the axillary nerve and arm length in a cadaveric adult Kenyan population.

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Methods: The distance of the axillary nerve from important bony landmarks such as the anterior and posterior edges of the acromion, and the lateral epicondyle of the humerus were measured and recorded.

Results: A total of fifty-one formalin prefixed left adult upper limbs were studied. The average distance of the nerve from the anterior and posterior edges of the acromion (AEA and PEA respectively) were 6.46cm (range 5.15-8.68cm) and 5.88cm (range 4.42-9.99cm) respectively. The average arm length (AL) was 31.96cm (range 27.29-38.74cm). A 1cm rise in AL had a predictable increase in nerve distances from anterior and posterior edges of the acromion by 0.104cm and 0.062cm respectively.

Conclusions: The nerve was located a minimum distance of 5.15cm and 4.42cm from the anterior and posterior edges of the acromion respectively.

Keywords: axillary nerve, arm length.

I. Introduction

The axillary nerve originates from the posterior cord of the brachial plexus. It then descends inferolaterally on the surface of subscapularis muscle to end in the quadrangular space by dividing into its two terminal divisions – the anterior and posterior (1, 2). The nerve supplies the shoulder joint, deltoid and the teres minor muscles.

Injury to this nerve can cause significant functional impairment such as limitation in shoulder abduction (3, 4). Axillary nerve injuries have been reported to be around 10% of all brachial plexus injuries (4). Trans-deltoid incisions or approaches to the proximal humerus and the shoulder joint such as open reduction internal fixation (ORIF) of proximal humerus fractures, and openrotator cuff repair places this nerve at increased risk of injury either through transection or traction (3).

Traditionally, the axillary nerve is described to lie about 5cm from the edge of the acromial process of the scapula. This measurement, however, has individual variability and differs from study to study (3, 5, 6).

II. Materials and Methods

This study conducted at the Human Anatomy laboratory of Moi University after ethical clearance from the Institutional Research and Ethics Committee (I.R.E.C) of Moi University. Fifty-one formalin prefixed left adult upper extremities disarticulated at the scapulothoracic junction were used. 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. A digital calibrated caliper [(Neiko® Tools Digital Caliper serial number 0.3.04.0487ECC) accurate to 0.01mm] was used to measure individual arm lengths and the lengths of the axillary nerve.

Hypodermic needles were introduced through the axillary nerve. This was to help in the representation of the course of the nerve on the outer surface of deltoid muscle and to minimize errors during subsequent measurements.

The distance from the acromion lateral edge to the lateral epicondyle of the humerus was measured and recorded as the arm length (AL).The course of the axillary nerve was represented on the outer surface of the deltoid muscle using hypodermic needles. A digital caliper was used to measure the distance from the anterior edge of the acromion (AEA) to the axillary nerve and recorded as the anterior distance (AD) as illustrated in figure 1 below.

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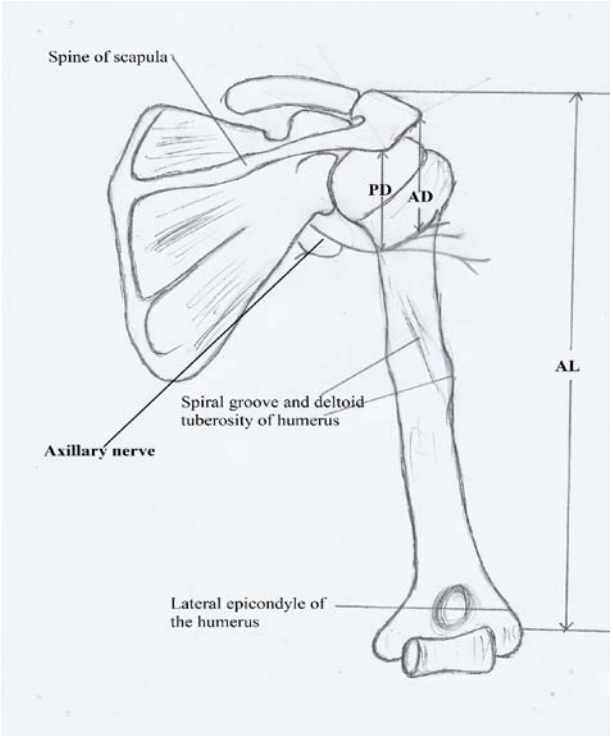

Figure 1: Measurements used to map out the axillary nerve (AL, arm length; AD, anterior distance from anterior edge of acromion to axillary nerve; PD, posterior distance from posterior edge of acromion to axillary nerve).

The distance from the posterior edge of the acromion (PEA) to the axillary nerve was measured and recorded as the posterior distance (PD). All measurements taken recorded in centimeters (cm). Correlation analysis was then performed between arm length (AL), and the anterior and posterior distances.

The ratio between arm length (AL) and the anterior distance (AD) was calculated for each cadaver and recorded as the anterior index (AI) which is the distance of the nerve from the anterior edge of the acromion divided by arm length, i.e. $AI = \frac{AD}{AL}$. Also, the ratio between arm length (AL) and the posterior distance (PD) was calculated and recorded as the posterior index (PI) which is the distance of the nerve from the posterior edge of the acromion divided by arm length, i.e. $PI = \frac{PD}{AL}$.

The distance of the nerve from important bony landmarks such as the anterior and posterior edges of the acromion, and lateral epicondyle of the humerus were measured and recorded in structured data collection forms. Data were then entered into a Microsoft® Excel® database and exported to SPSS version 21 for Windows® (SPSS, Chicago, IL, USA) for analysis.

III. Results

The average anterior distance (AD) was 6.46cm (SD 0.7cm) with a range of 5.15cm – 8.68cm. The average posterior distance (PD) was 5.88cm (SD 0.95cm) with a range of 4.42cm – 9.99cm.

Table 1: Axillary nerve distances from the acromion process of the scapula (AD-anterior distance, PD-posterior distance, AL-arm length).

Number	Parameter	Range (cm)	Mean ±SD, n=51
1	AD	5.15 – 8.68	6.46 (0.70)
2	PD	4.42 – 9.99	5.88 (0.95)
3	AL	27.29 – 38.74	31.96 (2.27)

The arm length (AL) had a mean of 31.96cm (SD 2.27cm) with a range of 27.29cm – 38.74cm as shown below.

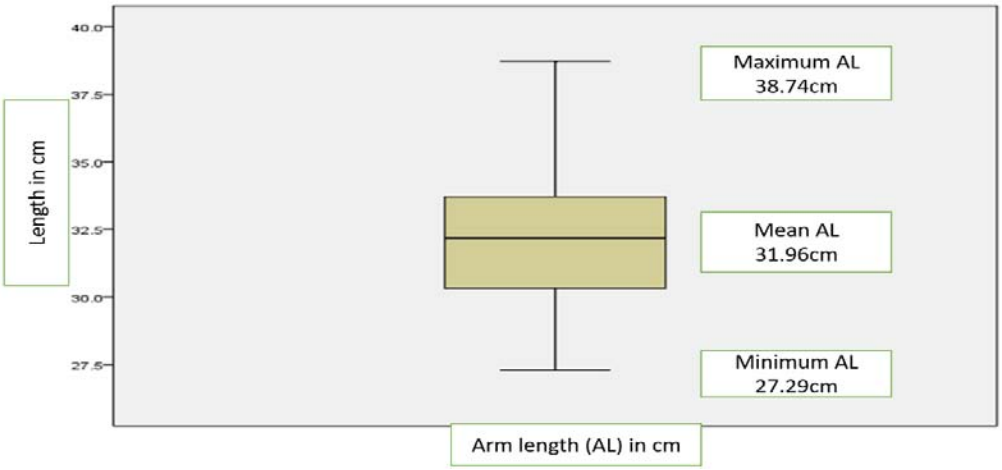

Figure 2: Average arm length (AL).

There was a significant correlation between AD and AL (r= .335; p=0.016), where AD is expected to significantly (p=0.016) increase by 0.104cm for every 1cm increase in AL.

The correlation between PD and AL (posterior index, PI) was not statistically significant (r=0.147; p=0.304). A regression model fitted on the same shows that PD is predicted to increase by 0.062cm for every 1cm increase in AL. However, this change is not statistically significant (p=0.304). The average AI and PI were 0.2±0.022cm (range 0.157- 0.253cm) and 0.185±0.033 (range 0.14-0.35cm) respectively.

IV. Discussion

From the present study, the average anterior distance (AD) was 6.46cm (range 5.15-8.68cm) while the average posterior distance (PD) was 5.88cm (range 4.42-9.99cm). The arm length had a mean of 31.96 cm (range 27.29-38.74cm). Statistical analysis of these measurements revealed that for the AI, for every 1cm increment in the arm length, the AD was predicted to increase by 0.104cm (p=0.016). This increment represented a significant change. While for the PI, for every 1cm increase in the arm length, the PD was predicted to increase by 0.062. This data did not represent a significant change (p=0.304).

The findings above are similar to those described by Cetik et al., (2006) on 24 embalmed adult cadaveric shoulders (3). The authors reported that the axillary nerve curved inferior to the anterior and posterior edges of the acromion process at an average distance of 6.08cm and 4.87cm respectively. They found a significant correlation between arm length and both the anterior ($r = 0.79$, $p < 0.001$) and posterior distances ($r = 0.61$, $p = 0.001$) respectively.

In a cadaveric study of 30 shoulders by Abhinav et al., (2008), the distance of the axillary nerve from the lateral edge of the acromion was measured in varying degrees of adduction and abduction of the shoulder joint. The average arm length (AL) was 31.0cm (range 27-34.5cm), with the axillary nerve located at an average length of 6.0cm (range 4.5-6.5cm) from the lateral edge of the acromion. This distance reduced significantly when the arm in an abducted position. Abduction moved the nerve closer to the acromion thereby putting the nerve at risk during surgery(6). The present study did not consider the nerve distances with abduction or adduction due to the stiff nature of the cadaveric specimens.

Liu et al., (2011) studied 44 embalmed adult cadaveric shoulders and found that the arm length varied amongst the Chinese and Caucasian populations. The average arm length ranged from 23.3-33.3 cm in their study. These lengths are shorter in comparison to those found in this present study because of the shorter stature of the adult Chinese in comparison to the adult Kenyan. Therefore, to avoid iatrogenic injury to the axillary nerve during drilling and screw insertion, drill guide protective systems should be placed directly on the bone during open reduction and internal fixation (O.R.I.F) of proximal humerus fractures (7).

In the current study, the average anterior (AI) and posterior indices (PI) were 0.20 (range 0.157-0.253) and 0.185 (range 0.14-0.35) respectively. These findings are similar to those reported by Cetik et al., (2006) who found figures of 0.20 and 0.16 for AI and PI respectively (3).

From the present study, a quadrangular safe area or zone which is located above the axillary nerve can be useful and safe during deltoid splitting incisions in proximal humerus fractures, intramuscular injections, and shoulder arthroscopy. This quadrangular shaped area is similar to that described by Cetik et al., (2006) as shown in figure 3 below.

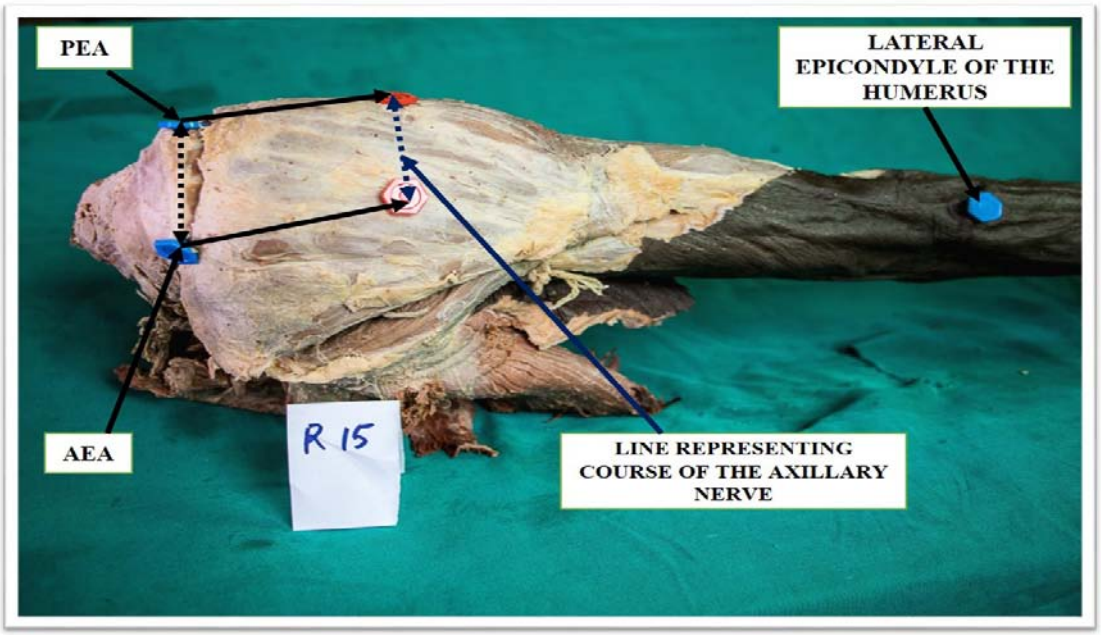

Figure 3: Photograph showing the quadrangular shaped safe area for deltoid dissections. (AEA- anterior edge of acromion; PEA- posterior edge of acromion).

Finally, the use of deltoid ratio, i.e. length and width of the deltoid muscle versus the distance from the acromion to the axillary nerve can be used to predict the location of the axillary nerve preoperatively (8). However, from the present study, measuring the deltoid length and width intraoperatively is a difficult task for the surgeon. The surgeon is advised to use easily palpable bony landmarks, i.e. the acromion process of the scapula (both the anterior and posterior edges), and the lateral epicondyle of the humerus to easily predict the course of the axillary nerve.

V. Conclusion

A 1cm rise in arm length had a predictable increase in nerve distances from anterior and posterior edges of acromion by 0.104 cm and 0.062 cm respectively.

A preoperative template of a quadrangular "safe zone/ area" as landmarks on the proximal deltoid muscle using minimum distances of 5.15cm and 4.42cm from anterior and posterior edges of acromion process of the scapula respectively should protect the axillary nerve and its branches during surgery.

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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