Absence of musculocutaneous nerve associated with the presence of an accessory head of the biceps brachii muscle: report of a bilateral case and its clinical implications

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SUMMARY

The anatomical variants of the biceps brachii muscle (BBM) are frequent, mostly unilaterally than bilaterally, and are associated with supernumerary muscle bellies, the total absence of the muscle or one of its heads, and variations in the points of origin and insertion. In the same way, the variants of the musculocutaneous nerve (MCN) can include alterations in its course, number of branches, or anatomical relations, whereas its absence is considered an atypical variation. The aim of this work was to report the absence of musculocutaneous nerve associated with the presence of one accessory head of the biceps brachii muscle. Dissection of a female cadaver, fixed in 10% buffered formaldehyde, which did not present previous surgeries in the studied area was performed. Variations were noted in both upper limbs related to accessory muscle bellies and change in innervation. Anatomical relations of muscles and nerves were determined by following proximal to distal ends, relation, vascularization, and innervation pattern. The absence of MCN associated with the presence of one accessory head of the BBM were found bilaterally. These anatomical variations are atypical. Clinically, these variations can produce compressive symptoms that could generate confusing diagnostics and conduce to unnecessary procedures on the arm, inducing iatrogenic actions.

Key words: Musculocutaneous nerve – Absence – Biceps brachii muscle – Accessory head

INTRODUCTION

The biceps brachii muscle (BBM) is in the anterior brachial region, comprised of two heads originated in the scapula. The short head (BBsh) originates in the vertex of the coracoid process, and the long head (BBlh) in the supraglenoid tubercle; the two form the mass of the muscle whose distal tendon is inserted in the radial tuberosity. The heads of the BBM receive innervation from the musculocutaneous nerve (MCN) and vascularization from the brachial vessels (Standring, 2016).

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The anatomical variations of this muscle can include accessory heads, total absence of the muscle or one of its heads, complete separation from the muscle belly, variations in the points of origin, and insertion or fusion with neighboring muscles (Testut, 1884; Tubbs et al., 2016).

On the other hand, the MCN originates from the lateral fascicle (C5-C6) of the brachial plexus, typically at the axillary level, where it is located laterally to the median nerve and axillary artery. It is directed inferiorly and laterally, perforating the coracobrachialis muscle, which it crosses to access the anterior compartment of the arm. In the arm, it passes between the BBM and the brachialis muscle, emerging at the level of the cubital fossa, deep to the cephalic vein, where it continues as the lateral antebrachial cutaneous nerve (Standring, 2016). In its course, it emits muscle branches for the coracobrachialis, BBM, and brachialis and an articular branch for the elbow joint capsule. In addition, it can emit communicating branches for the median, ulnar, radial, and medial brachial cutaneous nerves (Rouvière and Delmas, 2005). The MCN can vary in its course, number of branches, or anatomical relations (Gümüsburun and Adigüzel, 2000; Farfán et al., 2020), whereas its absence is considered an atypical variation (Kaur et al., 2014).

In the initial stages of limb development, a homogeneous somatic mesoderm-derived mesenchyme without the presence of nerve fibers is observed; later, at the base of the limb bud, the ventral primary rami of spinal nerves branch to the distal end (Keibel and Mall, 1912). Tosney and Landmesser (1985) demonstrate that the location and morphology of the growth cones of the motor neurons innervating the muscle primordia of the limbs are determined by the connective tissue cues where they develop (Tosney and Landmesser, 1985). Similarly, the somatic mesodermal-derived connective tissue is an important source of molecular signals for limb muscle pattern development (Chevallier et al., 1977; Kardon et al., 2003).

The aim of this work was to report the absence of musculocutaneous nerve associated with the presence of one accessory head of the biceps brachii muscle in an adult woman.

CASE REPORT

A case is described of the bilateral presentation of a nerve variation associated with a muscle variation, observed during the dissection of upper limbs in a cadaver, female, Caucasian, aged 87 years at the time of death, fixed in 10% formaldehyde buffer and conserved in a cold chamber at 4ºC. The cadaver had no prior surgeries in the studied area, and the cause of death was cardiorespiratory arrest.

Muscle variants

The right BBM presented a flat, thin accessory head, which originated on the anterior side of the distal third of the humeral diaphysis, near the insertion of the coracobrachialis muscle; from there, the fascicle joined the distal tendon of the BBM. Its irrigation came from fine brachial vessels, and its innervation from a branch originating from the lateral antebrachial cutaneous nerve. Separating the accessory head of the BBM, there is a muscle partition where the vessels and nerves travel (Fig. 1A, Table 1). The left BBM presented a spindle-shaped accessory head, which originated in the proximal third of the humeral diaphysis, between the insertion point of the coracobrachialis muscle and the origin of the brachial muscle (Fig. 1B, Table 1); from there, the fascicle joined the distal tendon of the BBM. Its irrigation came from fine brachial vessels, and its innervation from a branch originating from the lateral antebrachial cutaneous nerve. On the plane that separates the accessory head of the BBM, there is a muscle partition where the vessels and nerves travel (Fig. 1A, Table 1).

Nerve variants

In the upper right limb, the absence of the MCN was noted, originating that the muscle branch for the coracobrachialis muscle came from the lateral fascicle of the brachial plexus. The muscle branches for the BBlh, BBsh, and the brachial muscle came from the median nerve, as well as the lateral antebrachial cutaneous nerve. The muscle branch for the accessory head of the BBM originated jointly with this last nerve (Figs. 1A and 2A). In the upper left limb, the absence of the MCN is noted; in this case, the coracobrachialis mus-

Table 1. Accessory muscle belly measurements

	Right	Left
Overall length (mm)	133.66	163.59
Muscle belly length (mm)	80.61	104.74
Distal tendon length (mm)	58.05	58.85
Transverse muscle belly diameter (mm)	9.08	15.43
Anteroposterior muscle belly diameter (mm)	2.23	7.97

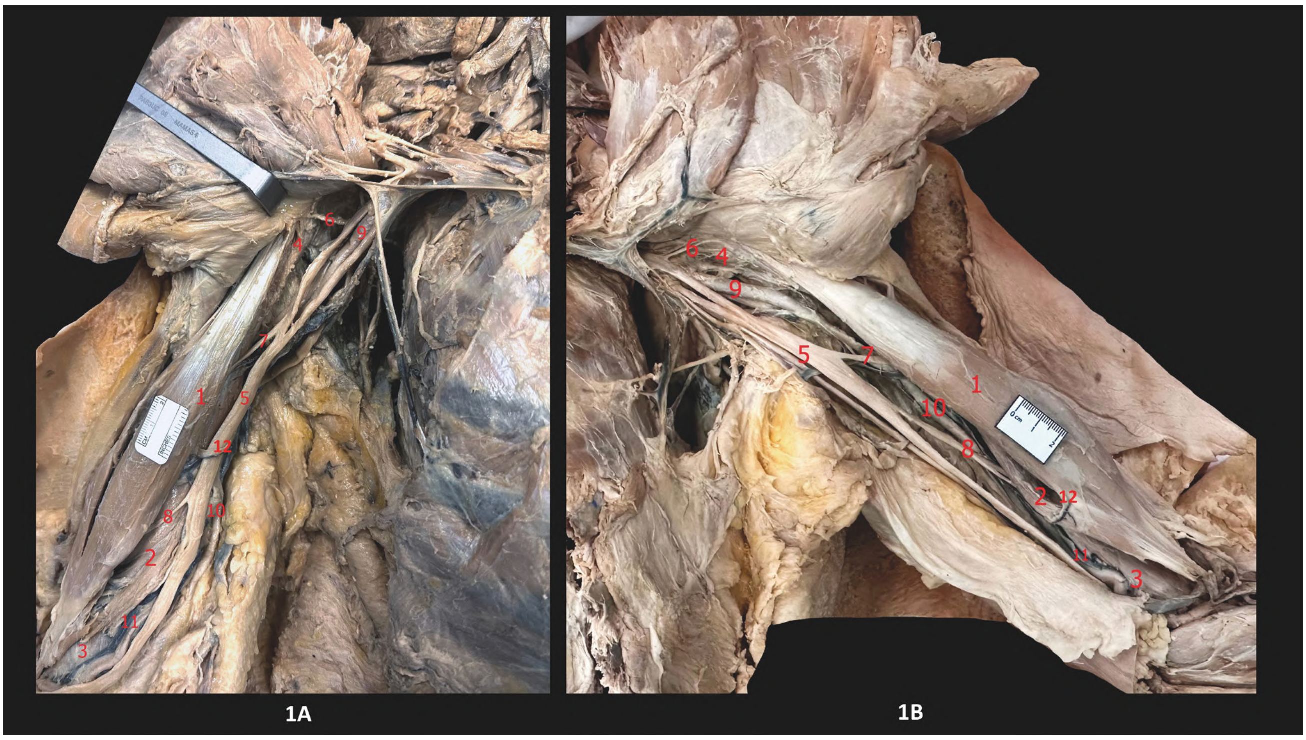

Fig. 1.- Dissection of the nerve variant. In "**A**" the right arm and in "**B**" the left side, showing the BBM with the accessory head. 1. Biceps brachii muscle (BBM); 2. Accessory head of the biceps brachii muscle; 3. Brachialis muscle; 4. Coracobrachialis muscle (covered by fascia); 5. Median nerve; 6. Muscular branch to the coracobrachialis muscle; 7. Muscular branch to the biceps brachii muscle; 8. Lateral antebrachial cutaneous nerve; 9. Axillary artery; 10. Brachial artery; 11. Brachial artery and vein; 12. Muscular branch of the brachial vessels.

cle received two muscle branches that originated from the lateral fascicle of the brachial plexus. The muscle branches for the BBlh, BBsh, and the brachial muscle came from the median nerve, as well as the lateral antebrachial cutaneous nerve. The muscle branch for the accessory head of the BBM originated jointly with this last nerve (Figs. 1B and 2B).

DISCUSSION

The evidence shows that the presence of one or more supernumerary muscle bellies is the most common variation of the BBM. In contrast, the total absence of the MCN and a complete takeover by the median nerve of the innervation of the coracobrachialis, biceps brachii, and the brachialis muscles is an unusual variation of the brachial plexus (Prasada Rao and Chaudhary, 2001). A meta-analysis that included 78 articles and 10,603 upper limbs reported that accessory heads have a prevalence of 9.6% in the BBM, being the presence of one accessory head the most frequent (8.4%). Nevertheless, the presentation of bilateral accessory heads, as reported in this study, is atypical (Lee et al., 2011). In fact, in a sample of 175 cadavers (350 arms), 15.4% of accessory humeral heads in the BBM were found, with 12.6% corresponding to unilateral and 2.8% to bilateral cases (Rodríguez-Niedenführ et al., 2003). In the case of the MCN absence, according to a systemat-

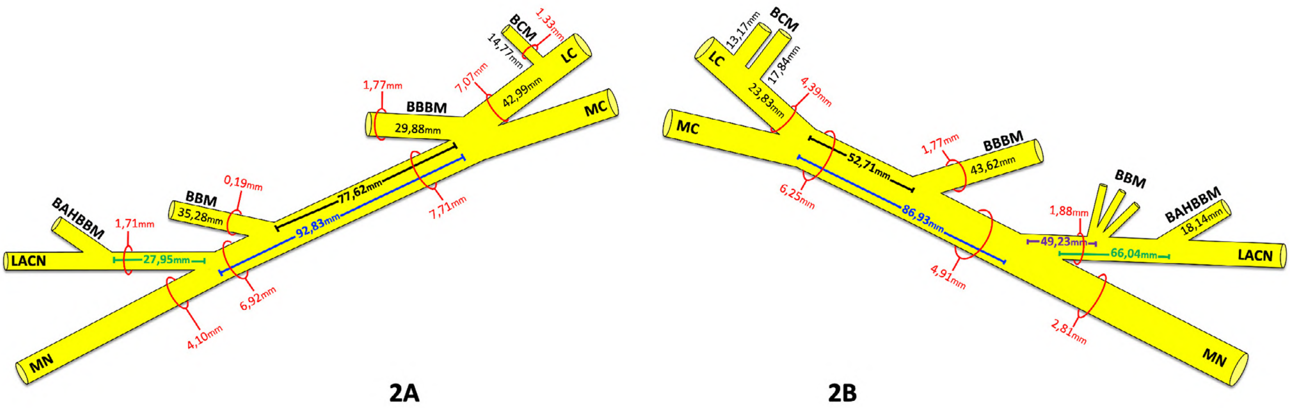

Fig. 2.- Scheme of the nerve distribution in the arm, in "**A**" the right side and in "**B**" the left side. On both sides: LC. Lateral cord of brachial plexus; MC. Medial cord of brachial plexus; MN. Median nerve; LACN. Lateral antebrachial cutaneous nerve; BCM. Branch to coracobrachialis muscle; BBBM. Branch to biceps brachii muscle; BBM. Branch to brachialis muscle; BAHBBM. Branch to accessory head of the biceps brachii muscle. The red circles indicate the transverse diameter of the nerve structures. The black bar within the median nerve indicates the distance from the formation of the median nerve to the origin of the first nerve branch. The blue bar within the median nerve indicates the distance from the formation of the median nerve to the origin of the second nerve branch. The purple and green bars within the second nerve branch indicate the distance between the origin of the second nerve branch and its terminal branches. The nerve branching is not symmetrical.

ic review and meta-analysis, the prevalence varies from 1.66% to 13% (Hunter and Zdilla, 2021; Choi et al., 2002).

A more comprehensive study about variations of the biceps brachii muscle was published by Rodriguez-Niedenführ et al. (2003): they generate a classification of accessory heads of the BBM. Using the place of origin and location of the accessory belly as criteria, they describe three types: superior humeral heads that represent 1.5%, inferomedial humeral heads corresponding to 9%, and inferolateral humeral heads corresponding to 0.3% (Rodríguez- Niedenführ et al., 2003). More recent classifications propose four types of accessory heads for the BBM with different subtypes (Szewczyk et al., 2022). Type I has two heads (64%); this subdivides into type IA with a single muscle belly and type IB with two muscle bellies. Type II has three heads (26%), classified as four subtypes: type IIA originates from the middle part of the humeral axis; type IIB originates in the coracoid process together with the short head; type IIC originates in the tendon of the pectoralis major muscle, and type IID originates in the glenohumeral joint capsule. Type III (6%) is characterized as presenting four heads, and type IV (4%) has five heads. In our report, both accessory bellies originate in the lower half of the humerus and were located medially to the BBM. In this sense, the accessory heads found correspond to the inferomedial humeral head type described by Rodríguez-Niedenführ et al. (2003), and to type IIA described by Szewczyk et al. (2022). Regarding MCN, it is classified by the communications between the musculocutaneous and median nerves, depending on whether the communicating branch arose from the MCN before (type I) or after (type II) it pierced the coracobrachialis muscle, and type III when the MCN did not pierce the coracobrachialis muscle (Venieratos and Anagnostopoulou, 1998). In that sense, the variation found here it is similar to type III; however, instead of having a communicating branch, the MCN is fused with the median nerve.

The presence of accessory heads of the BBM has been often associated with variations of the MCN (Wang et al., 2011; Yamamoto et al., 2018), describing alterations that include either change in its course, total absence or communications of the MCN with the median nerve in presence of the accessory heads of the BBM (Mehta, 2009; Lee et al., 2014; Tubbs et al., 2016). For example, cases of accessory heads associated with the presence of two MCN, one proximal that was adjusted to the normal course and ended after innervating the coracobrachialis muscles and BBM, and another distal MCN that emerged from the median nerve in the lower part of the arm, innervating the BBM and brachial muscles to end as a lateral antebrachial cutaneous nerve (Abu-Hijleh, 2005). In the same way, bilateral accessory heads of the BBM associated with course variations and branching patterns of the MCN have been reported. In that case, a third accessory head originated from the deep fascia of the brachial muscle on both arms. On the right side, the MCN did not perforate to the coracobrachialis muscle; however, it was also innervating the muscles of the anterior compartment of the arm. In contrast, on the left side, the MCN had the usual course (Saluja et al., 2017). This case appears similar to what is reported bilaterally here.

The origin of this variation comes from embryonic development. Long-standing experimental data indicate that in the limb bud, the branching of the motor rami of brachial and lumbar plexuses depends entirely on the segregation of mesenchymal-derived structures (Keibel and Mall, 1912). Between the fourth and seventh weeks of development, the muscular precursor cells derived from the dorsolateral region of cervical myotomes migrate to the upper limb bud. The cues coming from the connective tissue are relevant for the differentiation of the cleavage pattern of the ventral and dorsal limb compartment and for the distribution of motor neurons that will innervate it (Tosney and Landmesser, 1985). Then, the limb bud mesenchyme is penetrated by the ventral primary branches of the spinal nerves located in front of the upper limb bud, being necessary for muscle development. In particular, BBsh originates from a common muscular precursor with the brachial and coracobrachialis muscles, whereas BBlh originates from an independent precursor (Murillo-González et al., 2018). Pioneering work by W. H. Lewis in seven-week human embryos traced the composition of the brachial plexus branches (Lewis, 1902). In the developing brachial plexus, the median nerve emerges as a combination of ventral segmental branches, from which the MCN originates. In agreement with that, the variation reported here would have been generated by a defect in the separation of the median nerve and the MCN, altering the course of the MCN and, therefore, the contact between the upper limb bud and its developing nerves. This could modify the typical cone growth sequence, explaining the innervation of the anterior compartment arm muscles (Mehta, 2009; Pacholczak et al., 2011).

In practical terms, the accessory heads in the BBM produce greater force in forearm flexion. However, a supernumerary muscle belly can also cause neurovascular compression of the median nerve, the MCN, or the brachial artery, which can produce neurological and vascular alterations, making it clinically relevant. In this regard, when the patient is resistant to treatment, it would be necessary a careful evaluation of the arm anterior compartment looking for possible muscle variations (Enix et al., 2021). This is more relevant in the Asian population, where the prevalence of accessory heads in the BBM reaches 35%, unlike the non-Asian population where it has been reported at 25% (Techataweewan et al., 2016).

Finally, the presence of a supernumerary head could affect the course and branching of the MCN (Kosugi et al., 1992), therefore, it is advisable to take into account the anatomical variations of the MCN when faced with findings of this type muscle variation.

CONCLUSION

The absence of MCN associated with the presence of one accessory head of the BBM is atypical. Even in that case, it is clinically relevant because it can generate compressive symptoms that could confuse the specialist performing the diagnostic evaluation, and also the one conducting the procedures on the arm, inducing iatrogenic actions. For this reason, it is recommended that specialists in the area (surgeons and traumatologists) be aware of this type of variation.

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ETHICS APPROVAL AND CONSENT FOR PUBLICATION

The body was obtained through the Donation Program of the Faculty of Medicine at the Pontifical Catholic University of Chile (PUC), which complies fully with the World Medical Association's Declaration of Helsinki and national legal and ethical requirements. Consequently, the study was approved by the MED-UC Scientific Ethics Committee of the Pontifical Catholic University of Chile (No: 220304004).

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