Rare variations in the formation of median nerve - embryological basis and clinical significance

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ABSTRACT

During routine dissection in the Department of Anatomy, CMS, Nepal, anomalous median nerves with regard to their formation were found in three different adult male cadavers. In one cadaver, there was variation in the formation of the median nerve and its relation with the axillary artery. Another cadaver revealed the formation of the median nerve by three roots, while in the third one, the median nerve was found to be formed by four roots. However, in each of the three cadavers the distribution of the anomalous median nerve was normal in arm, forearm and palm. The arterial pattern in the arm (axillary and brachial arteries) was also found to be normal. In each case the opposite upper limb was also meticulously dissected to exclude bilateral abnormality. However, in each case the anomaly was unilateral. Photographs of the abnormalities were taken for proper documentation. The variations related to the formation of median nerve by more than two roots are relatively uncommon as compared to the other types of variations of median nerve. Some embryological explanations are available to explain these variations. Finally, knowledge of these variations is important particularly to the surgeons for carrying out surgical procedures in axilla and arm.

Keywords: Brachial plexus, median nerve, axillary artery, brachial artery.

Anomalies related to the formation, relations and distribution of median nerve are fairly common.

The median nerve is normally formed by the union of two roots: lateral root of median nerve (LRM) coming from the lateral cord (C5, C6, C7) of brachial plexus and medial root of median nerve (MRM) coming from the medial cord (C8, T1) of brachial plexus. The two roots embrace the third part of the axillary artery, uniting anterior or lateral to it. Some fibres from C7 often leave the lateral root in the lower part of the axilla passing distomedially posterior to the medial root, usually anterior to axillary artery, to join the ulnar nerve: they may branch from the seventh cervical ventral ramus. Clinically they are believed to be mainly motor to the flexor carpi ulnaris.

The median nerve enters the arm at first lateral to the brachial artery. Near the insertion of the coracobrachialis, it crosses in front of (rarely behind) the artery, descending medial to it, to the cubital fossa, where it is posterior to the bicipital aponeurosis and anterior to the brachialis, 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[1] Anomalous pattern of median nerve can be explained on the basis of embryological development.

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. Immediately the nerves enter 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.[2]

The growth as well as the pathfinding of nerve fibres towards the target is dependent upon concentration gradient of a group of cell surface receptors in the environment.[3] Several signalling molecules and transcription factors have been identified which induce the differentiation of the dorsal and ventral motor horn cells.

Misexpression of any of these signalling molecules can lead to abnormalities in the formation and distribution of particular nerve fibres.

The high percentage of anomalies as mentioned above emphasizes the complexities and irregularities of this anatomic region with regard to surgical approaches.[4] Knowledge of such variations is important for surgeons to perform surgical procedures in the axillary region and arm.[5]

Considering the high percentage of anomalies in the formation of median nerve and its paramount clinical

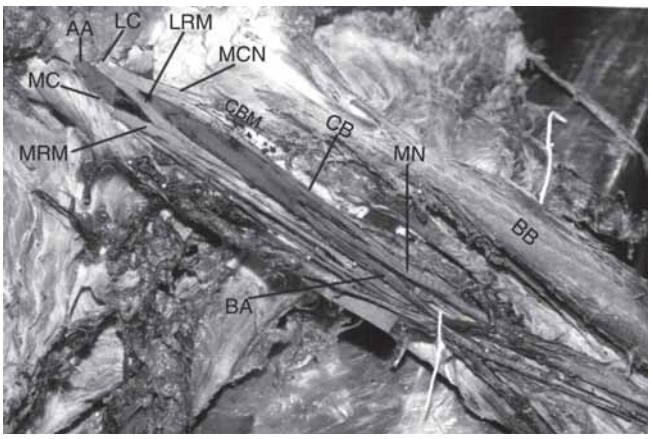

Fig. 1. Shows formation of median nerve at a higher level medial to the third part of axillar artery by union of lateral root of median nerve and medial root of median nerve. Futher, it continued posterior to brachial artery and recived a communicating branch from lateral cord of brachial plexus near the insertion of coracobrachialis muscle.

LC= Lateral Cord, MC = Medial Cord, LRM= Lateral root of median nerve, MRM= Medial root of median nerve, MCN= Musculocutaneous nerve, MN= Median nerve, CB= Communicating branch, AA= Axillary artery, BA= Brachial artery, BB=Biceps Brachii, CBM=Coracobrachialis Muscle

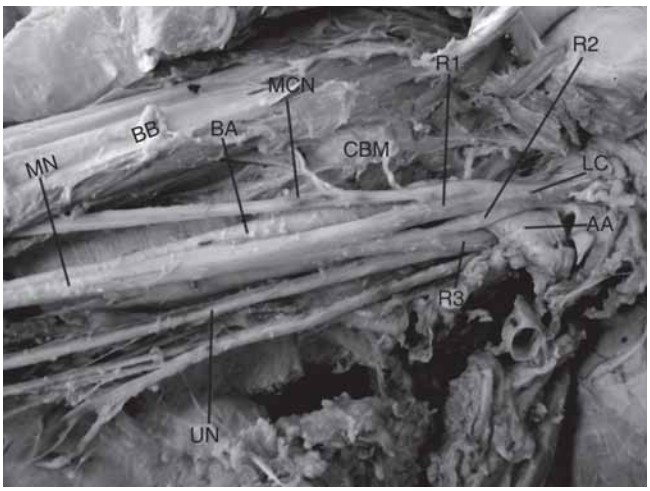

Fig. 2. Shows formation of median nerve by three roots, two from lateral cord joining individually with medial root of median nerve forming the median nerve trunk.

LC= Lateral Cord, R1= Root one, R2= Root two, R3= Root three, MN= Median nerve, MCN= Musculocutaneous nerve, UN= Ulnar nerve, AA= Axillary artery, BA= Brachial artery, BB=Biceps Brachii, CBM=Coracobrachialis Muscle

importance, the present variations are documented and an attempt has been made to explain these variations in the light of embryogenic development.

MATERIALS AND METHODS

During routine dissection in the Department of Anatomy, CMS, Nepal, anomalous median nerves with regard to their formation were found in three different adult male cadavers. Dissection of both the upper limbs (axilla, arm, cubital fossa, forearm and palm) was done thoroughly and meticulously in each of the three cadavers to find out the mode of formation, relations and distribution of the median nerve.

Arterial pattern in the axilla and arm was also noted to exclude any abnormality related to it. Formation and distribution of musculocutaneous nerve was noted in each case.

In one cadaver, there was variation in the formation of the median nerve and its relation with the axilllary artery. Another cadaver revealed the formation of median nerve by three roots, while in the third one the median nerve was found to be formed by four roots. However, in each of the three cadavers the distribution of the anomalous median nerve was normal in arm, forearm and palm. The arterial pattern of the arm (axillary and brachial arteries) was also found to be normal. Finally, the anomaly was found to be unilateral in each case. Photographs of the abnormalities were taken for proper documentation.

OBSERVATIONS:

In the present study, following variations related to the formation of median nerve were observed.

CASE 1:

The anomaly was present in the left side. The median nerve trunk was found at a higher level medial to the third part of axillary artery formed by the union of the lateral root (arising from the lateral cord of the brachial plexus) and the medial root (arising from the medial cord of the brachial plexus), the former passing anterior to the artery (Fig. 1).

After its formation, median nerve trunk continued posterior to the brachial artery. At the level of the insertion of coracobrachialis muscle, the median nerve trunk received a communicating branch from the lateral cord of brachial plexus, after the latter gave off the musculocutaneous nerve.

Finally, the median nerve trunk (consisting of lateral root, medial root and communicating branch from lateral cord) continued lateral to the brachial artery.

The distribution of median and musculocutaneous nerves was normal in arm. The arterial pattern in arm was also normal. The pattern of supply of median nerve in forearm and palm was also found to be normal. The right upper limb however revealed no abnormality.

CASE 2:

The anomaly was detected in the right side. The median nerve was formed by three roots (two from lateral cord and one from medial cord). Two roots were noted to arise from the lateral cord at the level of origin of coracobrachialis muscle. These two roots were found to be passing obliquely in front of second and third part of axillary artery and joining individually with medial root

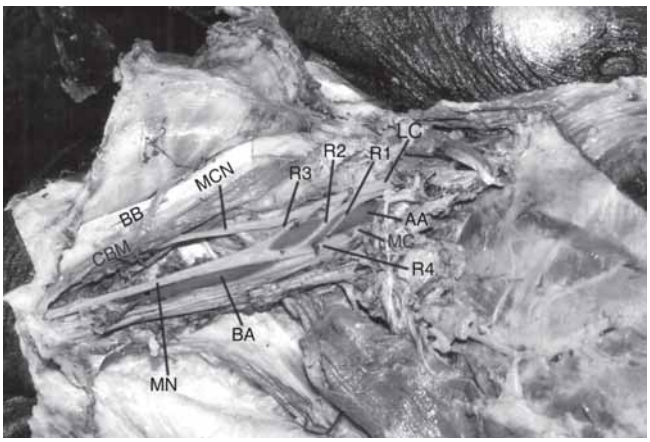

Fig. 3. Shows formation of median nerve by four roots, three from lateral cord of brachial plexus joining individually with medial root of median nerve forming the median nerve trunk.

MC=Medial Cord,LC= Lateral Cord, R1= Root one, R2= Root two, R3= Root three, R4= Root four, MN= Median nerve, MCN= Musculocutaneous nerve, UN= Ulnar nerve, AA= Axillary artery, BA= Brachial artery, BB=Biceps Brachii, CBM=Coracobrachialis Muscle

of median nerve (from medial cord of brachial plexus), the second root joining at a higher level than the first root (Fig. 2). The three roots together formed the median nerve trunk which was passing in front of third part of axillary artery overlapping the latter.

The arterial pattern particularly in relation with the roots of median nerve was observed. The second part of axillary artery was found to be passing in between the second root and third root of the median nerve. Further distribution of median nerve in the arm was normal. The pattern of supply of median nerve in forearm and palm was also found to be normal. The left upper limb however revealed no abnormality.

CASE 3:

The anomaly was detected in the right side. The median nerve was formed by four roots (three roots from lateral cord and one root from medial cord) (Fig. 3). The uppermost or highest root was noted to be at the level of origin of coracobrachialis muscle. The second root was found to be immediately below the first one. The third root was noted at the upper border of insertion of latissimus dorsi muscle. These three roots were found to be passing obliquely in front of second and third part of axillary artery and joining individually with the medial root of median nerve and forming median nerve trunk, in front of third part of axillay artery.

Further distribution of median nerve in the arm was normal. The arterial pattern in arm was also normal. The pattern of supply of median nerve in forearm and palm was also found to be normal. The left upper limb however revealed no abnormality.

DISCUSSION

Variations in the formation of median nerve were noted by some earlier workers. However, most of the variations as presented by them were related to anomalous relationship between median and musculocutaneous nerves. In one study, it was found that the lateral root was small and the musculocutaneous nerve was connected with median nerve in the arm.[6]

Another study involving dissection of ten cadavers, mentioned failure of separation of musculocutaneous nerve from the median nerve and the latter therefore gave off the branches that should arise from musculocutaneous nerve, namely branches to coracobrachialis, biceps brachii and major part of brachialis.[7]

However the variations related to the formation of median nerve by more than two roots which have been observed in the present study are rare as revealed by survey of literatures. These variations 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, ventral primary rami from the spinal nerves penetrate into the mesenchyme. At first, each ventral ramus divides into dorsal and ventral branches, but soon these branches unite to form named peripheral nerves which supply extensor and flexor group of muscles respectively.

Immediately after the above mentioned rearrangement of nerves, they enter the limb buds and establish an intimate contact with the differentiating mesodermal condensations and this early contact between the nerve and muscle cells is a prerequisite for their complete functional differentiation.[2]

Over the years, two principal theories have emerged concerning the directional growth of nerve fibres – the neurotropism or chemotropism hypothesis of Ramon *et al*[8] and the principle of contact-guidance of Weiss.[9] The salient feature of chemotropism is that axonal growth cones act as sensors to concentration gradients of molecules in the environment and grow up the gradient towards the source, i.e. the target. There is no doubt, however that contact guidance mechanisms operate in parallel with neurotropism. Adhesion to the structures with which the growth cone contacts also plays a role.

A group of cell surface receptors viz. neural cell adhesion molecule (N-CAM) and L1 and the Cadherins act as transcription factors which recognize and bind to components

of the extracellular matrix. Thus, both cell-cell and cell-matrix interactions may be involved in axonal pathfinding.[3]

Over or under expression of one or multiple transcription factors as mentioned above have been found to be responsible for the variations in the formation, relation and distribution of the motor nerve fibers.[3] The variations as noted in the present study may be attributed to misexpression of one or more transcription factors as mentioned above.

The variations in the formation and relations of median nerve in the arm bear remarkable clinical significance. Considering these variations Rao advocated that the clinicians and surgeons should be aware of such variations while performing surgical procedure in this region.[10] Injury to such a variant nerve in the proximal arm may lead to a galaxy of manifestations including sensory, motor, vasomotor and trophic changes[11]. The possible clinical implications of these variations relating either to the surgical approach to the shoulder joint and entrapment syndromes are important.[12]

Anomalies of axillary or brachial artery are frequently related to unusual pattern of brachial plexus and median nerve.[13] However, in the present investigation no abnormal arterial pattern was detected.

The variations related to the formation of median nerve by more than two roots are relatively uncommon as compared to the other types of variations of median nerve. Some embryological explanations are available to explain these variations. Finally, knowledge of these variations is important particularly to the surgeons for carrying out surgical procedures in axilla and arm.

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