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Original Article

Brachial Plexus: Variations in Infraclavicular Part and their Significance

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Abstract

Introduction: Brachial plexus extends from the neck to the axilla and gives motor and sensory nerves to the upper limb. The brachial plexus has two parts supraclavicular and infraclavicular parts.

Material and Methods: The present study was carried out on 15 adult human cadavers (15 specimens of the right and left side of the upper limb) in the Department of Anatomy, Government Medical College and Hospital, Chandigarh. All the cadavers were male.

Observations: Of 30 cases, one specimen (3.34%) had variation in the arrangement of all cords (lateral, medial, and posterior) respective to the 3rd part of axillary artery, i.e., all three t cords lie lateral to 3rd part of axillary artery. In one case (3.34%), it was observed that lateral cord gave separate branch to coracobrachialis muscle. Musculocutaneous nerve passes straight downward placed between biceps brachii and brachialis. Musculocutaneous nerve continues as lateral cutaneous nerve of forearm. In another two cases (6.66%), there is communication between musculocutaneous and median nerve. Five cases (16.66%) had variations in the formation of median nerve. Here, median nerve was formed from three roots of two roots were originating from lateral cord and one root from medial cord. In three cases (10%), there is higher origin of median nerve by joining of its two roots. In one case (3.34%), there are two upper subscapularis nerves from the posterior cord. Other branches of this cord are lower subscapular, nerve to latissimus dorsi, radial, and axillary nerve which is normal in their positions.

Discussion: Development of brachial plexus starts at 34th–35th day of intrauterine life and definitive adult pattern is visible by 46th–48th day of intrauterine life. The growing axons are regulated by chemoattractants and chemorepulsants in a site-specific fashion. Changes in the signaling pattern between mesenchymal cells and neuronal growth cones can lead to variations.

Conclusion: These variations are important for surgeons, neurosurgeons, and plastic surgeons in their respective field in knowing area of loss, loss of muscle power as well as in designing various surgeries.

Key words: Brachial plexus, Infraclavicular, Median nerve, Musculocutaneous nerve

INTRODUCTION

Brachial plexus extends from the neck to the axilla and gives motor and sensory nerves to the upper limb. It is formed by the union of the ventral rami of the lower four cervical and first thoracic spinal nerve (C5, 6, 7, 8, and T1).[1] The brachial plexus has two parts supraclavicular and infraclavicular parts. The supraclavicular part consists of roots, trunks, divisions, and some branches. The infraclavicular part of brachial plexus consists of three cords, lateral, medial, and posterior.[2] Cords of brachial plexus had same relation corresponding to their name with third part of axillary artery. Lateral cord is formed by the anterior division of upper and middle trunks and it lies lateral to the third part of axillary artery. The medial cord is formed by the anterior division of lower trunk and it maintains medial position in respect to third part of axillary artery. The posterior cord is formed by the union of all three posterior divisions of upper, middle, and lower trunks. It lies behind the third part of axillary artery; the branches of the posterior cord lie posterior to the third part of axillary artery.[3]

Each cord of the brachial plexus has its own branches which supply the different compartment muscles or structures of

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the upper limb. The present study was undertaken to observe variations in the cords, branches of each cord, and relation of these cords with the third part of axillary artery. Variations in the branches were observed up to the cubital fossa.

Hence, knowledge of variations is important for diagnosis based on clinical symptoms, during procedures like anesthetic blocks and designing surgical approaches for nerve compressions caused by tumor or trauma. Unawareness of these variations can cause irreversible damage to the structure during surgical procedure.

MATERIALS AND METHODS

The present study was carried out on 15 adult human cadavers (30 specimens of the right and left side of the upper limb) in the Department of Anatomy, Government Medical College and Hospital, Chandigarh. All the cadavers were male. Cadavers with no injury and disease in the neck, axilla, pectoral region, and upper limb were included in the study. Dissection was done according to Cunningham's manual of practical anatomy. The study was done to observe the variations in the infraclavicular part of brachial plexus. The observations were made carefully and recorded. Photographs of dissected parts were taken. The data obtained were compared with those of earlier workers on this topic, and an analysis of the findings was done.

Observations

Normally all three cords (lateral, medial, and posterior) are placed according to their name (lateral, medial, and posterior) to 3rd part of axillary artery.

Of 30 cases, only one specimen (3.34%) [Figure 1], had variation in the arrangement of all cords (lateral, medial, and posterior) respective to 3rd part of axillary artery, i.e., all cords lie lateral to 3rd part of axillary artery.

In the rest of 29 cases (96.6%), all cords were placed in their normal position in relation to 3rd part of axillary artery.

Normally, lateral cord gives three branches lateral pectoral, musculocutaneous, and lateral root of median nerve. Musculocutaneous nerve (C5, C6, and C7) pierces the coracobrachialis muscle and supplies it, passes between biceps brachii and brachialis muscle. Thereafter, it continues as lateral cutaneous nerve of forearm.

In one case (3.34%) [Figure 2], it was observed that lateral cord gave a separate branch to coracobrachialis muscle. Musculocutaneous nerve passes straight downward placed between biceps brachii and brachialis. Musculocutaneous nerve continued as a lateral cutaneous nerve of forearm.

In another two cases (6.66%) Figure 3, there was communication between musculocutaneous and median nerve. Normally, there is no communication between these nerves.

Median nerve is usually formed by the contribution of both lateral and medial cord (C5, C6, C7, C8, and T1) of brachial plexus. Lateral root (C5, C6, and C7) arises from lateral cord and medial root (C8 and T1) arises from medial cord of brachial plexus.

In the present study, five cases (16.66%) [Figure 3] had variations in the formation of median nerve. Here, median

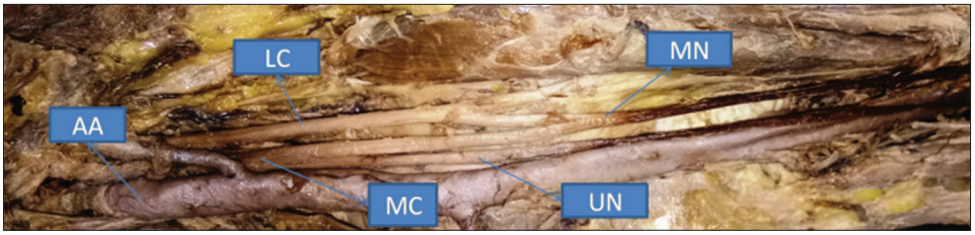

Figure 1: Infraclavicular part of brachial plexus showing all three cords are present lateral to axillary artery. AA: Axillary artery, LC: Lateral cord, MC: Medial cord, MN: Median nerve, UN: Ulnar nerve

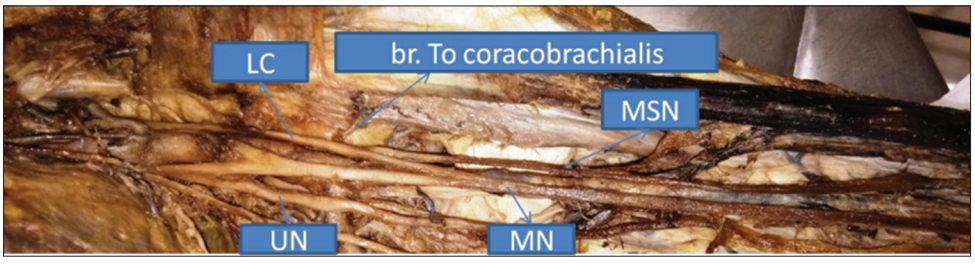

Figure 2: Infraclavicular part of brachial plexus showing separate branch to coracobrachialis muscle. LC: Lateral cord, MSN: Musculocutaneous nerve, UN: Ulnar nerve, MN: Median nerve

nerve was formed from three roots of two roots were originating from lateral cord and one root from medial cord. In these cases, lateral root from lateral cord united with medial root from medial cord to form median nerve. Later some fibers, i.e., extra root from lateral cord united with median nerve at lower level.

In three cases (10%) [Figure 4], there was a higher origin of median nerve by joining of its two roots. Normally, the formation of median nerve was at lower level and lateral to ulnar nerve.

In one case (3.34%) [Figure 5], there were two upper subscapularis nerves from posterior cord. Other branches of this cord were lower subscapular, nerve to latissimus dorsi, radial, and axillary nerve which are normal in their positions.

DISCUSSION

The brachial plexus is formed by ventral rami of C5–T1 spinal nerves and is for the nerve supply of the upper limb structures. This plexus may have a contribution from C4 or T2. Of these, two contributions of T2 spinal nerve are less common. C7–C8 ventral rami are largest and the smallest ventral rami are C5–T1. Three trunks, namely, upper, middle, and lower trunks, are formed by the union of these ventral rami, deep to scalenus anterior. The upper trunk is formed by spinal C5 and C6, the middle trunk is formed by continuation of spinal nerve C7. The lower trunk is formed by the union of C8 and T1. Each trunk further divides into anterior and posterior division. The formation of trunks is fairly consistent; they lie in front of one another rather than side by side, with the subclavian artery passing anteromedially. The phrenic nerve crosses C5 to pass anteromedially on the surface of scalenus anterior. The upper trunk divides above the clavicle and the divisions of middle and lower trunk are present deep to the clavicle. Further three cords are formed the joining of anterior and posterior divisions of three trunks. The lateral cord is formed from the anterior division of the upper and middle trunks, the posterior cord by all three posterior divisions of trunks. The medial cord is formed by continuation of the anterior division of the lower trunk. The part of the brachial plexus from the formation up to its passage into the upper limb through cervicoaxillary canal constitutes supraclavicular part of brachial plexus. Beyond this point,

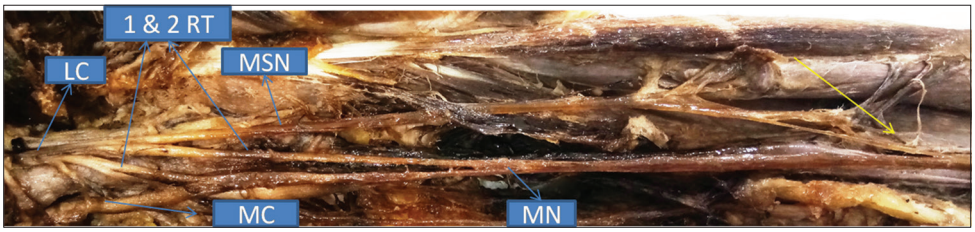

Figure 3: Infraclavicular part of brachial plexus showing three roots of median nerve and yellow arrow showing communication between musculocutaneous and median nerve. LC: Lateral cord, MC: Medial cord, MN: Median nerve, MSN: Musculocutaneous nerve

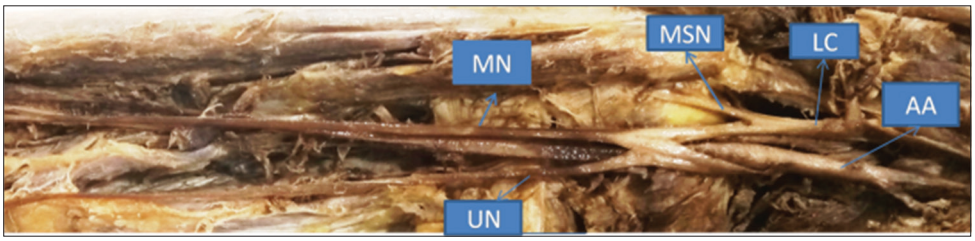

Figure 4: Infraclavicular part of brachial plexus showing higher origin of median nerve. MN: Median nerve, MSN: Musculocutaneous nerve, LC: Lateral cord, AA: Axillary artery, UN: Ulnar nerve

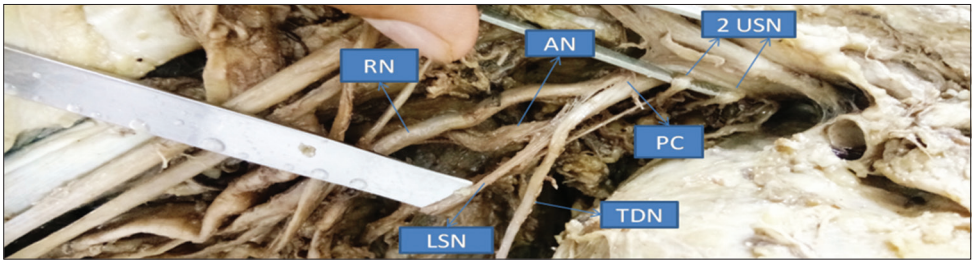

Figure 5: Infraclavicular part of brachial plexus showing two upper subscapular nerves. RN: Radial nerve, AN: Axillary nerve, USN: Upper subscapular nerve, PC: Posterior cord, TDN: Thoracodorsal nerve, LSN: Lower subscapular nerve

the brachial plexus cords and their branches extend as infraclavicular part of brachial plexus.[4]

Formation of the cords from divisions of the trunks is functionally important. Posterior cord formed from posterior divisions of all trunks supply extensor musculature of the upper limb while the lateral and medial cords formed from the anterior divisions innervate flexor musculature of the upper limb. The formation and relations of three cords are important to axillary structures especially axillary artery. Immediately inferior to clavicle, the posterior cord is lateral, the medial cord is posterior, and the lateral cord is anterior, in relation to axillary artery. The cords assume their appropriate relation above the axillary artery deep pectoralis minor. There is considerable variation in this arrangement; most commonly, the axillary artery lies anterior to three cords and median nerve. The branches of the posterior cord and the largest of the three trunks are consistent. In sequence, they are the upper subscapular, thoracodorsal, lower subscapular, axillary, and radial nerve. The branches of medial cord are medial pectoral nerve and medial cutaneous nerve of arm and forearm terminates by division into the medial root of median nerve and the ulnar nerve. The different branches of the lateral cord are lateral pectoral nerve, musculocutaneous nerve, and lateral root of median nerve.

The greatest variation in the formation of trunk nerves is found within the lateral cord. Occasionally, the musculocutaneous nerve arises more distally than usual, springing either directly from the lateral cord as two or three branches or even from the median nerve itself. Sometimes, the highest of these branches enter coracobrachialis no more than 2 or 3 cm below the coracoid process. The lateral root of median nerve may arise as two or three branches, and in some cases, it appears as a branch of musculocutaneous nerve. The ulnar nerve may arise as two or three branches. Like any other nerve plexus variations occur in the branches of this plexus also.[4]

Satyanarayana *et al.* published a case in which 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.[4] Similar variation was found in a case, i.e., all cords are present lateral to the third part of axillary artery [Figure 1].

A case reported by Jamuna and Amudha, only two cords anterior and posterior were formed and lie lateral to the axillary artery instead of developing three cords (medial, lateral, and posterior). Anterior cord is developed by the fusion of medial and lateral cord. Branches of both the cords (medial and lateral) arise from anterior cord.[5]

Singer observed very rare variation that all the roots of plexus fused to form a one cord, he reported that this variation is due to the abnormal formation of axillary artery.[6]

In three cases, Khake *et al.* reported that musculocutaneous nerve gave a separate branch to coracobrachialis muscle before piercing it. After this, it gave muscular branches to supply the biceps brachii and brachialis muscles, a communicating branch was also given to the median nerve. Distally nerve continued as lateral cutaneous nerve of forearm.[7] In the present study, in one case separate branch to coracobrachialis muscle was originated from lateral cord. Musculocutaneous nerve passed straight downward without piercing and giving any branch to coracobrachialis. It was placed between biceps brachii and brachialis where it gave muscular branches to both of them. Nerve continued distally as the lateral cutaneous nerve of forearm [Figure 2].

Chauhan and Roy studied 400 upper limb specimens and observed one case where the communicating branch joined the median nerve below the insertion of coracobrachialis muscle. The communicating branch was joined by a twig from musculocutaneous nerve at level of insertion of coracobrachialis muscle. The musculocutaneous nerve did not pierce the coracobrachialis muscle.[8] We observed in two cases, there is communication between musculocutaneous and median nerve in the arm below the insertion of coracobrachialis [Figure 3].

Arora and Dhingra reported that variation in which median nerve was formed by the contribution of three roots and musculocutaneous nerve was absent.[9]

Budhiraja and Rastogi reported formation of median nerve from three roots, i.e., upper two roots coming from lateral cord and third last root from medial cord.[10] In the present study, similar variation was seen in five cases [Figure 3].

In the present study, in three cases [Figure 4], there is higher origin of median nerve by joining of its two roots. Normally, formation of median nerve is at lower level and lateral to ulnar nerve. We could not found this type of variation in available literature.

Sinha and Chaware observed variation in the branches posterior cord where two upper subscapular nerves were given off instead of one. In the present study, a similar variation is observed in one case[11] [Figure 5].

Miller observed that abnormal formation in the development of trunks, divisions, and cords leads to variations in the branching pattern of brachial plexus.[12] Anatomical variations of brachial plexus can be traced by understanding its normal embryological development. Moore and Persaud noticed that development of brachial plexus starts at

34th–35th day of intrauterine life and definitive adult pattern is visible by 46th–48th day of intrauterine life.[13] Miller observed axillary artery has an important role in orientation of the divisions of the cords.[14]

Hamilton *et al.* explained that the paraxial mesoderm in growing embryo differentiates into myotome, dermatome, and sclerotome. Myotome forms muscles. During development, the cells of myotome usually elongate in a direction parallel to long axis of the embryo. Myotome enlarges rapidly both dorsally, flanking the neural tube and ventrally, where it extends into the somatopleure. At the same time, the fibers of ventral roots of the spinal nerve growing out of the neural tube and come in contact with the cells of appropriate myotome permanently. The myotome becomes divided by slight constriction into a dorsal epaxial portion and ventrolateral portion. Accordingly the ventral root nerve fibers split into a primary dorsal ramus and ventral ramus supplying to corresponding portions of the myotome. During further development, the nerve actually grows to the muscle and follows it during any subsequent migration.[15]

Sannes *et al.* stated that the growing axons are regulated by chemoattractants and chemorepulsants in a site-specific fashion. Changes in the signaling pattern between mesenchymal cells and neuronal growth cones can lead to variations.[16] Result of all these changes is anatomical variations in the formation and branching of brachial plexus. However, little functional significance a variation has the surgeon need to be aware of these while planning surgery and knowing its outcome in the axillary region below in different regions of the upper limb.

CONCLUSION

The present study was conducted with an objective to see variations in the branches of cords. We found many variations, i.e., separate branch to coracobrachialis, two upper subscapularis, three roots of median nerve, and communication between median and musculocutaneous nerve. These variations are important for surgeons, neurosurgeons, and plastic surgeons in their respective field in knowing area of loss, loss of muscle power as well as in designing various surgeries.

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