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CASE REPORT

A Rare Case of Atypical Formation of Musculocutaneous Nerve not Perforating Coracobrachialis Muscle: Embryological and Clinical Implications

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Abstract

An rare anomaly of the musculocutaneous nerve was detected during routine dissection of the left upper limb of a 42-year-old Turkish male cadaver. Musculocutaneous nerve extend in a common cover together with the lateral cord and lateral root of median nerve without separating from the lateral cord. The lateral and medial roots deriving from their corresponding cords combined ventral to the axillary artery forming a true common trunk of the musculocutaneous nerve and median nerve. The musculocutaneous nerve branched off from the median nerve 0.5 cm distal to the junction of the lateral and medial roots of median nerve. The musculocutaneous nerve traveled between the biceps brachii and coracobrachialis muscles without piercing the coracobrachialis muscle and crossed over the axillary artery. After passing between the biceps brachii and brachialis muscles, the musculocutaneous nerve continued as the lateral cutaneous nerve of the forearm. There was no prominent musculocutaneous nerve branch observed to innervate the coracobrachialis muscle. Very thin nerve branches were observed extending from the lateral cord and musculocutaneous nerve to the coracobrachialis muscle. A connection extending from the proximal part of the lateral cord to the point where the ulnar nerve originated in the distal part of the medial cord was also detected. Knowledge of upper extremity anatomical variations helps surgeons during surgical interventions and treatments to avoid potential iatrogenic injuries during surgery.

Key Words: *Brachial plexus; Coracobrachialis muscle; Embryology; Median nerve; Musculocutaneous nerve*

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Introduction

Variations in the course and branching of musculocutaneous nerve (MCN) are frequently documented in the literature [1-6]. In classical anatomy textbooks, it is stated that the MCN emerges from the lateral cord (LC) of the brachial plexus (C5-C7) against the lower edge of the pectoralis minor muscle, and where it then perforates and innervates the coracobrahialis muscle (CB). The MCN then travels on the lateral aspect of the arm between the biceps brachii and brachialis muscles, emerging as the lateral cutaneous nerve of the forearm [7,8].

It is also reported in standard anatomy text books that the MCN gives branches to CB before piercing the it, and to other muscles after piercing, such as the biceps brachii muscle and brachialis muscle [7,8].

Knowledge of branching patterns and course of the MCN is clinically important in microsurgical procedures, especially in compression neuropathies due to vigorous activity and strain injuries caused by surgical interventions [9-11]. These variations have been detected more frequently after the introduction of imaging techniques such as Magnetic Resonans Imaging (MRI) and Computed Tomography (CT) into medicine.

We report a rare variation of the MCN encountered during routine student dissections at Ondokuzmayıs University, Medical Faculty and discuss its embryological basis and clinical significance.

Case Report

We observed a MCN variation of the upper right limb of a 42 year- old Turkish male formalin fixed cadaver whose cause of death was heart failure. The upper limb dissections were performed according to the techniques in Cunningham's manual of practical anatomy [12]. In this case, the fibers of the MCN extend in a common cover together with the LC and lateral root of median nerve (MN) without separating from the LC. The lateral and medial roots of MN combined ventral to the axillary artery to form a true common trunk of the MCN and MN. The MCN branched off from the MN 0.5 cm distal to the junction of the lateral and medial roots of MN. Before providing a muscular branch to the biceps brachii muscle, the MCN crossed over the axillary artery for a short distance and traveled between the biceps brachii muscle and CB without piercing the CB. After passing between the biceps brachii and brahialis muscles the MCN emerged as the lateral cutaneous nerve of forearm. The MCN provided a branch to the biceps brachii muscle 7 mm distal to the common trunk, and to the brachialis muscle at the insertion site of the CB. There was no prominent MCN branch observed to innervate the CB. No anastomotic branches were observed between MCN and MN either in the axillary region or in the arm. Very thin nerve branches were observed, however, extending from the LC and MCN to the CB. We noticed that the MCN and MN are encased in the same connective tissue sheath to form a true common trunk. Dissection of the connective tissue sheath resulted in the trunk not being divided into MCN and MN. In our case, we also detected a connection extending from the proximal region of the LC to the point where the ulnar nerve originated in the distal part of the MC (Figures 1a and 1b).

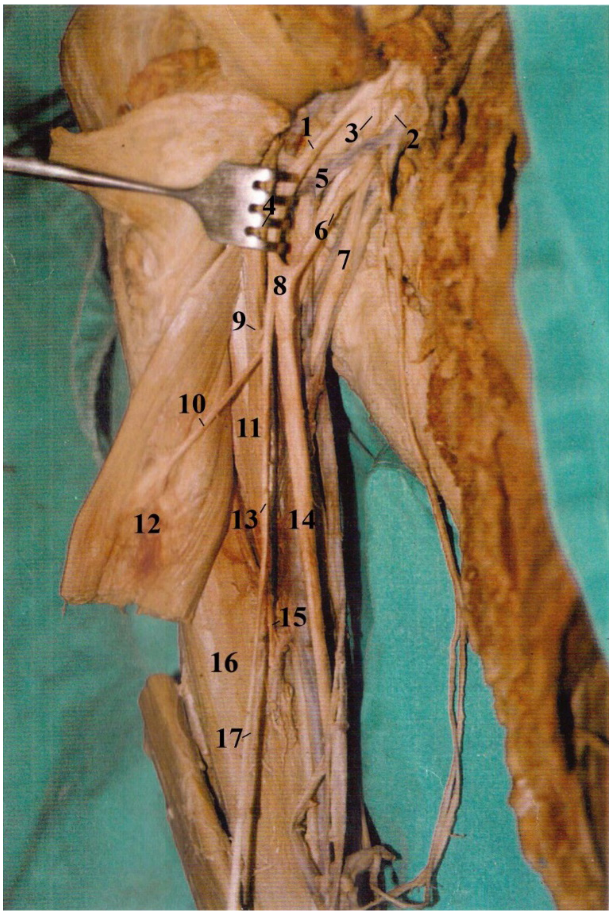

Figure 1a) *Photograph of the dissection showing the musculocutaneous nerve variation and brachial plexus in the upper right limb. 1-Lateral cord; 2-Medial cord; 3-Connection between the lateral cord and the medial cord; 4- Lateral root of the median nerve; 5-Axillary artery 6-Medial root of the median nerve;7-Ulnar nerve; 8-Common trunk of the musculocutaneous and median nerves; 9-Thin branch of the musculocutaneous nerve to the coracobrachialis muscle; 10-Musculocutaneoue nerve branch to the biceps brachii muscle; 11-Coracobrachialis muscle; 12-Biceps brachii muscle (two heads cut); 13-Musculocutaneous nerve; 14-Median nerve; 15-Musculocutaneoue nerve branch to the brachialis muscle; 16-Brachialis muscle; 17-Lateral cutaneous nerve of the forearm.*

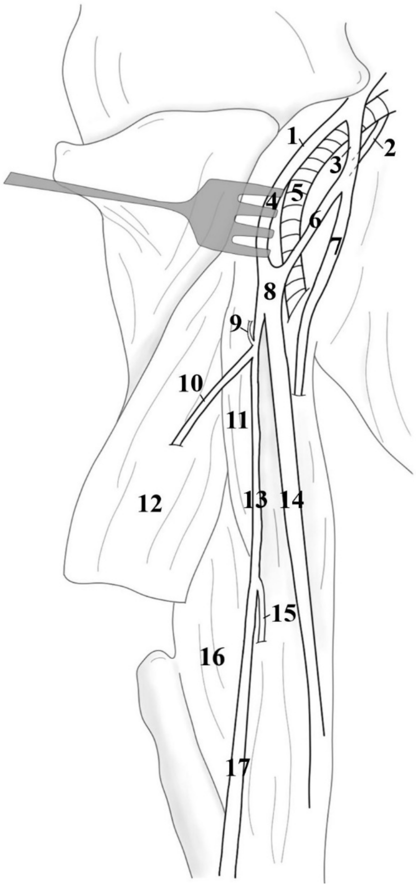

Figure 1b) *Illustration showing the anomaly of the musculocutaneous nerve and brachial plexus in the upper right limb. 1-Lateral cord; 2-Medial cord; 3-Connection between the lateral cord and the medial cord; 4- Lateral root of the median nerve; 5-Axillary artery; 6-Medial root of the median nerve; 7-Ulnar nerve; 8-Common trunk of the musculocutaneous and median nerves; 9-Thin branch of the musculocutaneou nerve to the coracobrachialis muscle; 10-Musculocutaneoue nerve branch to the biceps brachii muscle; 11-Coracobrachialis muscle; 12-Biceps brachii muscle (two heads cut); 13-Musculocutaneous nerve; 14-Median nerve; 15-Musculocutaneous nerve branch to the brachialis muscle; 16-Brachialis muscle; 17-Lateral cutaneous nerve of the forearm;*

Discussion

In the classification of MCN variations, its relationship with the LC,and the position and number of connections between MCN and MN are generally taken into consideration. According to our knowledge, MCN variation classifications were first made by Le Minor (1990), and five types were distinguished [4]. As defined in conventional anatomy textbooks, there is no connection between the MCN and MN, but cases where MCN pierces the CB are defined as Type I. Type II is similar to the normal pattern, with additional connection between MCN and MN at the level of the branch leading to brachialis muscle. In Type III, the LR from LC travels in a common sheath with the MCN and leaves it after giving off the muscle branches to form the LR and then the main trunk of the MN [4] (Figure 2).

In Type IV, the MCN is separated from MN as an independent nerve after some distance. The cases in which MCN were absent and its fibers run into the MN were defined as Type V. In this type, branches from the MN lead to the flexors of the arm. Since there is no MCN in Le Minor's Type V, the branches to the flexor muscles originated from the MN. In Type II and Type III, the LC formed a common trunk with MCN and pierced the CB [4] (Figure 2).

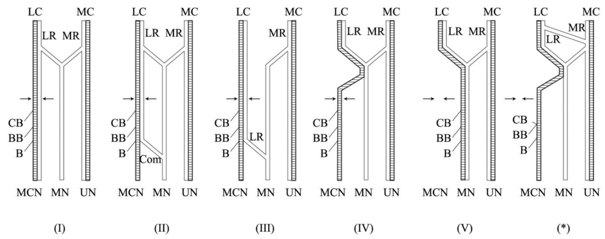

Figure 2) *Previously proposed classification of musculocutaneous nerve according to Le Minor (1990).; and our presented case.*Our presented case in light of previous classification. The arrows indicate the position of coracobrachialis muscle or whether musculocutaneous nerve or lateral cord pierces the coracobrachialis muscle. LC: Lateral cord; MC: Medial cord; LR: Lateral root of the median nerve; MR: Medial root of the median nerve; CB: Coracobrachialis muscle; BB: Biceps brachii muscle; B: Brachialis muscle; MCN: Musculocutaneous nerve; MN: Median nerve; UN: Ulnar nerve; Com: communication.*

While our case did not correspond to any of Le Minor's classifications, it was mostly similar to Type IV. Differently, in our case, MCN passed without piercing the CB.

Ferner (1938) classified the variations in which MCN passes without piercing the CB in two types as complete and incomplete. In the complete fusion type, MCN and MN combine to form a true trunk. This trunk provides branches to the muscles in the anterior compartment of the arm, and lateral cutaneous nerve of the forearm independently arises from this trunk. In the incomplete type, MCN and MN are encased in the same connective tissue sheath to form a common trunk in appearance. Dissection of the connective tissue sheath, however, results in the separation of the trunk into MCN and MN [13]. While our case is appeared be compatible with Le minor's Type IV,on the other hand we also found that the fibers showed a true common trunk of MCN and MN in accordance with the Ferner's complete fusion type.

In a study, by Hayashi et al. (2017),they described two different classifications that integrate the classifications made by Le Minor,and the level of connection between MCN and MN [16]. Accordingly, when the connection between the MCN and MN is not taken into account their Type 0 corresponded to Le Minor's Type V. When the connection between the two nerves (MCN and MN) is taken into account, the types they define correspond to Type II of Le Minor. In Venieratos and Anagnostopoulou's (1998) study, they identified three types in relation to CB [17]. Accordingly, in Type I, the connection was close to the entry of the MCN into the CB. In Type II the connection was distal to the CB, and in Type III, neither the nerve nor the connecting branch perforated the CB. According to this classification, our case can be assigned to the Type III since MCN does not pierce CB (Figures 1a and 1b).

Some authors identified three types of variations according to the number and height of connections between MCN and MN [18-21]. Of these, In type I of Choi et al.(2002), MCN fused with MN; In their type II,there was no connection between MCN and MN and in Type III,there were two connections between both nerves [18].Bergman et al.(1988) reported that the MCN originated from the LC in 90.5% of cases, from the LC and from the posterior cord in 4% of cases, from the MN in 2% of cases, and as two separate bundles from the LC and MC or posterior cord in 1.4% of cases [7]. Type V in the classification of Le Minor, that is, the absence of MCN or the combination of MCN with LC and MN, has been reported by various authors [7,15,16,22,23]. Aydin et al. (2006) reported two connections between MC and LC [23]. Nascimento et al. (2016) and Nasrabadi et al. (2017) also observed that the MCN branched normally but it did not pierce the CB, and had a connection with the MN distally [24,25]. Although the variations presented in our case are documented by other authors separately, the combination of variations in our case has not been documented elsewhere.

Embryology

Branch variations of brachial plexus can best be interpreted in the light of embryological explanations. These avariations are quite complex and occur as a result of abnormal embryological development of the plexus. The brachial plexus first looks like a single radicular cone in the upper limb. This cone is divided into ventral and dorsal segments. The MN roots, ulnar nerve and the MCN originate from the ventral segment [26].

The development of the brachial plexus begins in the fifth week of prenatal life. The mesenchyme of paraxial mesoderm provides progress of forearm muscles by expression of the Hox D genes [27,28]. Meanwhile, the paraxial mesoderm differantiates into myotomes, dermatomes and scleretomas. During development, myotome cells usually extend parallel to the long axis of the embryo. Between the fifth and sixth weeks, the myotomes expand dorsally, encircling the neural tube and extending ventrally into the somatopleure. The nerve is likewise divided into dorsal and ventral primary rami. At this time, the fibers of the ventral roots of the spinal nerve that develop from the neural tube make contact with the corresponding parts of myotomes [28-30].

The development of limb musculature is detected in the seventh week. When the upper limb buds are formed, the ventral primary branches of the spinal nerves grow to reach the mesenchyme of the limb bud, and come into close contact with the differentiating mesenchyme condensations. This early contact is a prerequisite to allow for the complete functional differentiation of nerve and muscle cells [31,32].

During further development, the nerve grows towards the muscle and follows it during any subsequent migration [30]. The growth cones of the motor axons reach the limb bud to develop the brachial plexus [27]. Peripheral extensions of motor and sensory neurons grow in different directions within the mesenchyme [31].

The direction of the developing axons is controlled by the highly coordinated site-specific expression of chemoattractants and signals between cones and mesenchyme [30,32,33]. Extracellular matrix components such as laminin, taniscin and fibronectin also play a role in the regulation of cell migration. Recognition of these molecules is regulated by integrin, which are surface receptors expressed by neuronal cells [33].

It is possible that the variation seen in our case is the result of an variation that occured due to factors affecting the developmental process of the arm muscles and peripheral nerves. This variation may be caused by a failure during the time when the nerve fibers that make up the LC reach the mesenchyme of the limbud in the MN and MCN. This variation may also have arisen as a result of a deficiency in the expression of some chemoattractants and chemorepulsants or the signal deficiency between mesenchyme and cones, as explained above. As a result the LR and MCN would completely fuse or be covered with the common connective tissue sheath. This could also result in the MCN failing to perforate the CB, and the MCN not separating from the LC beforehand, and MCN and MN being completely fused and covered by a common connective sheath.

Kouzumi (1989) stated that the CB consists of a superficial and a deep part. These parts are innervated by the MCN and the middle trunk, respectively, and that MCN does not pierce the CB if the superficial part insufficiently develops [3]. In our case, due to the reasons explained above, the fibers in the LC should have traveled within the MCN and the lateral root of MN, but this could not be fully ensured, and some fibers were traveling within the MR, which may have caused the connection between the LC and the MC. As stated by Kosugi (1992) this connection can also be considered a common or similar characteristic in terms of phylogenetic or comparative anatomy of species related to humans [34]. A nerve trunk equivalent to that of MN in the brachium has been reported in mammals and lower vertebrates [35,36]. In this species it has also been found that there is a connection between the MCN and the ulnar nerve [37]. Therefore, the palmar nerves of the upper limb initially consist of a common trunk and branch into three main nerves as differentiation occurs.

Clinical Relevance

Due to the variation in branching, course and distribution of the MCN, it is clinically important, especially in peripheral neurosurgical treatment [38]. The rare variation of MCN in the case presented here is clinically important for clinicians and surgeons.

Knowledge of the variations of MCN can prevent the nerve damage during surgical procedures, such as flap dissection around the shoulder, axillary region, shoulder reconstruction, axillary lymph node dissection, and brachial plexus repair [2,15, 39-41]. Awareness is also necessary for the success of the anesthetic plexus blockade in the axillary region at different levels of upper limb and the selective nerve block of the MCN [42,43].

Although isolated lesions of MCN are rare,iatrogenic injuries to the MN have been reported. Therefore, the presence of MCN with MN or when both nerves are covered by a common sheath, an injury to the brachium or axilla may result in paralysis or disfunction of the MN and MCN [13]. The lateral half of the proximal part of the MCN is the preferred site for transfer of any motor nerve, in which case the biceps brachii and brachialis muscles may have reinnervation [9]. In cases where coracoid mobilization is required, the location and anatomy of the MCN should be kept in mind in order to protect it [2]. In cases where MCN is with MN, traumas in the axilla or arm can cause combined paralysis of the two nerves [14,44].

Partial fusion of the MCN with the LC and MN indicates that most of the C5-C6 fibers are transferred to MN through the LR. In the presented case and in similar variations, the transfer of the MCN fibers to the MN may lead to unexpected clinical symptoms such as weak elbow flexion and supination of the elbow in flexion, as well as decreased sensation in the lateral aspect of the forearm [45].

Knowledge of such branching variations of MCN and brachial plexus will be useful for surgeons, anesthetists, radiologists and clinicians.

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