Why are medial cord variations seen infrequently?

Ajay R. Nene

Department of Anatomy, GSL Medical College, Rajahmundry, Andhra Pradesh 533296, India.

Summary

The brachial plexus is formed by a series of stages- roots, trunks, divisions, cords and branches. The lateral and medial cords are derived from ventral divisions of the trunks, while the dorsal divisions together form the posterior cord. The lateral and medial cords are destined to supply the pectoral region and front of the entire upper limb. Often, during their formation and course, the cords and their branches show a plethora of variations, especially the lateral cord and its branches. Compared to the lateral cord, the medial cord shows variations much more infrequently. In the present work, a comparative study was performed in a set of one hundred upper limbs to note the variations in these two cords and their branches. It was observed that the lateral cord variations outnumbered those of the medial cord. The reason for this probably lies in the development and histogenesis of the brachial plexus during embryonic life. The stepwise journey of the path-finding axons and their interactions with guidance cues probably explains why medial cord variations are seen more infrequently than those of the lateral cord.

Key words: Brachial plexus – Medial cord – Lateral cord – Variations

Introduction

The brachial plexus is a complex network of spinal nerves seen to extend from neck to the upper arm. It consists of complex anastomoses, branching and reanastomoses of anterior primary rami of the spinal nerves C5, 6, 7, 8 and T1; to form the 5 roots, 3 trunks, 6 divisions, 3 cords and their branches. The roots give rise to trunks. After its formation from the roots, each of the trunks divides into anterior and posterior divisions to supply the anterior and posterior compartments of the limb respectively. Hence the lateral cord (formed by the union of the anterior divisions of the upper and middle trunks), and the medial cord (formed as a continuation of the anterior division of the lower trunk) are destined to supply the anterior or flexor compartment of the entire upper limb, while the posterior cord (formed by the union of the posterior divisions of all three trunks) is destined to supply the posterior or extensor compartment of the entire upper limb. The lateral cord gives off three branches: namely the lateral pectoral

Submitted: May 3, 2010
Accepted: July 2, 2010

Correspondence to:
Dr Ajay R Nene. Department of Anatomy, GSL Medical College, NH-5, Lakshmipuram, Rajahmundry, Dist - East Godavari, Andhra Pradesh, Pin - 533296, India. Phone: 0883-2404167; Fax: 0883-2484888; Mobile: +919885338109.
E-mail: ajay.nene@gmail.com

nerve (supplying the pectoralis major and minor muscles), the musculocutaneous nerve (supplying the arm flexors and skin of the outer side of forearm) and the lateral root of the median nerve (supplying the forearm flexors). The medial cord gives off five branches: namely the medial pectoral nerve, (supplying the pectoralis major and minor muscles), the medial cutaneous nerve of the forearm (supplying the skin of the inner side of the forearm), the medial cutaneous nerve of the arm (supplying the skin of the inner side of the arm), the ulnar nerve (supplying the intrinsic muscles of the hand and two of the forearm flexors) and the medial root of the median nerve (supplying the thenar muscles). These cords of the brachial plexus show many variations. The lateral cord shows variations more commonly but medial cord variations are not seen so frequently. In the present study the variations of these two cords were observed and compared. An attempt was made to find a possible explanation for this disparity observed in the incidence of variations in the lateral and medial cords.

Material and Methods

Fifty pairs of upper limbs obtained from the same number of embalmed cadavers were used for this study. The cadavers were dissected according to Cunningham's manual of practical anatomy (Romanes, 1999). The study was performed over 3 years during Anatomy dissection classes for undergraduate students of the GSL medical college. The variations of the lateral and medial cords were carefully observed, documented, and photographed.

Results

The lateral cord of brachial plexus showed variations more frequently than the medial cord. The variations of lateral cord and its branches as observed in the present study were as follows: (1) a communicating branch between the musculocutaneous and median nerve was seen in 15 cases, with an average length of 2.7 cm, (seven on the right side and four on the left side); and two cadavers showed such a branch bilaterally (Fig. 1); (2) The median nerve was observed to be formed at a much lower level than normal in 6 cases, (three on the right side and one on the left side), with an average distance of 13.3 cm from the tip of coracoid process, while one cadaver showed such a formation bilaterally (Fig. 2); (3) In two cases, the musculocutaneous nerve passed down the arm without

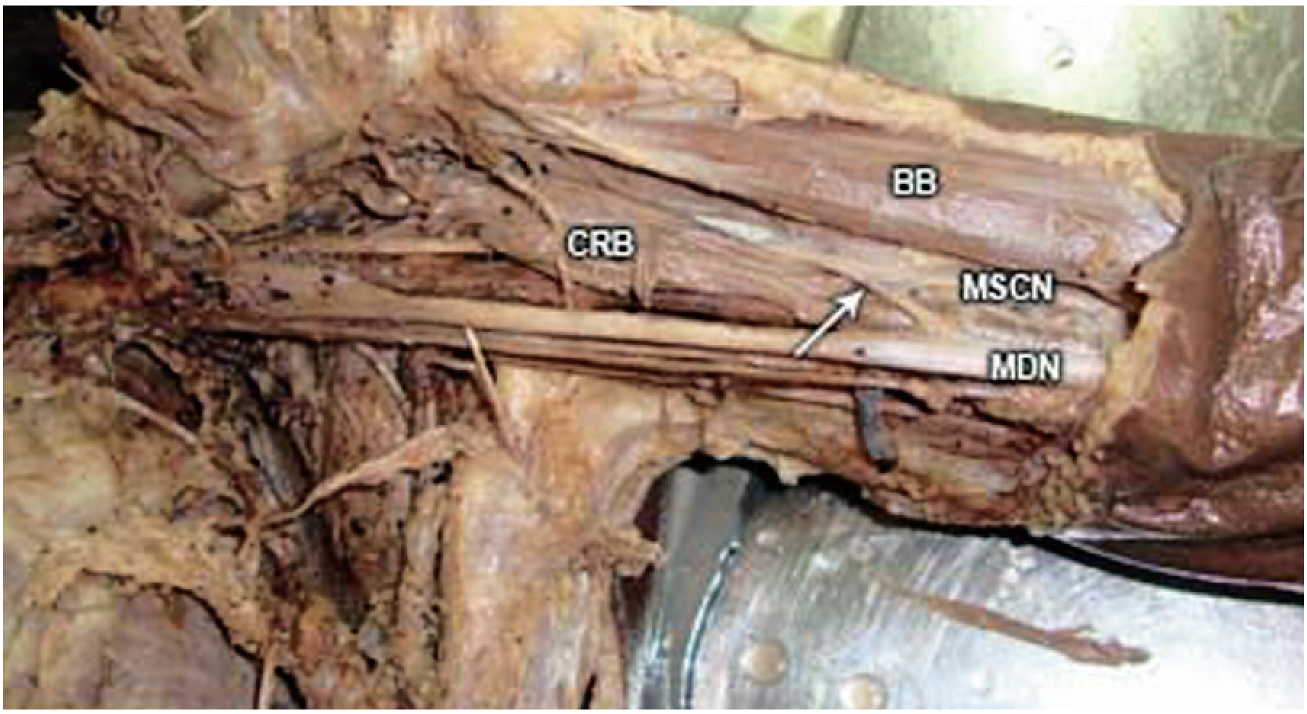

Fig. 1. A communicating branch between the median nerve and the musculocutaneous nerve. BB- Biceps brachii, CRB: Coracobrachialis, MSCN: Musculocutaneous nerve, MDN: Median nerve, Arrow: indicates the communicating branch.

piercing the coracobrachialis muscle, giving off one to two branches to the muscle instead. In another limb that nerve gave off a communicating branch to the median nerve (Fig. 3); (4) There was one case in which both the musculocutaneous and median nerves pierced the coracobrachialis muscle (Fig. 4); (5) One case was seen with two accessory communicating branches from the lateral cord and lateral root of the median nerve to the medial root of the

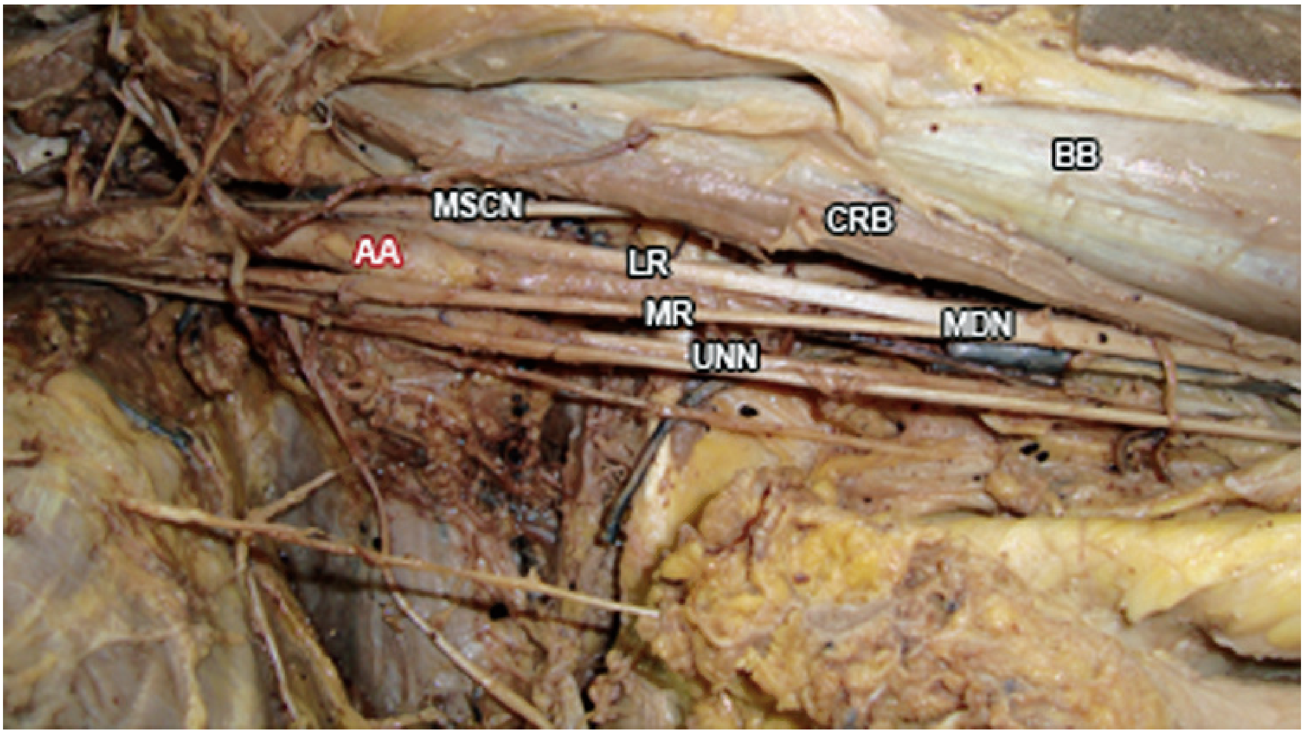

Fig. 2. Delayed formation of the median nerve. BB: Biceps brachii, CRB: Coracobrachialis, MSCN: Musculocutaneous nerve, LR: Lateral root of median nerve, MR: Medial root of median nerve, UNN: Ulnar nerve, AA: Axillary artery.

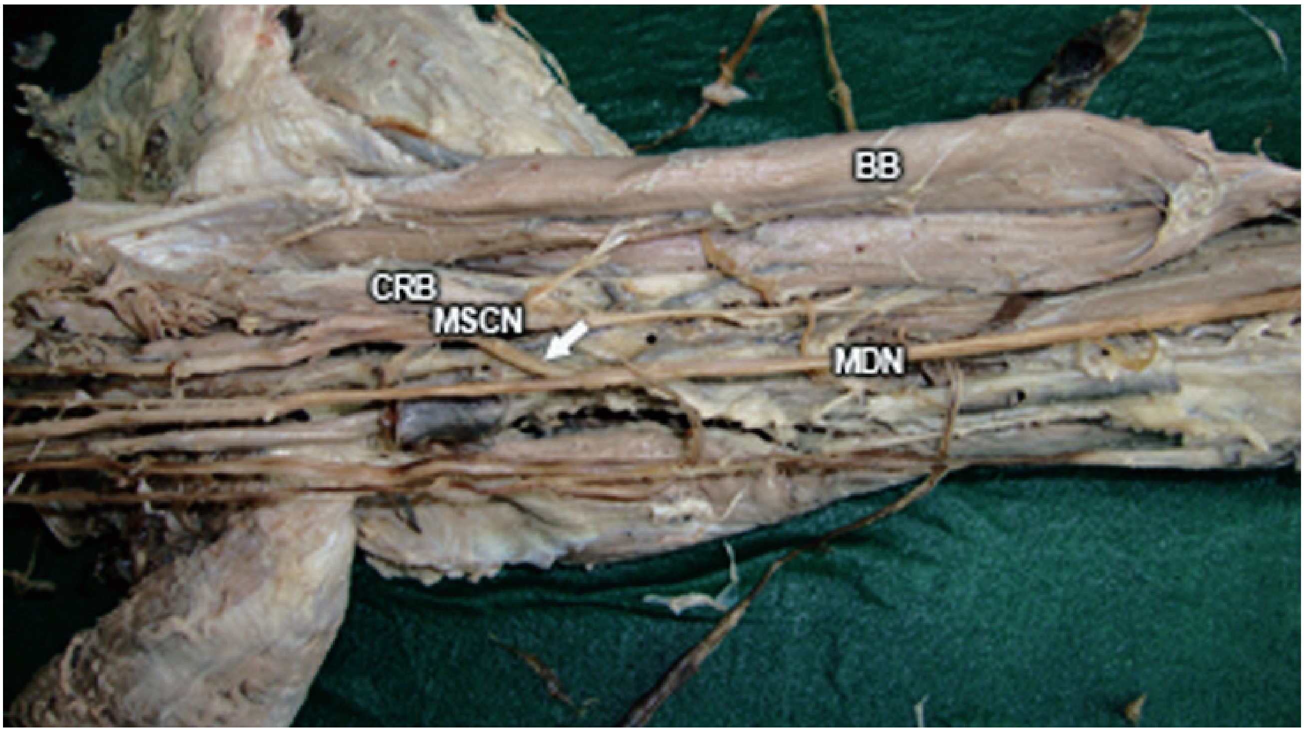

Fig. 3. Musculocutaneous nerve not piercing the coracobrachialis muscle and a communicating branch between the median and musculocutaneous nerve. BB: Biceps brachii, CRB: Coracobrachialis, MSCN: Musculocutaneous nerve, MDN: Median nerve, Arrow: communication between the musculocutaneous and median nerve.

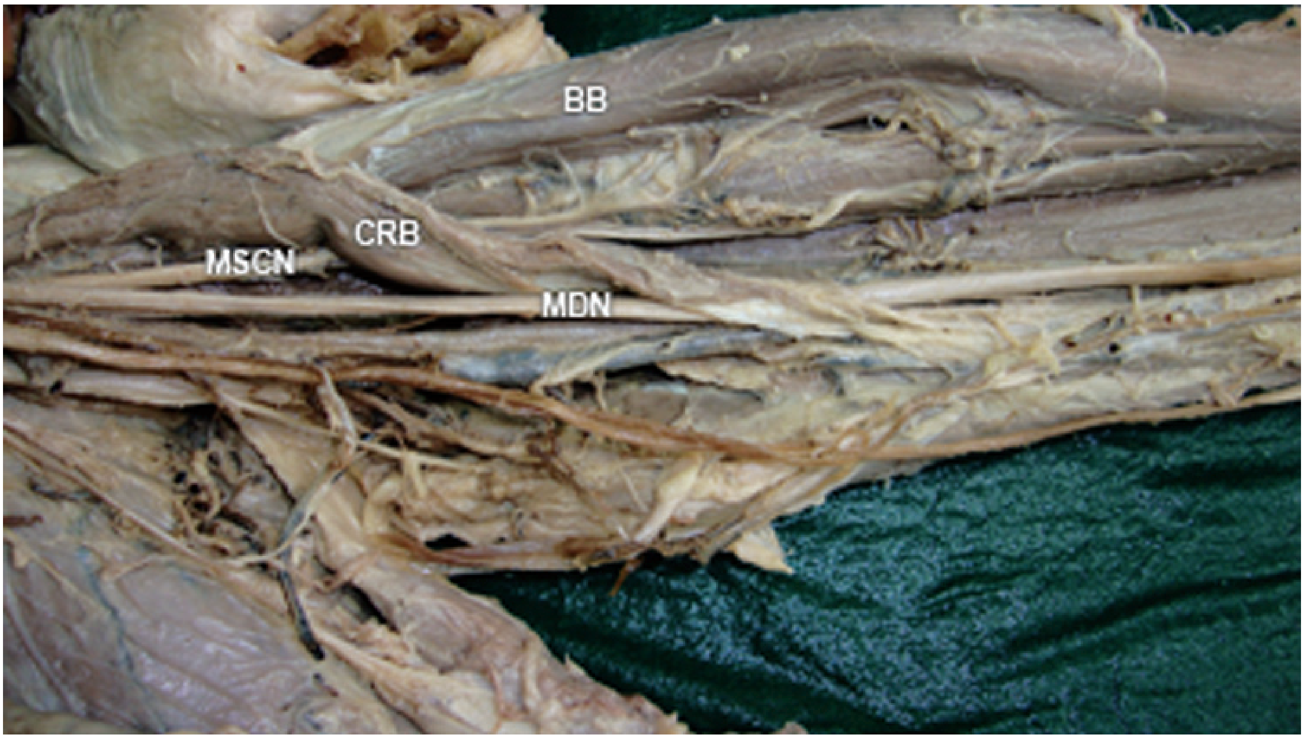

Fig. 4. Musculocutaneous and median nerves piercing the coracobrachialis. BB: Biceps brachii, CRB: Coracobrachialis, MSCN: Musculocutaneous nerve, MDN: Median nerve.

median nerve; (6) In another case, the median nerve was formed behind the axillary artery; (7) In yet another case, the median nerve joined the musculocutaneous nerve for a distance of 3.1 cm in the arm before parting ways, proximal to the cubital fossa.

In contrast, the medial cord did not show many variations. Those seen were a lower formation of the median nerve (six cases), a common trunk for the medial cutaneous nerve of the arm and forearm (one case) and the formation of the median nerve by the union of the medial and lateral roots behind the axillary artery (one case).

Discussion

Owing to its complex formation, variations are frequently encountered in the brachial plexus and its branches.

The communicating branch between the musculocutaneous and median nerve is well documented in the literature. In the study by Choi et al. (2002), connections between the musculocutaneous and median nerves were observed in 26.4% of 138 arms. The nerves were either fused or communicated by one or more branches. In their study, Venieratos and Anagnostopoulou (1998) reported an incidence of 13.9% of connections between the musculocutaneous and median nerves. They proposed a classification for communications between the musculocutaneous and median nerves. Type I – the communication is proximal to the entrance of the musculocutaneous nerve into the coracobrachialis muscle; Type II – the communication is distal to the muscle, and Type III – the nerve, as well as the communicating branch, do not pierce the muscle.

Kaus and Wotowicz (1995) reported an anastomotic branch from the musculocutaneous nerve to median nerve bilaterally in a cadaver. Kosugi et al. (1992); addressing the supernumerary head of the biceps brachii and the branching pattern of the musculocutaneous nerve, found a communication between the musculocutaneous and median nerves in 43 out of 75 limbs.

A more distal union than normal has also been reported in the literature for the two roots of the median nerve. Jakubowicz and Ratajczak (2000) reported that the two roots of the median nerve united lower than normal. They added that the two roots united with each other at about 5 cm above the epicondylar line. A low fusion of the two roots of the median nerve was also reported by Mohammed Badawoud (2003).

The musculocutaneous nerve commonly pierces the coracobrachialis muscle but in some cases, such as in the present study, the nerve does not pierce the muscle. This finding was also reported by el Naggar (2001).

In the present study, the musculocutaneous and median nerves pierced the coracobrachialis muscle at different sites in one case. Abhaya et al. (2003) have described a case in which the lateral cord pierced the coracobrachialis muscle.

Variations in the formation of the median nerve have ben reported. In the present study, there was a case in which there were two accessory communications: one between the lateral cord and the medial root of the median nerve and other between the lateral root and medial root of the median nerve. A similar formation was reported by Joshi et al. (2008) in their series of 85 cadavers. They described the formation of the median nerve in two stages. There were two roots from the lateral cord: a short root and a long root. The short root united first with the medial root of the median nerve, followed by the so-called long root.

Usually, the median nerve is formed anterior or anterolateral to the axillary artery, but in the present study in one case the nerve was formed by the fusion of lateral and medial roots behind the artery. Such a formation is rarely seen and when present it implies a possible source of compression of the nerve by the artery. A similar formation was reported by Chitra (2007).

After their formation, the median nerve and the musculocutaneous nerve run their separate courses and distribute their branches in the target areas. However, in the present study in one case the median nerve joined the musculocutaneous nerve for a short distance before separating from it. Such an observation was reported by Joshi et al. (2008) in their study, where the musculocutaneous nerve fused with the median nerve and its branches were distributed through those of the median nerve.

Along its course, the medial cord did not show many variations apart from a lower formation of the median nerve due to the fusion of the medial and lateral roots; a common trunk for the medial cutaneous nerve of the forearm and the medial cutaneous nerve of the arm; and the formation of the median nerve posterior to the axillary artery due to the fusion of the medial and lateral roots. These variations of the medial cord have not been reported often individually, since they are not encountered frequently.

Understanding the embryological stages in the development of the brachial plexus is important for explaining possible variations. The upper limb bud appears at 26-27 days in the developing embryo and motor axons from the spinal cord enter the limb bud during the fifth week (Moore, 1998). The motor neurons that innervate a muscle or muscle group are clustered in a motor pool in the spinal cord. The pathways between the motor neurons and muscles are accurate from the outset. Because the distance from the spinal cord to muscle is considerable, the axons receive guidance along the way to their targets. The steps taken by motor axons to reach limb muscles are as follows: first, motor axons leave the spinal cord and come together into segmental ventral roots. Second, axons rearrange in a plexus region. Thus, the axons destined for dorsal or ventral muscles are gathered into discrete nerves by the time they enter the base of the limb. Third, the axons run through large nerves within the limb, avoiding cartilage and skin. Fourth, the axons destined for one muscle gather together and leave the large nerves at discrete points to enter their target muscles. Finally the axons leave the intramuscular nerve to synapse on individual muscle fibers (Jassel and Sanes, 2000).

During the histogenesis of peripheral nerves, the normal development of peripheral nerve networks depends upon the ability of axons to locate & recognize their appropriate target. Developing axons choose specific routes in embryos during path-finding stage, followed by growth cones navigating towards their targets. Axon targets may be far away from their soma and they generally pass through intermediate targets to form axon networks. The terminal enlargement of a growing axon – 'the growth cone', arises from filopodia and leads the growth of an axon along its route. The growth cone is a sensory-motor organ that recognizes and responds to guidance cues which are present along the path in the surrounding environment. The cues are generally molecules which act as chemoattractants or chemorepellents. Reacting to these cues, the axon navigates over long distances to find the correct target (Kaplan et al., 2009). Axons reach their distant targets in a series of discrete steps, making decisions at relatively frequent intervals along their way. The axons take variety of paths to reach their destination. Some grow directly to their termination site; but others make a variety of apparent 'decision mistakes' and then change course or extend new branches. This is because different axons respond differently to a particular chemical molecule. Such corrections imply the existence of positional cues (Jassel and Sanes, 2000). This probably explains why variations occur in the course of a nerve and also why nerve fibers ultimately reach their destination. In doing so, they give rise to many such branches which are not usually seen and are regarded as variations.

In the present study, as well as in the literature, it was observed that the lateral cord of the brachial plexus shows variations much more frequently than the medial cord. Let us now consider this scenario of variations in the lateral and medial cords in the light of the axonal path-finding concept. The lateral cord through its branches –lateral pectoral nerve, musculocutaneous nerve and lateral root of the median nerve– is destined to supply the pectoral muscles, the anterior compartment muscles of the arm and skin of outer side of the forearm and most of the forearm flexors respectively. This means that for growing axons of the lateral cord in the path-finding stage, there is a host of intermediate guidance cues to be interpreted along the path to their destination. Depending upon the nature of the guidance cues, i.e. chemoattractants or chemorepellents, an axon would choose to continue along the same path, change the path or cease to advance. Since there are diverse destinations to be reached (pectoral region, arm and forearm), the axons must make frequent decisions all along their paths. Some axons destined for the pectoral region need to leave the lateral cord at a proximal level, while others which are assumed to innervate the flexors of the arm, would leave the lateral cord at an intermediate level. Finally there is a group of axons which continue distally to innervate the forearm flexors. This frequent decision-making along their path renders the axons vulnerable to making 'mistakes'; i.e. they may stray from the actual path.

Typically, such strayed axons ultimately reach their destination by correcting their deviation and while doing so they give rise to many variations. This explains the presence of the abnormal course of a nerve or its branches in relation to surrounding nerves and other tissues.

Through its branches, the medial cord supplies the pectoral muscles, the inner side of the skin of the forearm and arm, two of the forearm flexors, and all the intrinsic muscles of the hand. This means apart from the pectoral muscles and the skin of the inner side of the arm and forearm, the major region receiving motor innervation from the branches of medial cord includes mainly the hand and partly the forearm.

Barring the nerves for the pectoral muscles (medial pectoral nerve), the motor axons running in the medial cord of the brachial plexus have distant targets, located mostly in the hand (the ulnar nerve and the axons running in the medial root of the median nerve) and partly in forearm (ulnar nerve). This implies there are fewer decision-making points along the journey of the axons of the medial cord, since most of them are destined to supply intrinsic hand muscles. This reduces the chances of these axons straying and, concurrently, the formation of variations. This probably explains why medial cord variations are seen infrequently.

Concluding remarks

It is not rare to find variations along the path of the nerves of the brachial plexus. Certain infrequent variations are worthy of note, especially from the clinical point view, where they may help to explain an odd symptom or a clinical sign. The literature is replete with data of variations of the cords of the brachial plexus, but the reason for the presence of such variations lies in their embryological development. Owing to the pioneering work in the field of histogenesis and molecular biology, many anatomical riddles can now be solved. It appears that the number of variations in a nerve/cord depends upon the number of decision-making points along its path. Understanding the development of different tissues may answer most of our queries related to variations in anatomical structures.

Acknowledgements

I would like to extend my gratitude to Dr K. Gajendra, Professor and Head of Anatomy for his guidance, and Dr M.V.R. Sarma, Assistant Professor, for their assistance in the graphic work during the preparation of this manuscript.

References

Abhaya A, Khanna J, Prakash R (2003). Variation of the lateral cord of brachial plexus piercing coracobrachialis muscle. *J Anat Soc India,* 52: 168-170.

Badawoud Mohammed HM (2003). A study on the anatomical variations of median nerve formation. *Bahrain Med Bull,* 20: 1-5.

Chitra R (2007). A rare variant formation of the median nerve: a case report. *Internet J Neurology,* 8: no 2.

Choi D, Rodriguez-Niedenfuhr M, Vazquez T, Parkin I, Sañudo JR (2002). Patterns of connections between musculocutaneous and median nerves in the axilla and arm. *Clin Anat*, 15: 11-17.

El-Naggar MM (2001). A study on the morphology of the coracobrachialis muscle and its relationship with the musculocutaneous nerve. *Folia Morphol,* 60: 217-224.

Jakubowicz M, Ratajczak W (2000). Variation in morphology of the biceps brachii and coracobrachialis muscles associated with abnormal course of blood vessels and nerves. *Folia Morphol*, 58: 255-258.

Jassell Thomas M, Sanes Joshua R (2000). Principles of Neural Sciences, 4th ed. McGraw-Hill, Columbia USA, pp 1063-1084.

Joshi SD, Joshi SS, Athawale SA (2008). Hitch-hiking fibres of lateral cord in search of their destination. *J Anat Soc India,* 57: 57-59.

Kaplan S, Odaci E, Unal B, Sahin B (2009). Development of the peripheral nerve. *Int Rev Neurobiol*, 87: 9-26.

Kaus M, Wotowicz Z (1995). Communicating branch between the musculocutaneous and median nerves in humans. *Folia Morphol,* 54: 273-277.

Kosugi K, Shibata S, Yamashita H (1992). Supernumerary head of biceps brachii and branching pattern of the musculocutaneous nerve in Japanese. *Surg Radiol Anat*, 14: 175-185.

Moore KL, Persaud TVN (1998). The developing human: Clinically oriented Embryology, 6th ed. W.B. Saunders Company, Philadelphia.

Romanes GJ (1999). Cunningham's manual of practical anatomy, 15th ed. Oxford Medical Publications, Oxford, vol 1, pp 20-34.

Venieratos D, Anagnostopoulou S (1998). Classifications of communications between the musculocutaneous and median nerves. *Clin Anat*, 11: 327-331.