

Unusual Branching Pattern of the Lateral Cord of the Brachial Plexus Associated with Neurovascular Compression

Case report

*Hitendra K. Loh, Shikha Singh, Rajesh K. Suri

تفرع غير طبيعي للحبل الفرعي للضفيرة العضدية مصاحبة للإنضغاط

العصبي الوعائي

تقرير الحالة

هتندرة كومار لوه، شيخا سينغ، راجيش كومار سوري

ABSTRACT: The brachial *plexus* consists of a network of nerves that innervates the upper limbs and its musculature. We report a rare formation of the lateral cord of the brachial *plexus* observed during the dissection of a 47-year-old male cadaver at the Department of Anatomy, Vardhman Mahavir Medical College, New Delhi, India, in 2016. The lateral cord was exceptionally long with twin lateral pectoral nerves and twin lateral roots of the median nerve. The proximal lateral root of the median nerve was thin in comparison to the medial root of the median nerve. The distal lateral root of the median nerve was thicker and followed an unusual course through the *coracobrachialis* muscle. In the lower third of the arm, the median nerve and the brachial artery—along with its *vena comitans*—spanned through the *brachialis* muscle. Surgeons, anaesthesiologists, radiologists and anatomists should be aware of such anatomical variations as they may result in neurovascular compression.

Keywords: Anatomic Variation; Dissection; Brachial Plexus; Pectoral Nerves; Median Nerve; Musculocutaneous Nerve; Case Report; India.

الملخص: تتكون الضفيرة العضدية من شبكة عصبية تتخلل الأطراف العلوية وجهازها العضلي. نعرض هنا حالة لتشكل نادر من الحبل الفرعي للضفيرة العضدية لوحظت أثناء تشريح لجثة رجل يبلغ من العمر 47 عاماً في قسم التشريح، في كلية فاردمن ماهافير الطبية، نيودلهي، الهند، عام 2016. كان الحبل الجانبي الوحشي طويل بشكل استثنائي مع تشكل أعصاب مزدوجة صدرية وحشية وجذور مزدوجة للفرع الوحشي للعصب الناصف، كان الجذر الوحشي الأدنى للعصب الناصف رقيقاً بالمقارنة مع الجذر الأنسي لهذا العصب. كان الجذر الفرعي الأدنى من العصب المتوسط رقيقاً بالمقارنة مع الجذر الأوسط من العصب المتوسط. وكان الجذر الفرعي القاصي من العصب المتوسط سميكاً ويتبع مسار غير طبيعي من خلال العضلات الغرابية العضدية. في الثلث السفلي من الذراع، تخلل العصب المتوسط والشريان العضدي والوريد المرافق العضلة العضدية. ينبغي أن يعلم الجراحين وأطباء التخدير وأطباء الأشعة وعلماء التشريح بهذه الاختلافات التشريحية لأنها قد تؤدي إلى ضغط وعائي عصبي.

الكلمات المفتاحية: إختلافات تشريحية؛ تشريح؛ الضفيرة العضدية؛ الأعصاب الصدرية؛ العصب المتوسط؛ العصب العضلي الجذلي؛ تقرير حالة؛ الهند.

THE BRACHIAL PLEXUS IS A NETWORK OF multiple nerves which innervates the upper arm and the muscles which control movement of the shoulder girdle.¹ The union of the anterior divisions of the upper and middle trunk in the infraclavicular part of the brachial *plexus* forms the lateral cord (LC). The first branch of the LC, the lateral pectoral nerve (LPN), pierces the clavipectoral *fascia* to supply the *pectoralis major* muscle.¹ In addition, the LPN gives rise to a communicating twig to the medial pectoral nerve across the axillary artery, through which it supplies the *pectoralis minor* muscle. The next branch, the musculocutaneous nerve (McN), runs obliquely downwards to pierce and supply the

coracobrachialis (CB) muscle.¹ Inferiorly, the McN also supplies the *biceps brachii* (BB) and the *brachialis* muscles before forming the lateral cutaneous nerve of the forearm. The third branch is the lateral root of the median nerve (MN), which is a continuation of the LC; this joins the medial root to enfold the axillary artery and forms the MN.¹ Clavicular and sternal attachments of the *pectoralis major* muscle are supplied by the medial pectoral nerve, whereas the inferior third and costo-abdominal insertions of the *pectoralis major* muscle are innervated by the LPN.²

Various arterial, neural and muscular variations in the upper limbs have been described in the literature.^{3–5} However, anatomical variations in the course

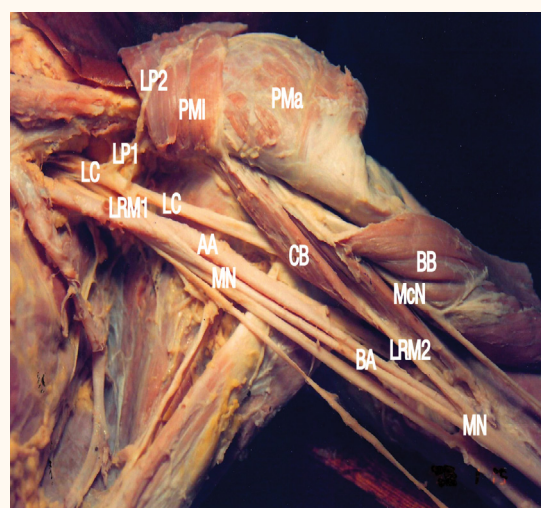


Figure 1: Photograph from the anterior view of the dissected axillary fossa and the upper arm of an embalmed 47-year-old male Indian cadaver showing an unusual variation of the left brachial plexus. The *biceps brachii* has been cut and reflected.

LP2 = distal lateral pectoral nerve; PMi = pectoralis minor; PMa = pectoralis major; LP1 = proximal lateral pectoral nerve; LC = lateral cord; LRM1 = proximal lateral root of the median nerve; AA = axillary artery; CB = coracobrachialis; BB = biceps brachii; MN = median nerve; McN = musculocutaneous nerve; BA = brachial artery; LRM2 = distal lateral root of the median nerve.

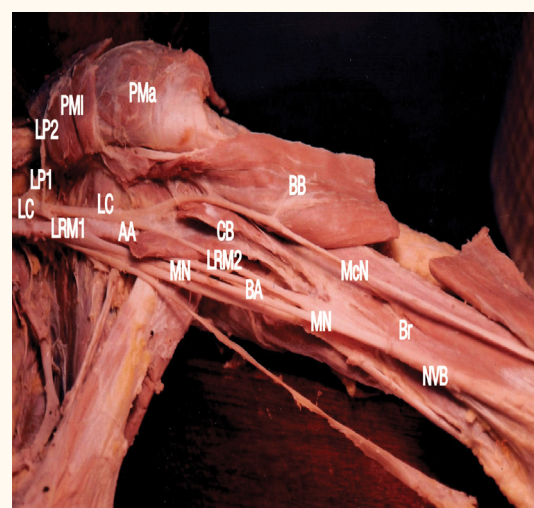


Figure 2: Photograph from the anterior view of the dissected axillary fossa and the upper arm of an embalmed 47-year-old male Indian cadaver. The *coracobrachialis* muscle has been partially removed to expose the distal lateral root of the median nerve. The *biceps brachii* has been cut and reflected.

PMa = pectoralis major; PMi = pectoralis minor; LP2 = distal lateral pectoral nerve; LP1 = proximal lateral pectoral nerve; BB = biceps brachii; LC = lateral cord; LRM1 = proximal lateral root of the median nerve; AA = axillary artery; CB = coracobrachialis; McN = musculocutaneous nerve; MN = median nerve; LRM2 = distal lateral root of the median nerve; BA = brachial artery; Br = brachialis; NVB = lower part of the neurovascular bundle.

and branching patterns of the distal part of the brachial artery are extremely rare. These may include variations in the course beneath the supracondylar process, through the *brachialis* or *pronator teres* muscles or a low division under the *pronator teres* muscle.^{4,6} Awareness of neural variations in the brachial plexus region is essential for surgeons, anaesthesiologists, radiologists and anatomists. The presence of anatomic variations in the peripheral nervous system may also explain unusual clinical findings or symptoms.⁷ This case describes an interesting and rare variant of the LC of the brachial plexus with a duplication of the LPN, twinning of the lateral root of the MN, the absence of the medial pectoral nerve, an atypical formation of the MN and an abnormal course of the McN.

Case Report

A routine undergraduate medical dissection of an embalmed 47-year-old male Indian cadaver took place at the Department of Anatomy, Vardhman Mahavir Medical College, New Delhi, India, in 2016. During the dissection, an unusual variation of the left brachial plexus was noted [Figure 1]. The LC was unusually long at 8.9 cm and gave rise to a double LPN. The proximal LPN (LP1) was thicker, pierced the clavicular fascia and entered the superficial surface

of the *pectoralis major* muscle. The distal LPN (LP2) was slender, branched one centimetre away from the LP1 and entered the *pectoralis minor* muscle from its deeper aspect. The LC also supplied double lateral roots of the MN. The proximal lateral root of the MN (LRM1) was slender and originated 3.7 cm from the formation of the LC. The distal lateral root of the MN (LRM2) measured 9.2 cm in length, was significantly thicker and arose 9 cm from the formation of the LC [Figure 2].

Upon reaching the CB, the LRM2 pierced the muscle belly and joined the MN in the mid-arm. At the formation of the MN, the LRM1 was very thin in comparison to its medial root, whereas the LRM2 was significantly thicker. The proximal course of the McN passed between the BB and CB muscles and traversed between the BB and *brachialis* muscles distally to continue as the lateral cutaneous nerve of the forearm. The MN and the brachial artery, flanked by its *vena comitans*, were wrapped in a common fascial sheath and traversed through the *brachialis* muscle in the lower third of the arm. The intramuscular course of this neurovascular bundle was 5.9 cm in length and the medial pectoral nerve was absent. The anatomy of the brachial plexus on the right side of the cadaver was normal. All measurements were recorded using a thread to follow the course of the nerves.

Discussion

The current report describes a case in which there were two LPNs present: the LP1, which supplied the *pectoralis major* muscle after piercing the clavipectoral fascia, and the LP2, which supplied the *pectoralis minor* directly. The occurrence of a duplicate LPN arising from the anterior division of the upper and middle trunk instead of the LC has been previously reported in the literature.⁸ A common trunk of origin of the medial pectoral nerve and the LPN from the middle trunk of the brachial plexus has also been documented.⁹ Awareness of variations in the anatomy and course of the pectoral nerves is crucial during surgery; for example, when using pectoral muscle flaps during breast surgeries or when the brachial plexus pectoral nerves are transferred to supply a paralysed arm during traction injury repairs.^{10,11}

Cases in which the LC of the brachial plexus pierces the CB muscle and divides into the McN and the lateral root of the MN are very rare.⁴ In the present case, the LC was longer than usual and gave rise to the LP1, LP2 and LRM1 before dividing into the McN and the LRM2 upon reaching the CB muscle. The McN then continued between the BB and CB muscles in the arm instead of piercing the CB muscle; hence, the MN presented with double lateral roots (the LRM1 and LRM2). Moreover, the LRM1 was very thin compared to the LRM2 which joined the MN in the mid-arm. This difference in thickness, along with the abnormal course of the LRM2 through the CB, is clinically significant. Durgesh *et al.* reported a case in which the McN passed along the medial edge of the CB muscle without penetrating it.¹² Jamuna *et al.* reported a case whereby the McN joined the MN after piercing the CB muscle and Abhaya *et al.* reported a rare case in which the LC directly pierced the CB before dividing into the McN and the lateral root of the MN.^{3,13} Abnormal variations in the formation and course of the McN are important as they may affect the outcomes of surgical interventions for shoulder joint trauma, flap dissections, explorative procedures, axillary blocks and post-traumatic evaluations.¹⁴

Anatomical variations in the brachial plexus arise during embryonic development. In a developing embryo, the upper limb bud appears by the 27th gestational day.¹⁵ After the fifth gestational week, motor axons originating from the spinal cord enter the limb buds and the brachial plexus forms as a single radicular cone by the 34–35th gestational day. Following this, the brachial plexus splits into ventral and dorsal segments and the roots of the MN and ulnar nerve are derived from the ventral segments.¹⁵ By the 48th gestational day, the localisation of the upper limb

nerves is established. Communication between the McN and the MN can therefore be attributed to their common embryological derivation during the development of the brachial plexus.¹⁵ Altered signalling amongst mesenchymal cells and neuronal growth cones during the union of the brachial plexus cords has been previously found to result in variations in neural anatomy.¹⁶

In the current case, there were two potential sites which may have resulted in neurovascular compression in the arm: the entrapment of the LRM2 through the CB muscle or a potential injury to the LRM2 in the middle arm and the irregular course of the MN and the brachial artery through the *brachialis* muscle in the lower arm.¹⁷ Entrapment injuries in the arm may lead to paresthesia along the preaxial border of the forearm, weak elbow flexion and other manifestations of a MN injury.¹⁷ Entrapment of the MN and brachial artery is widely studied.¹⁸ However, it is rare for anatomical variations to occur in the distal part of the brachial artery in the muscles of the arm and forearm.^{4,6}

The MN and the brachial artery cross the mid and lower arm as the main neurovascular complex.¹⁹ However, their proximity to the medial intermuscular septum and the medial side of the BB and *brachialis* muscles make them vulnerable to various entrapment syndromes; moreover, while MN entrapment can occur at several sites from the upper arm to the carpal tunnel, it is especially common at sites below the elbow.²⁰ The MN and brachial artery can also be compressed by the *lacertus fibrosus* in the lower arm.²¹ This is critical as the nerve can lose its suppleness and become stretched by joint movement when it becomes attached to adjacent structures. Although nerve compression is easily managed and can be resolved by releasing the neurovascular structure from the entrapment, clinicians should be aware of potential entrapment injuries as they can lead to neuropathy, loss of muscle strength and atrophy.²²

Conclusion

This case describes the unusual occurrence of a double LPN, double lateral roots of the MN and an anomalous course of the McN. These rare variations are potential sites for neural or neurovascular compression in the middle and distal arm, respectively. Radiologists, neurovascular surgeons, anaesthesiologists and anatomists should consider such potential variations when dealing with the brachial plexus region.

References

1. McMinn RM. *Last's Anatomy: Regional and applied*, 8th ed. London, UK: Churchill Livingstone, 1990. Pp. 68–9.
2. Cunningham DJ, Romanes GJ. *Cunningham's Textbook of Regional Anatomy*, 11th ed. London, UK: Oxford University Press, 1972. P. 308.
3. Abhaya A, Khanna J, Prakash R. Variation of the lateral cord of brachial plexus piercing coracobrachialis muscle. *J Anat Soc India* 2003; 52:168–70.
4. Bergman RA, Afifi AK, Myiauchi R. *Illustrated encyclopedia of human anatomic variation*. From: www.anatomyatlases.org/AnatomicVariants/AnatomyHP.shtml Accessed: Nov 2016.
5. Vollala VR, Nagabhooshana S, Bhat SM, Potu BK, Rodrigues V, Pamidi N. Multiple arterial, neural and muscular variations in upper limb of a single cadaver. *Rom J Morphol Embryol* 2009; 50:129–35.
6. Wysiadecki G, Polguj M, Haładaj R, Topol M. Low origin of the radial artery: A case study including a review of literature and proposal of an embryological explanation. *Anat Sci Int* 2016. doi: 10.1007/s12565-016-0371-9.
7. Thwin SS, Zaini F, Than M, Lwin S, Myint M. Unusual variations of the lateral and posterior cords in a female cadaver. *Singapore Med J* 2012; 53:e128–30.
8. Bhanu SP, Sankar DK, Susan PJ. Formation of median nerve without the medial root of medial cord and associated variations of the brachial plexus. *Int J Anat Var* 2010; 3:27–9.
9. Khullar M, Sharma S, Khullar S. Multiple bilateral neuro-anatomical variations of the nerves of the arm: A case report. *Int J Med Health Sci* 2012; 1:75–84.
10. David S, Balaguer T, Baque P, de Peretti F, Valla M, Lebreton E, et al. The anatomy of the pectoral nerves and its significance in breast augmentation, axillary dissection and pectoral muscle flaps. *J Plast Reconstr Aesthet Surg* 2012; 65:1193–8. doi: 10.1016/j.bjps.2012.03.032.
11. Samardzic M, Rasulic LG, Grujicic DM, Bacetic DT, Milicic BR. Nerve transfers using collateral branches of the brachial plexus as donors in patients with upper palsy: Thirty years' experience. *Acta Neurochir (Wien)* 2011; 153:2009–19. doi: 10.1007/s00701-011-1108-0.
12. Durgesh V, Rao RR. Musculocutaneous nerve revisited. *Int J Basic Appl Med Sci* 2013; 3:34–6.
13. Jamuna M, Amudha G. A cadaveric study on the anatomic variations of the musculocutaneous nerve in the infraclavicular part of the brachial plexus. *J Clin Diagn Res* 2011; 5:1144–7.
14. Mavishettar SM, Iddalagave S. Musculocutaneous nerve and its variations. *Int J Gen Med Pharm* 2013; 2:53–64.
15. Uyaroglu FG, Kayalioglu G, Erturk M. Anastomotic branch from the median nerve to the musculocutaneous nerve: A case report. *Anat* 2008; 2:63–6. doi: 10.2399/ana.08.063.
16. Sanes DH, Reh TA, Harris WA. Axon growth and guidance. In: *Development of the Nervous System*, 3rd ed. San Diego, California, USA: Academic Press; 2011. Pp. 105–42. doi: 10.1016/B978-0-12-374539-2.00009-4.
17. Neal S, Fields KB. Peripheral nerve entrapment and injury in the upper extremity. *Am Fam Physician* 2010; 81:147–55.
18. Bilecenoglu B, Uz A, Karalezli N. Possible anatomic structures causing entrapment neuropathies of the median nerve: An anatomic study. *Acta Orthop Belg* 2005; 71:169–76.
19. McNamara B. Clinical anatomy of the median nerve. *Adv Clin Neurosci Rehabil* 2003; 2:19–20.
20. Birch R. Operating on peripheral nerves. In: *Surgical Disorders of the Peripheral Nerves*, 2nd ed. London, UK: Churchill Livingstone, 2011. Pp. 231–302. doi: 10.1007/978-1-84882-108-8_7.
21. Kumar H, Das S, Gaur S. Case report: Entrapment of the median nerve and the brachial artery by the lacertus fibrosus. *Arch Med Sci* 2007; 3:284–6.
22. Green DP, Hotchkiss RN, Pederson WC. *Green's Operative Hand Surgery*, 4th ed. Philadelphia, Pennsylvania, USA: Churchill Livingstone, 1999. Pp. 1417–22.