

VARIATIONS IN THE RELATIONS OF BRACHIAL PLEXUS AND AXILLARY ARTERY

Prashant Moolya ^{*1}, Lakshmi Rajgopal ².

^{*1} Assistant Professor, Department of Anatomy, B.K.L.Walawalkar Rural Medical College, Savarde, Maharashtra, India.

² Professor (Additional), Department of Anatomy, Seth GSMC and KEM Hospital, Mumbai, Maharashtra, India.

ABSTRACT

Introduction: 'Brachial plexus' which literally means 'arm braid' (brachium=arm; plexus=braid) is an important content of axilla. Knowledge about relationship of cords and branches of brachial plexus to axillary artery is mandatory for the anaesthetists for giving brachial plexus block by axillary approach, for the surgeons who operate in the axillary region and for the radiologists for interventional therapy.

Aim: The aim of this study was to find out about the variations in the relationship of cords and branches of brachial plexus to the axillary artery.

Materials and Methods: The present study was carried out by dissection of 120 (60 right and 60 left) upper limbs in 60 embalmed cadavers that were available in the department of Anatomy of a Medical College.

Results: With reference to the first, second and third parts of axillary artery variation in relations of cords and branches of brachial plexus were noted, when the axillary artery was not passing between the two roots of median nerve. The relationship of lateral cord and its branches to axillary artery were almost constant, but that of medial and posterior cord and its branches varied.

Conclusion: Knowledge of variation in course and relations of axillary artery is useful in surgical procedures pertaining to axillary region and for the anaesthetist to perform brachial plexus block by axillary approach.

KEY WORDS: Axillary artery, brachial plexus, brachial plexus block.

Address for Correspondence: Dr. Prashant Moolya, Assistant Professor, Department of Anatomy, B.K.L.Walawalkar Rural Medical College, Savarde, Maharashtra-415606, India.

E-Mail: pmsangli2@yahoo.co.in

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INTRODUCTION

'Brachial plexus' literally means 'arm braid' (brachium=arm; plexus=braid) and has been a topic of discussion in medical literature through the centuries, right from the first anatomical dissection in the ancient period. Hippocrates provided one of the first known references that stressed the importance of nerves, warning physicians to avoid injuring the nerves within the

dislocated shoulders of soldiers during repair [1]. The brachial plexus is situated in the posterior triangle of the neck and in the axilla. Brachial plexus is formed by the union of the ventral primary rami of lower four cervical (C5, C6, C7 and C8) nerves and the first thoracic (T1) nerve.

Injecting an anaesthetic solution into or immediately surrounding the axillary sheath interrupts

nerve impulses and produces anaesthesia of the structures supplied by the branches of the cords of the plexus. Sensations are blocked in all deep structures of the upper limb and the skin distal to the middle of the arm. This procedure combined with an occlusive tourniquet technique to retain the anaesthetic agent, enables surgeon to operate on the upper limb without using a general anaesthetic. The brachial plexus can be anaesthetized using a various sites for injection e.g. Interscalene, supraclavicular and axillary approaches [2].

Compression of the axillary artery and vein causes ischemia of the upper limb and subsequent distension of the superficial veins. These signs and symptoms of hyperabduction syndrome result from compression of the axillary vessels and nerves.² Brachial plexus and axillary artery are intimately related so any variation pertaining to either of their course may raise the sign and symptoms of hyperabduction syndrome.

As the embryonic somites migrate to form the extremities, they bring their own nerve supply, so that each dermatome and myotome retain their original segmental innervation. Throughout somite migration, some of the nerves come into close proximity and fuse in a particular pattern, forming a plexus early in fetal life. However, the neurovascular bundle changes with growth, with respect to relative elongation of the neck and alterations of the ribs [3-5]. Its location and osseous relations make the plexus vulnerable to damage by traction, especially during routine neck dissection, penetrating wounds and compression from cervical ribs or damage to related vertebrae.

The frequency of variations found in the arrangement and distribution of the branches in the brachial plexus, make this anatomical region extremely complicated. During medical interventions like anaesthetic blocks, surgical approaches and while interpreting compressions of nerves caused by tumour, trauma etc. one has to keep in mind these anatomical variations. Therefore considering its clinical and surgical importance in axillary region the present study was undertaken to know the variation in relationship of cords and branches of brachial plexus to axillary artery.

Aim and Objectives: The aim of this study was to find out about the variations in the relationship of cords and branches of brachial plexus to the first, second and third parts of the axillary artery.

MATERIALS AND METHODS

The present study was carried out by dissection of 120 (60 right and 60 left) upper limbs in 60 embalmed cadavers that were available in the department of Anatomy of a Medical College over a period of 2 years. All cadavers of both sexes available during the study period were included. In this study, 6 limbs (4 left and 2 right) were excluded because of damaged nerves and fractured humerus. The skin over the axillary region was incised and the fascia was reflected. Pectoralis major and pectoralis minor muscles were cut and reflected to uncover the axillary sheath, which surrounds the axillary vessels and brachial plexus. The axillary vein and its tributaries were identified and separated from the underlying axillary artery and brachial plexus.

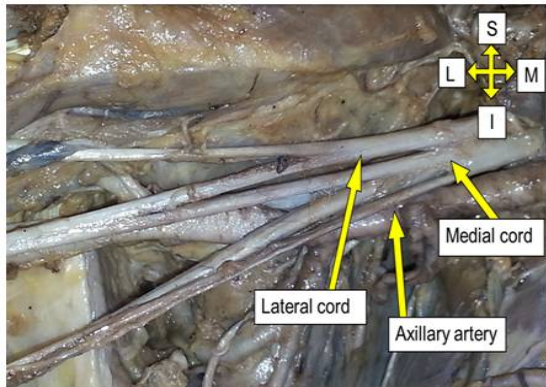
The infraclavicular part of brachial plexus was dissected and exposed. The three cords of brachial plexus (lateral, medial and posterior) were identified according to their relationship to the second part of the axillary artery posterior to the pectoralis minor muscle. The various branches were also identified. Relationship of the cords and the branches of brachial plexus to the first, second and third parts of axillary artery were studied and any variation present was noted and recorded.

The dissected specimens were numbered; photographs were taken and the observations were tabulated and statistically analysed.

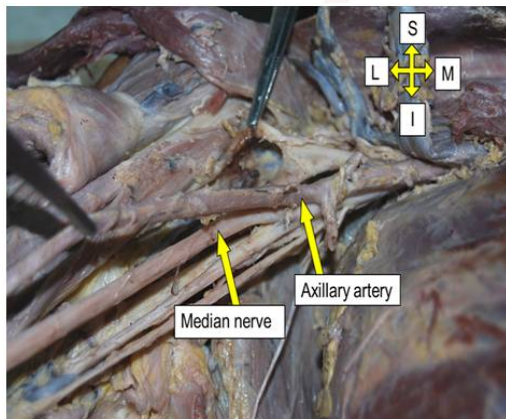
RESULTS

114 upper limbs were dissected of which 58 were of right side and 56 were of left side. Hundred limbs belonged to male cadavers and fourteen limbs belonged to female cadavers. The ages of cadavers, at the time of death ranged between 18 to 90 years.

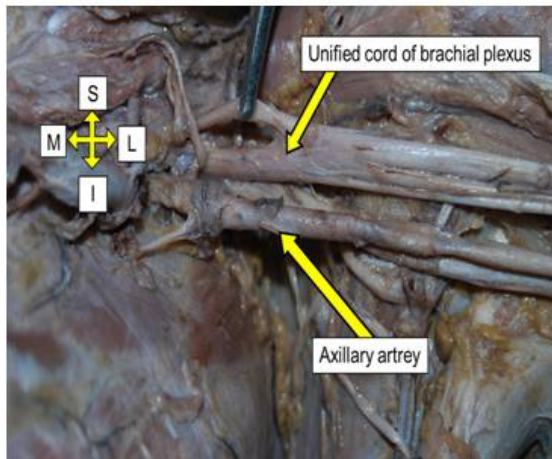
In the present study the relationship of cords and branches of brachial plexus to the first, second and third part of axillary artery is tabulated in table 1, table 2 & table 3 respectively.

Fig. 1: Axillary artery lying posterior to medial and lateral cords of brachial plexus.

S= Superior I= Inferior M= Medial L=Lateral

Fig. 2: Axillary artery lying superficial to median nerve.

S= Superior I= Inferior M= Medial L=Lateral

Fig. 3: Variation in relationship of axillary artery lying posteromedial to the unified cord of brachial plexus.

S= Superior I= Inferior M= Medial L=Lateral

Table 1: Relationship of the cords of brachial plexus to the first part of axillary artery.

Relations of cords	Lateral cord		Medial cord		Posterior cord	
	Right	Left	Right	Left	Right	Left
Inferior	-	-	1 (1.80%)	-	-	-
Superior	58	56 (100%)	2 (3.4%)	2 (3.6%)	54 (93.1%)	54 (96.4%)
Posterior	-	-	55 (94.8%)	54 (96.4%)	4 (6.90%)	2 (3.60%)
Anterior	-	-	-	-	-	-

Table 2: Relationship of the cords of brachial plexus to the second part of axillary artery

Relations of cords	Lateral cord		Medial cord		Posterior cord	
	Right	Left	Right	Left	Right	Left
Medial	-	-	55 (94.90%)	52 (92.80%)	-	-
Lateral	58 (100%)	56 (100%)	2 (3.4%)	2 (3.60%)	-	1 (1.80%)
Posterior	-	-	-	2 (3.60%)	58 (100%)	55 (98.20%)
Anterior	-	-	1 (1.70%)	-	-	-

Table 3: Relationship of the branches of the cords of brachial plexus to the third part of axillary artery.

Branches of cords of brachial plexus	Medial		Lateral		Anterior		Posterior	
	Right	Left	Right	Left	Right	Left	Right	Left
Median nerve	9	9	43	41	5	6	1	-
Ulnar nerve	55	54	2	2	-	-	1*	-
Musculocutaneous nerve	-	-	56**	53**	1	-	-	-
Medial cutaneous nerve of arm	55	54	2	2	-	-	1*	-
Medial cutaneous nerve of forearm	55	54	2	2	-	-	1*	-
Upper subscapular nerve	-	-	-	-	-	-	58	56
Lower subscapular nerve	-	-	-	-	-	-	58	56
Thoracodorsal nerve	-	-	-	-	-	-	58	56
Axillary nerve	-	-	-	-	-	-	58	56
Radial nerve	-	-	-	-	-	-	58	56

* denotes posteromedial

** denotes musculocutaneous nerve absent in 2 limbs

Table 4: Variation in the relationship of axillary artery to median nerve.

Authors	Sample Size	Cases showing variations	Axillary artery posteromedial to median nerve		Axillary artery superficial to median nerve
			Unified cord	Aberrant connection	
Miller (1939) [12]	480	42	-	1	17
HJ Yang et al (2009) [17]	607	12	5	6	-
Present study	114	5	2	-	1

With the reference to the first part of axillary artery, the lateral cord of brachial plexus was superior in 100% of cases; the medial cord was posterior in (95.6%) of cases and the posterior cord was superior in (94.7%) of cases. With the reference to the first part of axillary artery in males, the lateral cord of brachial plexus was superior in 100% of cases; the medial cord was posterior in 95% of cases and the posterior cord was superior in 95% of cases.

With the reference to the first part of axillary artery in females, the lateral cord was superior in 100% of cases; medial cord was posterior in 100% of cases and the posterior cord was superior in 92.8% of cases.

With the reference to the second part of axillary artery, the lateral cord was lateral in 100% of cases; the medial cord was medial in 93.9% of cases and the posterior cord was posterior in 99.2% of cases.

With the reference to the second part of axillary artery in males, the lateral cord was lateral in 100% of cases; the medial cord was medial in 93% of cases and the posterior cord was posterior in 99% of cases.

With the reference to the second part of axillary artery in females, the lateral cord was lateral in 100% of cases; the medial cord was medial in 100% of cases and the posterior cord was posterior in 100 % of cases.

DISCUSSION

With the advancement in the field of regional anaesthesia and better understanding of applied anatomy, peripheral nerve blocks are becoming more and more popular. Brachial plexus blocks are easy and relatively safe procedures and achieve ideal operating conditions by producing complete muscle relaxation, pain relief, maintaining stable intra-operative hemodynamics.

Axillary artery pulsation serves as an important landmark in brachial plexus blocks [7]. In this procedure, the axillary artery is palpated with the arm abducted at right angles to the body and the injection is made at the highest point in the axilla where the pulsations of the axillary artery can be felt. Disturbed relationship of axillary artery with the brachial plexus, may lead to partial failures of brachial plexus blocks using the axillary artery approach [8]. So knowledge pertaining to the relationship of cords and its branches to the axillary artery is of utmost importance.

Walsh [9] was the first one to describe variation in the formation of brachial plexus and he had described a single trunk in the formation of brachial plexus. Singer [10] also reported the formation of a single cord of brachial plexus due to abnormal formation of axillary artery. Kerr [11] classified the variations of brachial plexus into three groups and seven subgroups and also noted variation in the relationship of the variable cords to axillary artery.

The concept of an intersegmental artery was introduced by Miller (1939) [12] to describe variable arrangements between the axillary artery and the brachial plexus. Miller hypothesized that the relationship between the axillary artery and the brachial plexus was closely related to the origin of the axillary artery. An ordinary axillary artery is the continuation of the seventh intersegmental artery that penetrates the plexus between its middle and inferior trunks. A variant intersegmental axillary artery is a continuation of the sixth, eighth, or ninth intersegmental artery depending on its passage through the trunks. Miller's study has implications for the classification of axillary arterial courses based on the developmental process.

An interesting question is whether variations of the brachial plexus induce segmental arterial variation, or whether arterial variation induces variations in the plexus. Embryologic study may suggest an answer for this question as it can address whether the nerves or the arteries develop earlier. In the upper limb buds of mouse embryos, the primary artery appears earlier than the brachial plexus [13].

However, they stated that it is hard to determine whether the formation of the brachial plexus depends on the route selection of the axillary artery, or vice versa.

Singhal S. et al.(2007) reported the lateral root of median nerve crosses the artery anteriorly and meets the medial root such that the median nerve lies medial to the third part of axillary artery [14]. Das and Paul have observed a similar case where there were two lateral roots of the median nerve [15]. In a study done by Pandey and Shukla on 172 cadavers, in 8 cadavers, the median nerve was formed medial to the artery and travelled as such [16]. Anomalous branches of lateral cord crossing the artery anteriorly may cause compression syndromes producing ischemia. The subclavian and axillary systems of arteries are derived from the seventh cervical intersegmental artery. Hence, the artery passes between the lateral and medial cords, representing the fifth, sixth and seventh cervical nerve on one hand and the eighth cervical and first thoracic on the other. Sometimes, the artery may arise from the sixth, the eighth or

the ninth intersegmental artery and then it has abnormal relations to the plexus and the plexus is in turn modified by the presence of the abnormally placed artery. This might explain the various abnormalities in the case seen by Singhal S. et al [14].

Yang HJ et al (2009) analyzed the abnormal position and course of the axillary artery related to the brachial plexus in 607 axillae of 306 cadavers. They found 12 unusual axillary arteries that did not pass through the median loop. Eleven arteries were determined to be ninth intersegmental arteries and one as the sixth intersegmental artery. All ninth intersegmental arteries ran caudally to the brachial plexus. In six cases of this type, abnormal connections interfering with the normal arterial position were observed in the brachial plexus. In another five cases of this type, the lateral and medial cords merged and the axillary artery passed anteromedial to the plexus. The sixth intersegmental axillary artery pierced the musculocutaneous nerve which was from the unified lateral and medial cords. In the study authors discussed how the anomalous structure of the brachial plexus could involve the deterioration of the course of the axillary artery. The anatomical details of this study may be helpful for clinicians. In the modern medical field, variations in the positional relationships of the brachial plexus and axillary arteries may be associated with unexpected failure or complications of clinical procedures [17]. For example, positional variation of the axillary artery may result in incomplete axillary block [18] since it is the palpable landmark of the axillary sheath when performing an axillary anesthetic block [19]. This kind of variation may also increase the incidence of brachial plexus injury after cannulation [20]. Repairing acute traumatic injury of the axillary artery and brachial plexus causes difficulties for surgeons because of in continuity lesions, loss of substance, or double-level lesions [21]. Simultaneous variations in the course of the axillary artery and brachial plexus may add great confusion to this situation. Awareness of segmental variation in the axillary artery may help medical practitioners to avoid unexpected failures during invasive procedures. Although conventional techniques are based on concrete

knowledge of anatomy, awareness of segmental variations and use of imaging tools can assist practitioners to avoid unwanted outcomes [17].

Satyanarayana et al. (2009) reported in one case as all the three cords namely lateral, medial and posterior cords of brachial plexus were noted to be lateral to the third part of axillary artery [22].

In the present study, the relationship of cords and branches of brachial plexus with all the three parts of axillary artery were noted. Variations in the relation of brachial plexus to the axillary artery were found when the artery was not passing between two roots of median nerve. The relationship of lateral cord and its branches to axillary artery were almost constant, but that of medial and posterior cord and its branches varied. In relation to the first part of axillary artery, lateral cord was superior in all (114) limbs; medial cord was inferior in one limb, superior in 4 limbs, posterior in 109 limbs; posterior cord was superior in 108 limbs and posterior in 6 limbs (Fig. 1). In relation to the second part of axillary artery, lateral cord was lateral in 114 limbs; medial cord was medial in 107 limbs, lateral in 4 limbs, posterior in 2 limbs, anterior in one limb; posterior cord was posterior in 113 limbs and lateral in one limb. In relation to the third part of axillary artery, branches of posterior cord were all posterior; branches of lateral cord were all lateral; amongst branches of medial cord, ulnar nerve, medial cutaneous nerve of arm, medial cutaneous nerve of forearm were medial in 109 limbs, lateral in 4 limbs and posterior in one limb. Much variation was seen in relationship of median nerve which was lateral in 84 limbs, medial in 18 limbs and anterior in 11 limbs.

Comparing the studies done by HJ Yang et. al (2009), Satyanarayana et al (2009) and Miller (1939), in the present study, we found 5 limbs which had variation in the course of axillary artery with relation to brachial plexus. Axillary artery was lying medial to the cords of brachial plexus in 4 limbs and anterior to the branches of brachial plexus (Median nerve) in one limb (Fig.2). Out of the 4 limbs in which axillary artery was medial in relation to the cords, in two cases cords of brachial plexus were unified (Fig.3) and remaining two had routine cord formation but the axillary artery was not passing

between the two roots of median nerve.

CONCLUSION

Knowledge pertaining to the relationship of cords and branches of brachial plexus to the axillary artery is important for the anaesthetist as any variation in the relations could be the probable cause of failure of anaesthesia in that region. Various interventional studies like angiography could be used to determine the normal and anomalous positions of arteries and veins pre-operatively, but in case of nerves it is not possible to detect such an anomaly. It is only at the time of surgery that the surgeon is exposed to such variations. Therefore, the prior anatomical knowledge of such anomalies may provide great help to the operating surgeons in the axillary region.

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Conflicts of Interests: None

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