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Original Article

Anatomical Variations in Origin, Number, Course, and Relations of the Roots of Median Nerve and the Low-level Formation of Median Nerve Trunk

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Abstract

Introduction: Normally, the median nerve (MN) is formed by the union between medial and lateral roots of MN in relation to the third part of axillary artery in the axilla. The anatomical variations of origin, number, course, and relations of the roots of MN and the level of formation of MN trunk are most common.

Materials and Methods: On routine dissection of pectoral, axillary, and arm regions of 40 adult embalmed cadavers in the dissection hall, Department of Anatomy, Great Eastern Medical School, Ragolu, Srikakulam, Andhra Pradesh, India, during 2015-2016, the various anatomical variations in origin, the number, course, and relations of the roots of MN and the level of formation of MN trunk in both upper limbs in four cadavers and in left upper limb in one cadaver were observed and photographed.

Results: We observed the variations in origin, the number, course, and relations of the roots of MN and the level of formation of MN trunk in both upper limbs in four cases and in left upper limb in one case during routine dissection of 40 adult embalmed cadavers.

Conclusion: The knowledge of these anatomical variations is of utmost important for the general surgeons, traumatologists, neurovascular surgeons, and radiologists to avoid complications.

Key words: Axillary artery, Coracobrachialis, Lateral cord, Medial cord

INTRODUCTION

The brachial plexus is formed by the ventral primary rami (VPR) of C5 to T1. It presents five stages of formation, namely root stage, trunk stage, division stage, cord stage, and branch stage in the cervical region and axilla. The VPR of C5 and C6 join to form upper trunk, the VPR of C7 is continued as the middle trunk, and the VPR of C8 and T1 join together to form lower trunk. Each trunk divides into anterior and posterior divisions. The anterior divisions of upper and middle trunks join to form lateral cord. The anterior division of lower trunk is continued as medial cord. The posterior divisions of all trunks join to form posterior cord. The lateral cord gives rise to lateral root of median, musculocutaneous nerve, and lateral pectoral nerve. The medial cord gives rise to medial root of median, medial pectoral nerve, medial cutaneous branch of arm, medial cutaneous branch of forearm, and ulnar nerve. The posterior cord gives rise to upper and lower subscapular nerves, thoracodorsal nerve, axillary nerve, and radial nerve. The cords of brachial plexus are related with the 1st and 2nd parts of brachial plexus in the axilla, but the branches of cords are related with the 3rd part of axillary artery in the axilla. The lateral and posterior cords lie lateral to 1st part of axillary artery whereas the medial cord lies posterior to 1st part of axillary artery. The three cords are related with 2nd part of axillary artery with their respective locations. The lateral root of median, musculocutaneous nerve, coracobrachialis, and short head of biceps brachii lie lateral to 3rd part of axillary artery. The medial root of median lies in front of the 3rd part of axillary artery. The medial cutaneous

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nerve of forearm and ulnar nerve lie in between 3rd part of axillary artery and axillary vein. The axillary and radial nerves lie posterior to 3rd part of axillary artery. Usually, there are two nerve communications in front of axillary artery – one communication between medial and lateral pectoral nerves in front of 1st part of axillary artery and another between medial and lateral roots of median in front of 3rd part of axillary artery.[1-7]

MATERIALS AND METHODS

On routine dissection of pectoral, axillary, and arm regions of 40 adult embalmed cadavers in the dissection hall, Department of Anatomy, Great Eastern Medical School, Ragolu, Srikakulam, Andhra Pradesh, India, during 2015-2016, the various anatomical variations in origin, the number, course, and relations of the roots of median nerve (MN) and the level of formation of MN trunk in both upper limbs in four cadavers and in left upper limb in one cadaver were observed and photographed.

RESULTS

We observed the following variations in origin, the number, course, and relations of the roots of MN and the level of formation of MN trunk in both upper limbs in four cadavers and in the left upper limb in one cadaver out of 40 adult embalmed cadavers during routine dissection.

In both the upper limbs of four (2 male and 2 female) cadavers, the normal relation of cords of brachial plexus with the first and second parts of axillary artery was observed. An additional lateral root of MN originating from lateral cord lying to lateral to the first part of axillary artery, crossing in front of the second part of axillary artery was found to join with medial root of median (originating from medial cord lying posterior to the first part of axillary artery) medial to the second part of axillary artery. Normally, originating lateral root of MN from lateral cord lying lateral to the third part of axillary artery, crossing in front of third part of axillary artery was found to join with the medial root of median from medial cord to form MN trunk medial to third part of axillary artery (Figures 1 and 2). It was observed that the MN was formed by the union of two lateral roots and one medial root in 10% of cases. The further course, relations, and distribution of branches of MN distal to its formation were found normal. No vascular anomalies were observed.

In the left upper limb of one male cadaver, an addition lateral root of MN and long lateral root of MN originating from lateral cord, lying in relation to lateral aspect of the first and third parts of axillary artery, respectively, crosses in front of the second and third parts of axillary artery, respectively, to join with long medial root of MN from medial cord to form the trunk of MN medial to the second part of axillary artery and upper part of brachial artery, respectively (Figure 3). The further course, relations, and distribution of branches of MN distal to its formation were found normal. No vascular anomalies were observed.

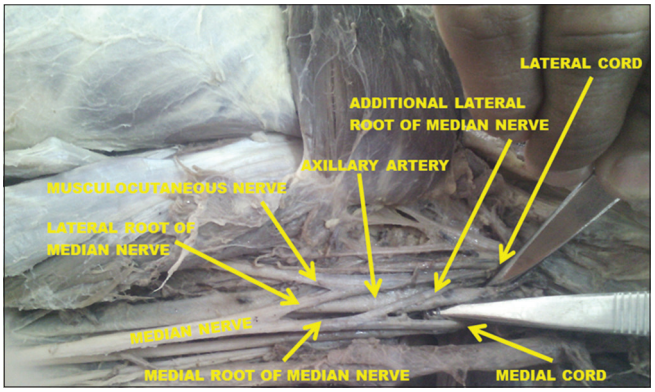

Figure 1: Formation of median nerve by two lateral roots and one medial root in right axilla (Additional lateral root of median originating from lateral cord lying lateral to 1st part of axillary artery, crossing in front of 2nd part of axillary artery, joins with medial root of median (originating from medial cord lying posterior to 1st part of axillary artery) lying medial to 2nd part of axillary artery. The lateral root of median crossing in front of 3rd part of axillary artery joins with medial root of median to form trunk of median nerve medial to 3rd part of axillary artery in the right axilla)

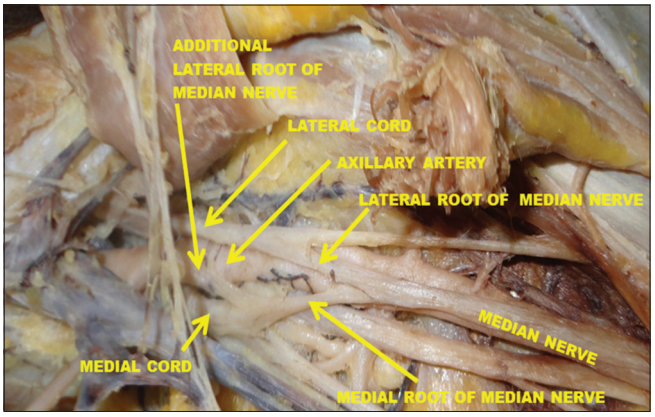

Figure 2: Formation of median nerve by two lateral roots and one medial root in left axilla (Additional lateral root of median originating from lateral cord lying lateral to 1st part of axillary artery, crossing in front of 2nd part of axillary artery, joins with medial root of median (originating from medial cord lying posterior to 1st part of axillary artery) lying medial to 2nd part of axillary artery. The lateral root of median crossing in front of 3rd part of axillary artery joins with medial root of median to form trunk of median nerve medial to 3rd part of axillary artery in the left axilla)

Table 1: Variations in number of median nerve roots

S. No.	Name of the author	Total number of roots of median nerve	Total number of lateral roots	Total number of medial roots
1	Anrkooli *et al*. (2007)	3	2	1
2	Eglseder and Goldman (1997)	2	2	-
3	Arquez and Hurtado (2016)	3	2	1
4	Chauhan and Roy (2002)	3	2	1
5	Satyanarayana and Guha (2008)	4	3	1
6	Sargon *et al*. (1995)	3	2	1
7	Seedi and Rufai (2003)	3	2	1
8	Meshram *et al*. (2012)	4	3	1
9	This study	3	2	1

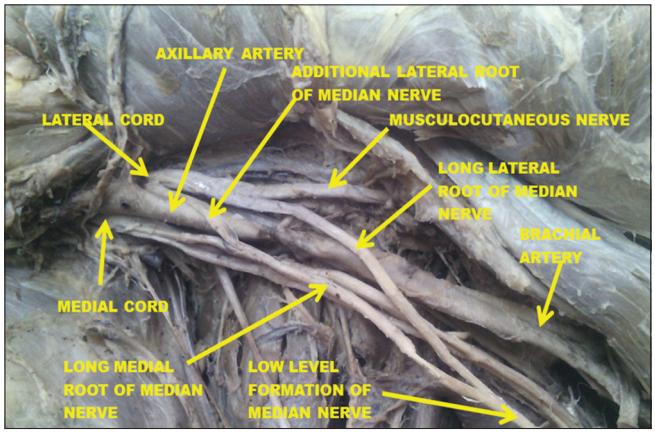

Figure 3: Low-level formation of median nerve by three roots in left axilla and upper arm (Additional lateral root of median originating from lateral cord lying lateral to 1st part of axillary artery, crossing in front of 2nd part of axillary artery, joins with long medial root of median lying medial to 2nd part of axillary artery. The long lateral root of median crossing in front of 3rd part of axillary artery joins with long medial root of median to form trunk of median nerve medial to upper part of brachial artery in left axilla and upper part of left arm)

DISCUSSION

The anatomical variations in origin, the number, course, and relations of the roots of MN and the level of formation of MN trunk are common. The variations of the lateral cord of brachial plexus regarding composition of fiber bundle and the absence or communication between its branches are common and being reported by several authors.[8-16] Satyanarayana and Guha,[17] Uzun and Seelig,[18] and Meshram *et al*.[19] found a four rooted MN with three lateral and one medial root. Pandey and Shukla[20] have found in 4.7% cases that the roots of MN joined on medial side of axillary artery, and in 2.3% cases the roots did not join but continued separately. Eglseder and Goldman[21] found that the MN nerve was formed of two lateral roots in 14% of their specimens. Sargon *et al*.,[22] Chauhan and Roy,[15] Saeed and Rufai,[13] Anrkooli *et al*.,[23] Satyanarayana *et al*.,[17] and Arquez and Hurtado[24] reported the formation of MN by two lateral and one medial root. In this study, two lateral roots were found joining with one medial root to form MN in 10% of cases (Figures 1-3, Table 1).

Meshram *et al*.[19] reported that the right MN was formed by four roots; three were coming from lateral cord and one from medial cord of brachial plexus. The uppermost or highest root was noted to be at the level of the first part of axillary artery where it gave origin to superior thoracic artery. The second root was found to be 2 cm below the first one and the third root was found 3 cm below the second root. The highest root of MN crossed the axillary artery from lateral to medial side and joined with medial root immediately on medial side of artery. The remaining two roots were found to be passing obliquely in front of the second and third part of axillary artery and joining individually with the medial root of MN and forming the main trunk of MN in front of third part of axillary artery. Devi *et al*.[25] (2011) found the formation of MN at the junction of middle and the lower 1/3rd of arm. In this study, an addition lateral root and medial root were seen originating from the corresponding lateral and medial cords, respectively, lying in relation to the first part of axillary artery in both upper limbs of four cadavers and in the left upper limb of a male cadaver (Figures 1-3).

The incidence of distal formation of MN was more common (8.5%, Uysal *et al*. (2003);[26] 12%, Matejcik (2003);[27] 2.1%, Mohammed and Badawoud (2003)[28] than that of high level formation. Uysal *et al*. (2003)[26] reported the variations of the brachial plexus to be more common in females and on the right side. Rajendran and Nivedha[29] (2004) noted that the MN in addition to its formation in the middle of arm, gave off muscular branches to arm muscles and musculocutaneous nerve. In this study, the low-level formation of MN lying medial to the upper part of brachial artery was observed in the left upper limb of a male cadaver (Figure 3).

According to Hollinshead,[11] anomalies of nerves are accompanied by abnormalities of vessels. The variations of brachial plexus were associated with those of subclavian,

axillary, and brachial arteries. However, in this study, such vascular abnormalities were not present.

Embryologically, the muscles of the upper limb develop from the migration of mesenchyme of the myotomes of somites from paraxial mesoderm during the 5th week of embryonic life[30] and local mesenchyme. Spinal nerves are derived from two sources, the motor nerve from the neural tube and the sensory nerves from the neural crest cells.[31,32] The axons of neurons penetrating into the mesenchyme in different directions[32,33] enter into the limb buds and establish an intimate contact with the differentiating mesoderm condensations which develop into muscles of limbs. This early contact between the nerve and muscle cells is a prerequisite for their complete functional differentiation.[34] According to Sannes *et al.*,[35] the guidance of the developing axons is regulated by expression of chemoattractants and chemorepulsants in a highly coordinated site specific fashion.[36] Any alterations in signaling between mesenchymal cells and neuronal growth cones can lead to significant variations. Once formed, any developmental differences would persist postnatally.[33,37] In this study, as the muscles are developed, the neuronal signaling of these muscles would have gained nerve fibers from the lateral cord of brachial plexus by an alternate route in the form of additional lateral root to join with medial root to form MN trunk.

CONCLUSION

Variations in the roots of MN and level of formation of MN are the most common. The knowledge of these anatomical variations is essential for surgeons and radiologists to prevent complications during diagnostic and therapeutic procedures.

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