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Ulnar-Median Nerve Transposition: Embryology and Clinical Implications

Olutayo Ariyo* **and Raymond Shea J**

Department of Pathology, Anatomy and Cell Biology, SKMC, Thomas Jeffesron University, Philadelpphia, PA, United States

***Corresponding author:** Olutayo Ariyo, Department of Pathology, Anatomy and Cell Biology, SKMC, Thomas Jeffesron University, Philadelpphia, PA, United States, Tel: 610-638-9278; E-mail: tmajor33@hotmail.com

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Abstract

Branches of the brachial plexus situated within the flexor compartment of the arm, the musculocutaneous, median and ulnar nerves maintain a predictive topography. The musculocutaneous nerve courses lateralward, the ulnar medial-ward, and the median between these. The present case features bilateral occurrence of ulnar and median transposition in a 74-year-old female cadaver. This transposition is related to dissimilar lengths of the lateral and medial roots of the median nerve. Both lateral roots of the median nerve were found to be unusually longer than usual. In addition, both medial roots coursed infero-medially instead of its usual superolateral coursing from their respective medial cords. These anomalies resulted in the median nerve being placed postero-inferior and medial to the ulnar nerve both lateral roots were observed crossing anterior to and impinging on their respective ulnar nerve. Clinical implications of the observed transposition include possible neurographic or MR ultrasonography misinterpretation of images. In addition such transposition may pose challenges to trauma surgeons engaged in nerve reconstruction following crush or mangled arm injuries. Anesthesiologists engaged in selective median or ulnar nerve blocks may witness increased procedural time and failures, as well as unexplained failure of analgesia in the skin areas normally supplied by their intended blocked nerve, a clinical situation that can be resolved by performing a neurostimulation.

Keywords: Ulnar-median nerve transposition; Anatomic land mark guide; Ultrasound guided localization; Neuro-stimulation

Introduction

Among the ventral primary rami contributing to the brachial plexus, the upper two rami (C5 and C6) join, as do the lower two rami (C8 and T1). The middle ramus (C7) continues on its own. The five ventral primary rami are thereby reduced to three nerve trunks. Each trunk then separates into an anterior and a posterior division. All three posterior divisions unite into a single posterior cord, which courses deep to the second part of the axillary artery, to innervate the posterior or extensor musculature of the upper limb. The fundamental simplicity of the brachial plexus would be more obvious if the three anterior divisions were also to unite into a single common flexor cord. But instead there are two, the lateral and medial cords of the brachial plexus innervating the anterior or flexor musculature. The principal peripheral nerves of the brachial plexus are the Musculocutaneous Nerves.

MCN derived from the lateral cord, while the Ulnar Nerve (UN) is from the medial cord. The Median Nerve (MN)s formed from two cords, the lateral (C5,6,7) and medial (C8, T1), their roots embracing the third part of the Axillary Artery (AA), uniting lateral or anterior to the AA. Initially running lateral to the AA, the nerve crosses lateromedially near the distal attachment of the coracobrachialis. The proximal relationship of the MN to the brachial artery serves as an anatomic guide-mark during anesthesia to guide MN block. Variations between these peripheral nerves are related more to communications between members, with most of these between the MCN and the MN. Veniaratos and Anagnostopoulu reported 22 communications in 16 out of 79 cadavers [1]. There are reports of the MCN running entirely fused with the lateral root or with the MN itself, before emerging as twigs supplying their respective flexor arm muscles [2].

Communications between ulnar and MN are restricted mostly to communications in the distal forearm region and are classified either as Martin-Gruber anastomosis or the Marinacci anastomosis, a reversed type of the Martin Gruber anastomosis [3].

In the usual MN formation, the lateral root usually travels inferormedially and the medial root courses in the opposite direction superolaterally. Altered relationships in the topography between the MN and AA had been widely reported in surgical, radiologic and cadaver dissection studies, but from a very extensive literature search, we came across no report of a transposition of the MN and UN.

A bilateral occurrence of such transposition makes this a very rare variant and carry clinical implications in relation to diverse surgical interventions in the upper limb, most especially during anesthetic procedures as well as nerve reconstruction following crush or mangled arm injuries. During dissection, we encountered transposition of the MN and UN, occurring bilaterally in the upper limbs of a 74 year-old-female cadaver (Figures 1 and 2). We observed that both lateral roots of the MN were much longer than usual. The average length of the typical lateral root measures about 3.75 cm. The lateral root in the left upper limb in our report measured about 7.5 mm (Figure 1) while the right measured about 5 cm (Figure 2).

In the typical MN formation, the lateral root usually course inferomedially, while the medial root runs in the opposite direction superolaterally, both roots joining to form the MN. We observed that both lateral roots in our cadaver had a normal inferomedial coursing, even though were much longer than normal (Figures 1 and 2).

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We also observed that in both limbs, instead of coursing superolaterally, the medial roots were engaged in a reversed superomedial coursing (Figures 1 and 2), and a transposition had occurred by the time the two roots of the MN joined, which resulted in the UN and not the MN running in close proximity to the AA (Figures 1 and 2). We also observed a fused lateral and posterior cords in the right upper limb which gave rise to both the radial and MCN nerves (Figure 2). Both lateral roots travelled anterior to and impinged on their ipsilateral UN before joining their respective medial counterpart to form the MN (Figures 1 and 2).

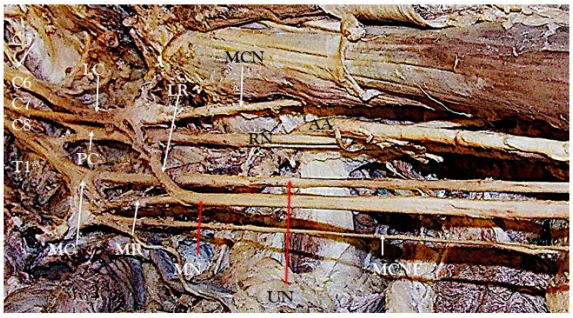

Figure 1: This image shows the ulnar nerve in the L limb emanating superior to and laterally placed to the medial root of the median nerve, contrary to a medial topographic relationship. The lateral root of the MN is unusually longer than normal and can be observed impinging on the ulnar nerve. The lateral and the medial roots join to form the median nerve with a resultant transposition of the ulnar and median nerves. MN: Median Nerve; UN: Ulnar Nerve; MCN: Musculocutaneous Nerve; RN: Radial Nerve; MCNF: Medial Cutaneous Nerve of Forearm; LC: Lateral Cord; PC: Posterior Cord; MC: Medial Cord; C5-C8: ventral rami of cervical 5-8. *T1 ventral rami that completes the formation of the brachial plexus (C5-T1) not shown clearly in this picture.

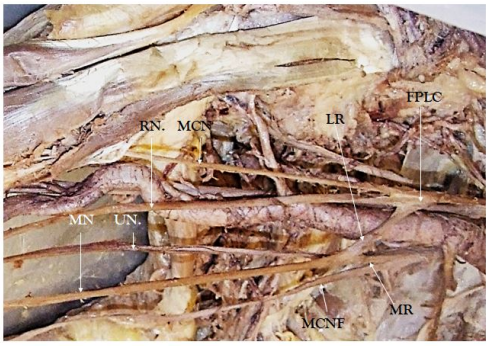

Figure 2: This image shows the fusion of both the lateral and posterior cords in the right limb and gave rise to both the musculocutaneous and radial nerves. The lateral root impinged on the ulnar nerve before joining the medial root to form the median nerve. FLPC: Fused Lateral and Posterior Cords.

Both the AA and brachial arteries featured several levels of kinking, twists and tortuosity that were more pronounced on the right limb (Figure 2) than in the left limb (Figure 1). We did not observe any communication between the MCN and the MN in both limbs, nor between the UN and MN respectively. We observed however that just proximal to the cubital fossa, the MN coursed superolaterally and the UN inferomedially to be placed in their respective usual anatomical guide marks at the elbow region.

Discussion

The usual reliable and predictive topographical relationship between the MN and UN were not the case in both upper limbs of our cadaver, with the UN and not the MN observed in close relationship to the AA. Anatomically, the very close relationship between the AA and the MN is employed as a predictable and reliable landmark by anesthesiologists, locating the artery's pulsation, followed by infiltrating the anesthetic agent in the artery's immediate neighborhood for a selective MN blockade in the axilla or mid-humeral. Despite the extensive reports of communications between the MN and UN, we found no report of a transposition of these nerves. Although much greater levels of communications exist between the MN and the MCN nerves [1,2].

Saeed WR et al., reported that communications between the MN and UN tend to occur mostly in the hand and distal forearm regions and most often are directed from the ulnar to the median nerve [4], Santoro L et al., classifying them as either a Martin-Gruber anastomosis in which the communication is from MN to UN, or the reverse Martin-Gruber called the Marinacci anastomosis in which the anastomotic branch originates proximally in the UN and unites distally to the MN [3]. Such communications may be associated with increased latency following anesthetic infiltration of either the MN or UN. Paraskevas G, et al., reported the case of a rare ulnar nerve branch called a Kaplan anastomosis which is a rare UN branch, a communication, anastomosing the dorsal cutaneous branch with the ulnar nerve prior to its bifurcation into the superficial and deep ramus [5].

It is presumed that the development of the brachial plexus involves a single radicular cone of axons of spinal nerves and these spinal nerves organize themselves to form dorsal and ventral divisions. Neurobiotaxis has been attributed to abnormal pathway [6], while altered signaling between the mesenchymal cells and neuronal growth cones or circulatory factors at the time of fission of brachial plexus cords has been reported to be the main cause of variation in nerve pattern [4]. An altered signaling therefore between the mesenchyme which forms the medial cord and neuronal growth cones or circulatory factors may have been responsible our medial root to course inferomedially and not superolaterally.

Samnes et al. postulated that guidance of the developing axons is regulated by expression of chemo-attractants and chemorepellants in a highly coordinated site specific fashion, and that any alteration in signaling between mesenchymal cells and neuronal growth cones can lead to significant variations [7].

Knowledge of the variation patterns in the formation of the brachial plexus is very vital to and a guide to Hand, Orthopedic, and vascular surgeons engaged in nerve reconstruction following crush or mangled arm injuries in avoiding inadvertent mal-suturing of different nerve endings and also assist in proper interpretation of neurographic or ultrasound guided-nerve imaging. Attempted selective MN or UN

blockade in the axilla or proximal arm in an unsuspected transposition can result in increased procedural duration and failures.

Motor responses following an unsuspected MN transposition would result in paradoxical flexion of the medial 1½ digits instead of the lateral 3½ digits, a clinical dilemma that would be solved not by a high resolution MRI or ultrasound scan, but by simply performing a neurostimulation. Tuominen et al., Elfert and Hahnel had reported the latter being responsible for improved success rates, reduced theoretical risk of nerve damage and localizing nerves more accurately, as well as avoiding deliberate arterial puncture [8,9]. Our reported case is a rare incidental finding. Future study will embark on finding the incidence of such a transposition in a large and statistically significant cadaveric sample.

Conflict of Interest

None

Acknowledgment

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