



## Case Report

### Multiple bilateral Neuroanatomical variations of the nerves of the arm-A Case Report

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#### ABSTRACT:

Variations in arrangement and distribution of lateral and medial cords of brachial plexus and their branches in infraclavicular part of plexus are common in one or both axillae and have been reported by several investigators since the 19<sup>th</sup> century. The present case report describes multiple bilateral neuroanatomical variations in the upper arm involving both these cords simultaneously observed during routine educational dissection of upper extremity in a 52-year-old male cadaver. Such multiple variations coexisting in the same case have not been reported often in literature. Precise knowledge of such variations may help while planning surgeries in the region of axilla and arm, traumatology of the shoulder joint and plastic and reconstructive repair operations, as these nerves are more liable to be injured during operations. Considering the clinical importance of the variations documented in this case report an attempt has been made to explain these variations in light of embryogenic development.

**KEY WORDS:** brachial plexus, infraclavicular, lateral cord, medial cord, neuroanatomical variations.

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## INTRODUCTION:

Brachial plexus is a complex of nerves originating in the neck and axilla and is formed by the anterior primary rami of spinal nerves C5, C6, C7, C8 and T1. The fibres of the plexus may be joined by branches from the fourth cervical and second thoracic nerves which then unite, divide and unite again to form three trunks (upper, middle and lower), three cords (medial, lateral and posterior) and the nerves of the upper extremities. C5 and C6 roots join to form the upper trunk. C7 root forms the middle trunk. C8 and T1 roots join to form the lower trunk. Each trunk divides into ventral and dorsal divisions. Ventral division of the lower trunk forms medial cord. Dorsal divisions of all the three trunks join to form posterior cord. Ventral divisions of upper and middle trunks join to form lateral cord [1].

Normally, the lateral cord (LC) gives its first branch, the lateral pectoral nerve (LP) which passes forwards on the lateral side of the first part of the axillary artery, to supply the pectoralis major (P<sub>Ma</sub>) muscle in the anterior axillary wall. The remaining part of the LC divides into the musculocutaneous nerve (MCN) and the lateral root of the median nerve (LR). The MCN pierces the coracobrachialis (CB) muscle and then passes obliquely down to the lateral side of the arm between the biceps brachii (BB) and brachialis (BR) muscle, pierces the deep fascia lateral to the tendon of BB near elbow and then it continues as the lateral cutaneous nerve of the forearm (LCNF); without exhibiting any communication with MN or any other nerve. In its course through the arm it supplies the CB, BB and the greater part of the BR muscle. The branch to CB arises from the MCN close to its origin, and in some instances as a separate filament from the LC of the brachial plexus. The branches to the BB and BR are given off after the MCN has pierced CB; that supplying the BR gives a filament to the elbow joint. The nerve also sends a small branch to the bone, which enters the nutrient foramen with the accompanying artery [2].

The medial cord (MC) of the brachial plexus divides into five terminal branches, medial pectoral nerve, medial root of median nerve, medial cutaneous nerve of arm, medial cutaneous nerve of forearm and ulnar nerve. All the branches are usually separated at its origin itself [3].

The medial pectoral nerve (MP) after arising from the MC of the brachial plexus passes medial to the first part of the axillary artery; supplies and pierces pectoralis minor (P<sub>Mi</sub>) to enter pectoralis major (P<sub>Ma</sub>) [2].

The median nerve (MN) is formed anterior or anterolateral to the third part of the axillary artery by the union of its medial root (MR) from the MC and lateral root (LR) from the LC of the brachial plexus. The MN passes in the arm at first lateral to brachial artery and near the insertion of CB it crosses in front of (rarely behind) the artery, descending medial to it in the cubital fossa, where it passes posterior to the bicipital aponeurosis and anterior to BR muscle, separated by the latter from the elbow joint. It usually enters the forearm between the heads of the pronator teres, crossing to the lateral side of the ulnar artery and separated from it by the deep head of pronator teres. Thus, the MN passes through the anterior compartment of arm without innervating any flexure muscle of the arm [4].

## CASE REPORT:

During the routine educational dissections for the medical undergraduate students in Guru Gobind Singh Medical College, Faridkot, Punjab; in a male cadaver of approximately 52 years of Asian origin, in the region of axilla and arm, we found multiple variations involving the branches of the medial and lateral cords of the brachial plexus.

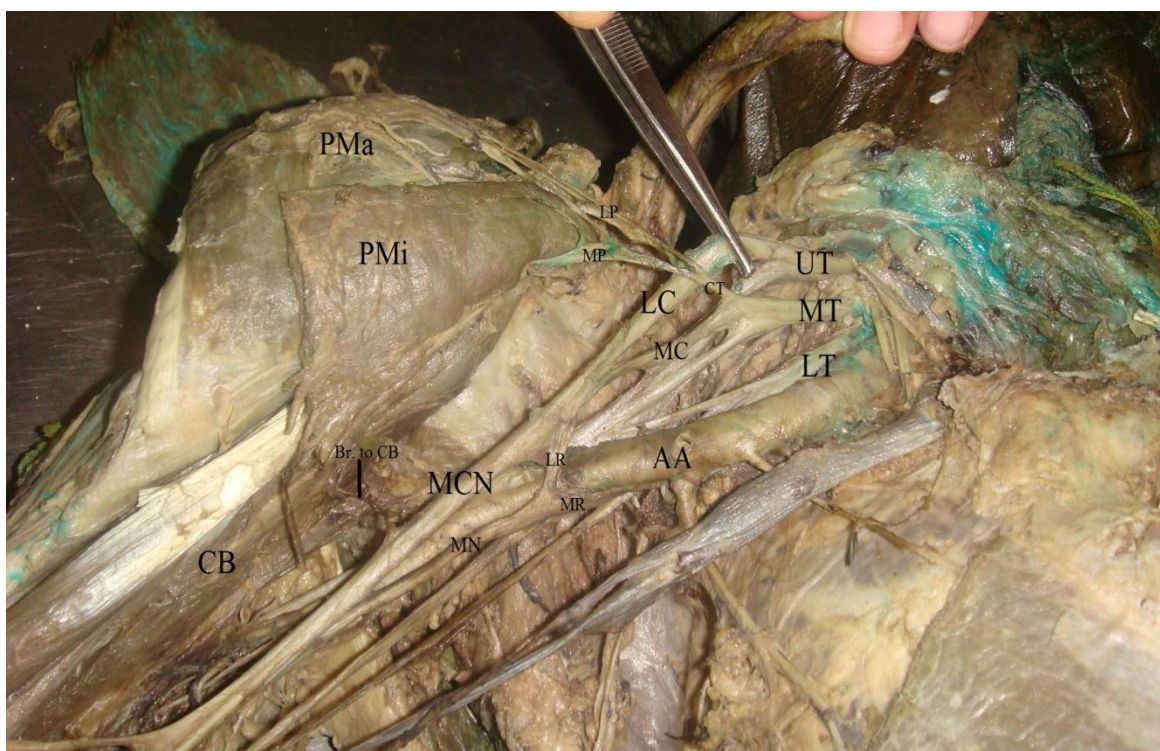
Skin, superficial and deep fasciae, were excised to get a view of the arm contents. The P<sub>Ma</sub> and P<sub>Mi</sub> muscles were reflected laterally after detaching them from their origins, to expose the brachial plexus. The brachial plexus comprised of three

trunks giving rise to two divisions each. Subsequently, the three cords of the brachial plexus were formed as usual.

The medial and lateral pectoral nerves are normally the branches of the medial and lateral cords of brachial plexus respectively; but in our case, they arose as a common trunk (CT) from the middle trunk of the brachial plexus. This common trunk subsequently gave rise to the two pectoral nerves (MP and LP), which then innervated the PMa and PMi muscles. (Figure 1)

The musculocutaneous nerve (MCN) was formed as usual from the LC of the brachial plexus. The MCN did not pierce the CB muscle. Instead, it descended medial to CB, crossed the brachial artery (Br. A.) from lateral to medial and finally fused with the MN. During its oblique course over the Br. A., it gave its only branch which supplied the CB muscle. In our case, the MCN did not supply the BB and BR muscles; contrary to what is mentioned in the standard textbooks of anatomy. (Figure 1)

Figure 1: Showing the fusion of the Median and Musculocutaneous nerves and variable origine of medial and lateral pectoral nerves.



MP:Medial pectoral nerve, LP: Lateral pectoral nerve, CT: common trunk , MT:middle trunk, PMa: pectoralis major, PMi: pectoralis minor muscles, UT: Upper trunk of brachial plexus, LT: Lower trunk of brachial plexus, MN:Median nerve, AA:axillary artery, MR and LR: Medial and lateral roots of MN, MC and LC: medial and lateral cords of brachial plexus respectively,MCN:Musculocutaneous nerve; CB:Coracobrachialis muscle Br. to CB – Branch to Coracobrachialis muscle (CB).

The median nerve (MN) was formed as usual by the union of the medial (MR) and lateral (LR) roots of the median nerve arising from the medial and lateral cords of the brachial plexus respectively. The LR of the MN crossed the third part of the axillary artery from lateral to medial to unite with the MR of the MN. Consequently, the MN was formed medial to and not anterior or lateral to the artery as mentioned in the standard textbooks. The MN so formed descended medial to the Br. A. and then fused with the MCN distal

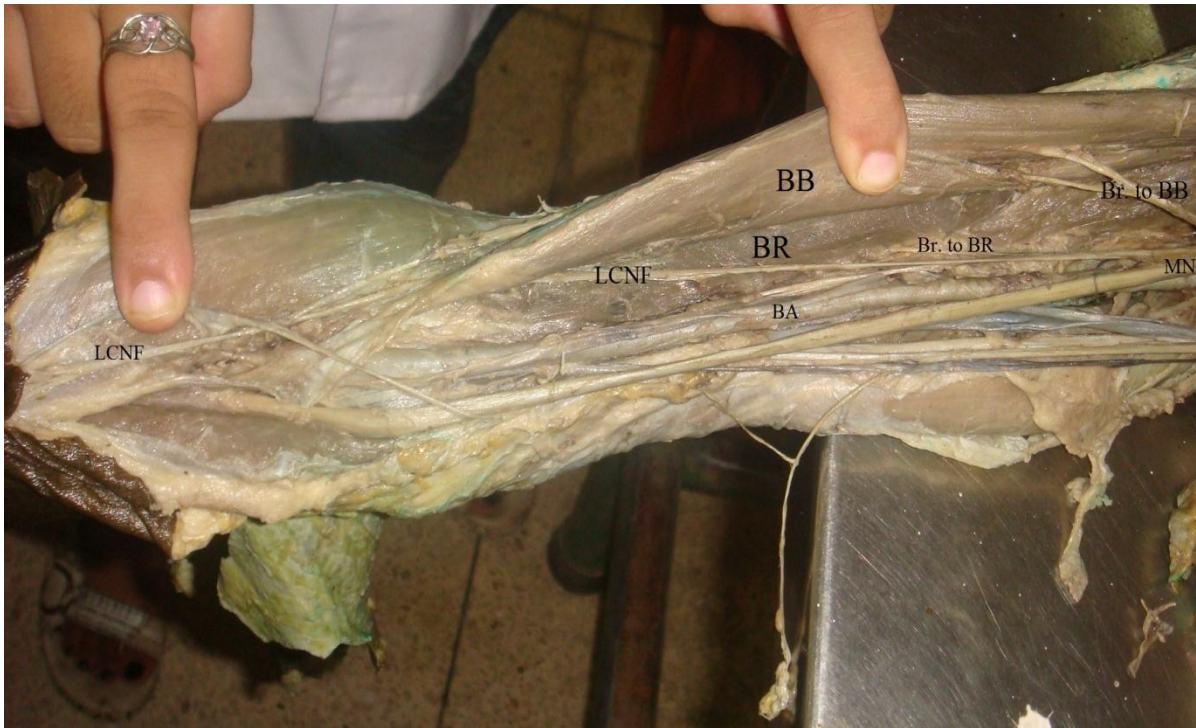
to the origin of the branch to CB muscle from the MCN. (Figure 1) The other two muscles of the front of the arm viz. BB and BR were supplied by the MN after it received the MCN (Figure 2). Similarly the lateral cutaneous nerve of arm (LCNF) also emerged from the MN (Figure 3). The opposite upper extremity was also meticulously dissected and similar findings were recorded on this side also. Photographs were taken for proper documentation.

Figure 2: Showing the innervation of Biceps Brachii and Brachialis by the Median nerve.



BB: Biceps Brachii, BR : Brachialis, Br. to BB – branch to biceps brachii, Br. to BR – branch to brachialis.

Figure 3: Showing the origin of Lateral Cutaneous Nerve of Forearm from the Median nerve.



MN:Median nerve, BB:Biceps Brachii, BR :Brachialis, Br. to BB – branch to biceps brachii, Br. to BR – branch to brachialis, BA: Brachial artery, LCNF:lateral cutaneous nerve of the forearm

## DISCUSSION

Variations in the formation and branching pattern of brachial plexus and the nerves supplying upper limb are common and they have been reported by several investigators [5]. Such comprehension is useful in nerve grafting and neurophysiological evaluation for diagnosing peripheral neuropathies [6].

Origin of both the pectoral nerves (LP and MP) showed deviation from the usual pattern i.e. in place of arising separately from the LC and MC of the brachial plexus respectively; they arose as a common trunk (CT) from the middle trunk of the brachial plexus. This CT subsequently gave rise to the two pectoral nerves (MP and LP), which then innervated the PMa and PMi muscles; depicted in Figure 1. No accurate description of a similar case has been found in the literature. But there is a case reporting the origin of LP nerve as two separate branches from the anterior divisions of upper and

middle trunks of brachial plexus instead of arising from the LC. These two branches then joined together to form the LP nerve [3]. Understanding of such variations is clinically important for diagnosing unexplained clinical signs and symptoms, during nerve blocks and certain surgical procedures around the neck and proximal arm. This knowledge is important while performing neurotization of brachial plexus lesions, shoulder arthroscopy by anterior glenohumeral portal and shoulder reconstructive surgery so that these structures can be identified and protected.

The MCN ordinarily enters CB muscle from its medial aspect approximately 5 cm distal to the tip of coracoid process but is shown to have frequent variations. Instead of piercing the CB muscle, the nerve may adhere to the MN for some distance down the arm and then, either as a single trunk or

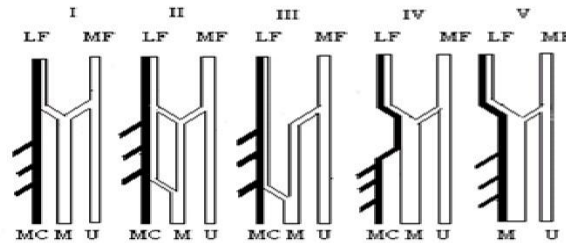
as several branches passes between the BB and BR muscles to supply all the three muscles. Sometimes only a part of the nerve follows this course; this part then rejoins the main trunk after it transits through and supplies CB [7, 8]. In some cases, instead of the whole trunk of the nerve piercing CB, only its muscular branch or only its cutaneous branch pierces the muscle. The MCN may be accompanied by fibers from the MN as it transits CB; a communicating branch passes from the MCN to the MN. Occasionally, the nerve perforates not only CB, but also the BR or the short head of the BB muscles. Very rarely the LC of brachial plexus may pierce CB and then divide into the MCN and the LR of the MN [9]. Sometimes, instead of penetrating CB, the nerve may pass behind it or between it and the short head of the BB muscle. Studies by Nakatani et al revealed three variations in which the MCN did not pierce the CB [10]. In our case also, MCN didn't pierce the CB muscle. Instead, it descended medial to CB.

The MN lying medial to the Br. A. as in our case; has been reported earlier by Das and Paul [11]. The variations in the formation and relations of median nerve in the arm bear remarkable clinical significance. Considering these variations it is advocated that the clinicians and surgeons should be aware of such variations while performing surgical procedure in this region since an injury to such a variant nerve in the proximal arm may lead to a galaxy of manifestations including sensory, motor, vasomotor and trophic changes [12]. The median, musculocutaneous and ulnar nerves after their origin from the brachial plexus, pass through the anterior compartment of the arm without receiving any branch from any other nerve in the neighbourhood [4].

Although communications between the nerves in the arm are rare, the communications between the MN and the MCN have been described since the nineteenth century [13]. The LR of the MN carries fibres that may pass through the MCN, and a communicating branch from the latter usually joins the MN in the lower third of arm [7]. Anastomosis between the MCN and the MN is by far the most common and frequent of all the variations that are observed among the branches of the brachial plexus [8]. Table 1 depicts the incidence of communication between musculocutaneous nerve and median nerve irrespective of its site or type as reported earlier from time to time. It is seen to vary between wide ranges of 1.4% to 63.5%.

The communications between the MCN and the MN have been classified into different types by Li Minor, Venieratos and Anagnostopoulou and Choi et al [14,8,6]. Li Minor categorized these communications into following five types [14]: In type I, there is no communication between the MN and the MCN as described in the standard textbooks of Anatomy. The MCN pierces the CB muscle and innervates the CB, the BB and the BR. In type II, although some fibers of the medial root of the MN unite with the lateral root of the MN and form the main trunk of MN, remaining medial root fibers run in the MCN leaving it after a distance to join the main trunk of MN. In type III, the lateral root fibres of the MN pass along the MCN and after some distance, leave it to form the lateral root of the MN. In type IV, the MCN fibres join the lateral root of the MN and after some distance the MCN arises from the MN. In type V, the MCN is absent and the entire fibres of the MCN pass through the lateral root of MN and fibres to the muscles supplied by MCN branch out directly from the MN. (Figure 4)

Figure 4: Li Minor's classification of communication between musculocutaneous and median nerve.



MC: Musculocutaneous nerve, M: Median nerve, U: Ulnar nerve, LF: Lateral cord of brachial plexus, MF: Medial cord of brachial plexus

Venieratos and Anagnostopoulou also described three different types of communications between MN and MCN in relation to the CB muscle. In type I, the communication between MCN and MN is proximal to the entry of the MCN into the CB, whereas in type II, the communication is distal to its entry into the muscle and in type III neither the nerve nor its communicating branch pierce the CB muscle [8].

In the most recent observations recorded by Choi et al, communications between the MN and the MCN have been broadly classified into 3 patterns. In pattern 1, the two nerves are fused (19.2%). In pattern 2, there is one supplementary branch between the two nerves (72.6%); Pattern 2a. Single root from MCN, contributes to the connection (69.9%), Pattern 2b. There are two roots from MCN (2.7%). In pattern 3, there are two connecting branches between the two nerves (6.8%) [6].

Communication between the MCN and MN in the present case could not be incorporated exactly into any of the types described by Li Minor [14]. However it fits into type II of Venieratos and

Anagnostopoulou or into pattern 1 of Choi et al [8,6]. Lang and Spinner have reported one case of complete fusion of the MN and MCN [15]. Similar two cases of fusion of these two nerves were found by Watanabe et al [16]. Rao and Chaudhary reported eight instances of communication from MCN to the MN and bilateral communication in two cadavers [12]. Chauhan and Roy also reported an unusual communication between the MN and MCN in their case report [17].

The most frequent variation is the presence of a communicating branch that emerges from the MCN and goes distally to join the MN, an anastomosis observed in the lower third of arm [8]. If this branch is given off in upper third of the arm, it is generally considered as third (double lateral) root of the median nerve [18]. In the present case, the musculocutaneous nerve in upper third of the arm, passed medially downwards and joined the MN. It can be considered as the double lateral root of the MN or in other words the MN nerve can be said to be formed by three roots: a)

one from the lateral cord; b) one from the MCN; c) and the third from the medial cord.

Similar variation was observed earlier by different authors - The median nerve, instead of having two

roots may have three roots - either one each from lateral cord, medial cord and MCN or two from lateral cord and one from the medial cord or it may have even four roots – three from the lateral cord and one from the medial cord [17,18].

“Table : Showing the incidence of communication between the musculocutaneous nerve and the median nerve”

Sr. no.	Author	Year	Incidence (%)
1.	Watanabe et al <sup>[16]</sup>	1985	01.4
2.	Kosugi et al <sup>[19]</sup>	1986	21.8
3.	Yang et al <sup>[23]</sup>	1995	12.5
4.	Venieratos and Anagnostopoulou <sup>[8]</sup>	1998	13.9
5.	Chiarapattanakom et al <sup>[20]</sup>	1998	16.0
6.	Rao and Chaudhary <sup>[12]</sup>	2000	33.3
7.	Choi et al <sup>[6]</sup>	2002	26.4
8.	Guerra-Guttenberg and Ingolotti <sup>[24]</sup>	2009	53.6

## ONTOGENY

The variations documented in this case report can be explained in the light of embryogenic development. The first indication of limb musculature is observed in the seventh week of development as condensation of mesenchyme near the base of the limb buds. With further elongation of the limb buds, the muscle tissue splits into flexor and extensor compartments. The upper limb buds lie opposite the lower five cervical and upper two thoracic segments. As soon as the buds form, the ventral primary rami of the spinal nerves penetrate into the mesenchyme of limb bud. At first, each ventral ramus divides into dorsal and ventral branches, but soon these branches unite to form named peripheral nerves which supply the extensor and flexor groups of muscles respectively. Immediately after entering the limb bud, they establish intimate contact with the differentiating mesodermal condensations and the early contact between nerve and muscle cells is a

prerequisite for their complete functional differentiation [4].

The growth as well as the pathfinding of nerve fibres towards the target is dependent upon the concentration gradient of a group of cell surface receptors and several signalling molecules in the environment. Significant variations in the nerve patterns may be a result of altered signalling between mesenchymal cells and neuronal growth cones or circulatory factors at the time of fusion of brachial plexus cords [19]. Specifically, such developmental abnormalities for axonal guidance in the coracobrachialis muscle could readily produce a situation where the MCN does not pass through the coracobrachialis muscle, as seen here [8, 19] Iwata in his studies held the failure of the differentiation of nerves as a cause for some of the fibres taking an aberrant course as a communicating branch. Likewise, Chiarapattanakom et al stated that the lack of coordination between the formation of the limb



muscles and their innervation is responsible for the appearance of a communicating branch [20]. Once formed, any developmental differences would obviously persist postnatally.

## PHYLOGENY

Communication between the MCN and MN is considered as a remnant from the phylogenetic or comparative point of view. Kosugi et al reported that there was only one trunk equivalent to the MN in the thoracic limb of the lower vertebrates (amphibians, reptiles and birds) [19]. In the context that ontogeny recapitulates phylogeny; it is possible that the variation seen in the current study is the result of a developmental anomaly. Studies of comparative anatomy have observed the existence of such connections in monkeys and in some apes; the connections may represent the primitive nerve supply of the anterior arm muscles [21].

## CONCLUSION

Communications between the musculocutaneous and the median nerves are not rare but the existence of multiple neuroanatomical variations in the same body in a single cadaver is a rarity.

Knowledge of the anatomical variations of these nerves at the level of upper arm is essential in light of the frequency with which surgery is performed in the axilla and the surgical neck of the humerus. A good knowledge of the possible communications between the MCN and the MN may prove valuable in the traumatology of shoulder joint as well as in circumventing iatrogenic damage during repair operations of these regions. To prevent unwanted outcomes of operations conducted on MCN, it is suggested that the presence of MN and MCN communications should be ruled out. Studies of the anatomical variations of peripheral nerves are important also because most of the times, they bring clarity to otherwise incomprehensive clinical findings.

We believe that study of variation in the peripheral nerves noticed in cadaveric dissections should be included in surgical training programs, even if they are not necessary for inclusion in routine anatomy education in medical schools.

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