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A CADAVERIC STUDY ON THE POSITION OF AXILLARY NERVE, ITS VARIATION IN INDIAN POPULATION AND ITS ORTHOPAEDIC IMPORTANCE

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ABSTRACT

Background and Objectives: Axillary nerve is a terminal branch of the brachial plexus and can undergo injuries or isolated damages during certain orthopaedic procedures. Lack of knowledge in position of the nerve and its variation in the Indian population may lead to in-creased chances of its injuries. This study aims to determine the mean distance of axillary nerve from the (i) anterolateral border of the acromion process and its relation to the length of the humerus, (ii) the distance from the anteromedial tip of the coracoid process; and to compare the data with similar studies from other countries to analyse its differences. **Methodology:** A cross-sectional study comprising of sixteen upper limbs of embalmed human cadavers with two different approaches namely antero-superior and the deltopectoral approach. The axillary nerve is then found and measured between their respective bony landmarks. **Results:** Axillary nerve's position when measured from the acromion process had a positive correlation with the humeral length ($r=0.95$, $p<0.0001$). The mean values are then compared with similar studies done in other countries and in India for analysing variations. **Interpretations and Conclusion:** The mean distance of the axillary nerve from the anterolateral edge of the acromion process and the tip of the coracoid process were measured and found out to be 5.63cm and 3.71cm respectively. An appreciable variation is observed while comparing with papers from other countries. This gives an awareness of the position of the axillary nerve and its variation in the Indian population.

KEYWORDS: Axillary nerve, anteromedial, deltopectoral.

INTRODUCTION

Axillary nerve (root value: C5 and C6) emerges as a branch of posterior cord of brachial plexus and gives solid branches to teres minor and deltoid. It additionally supplies the shoulder joint and the skin over it.[1] Due to its unique anatomical position, it is usually overlooked by surgeons and is prone to injury. The axillary nerve is most commonly injured-6% of all the brachial plexus injuries[2][3]; during numerous orthopaedic surgeries like shoulder arthroscopy (16.7% incidence of axillary nerve injury in reverse shoulder arthroplasty[21]), shoulder joint replacement (1-2% of nerve injuries in rotator cuff disorders[23]), and plate fixation (following after retraction of deltoid muscle) of the proximal humerus.[4] The axillary nerve is liable to be injured via acute trauma to the shoulder or via chronic repeated trauma like in 'quadrilateral area syndrome' (entrapment of axillary nerve).[5] Most of the consequences are neurapraxia and in many cases, complete resection of axillary nerve and irreversible paralysis of the muscles supplied by it may also occur. This is observed typically during several surgical approaches in the shoulder, and the lack of awarenessof the axillary nerve's position and its variation can cause these problems. Hence, It isvery much necessary to appreciate the exact anatomical location of the nerve and its course to prevent the possible damages and to protect the nerve during surgeries and injections.

This study can clear the controversy of the variations in the position of the axillary nerve in Indian population, hence, beneficial for the orthopaedic surgeons and practitioners, especially during two different approaches (commonest: anterosuperior approach[6][10] used presently in some surgeries like shoulder arthroplasty, inferior capsular shift, etc., and the deltopectoral approach[7][8]) in procedures like shoulder joint replacement and especially minimally invasive plate osteosynthesis technique forproximal humerus fractures[6] as will be used in the methodology as well.[3][10][11]

MATERIALS AND METHODS

The instruments used consisted of electronic vernier calipers, common tools for dissections (scalpel, scissors, knife, arterial forceps-toothed and non toothed, clamps), inch tape and threads.

Anterosuperior approach to measure the distance between the axillary nerve and the anterolateral edge of the acromion process

The specimens were dissected with the shoulder positioned in neutral rotation. Before skin incision, the accompanying parameters were distinguished: coracoid process, anterolateral out-skirt of the acromion, spine of the scapula and the acromioclavicular joint. The entry point was made beginning from the acromioclavicular joint over the front of the acromion and broadened distally through the muscle gut of the deltoid, 5- 7cm from the anterolateral edge of the acromion.

Upon completion of the incision, the anterior and middle portions of the deltoid were identified. The dissection was then made between these two portions to approximately five to seven centimetres from the anterolateral border of the acromion, with distal exposure of the axillary nerve.

After identification of the axillary nerve, the deltoid was detached from the acromionto its anterolateral portion and the distance of that portion and the axillary nerve was measured with an electronic vernier caliper. [Figure I: measurement of the axillary nerve's position (blue star) from the anterolateral edge of the acromion process (blue arrow) and raw data provided in Table I].

Anterior deltopectoral approach to measure the distance between the axillary nerve and the anteromedial aspect of the tip of coracoid process

The incision was made 12-14cm long between the coracoid process and the proximal humerus shaft by a curved line. The deltopectoral groove and cephalic vein was then identified. The cephalic vein was then retracted or removed. The deltoid muscle (inferior part) and the pectoralis muscles were then dissected to expose the clavipectoral fascia. The coracoid process and the conjoint tendon were identified, andthe clavipectoral fascia was incised lateral to the conjoint tendon and inferior to the coracoacromial ligament. The deltoid muscle was retracted later-ally and the conjointtendon was retracted medially. The biceps brachii (especially the short head) and the coracobrachialis muscle were also removed and detached from the coracoid process. Hence, the proximal humerus was exposed with the confirmed anatomical landmarks (subscapularis tendon, lesser tuberosity, and greater tuberosity). The subscapularis tendon was then identified and divided vertically lateral to the musculotendinous junction. Hence, the axillary nerve was found distal to the subscapularis and medial tothe proximal humerus entering the quadrangular space [Figure II: identification of theaxillary nerve (blue arrow)].

After identification of the axillary nerve, the attachments present, the distance from the anteromedial tip of the coracoid process to the origin of the branching of the axillary nerve was then measured using an electronic vernier caliper. [Figure III: Measurementof the axillary nerve (blue arrow) from the anteromedial tip of the coracoid process (blue star) and raw data provided in Table I].

The two approaches were precisely done with the help of an orthopaedic surgeon.

In the end, after rejection of some shoulders specimens that didn't meet the requirements, sixteen adult specimens were taken into consideration for the calculation of mean and standard deviation, and for the comparison with other studies.

Correlation analysis between the distance measured from the nerve to the acromion process and the humeral length (anterior distance) were also calculated and plotted using GraphPad Prism 8.2.1(Table V and Table VI provides the raw data with the correlation analysis plotted in Graph I and Graph II) After this, the mean and standard deviation of the distances was found (Table II) and compared with other studies if similar measurements are taken to analyse the variation of the distances and the position of the axillary nerve in the Indian population (Table III and Table IV).

STUDY DESIGN

This is a cross sectional study conducted in the Department of Anatomy in the year 2019. The paper authored by Gurushantappa et al (2015)[11] revealed a mean of 3.56. Employing the above findings in the South Indian population, the sample sizeof the present study has been estimated with a confidence interval of 95% as 16.

Sixteen shoulder specimens from human embalmed cadavers of both males andfemales were dissected. Cadavers with damaged and pathological upper limb specimens were excluded from the study.

All the human shoulder cadavers were routinely fixed in formalin as per standard procedure and the specimens having shoulder pathologies or which had surgical procedures were excluded.

RESULTS

The mean distance of the axillary nerve from the anterolateral edge of the acromion process is found to be 5.89 cm and the mean distance of the axillary nerve from the tipof the coracoid process from the origin of the axillary nerve is found to be 3.89 cm. The axillary nerve's position when measured from the acromion process had a positivecorrelation with the humeral length ($r=0.95$, $p<0.0001$). The axillary nerve's position when measured from the tip of the coracoid process had no correlation with the humeral length ($r=0.30$, $p = 0.259$).

The values have been measured with other papers to compare and analyse the variations found in the Indian population. The variation of the distances of the axillary nerve from these bony prominences are appreciable when compared to studies providing these values from different countries. However, the variations are almost negligible when comparing the same values with the Indian papers.

Table I: The raw data set extracted from the methodology of the currentstudy is given as below:

S. No.	Distance (in mm) of Axillary Nerve measured from	
	Anterolateral Edge of Acromion Process	Anteromedial Aspectof Tip of Coracoid Process
1	57.7	38.2
2	60.1	38.8
3	59.5	37.1
4	59	38.1
5	59.1	41
6	60.3	39.3
7	58.8	38.1
8	56.3	39.1
9	58.1	40
10	59.3	38.5
11	57.2	37.7
12	59.1	37.7
13	57.2	38
14	60.2	40.2
15	58.9	40
16	60.9	41.9

The raw data is then converted to cm in measurements and the mean, median,range and standard deviation were calculated using GraphPad Prism 8.2.1.

Table II: Measurement of mean, standard deviation and range of thedistances measured from the mentioned landmarks to the axillary nerve's position.

	Distance from Acromion Process (in cm)	Distance from Coracoid Process (in cm)	Humeral length (in cm)
Number ofvalues	16	16	16
Minimum	5.630	3.710	27.30
Maximum	6.090	4.190	31.90
Mean	5.886	3.898	30.2678
Std. Deviation	0.1273	0.1329	1.3773

The values are measured with other studies to find the variation in andwithin Indian population.

Table III: Comparison of distance of axillary nerve from the anterolateral edge of the acromion process with different authors.

Author with Year ofStudy and Country	Number of Specimens	Distance from anterolateral edge of acromion process (in cm) Mean (SD; Range)
Abhinav G et al.(2008), Leicester, UK	13	6.0 (0.6 ; 4.5 - 6.5)
Cetik et al. (2006),Turkey	24	6.08
Rotari V et al. (2012), France**	16	7.2
Roberto Yukio et al.(2015), Brazil	22	5.32 (- ; 4.3 -6.4)
Stecco et al. (2010), Italy	16	6.8
Patra A et al.(2018), India	60	5.22 (Minimum : 3.5)
Present Study	16	5.89 (0.12 ; 5.6 - 6.0)

The mean value of the present study is statistically significant (P<0.05) witha 95% of confidence interval (CI) when compared to the mean values of theother studies.
***Although, the T test value when compared with the present values and thestudy by Rotari et al. was found to be insignificant (P=0.063).*

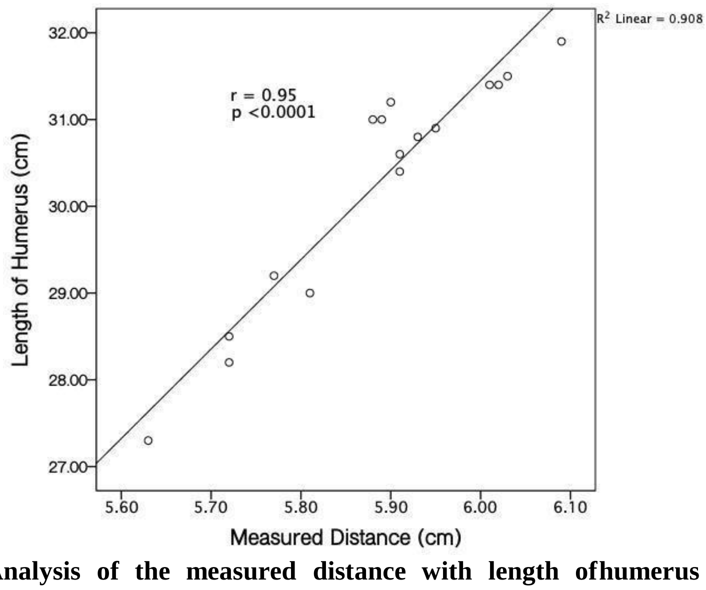
Table IV: Comparison of distance of origin of axillary nerve from the tipof the coracoid process with different authors.

Author with Year of Study and Country	Number of Specimens	Distance from tip ofcoracoid process (in cm) Mean (SD; Range)
Tubbs et al.(2001), USA	30	4
Apaydin et al. (2007), Turkey	30	3.7
Gurushantappa etal. (2015), India	50	3.56
Suman Tiwari et al. (2017), India	50	3.67
Present Study	16	3.89 (0.13; 3.7 - 4.1)

The mean value of the present study is statistically significant (P<0.05) with a 95% of confidence interval (CI) when compared to the values of theother studies.

Table V: Raw Data of length of humerus measured anteriorly with each values of the distance of axillary nerve from the anterolateral edge of the acromion process.

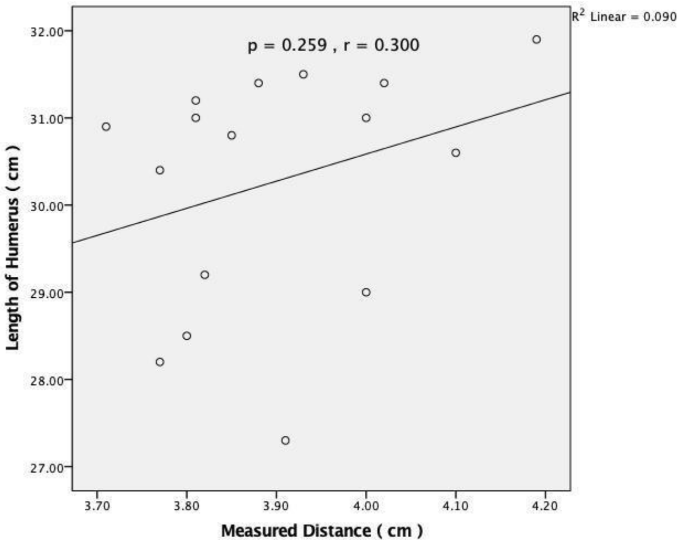
Distance of axillary nerve from anterolateral edge of acromionprocess (in cm)	Length of humerus (in cm)
5.77	29.2
6.01	31.4
5.95	30.9
5.9	31.2
5.91	30.6
6.03	31.5
5.88	31
5.63	27.3
5.81	29
5.93	30.8
5.72	28.2
5.91	30.4
5.72	28.5
6.02	31.4
5.89	31
6.09	31.9



Graph I: Correlation Analysis of the measured distance with length ofhumerus (anterior distance) in the present study of table 5.

Table VI: Raw data of length of humerus measured anteriorly with each values of the distance of axillary nerve from the tip of the coracoid process.

Distance of axillary nerve from the tip of the coracoidprocess (in cm)	Length of humerus (in cm)
3.82	29.2
3.88	31.4
3.71	30.9
3.81	31.2
4.1	30.6
3.93	31.5
3.81	31
3.91	27.3
4	29
3.85	30.8
3.77	28.2
3.77	30.4
3.8	28.5
4.02	31.4
4	31
4.19	31.9



Graph II: Correlation Analysis of the measured distance with length of humerus (anterior distance) in the present study of table 6.

Figure 1.

Figure 2.

Figure 3.

DISCUSSION

The distance of the axillary nerve from the anterolateral edge of the acromion process varies from 5.22 cm to 6.08 cm from various studies, and is summarized in Table 3. The highest mean value was observed in the study by Cetik et al.[12], and the present study value are well within the range. The mean value of the present study is statistically significant (P<0.05) with a 95% confidence interval, when compared to the values of the other studies.

The distance of the axillary nerve from the tip of the coracoid process varies from 3.56cm to 4 cm from various studies, and is summarized in Table 4. The highest mean value was provided by Tubbs et al.[15], and the present study value are well within the range again. The mean value of the present study is statistically significant (P<0.05) with a 95% confidence interval, when compared to the values of the other studies.

In our study, all the specimens contained the origin of axillary nerve, branching out from the posterior cord of the brachial plexus. The variations examined may be usually seen due to the variation of the origin of the nerve from the posterior cord of the brachial plexus.[18] Another reason that the variations stay put regionally is due to its correlation with the length of the upper arm as well. Gurushantappa et al.[11], Abhinav G et al.[14], and others have also concluded that there is a strong correlation with the position of axillary nerve in the deltoid muscle and quadrangular space; and the length of the humerus. Hence, the average growth and humeral length of the Indian population may act as a determining factor in providing these variations regionally.

The embryological reasons for variations of peripheral nerves are as follows: Position and width of a limb bud decide its innervations. The limb bud is provided by the nervesof region of where it is embedded. Isolation of the growing structure within the limb coordinates the developing nerve filaments (axons) and decides the bundling, prompting to the arrangement of roots and trunks. As the outflow of chemoattractants and chemorepulsants manages the developing nerve strands (axons) in an exceptionally composed site-explicit design, any adjustments in motioning between the mesenchymal cells and neuronal development cones can prompt critical varieties.[18]

From the studies by Cetik et al.[12], Patra A et al.[19] and Carla Stecco et al.[17], we can infer the “safe space” of the axillary nerve in the deltoid muscle, and how long cana deltoid splitting incision should be to prevent any iatrogenic and traumatic injuries of the said nerve during operations in the shoulder regions, or during transdeltoid andanterosuperior approaches of the shoulder. Abhinav G et al.[14] concludes with theirstudy that the deltoid split should not be done more than 5 cm from the anterolateral edge of the acromion process.

The present study additionally provides a similar conclusion to the Indian orthopaedic and neurosurgeons even if the variations are appreciable and the minimum distance ofthe position of the nerve stays more than 5 cm, as summarized in Table 2.

This data can also be used in terms of clinical settings, since axillary nerve can also be injured during intramuscular injections in the deltoid muscle and during anaesthetic blocks.[22]

Hence, from the present study, the variation of the axillary nerve’s position in the Indian population; comparing with studies of other countries are appreciable, but negligible within the population; and these values can be updated and kept in mind by Indian orthopaedic surgeons and neurosurgeons (especially for surgeons who may have the work experience in other countries in their past) during plate fixation, joint re- placement surgeries, neurotization, etc. to minimize the chances of axillary nerve injuries.

Furthermore, the knowledge of the position of the axillary nerve inferred from this study can also be employed by anaesthetists during ad-ministrations of anaesthetic blocks for axillary nerve. This also decreases the risks of traumatic nerve injuries during intra muscular injections in the deltoid.

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