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Classifying Musculocutaneous Nerve Variations Depending on the Origin

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Abstract

Variations of the musculocutaneous nerve (MC) are not common. Much has been reported on the relationship in between the MC and the coracobrachialis muscle as well as the connections between the MC and median nerve. However, the classification of MC variations according to the origin of MC is seldom seen. We observed and analysed a total of 160 upper limbs from 80 adult cadavers to record anatomical variations in the MC. These variations were classified into five groups depending on the origin of MC: Group 1: The normal type. Classic description found in textbooks (142 arms, 88.75%); Group 2: Multi-branch type. Two or three branches originated from the lateral cord of the brachial plexus, dominating the corresponding muscles. (3 arms, 1.87%); Group 3: Mixed type. The lateral cord of the brachial plexus and median nerve sent branches to constitute the MC respectively. (1 arm, 0.63%); Group 4: Absence type. The MC originated from the median nerve directly. (5 arms, 3.12%); Group 5: Combining type. The MC originated from the lateral cord of the brachial plexus, then gave branches to the corresponding muscles, and finally joined the median nerve (9 arms, 5.63%). The new classification proposed is thought to make easy our clinical practice and to avoid errors caused by anthropometric differences.

Keywords: Musculocutaneous nerve; Anatomical variation; Classification; Peripheral nerve repair; Anesthesia

Introduction

The brachial plexus innervates muscles, joints, and skin of the upper limb by means of supraclavicular and infraclavicular branches. The latter come from the lateral, medial, and posterior cords of the brachial plexus. The lateral cord gives rise to the lateral root of the median nerve, the lateral pectoral nerve, and the musculocutaneous nerve (MC). The musculocutaneous nerve is the continuation of the lateral cord of the brachial plexus. It pierces the coracobrachialis muscle and descends laterally between the biceps and brachialis muscles and supplies all the muscles in the anterior (flexor) compartment of the arm. Much research has been conducted on the classification of variations in the musculocutaneous nerve. There are different priorities and different methods. Some authors frequently reported the musculocutaneous nerve not perforating the coracobrachialis muscle and the presence of communicating branches with the median nerve.

For example, the relationship in between the MC and the coracobrachialis muscle was first observed by the Italian anatomist Giulio Casserio (1556–1616), pupil of Fabricius and teacher of William Harvey (1578–1657) at Padua [1,2]. Subsequently, it was observed and discussed by various authors Kosugi et al. [3-8]. In addition, the distribution of MC, or rather, the innervation of the brachialis muscle was reported by Yang et al. [2,4]. Furthermore, the connections at the arm level between the MC and median nerve (MN) were described by many authors [9-21]

However, the classification of MC variations according to the origin of MC is not reported often. This method of variations of MC is easy-to-understand and clinically important for surgeons, orthopaedists, and anaesthetists performing pain management therapies or regional anaesthesia to the upper limb. The aim of this study is to describe variations depending on the origin of MC in adult cadavers and provide morphological basis for clinical diagnosis and treatment of diseases.

Materials and Methods

A total sample of 80 adult cadavers (160 arms) was examined at the Department of Anatomy, North China University of Science and Technology. These cadavers' heights range between 155 cm and 178 cm (168 cm on average). And there is no operation trace and history of illness associated with musculocutaneous nerve and its branches. They were fixed and preserved in alcoholic solution for the anatomical practice, prepared with ethyl alcohol, formalin, phenol and other chemicals. The upper limbs were dissected through a longitudinal incision on the anterior aspect of the arm from the level of the acromion to the elbow.

The skin, subcutaneous fat and fascia were removed to expose the musculocutaneous nerve. The origin, course, branching and distribution of MC were observed in detail. After observation of the relationships to whole MC, the specimens of variation were measured with Vernier callipers. The variation was drawn in each specimen, and the patterns were summarized.

Results

Through the observation of the 160 cases of specimens, we classified the variations into five main groups (Table 1).

Group 1, The Normal type: The musculocutaneous nerve is the continuation of the lateral cord of the brachial plexus. It pierces the coracobrachialis muscle and descends laterally between the biceps and brachialis muscles and supplies all the muscles in the anterior (flexor) compartment of the arm. Variations from the normal pattern were seen in 142 (88.75%) of the whole sample of 160 cadavers (Figure 1).

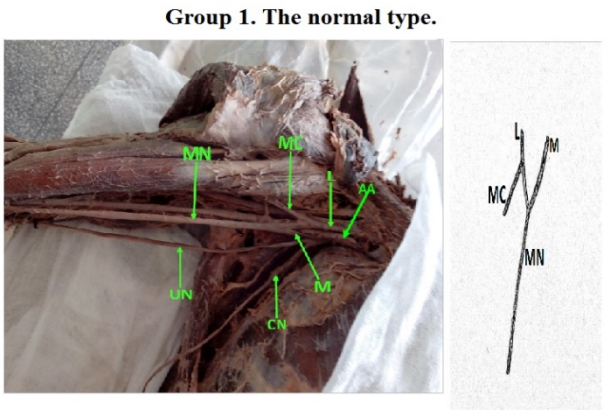

Figure 1: The normal type (Group 1). MC is the continuation of the lateral cord of the brachial plexus (L). It pierces the coracobrachialis muscle and descends laterally between the biceps and brachialis muscles and supplies all the muscles in the anterior (flexor) compartment of the arm. (L: Lateral Cord of the Brachial Plexus; M: Medial Cord of the Brachial Plexus; MN: Median Nerve; MC: Musculocutaneous Nerve; UN: Ulnar Nerve; CN: Medial Antebrachial Cutaneous Nerve; AA: Axillary Artery).

Group 2, The Multi-branch type: Two or three branches which were separated from the lateral cord of the brachial plexus formed the MC and dominated the corresponding muscles. This group occurred in 3 (1.87%) of the 160 dissected limbs (Figure 2).

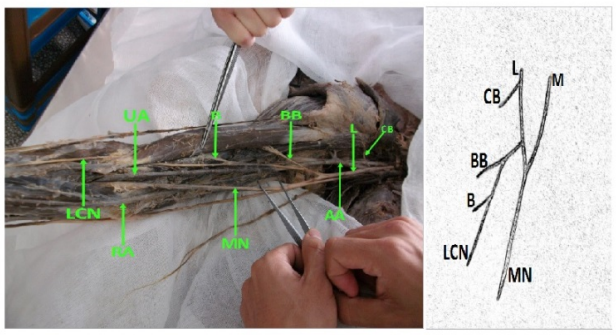

Figure 2: Multi-branch type (Group 2). Two branches (CB, the common trunk between BB and B) originated from the lateral cord of the brachial plexus. (L: Lateral Cord of the Brachial Plexus; CB: Branch to Coracobrachialis; BB: Branch to Biceps Brachii; B: Branch to Brachialis; MN, Median Nerve; MC: Musculocutaneous Nerve; LCN: Lateral Cutaneous Nerve; AA: Axillary Artery; UA: Ulnar Artery; RA: Radial Artery).

Group 3, The Mixed type: The lateral cord of the brachial plexus and median nerve sent branches to constitute MC respectively. In other words, the MC originated from the brachial plexus and median nerve. It occurred in 1 (0.63%) of the 160 dissected limbs (Figure 3).

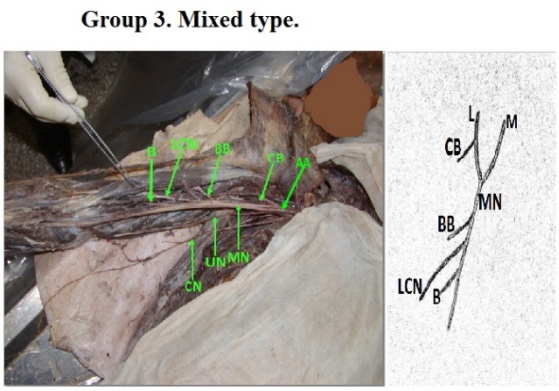

Figure 3: Mixed type (Group 3). The MC originated from the brachial plexus and median nerve. In this case, CB originated from the brachial plexus, BB and B originated from median nerve. (CB: Branch to Coracobrachialis; BB: Branch to Biceps Brachii; B: Branch to Brachialis; MN: Median Nerve; LCN: Lateral Cutaneous Nerve; UN: Ulnar Nerve; CN: Medial Antebrachial Cutaneous Nerve; AA: Axillary Artery).

Group 4, The Absence type: the MC originated from the median nerve directly, which means that it is a branch of the median nerve. We called it as absence of MC. It occurred in 5 (3.12%) of the 160 dissected limbs (Figure 4).

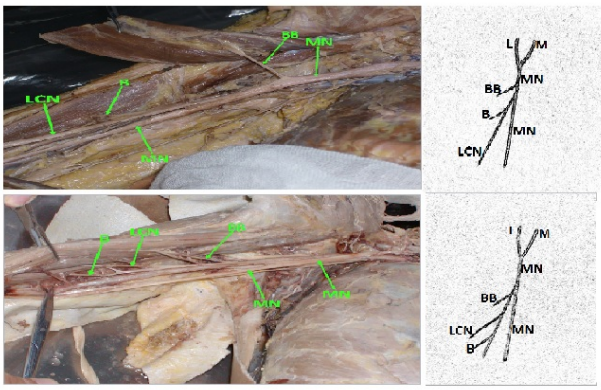

Figure 4: Absence type (Group 4). The MC originated from the median nerve directly, which means that it is a branch of the median nerve. In the above two cases, BB, B and LCN originated from the median nerve. (BB: Branch to Biceps Brachii; B: Branch to Brachialis; LCN: Lateral Cutaneous Nerve; MN: Median Nerve).

Group 5, The Combining type: The MC originated from the lateral cord of the brachial plexus, then gave branches to the corresponding muscles, and finally joined the median nerve. It occurred in 9 (5.63%) of the 160 dissected limbs (Figure 5).

	Group 1	Group 2	Group 3	Group 4	Group 5
cases	142	3	1	5	9
%	88.75%	1.87%	0.63%	3.12%	5.63%

Table 1: Distribution of variations of musculocutaneous nerve in 160 cases of specimens.

Discussion

The course of the musculocutaneous nerve is traditionally described as follows: After a 6.7 ± 1.6 cm distance from its origin [22], it pierces the coracobrachialis muscle and descends laterally in between the biceps brachii and brachialis muscle. It supplies the coracobrachialis before the nerve enters the muscle. Branches to the biceps brachii and brachialis are supplied after the MC has pierced the muscle, approximately 14.1 ± 1 cm from its origin [22]. In the elbow, it perforates the deep fascia lateral to the tendon of biceps and continues as the lateral cutaneous nerve of the forearm [23-29].

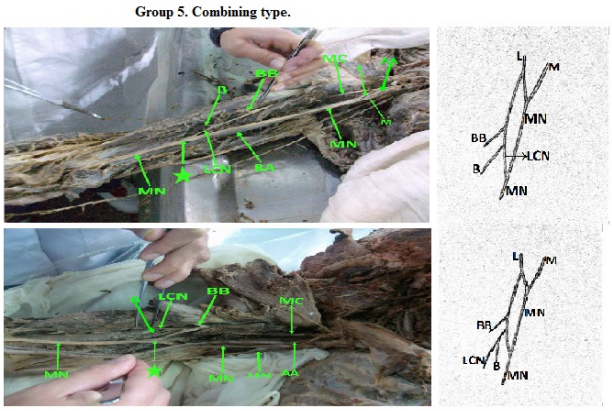

Figure 5: Combining type (Group 5). The MC originated from the lateral cord of the brachial plexus, then gave branches (BB,B) to the corresponding muscles, and finally joined MN. (L: Lateral Cord of the Brachial Plexus; M: Medial Cord of the Brachial Plexus; BB: Branch to Biceps Brachii; B: Branch to Brachialis; LCN: Lateral Cutaneous Nerve; MN: Median Nerve; MC: Musculocutaneous Nerve; UN: Ulnar Nerve; CN: Medial Antebrachial Cutaneous Nerve; AA: Axillary Artery; BA: Brachial Artery; : The MC Joined to the MN).

In addition to the normal course, there also exist lots of variations of the MC. And many ways to classify variations in the MC have been published, some of which were modified or extended by the authors who could not classify their findings with current taxonomies. Next, this article describes some current classifying methods of MC variations, their clinical importance and problems of the three articles in detail [3,8,20-32] as well as some other classifications roughly. And the different methods for classification of the MC described by the mentioned authors were presented in the Table 2.

Kosugi et al. [3] classified the MC variations by the number and direction of the connecting branches into five groups. Group 1: pattern without communication. Group 2: A communicating branch from the MC to the median nerve. And it was subdivided into three subgroups. Subgroup A: the origin of the branch was before the musculocutaneous entered the coracobrachialis. Subgroup B: the communicating branch passed through the muscle. Subgroup C: the communicating branch originated after the nerve exited the muscle. Group 3: a branch running form the median nerve to the MC. Group 4: Both the above communications (Groups 2 and 4) were present in the same limb. Group 5: other patterns. Clinically, they expounded that the palmar nerves of the upper limbs were originally formed of one common trunk and three main nerves branched off as differentiation occurred. In addition, from a clinical point of view, such taxonomy is of great importance during flap dissections, posttraumatic evaluations of the arm or peripheral nerve repair [33]. Nevertheless, the differences of the origin of MC may not be paid enough attention to.

Yang et al. [24] classified the distribution of motor fascicles to biceps and brachialis. The innervation pattern of the biceps was divided into three types. Type I: a primary motor branch bifurcates into two secondary nerve branches, each separately innervating the long and short heads of the biceps. Type II: two primary motor branches from the main musculocutaneous nerve trunk. The proximal branch innervates the short head of the biceps and the distal branch innervates the long head of the biceps. Type III: primary motor branch from the main musculocutaneous nerve trunk that bifurcates into two secondary branches to individually innervate the two heads of the biceps, plus an additional primary branch, distal to the former that innervates the distal part of the biceps at its common belly. And the innervation pattern of the brachialis muscle was divided into two types. Type I: Single primary branch innervating the brachialis from the main musculocutaneous nerve trunk. Type II: two primary branches that innervate the brachialis from the main musculocutaneous nerve trunk. On clinical, they documented the innervation of the biceps and brachialis in detail, which enable ready location to their motor nerves. And the point where the motor branch arose from the main MC trunk has also been recorded. The method is meaningful and easy to apply in surgical contents during the management of complex problems of the nervous system whereas, they placed more emphasis on the relation to the biceps and the brachialis muscle. Besides, Yang et al. [24] used cadaveric upper limb specimens disarticulated at the shoulder. That the brachial plexus was sectioned at the level of the cords might disturb the measurements.

Choi et al. [20] described three patterns of connections between the MC and the median nerve. Pattern 1: Fusion of MC and median nerves. Pattern 2a: Single connecting branch between the musculocutaneous and median nerves. Pattern 2b: Two or three branches from the MC joining to form one anastomotic branch to the median nerve. Pattern 3: Two connecting branches between the median and musculocutaneous nerve were present. Clinically, they presented a unified classification including their own results and those of others, and analyzed the related morphological features of their variation and distribution by side and gender. This musculocutaneous-median nerve connection has been considered clinically important for the correct interpretation of clinical neurophysiology, understanding the anatomy of anterior repairs for trauma to the shoulder, and in the understanding of median and musculocutaneous nerve dysfunction [30,34] Flatow et al. and Sonck et al.). But variations of MC not only exist between the MC and MN, there are still some other more complex variations. This method of classification may not be comprehensive.

In addition, a simple three-point classification, which was based on the position of the origin of the anastomotic branch in relation to the coracobrachialis muscle, but omitting many morphological details, has been proposed [4]. And some classifications focus on the absence of the MC has also been suggested [8,25-27] Further classification systems have been used making it difficult to compare studies [25,28-32,35].

These varied approaches to classification made us review previous studies and reclassify the results together with our data. Their disadvantages also let us be more focused and cautious. To avoid these, the following classification is put forward. In this article, five groups of classification methods based on the origin of the MC were illustrated. Group 1: Classic description found in text books (88.75%, Figure 1). Group 2: Two or three branches originated from the lateral cord of the brachial plexus, dominating the corresponding muscles (1.87%, Figure 2). Group 3: The lateral cord of the brachial plexus and median nerve sent branches to constitute MC respectively. In other words, the MC originated from the brachial plexus and median nerve (0.63%, Figure 3). Group 4: The MC originated from the median nerve directly, which means that it is a branch of the median nerve (3.12%, Figure 4). Group 5: The MC originated from the lateral cord of the brachial plexus, then gave branches to the corresponding muscles, and finally joined the median nerve (5.63%, Figure 5).

	Different Methods
Kosugi et al. [3]	By the number and direction of the connecting branches of the MC
Yang et al. [24]	By the innervation of the biceps and brachialis
Choi et al. [20]	By the connections between the MC and the median nerve
Venieratos and Anagnostopoulou [4]	By the position of the origin of the anastomotic branch in relation to the coracobrachialis muscle
Buch-Hansen et al. [25]	By the absence of the MC

Table 2: Different methods for the classification of the musculocutaneus nerve, described by previous authors.

The variations of MC are clinically important for surgeons, orthopaedists, and anaesthetists performing pain management therapies or regional anaesthesia to the upper limb. On the one hand, during flap dissections, unexpected nerve damages could arise especially by surgeons who are familiar with routine course of peripheral nerves and their relationship with neighbouring structures but inexperienced in variations (Ibrahim et al.). Any injury to musculocutaneous nerve in a patient with this kind of variation presents as double nerve injury, which makes the diagnosis more problematic. On the other hand, although anterior approach for internal fixation of humeral fractures seems to be safer than the posterior approach because of high risk of radial nerve damage in posterior approach, again the surgeon should be familiar with the neurovascular variations in arm not to cause an iatrogenic damage to these structures during their retraction for exposure of fracture line. Additionally, blocking techniques can be used on MC because the control of flexion spasticity at the elbow is often important in the treatment in certain types of cerebral or spinal cord damage [36]. Thus, a more precise knowledge of the MC than that found in classical anatomical texts is of great need. Surgeons should be aware of these nerve variations. Our methods are meaningful and easy to apply in surgical or clinical contents during the management of complex problems of the nervous system. And the variations of MC should be given much attention during clinical investigation and management of disorders of the upper limb.

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