

FOLIA MEDICA CRACOVIENSIA

Vol. LIX, 3, 2019: 45–52

PL ISSN 0015-5616

DOI: 10.24425/fmc.2019.131135

## Fusion between the median and musculocutaneous nerve: A case study

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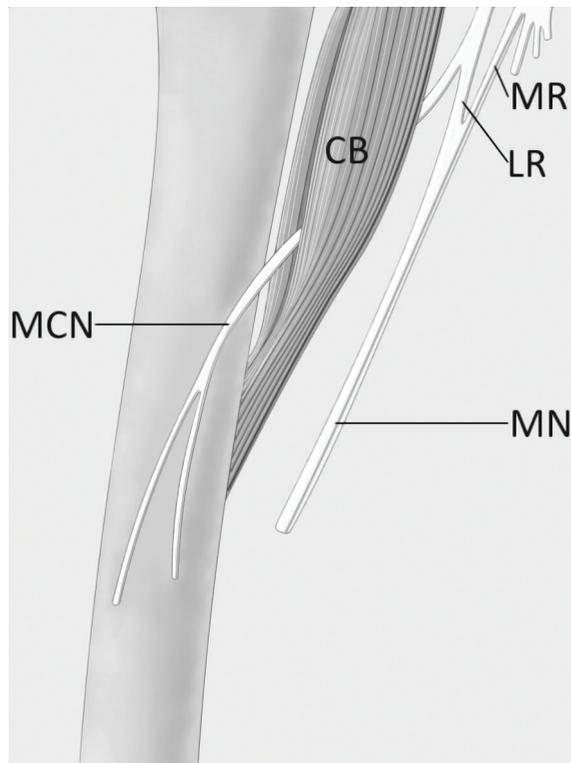
**Abstract:** The musculocutaneous nerve (C5–C7) is a terminal branch of the lateral cord of the brachial plexus and provides motor innervation to the anterior compartment of arm muscles. Both the musculocutaneous and median nerve may show numerous anatomical variations. Keeping in mind possible aberrations in the course of the upper limb nerves may increase the safety and success rate of surgical procedures. The presented report is a detailed anatomical study of the fusion between the median and musculocutaneous nerve, supplemented by intraneural fascicular dissection. In the presented case, the musculocutaneous nerve was not found in its typical location in the axillary cavity and upper arm during the preliminary assessment. However, a careful intraneural fascicular dissection revealed that musculocutaneous nerve was fused with the median nerve and with its lateral root; Those nerves were surrounded by a common epineurium, however they were separable. The muscular branch to the biceps brachii muscle arose from the trunk (fascicular bundle) dissected out from the median nerve and corresponding to the musculocutaneous nerve. Such variation may be of utmost clinical importance, especially during reconstructions of the brachial plexus or its branches.

**Key words:** anatomic variation, brachial plexus, median nerve, musculocutaneous nerve.

### Introduction

The musculocutaneous nerve (C5–C7) is a terminal branch of the lateral cord of the brachial plexus and provides motor innervation to the anterior compartment of arm muscles. Those muscles flex the arm in shoulder and the elbow. In addition, the biceps

brachii muscle is a strong forearm supinator. When the musculocutaneous nerve is affected, those movements are weakened [1, 2]. Typically, the musculocutaneous nerve pierces the coracobrachialis muscle and then runs between the biceps brachii and brachialis muscle (Fig. 1). The terminal branch of the nerve is known as the lateral cutaneous nerve of the forearm, which provides sensory innervation from the skin of the antero-lateral aspect of the forearm [3]. The median nerve originates from the skin of the antero-lateral aspect of the forearm [3]. The median nerve originates with two roots: the lateral root (C5–C7) arises from the lateral cord of the brachial plexus, while the medial root (C8–Th1) takes origin from the medial cord of the plexus. Both roots merge in the axillary cavity and form so called “loop of the median nerve”, which usually occupies an anterior position to the axillary artery [4]. Typically, the median nerve does not give muscular branches to arm muscles; Its territory involves the forearm and hand [3].



**Fig. 1.** Typical formation and course of the median (MN) and musculocutaneous (MCN) nerves. The median nerve originates in the axillary cavity from the medial (MR) and lateral (LR) root. The musculocutaneous nerve pierces the coracobrachialis muscle (CB). This figure is a modification of the drawing taken from Haładaj *et al.* [6] under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium.

Both the musculocutaneous and median nerve may show numerous anatomical variations [5–13]. Keeping in mind possible aberrations in the course of the upper limb nerves may increase the safety and success rate of surgical procedures [14–16]. Thus, recording and describing anatomical variations of nerves may still have significant practical value. The presented report is a detailed anatomical study of the fusion between the median and musculocutaneous nerve, supplemented by intraneural fascicular dissection.

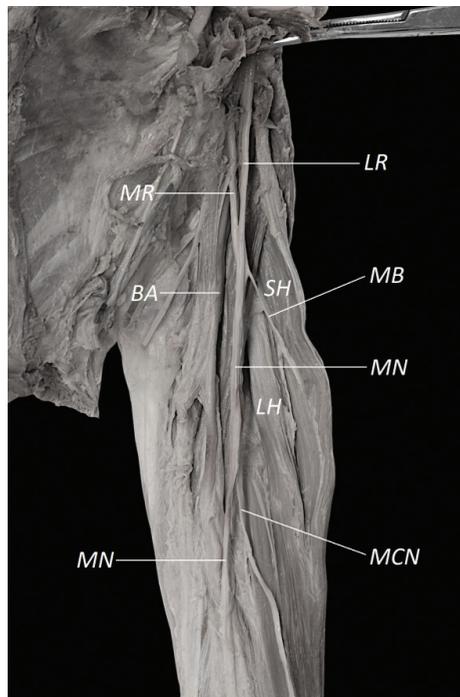
## Materials and Methods

An atypical appearance of the musculocutaneous nerve was observed during routine dissections of an isolated left male upper limb fixed in 10% formalin solution. A detailed examination of the atypical formation of the musculocutaneous nerve was revised by the intraneural fascicular dissection, according to previously described protocol [17]. The procedure was performed with microsurgical instruments (dissector and forceps) and a magnified vision of x2.5 using a HEINE® HR 2.5 X High Resolution Binocular Loupe (HEINE Optotechnik GmbH & Co. KG, Herrsching, Germany). The measurements were taken with a Digimatic Calliper (Mitutoyo Corporation, Kawasaki-shi, Kanagawa, Japan). The research project was approved by the Bioethics Committee of the Medical University of Lodz.

## Results

In the presented case, the musculocutaneous nerve was not found in its typical location; It appeared to be absent in the axillary cavity and upper arm during the preliminary assessment. (Fig. 2). The coracobrachialis muscle was one-headed and was not pierced by any nerve. The two roots of the median nerve merged at the level of inferior border of the pectoralis major muscle, anterior to the third part of the axillary artery (Fig. 2). Thus, the loop of the median nerve was single and elongated. The diameter of the medial root of the median nerve measured 4.32 mm, while the diameter of the lateral root was 4.71 mm. The lateral root of the median nerve gave off one (of 0.87 mm diameter) branch to the coracobrachialis muscle. The diameter of the median nerve at its origin was 6.42 mm. A single branch to the biceps brachii muscle (of 1.56 mm diameter), divided further into sub-branches reaching both heads of the muscle, seemed to be a branch of the median nerve and arose 16 mm below the point of fusion of both roots of the nerve (Fig. 2). In the arm, the median nerve occupied a normal, superficial position in relation to the brachial artery. The musculocutaneous nerve, with a diameter of 2.49 mm, branched off the median nerve 92 mm below the inferior border of the pectoralis major muscle and then entered between the distal parts of the biceps brachii and brachialis muscles (Fig. 2). Then the nerve gave

a muscular branch (od 1.12 mm diameter) to the brachialis muscle and continued on its typical course as the lateral cutaneous nerve of the forearm (of 1.85 mm diameter). The diameter of the median nerve after giving off the musculocutaneous nerve was 5.21 mm. At the further stage of examination, the specimen of the brachial plexus was harvested and immersed in 10% acetic acid solution for two weeks to facilitate removal of the epineurial sheath. Then, a careful fascicular dissection revealed that the musculocutaneous nerve was fused with the median nerve and its lateral root; Those nerves were surrounded by a common epineurium, however they were separable. The muscular branch to biceps brachii muscle arose from the trunk (fascicular bundle) dissected from the median nerve and corresponding to the musculocutaneous nerve. Intraneural fascicular dissection also revealed, that no fascicles from the medial root of the median nerve reached the atypical musculocutaneous nerve. The course and the branching pattern of the median nerve was typical after reaching between muscles in the anterior compartment of the forearm.



**Fig. 2.** Photograph of the specimen showing the fusion between the musculocutaneous and median nerve. Anterior view to the left axillary cavity and arm. The musculocutaneous nerve (MCN) branches off the median nerve and runs as separate structure only in the distal half of the arm. (BA) brachial artery, (LR) lateral root of the median nerve, (MR) medial root of the median nerve, (MB) muscular branch to the biceps brachii muscle, (LH) long head of the biceps brachii muscle (reflected to expose the internal surface of the muscle), (SH) short head of the biceps brachii muscle (reflected to expose the internal surface).

## Discussion

According to Bergman *et al.* [5] the typical origin of musculocutaneous nerve from lateral cord of the brachial plexus is observed in about 90.5% of cases. Typically, the musculocutaneous nerve branches off from the lateral cord of the brachial plexus and, after a short course, pierces the coracobrachialis muscle (Fig. 2). However, instead of piercing the coracobrachialis muscle, the nerve may occupy an anterior position to the muscle belly; Claassen *et al.* [4] estimated the prevalence of such variant to be 1.8%.

In rare cases, the musculocutaneous nerve may be fused with the median nerve at a certain distance, and then continue the course as a single trunk or several branches (with prevalence ranging from 0.6% to 8%) [4–7, 11, 18]. Such a variation may be classified as the musculocutaneous nerve being a branch of the median nerve or as the absence of the musculocutaneous nerve [5, 11, 12, 19–22]. For example, Nakatani *et al.* [12] reported a case of absence of the musculocutaneous nerve with innervation of the coracobrachialis, biceps brachii, brachialis and the skin of the anterolateral surface of the forearm by branches from the lateral cord of the brachial plexus. Parchand and Patil [20], in turn, described the case, in which the median nerve supplied the biceps, coracobrachialis and brachialis muscles and gave the lateral cutaneous nerve of the forearm. Gümüşburun and Adigüzel [19] reported variation of the brachial plexus characterized by the absence of the musculocutaneous nerve; In this case the musculocutaneous nerve was absent, the coracobrachialis muscle was innervated by two branches from the lateral cord, the median nerve gave off muscular branches to the biceps brachii and brachialis muscle and also gave off the lateral cutaneous nerve of the forearm. Aydin *et al.* [23], Bhanu and Sankar [24], Prasada Rao and Chaudhary [18], as well as Raza *et al.* [21] described another variant, in which the innervation of the coracobrachialis muscle was provided by a direct branch from the lateral root of the median nerve and the musculocutaneous nerve was absent; Also in this case, the branches of the median nerve supplied the biceps brachii and brachialis muscle and the last branch continued as the lateral cutaneous nerve of the forearm. Combined variations involving the lack of the musculocutaneous nerve and associated with an atypical morphology of muscles or blood vessels were also reported [6, 25, 26].

The cases presented above seem to be similar to our findings. However, the cited authors (with the exception of Haładaj *et al.* [6]) did not perform a fascicular dissection to verify the presence of nerve fascicles being a remnant of the musculocutaneous nerve. As the results of retrograde fascicular dissection performed in the case described in this report confirmed the presence of the fascicular bundle corresponding to the musculocutaneous nerve, the term “fusion” seems to be most justified to describe our case. In this case, the close relationship between the median and musculocutaneous nerve was constituted mainly by common epineurium. Thus, further

studies using fascicular dissection should be performed in cases of the absence of the musculocutaneous nerve to trace the real source of the muscular branches from the median nerve to the anterior group of arm muscles.

Numerous factors may influence the occurrence of the aberrant course of the neural structures in the developing embryo. The background of anatomical variations of neurovascular structures based on molecular signals and factors were suggested by Carmeliet [27]. Also research in comparative anatomy may put some light on cases of the absence of the musculocutaneous nerve; Due to the fact that the musculocutaneous nerve is absent in lower vertebrates, the absence of this nerve in humans may be considered a phylogenetical remnant [11]. Embryological studies suggest that the musculocutaneous nerve is derived from the median nerve [11]. All those facts may explain the close relationship that occur occasionally between median and musculocutaneous nerve.

Anatomical variations may influence the safety and success rate of the surgical procedures [10, 14, 15, 17, 28]. To take a specific example, Hagemann *et al.* [15] reported adverse clinical outcomes of the median to musculocutaneous nerve transfer abandoned due to neuroanatomic variation. Atypical nerves' formation may also influence clinical manifestation of the nerves lesions [10, 17, 28]. Moreover, the knowledge of exact fascicular location may be crucial in brachial plexus surgery. Taking into account numerous variations of the median and musculocutaneous nerve, advanced anatomical studies using fascicular dissection may fill the gaps in our knowledge about cases of and help clinicians to deal with atypical cases.

## Conclusions

The results of retrograde fascicular dissection confirmed the presence of the separate fascicles corresponding to the musculocutaneous nerve in case of the fusion between the median and musculocutaneous nerve. Such variations may be of utmost clinical importance, especially during reconstructions of the brachial plexus or its branches.

## Conflict of interest

None declared.

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