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CASE REPORT

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Bilateral anatomic variation in the relation of the upper trunk of the brachial plexus to the anterior scalene muscle

M. Radunovic[1], B. Vukcevic[1], M. Abramovic[1], N. Vukcevic[1], N. Radojevic[2], A. Vuksanovic-Bozaric[1]

[1]*Faculty of Medicine, University of Montenegro, Podgorica, Montenegro*
[2]*Department of Forensic Medicine, Clinical Centre of Montenegro, Podgorica, Montenegro*

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The brachial plexus represents a field of many anatomical variations with important clinical implications, especially in the diagnosis and treatment of the thoracic outlet syndrome (TOS). The case described in this paper presented a novel bilateral variation in the relation of the upper trunk of the brachial plexus to the anterior scalene muscle. The ventral rami of the C5 and C6 spinal nerves perforated the anterior scalene muscle simultaneously through a common opening, and joined to form the upper trunk. Previous literature reports described variations of the brachial plexus and the scalene muscles, as well as the embryological basis for their presence. The case reported herein helps to improve the comprehension of the TOS, as well as the diagnostic and therapeutical approach to this syndrome. (Folia Morphol 2019; 78, 1: 195–198)

Key words: anterior scalene muscle, brachial plexus, thoracic outlet syndrome, upper trunk, variation

INTRODUCTION

The brachial plexus (BP) is the source of the motor and sensory innervation of the upper extremity, representing a field of many anatomical variations. The BP is usually formed by three trunks: the upper trunk (UT) formed by the ventral rami of the C5 and C6 spinal nerves, the middle trunk — which is a continuation of the ventral ramus of the C7, and the inferior trunk formed by the ventral rami of the C8 and T1 [6, 10]. The three trunks usually pass through the interscalene triangle — bounded anteriorly by the anterior scalene muscle (ASM), posteriorly by the middle scalene muscle (MSM) and inferiorly by the first rib [22]. The ASM arises from the transverse processes of the C3 to C6 vertebrae, and it inserts into the Lisfranc tubercle of the first rib, between the grooves for the subclavian artery (SA) and subclavian vein (SV). The MSM arises from the transverse processes of the C2 to C7 vertebrae, and it attaches to the first rib posterior to the attachment of the ASM [5].

Variations in the formation of the BP's trunks [4, 7, 23–25], as well as in their relation to the scalene muscles [5, 18], have been described in the literature. Certain variations are linked to the neurogenic thoracic outlet syndrome (TOS) [9], due to the proximity of the muscle fibres and the nerves. Knowing precisely the functional anatomy of the BP and its relations to the nearby structures is necessary in order to diagnose and treat diseases and injuries of the neck, including the TOS. The case described herein presented a previously unreported variation in the relation of the UT to the ASM.

CASE REPORT

A novel variation was originally observed during the anatomical dissection of a 56-year-old male ca-

Address for correspondence: B. Vukcevic, MD, Teaching Assistant in Anatomy, Faculty of Medicine, University of Montenegro, Ljubljanska 1, 20000 Podgorica, Montenegro, tel: +382 69 799 114, e-mail: batricvukcevic@gmail.com

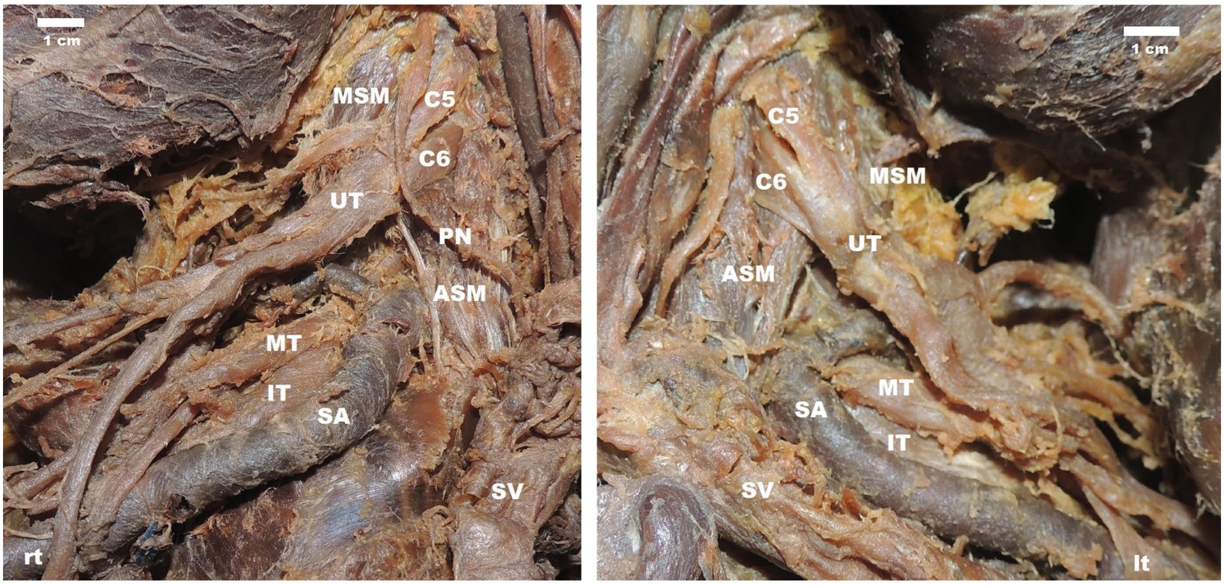

Figure 1. Bilateral variation of the upper trunk of the brachial plexus; rt — right side; lt — left side; ASM — anterior scalene muscle; MSM — middle scalene muscle; PN — phrenic nerve; UT — upper trunk; MT — middle trunk; IT — inferior trunk; C5 — ventral ramus of the fifth cervical nerve; C6 — ventral ramus of the sixth cervical nerve; SA — subclavian artery; SV — subclavian vein.

daver, preserved by injection of 4% formaldehyde in the femoral artery and subjected to a year-long immersion in a formalin solution. After removing the skin of the neck and the platysma, as well as the sternocleidomastoid and the omohyoid muscle, the lateral cervical region was investigated. On the right side, the C5 and C6 arose through an opening on the anterior surface of the ASM, located 32 mm superior to the ASM attachment on the first rib. The left side showed the C5 and C6 passing through an opening on the lateral margin of the ASM, thus separating the anterior and posterior muscle belly (Fig. 1). The opening on the left ASM was 33 mm superior to the same reference point. Bilaterally, the C5 and C6 joined to form the UT shortly after their relation to the ASM. The SA and the middle and inferior trunks of the BP passed through the interscalene triangle on both sides, with the SV passing in anteriorly the ASM. Further dissection of the neck and the axilla proved the branching of the BP's trunks and the vascular anatomy to be normal.

DISCUSSION

Variations of the BP and the scalene muscles are embryologically determined. The upper extremities' buds develop from the mesenchyme during the fourth week of foetal development. The neck muscles arise from the premuscle mass of the shoulder girdle [12]. During the buds' development, the spinal nerves' axons follow the muscular growth, with the ventral rami of the C4-8 and T1 presenting near the end of the 4th week [11]. Shinohara et al. [19] report that the mentioned rami form the BP on the 33rd day of intrauterine life. Thereafter, the scalene muscles become fully developed around the 50th day [20]. Milliez i Sakka [13] state that the ASM and the MSM develop from a common premuscle mass, which is later penetrated by the BP and the SA [13]. Takafuji and Sato [21] suggest that the original ASM has divergent fibres — anterior and posterior to the SA — with the latter fibres receding during the development of the neck. The authors hypothesize that the persistence of the posterior fibres may affect the relation of the ASM to the BP [21]. The interaction of the neural primordium to the premuscle mass [15] and the blood vessels [2] is considered as the key factor in the development of the anatomical variations of the neck and the axilla. The development of the BP may orchestrate the variations in its relation to the ASM, given the fact that the BP develops prior to the completion of the scalene muscles development.

The results published by Natsis et al. [14] showed the UT perforating the ASM in 12 cadavers (bilaterally in 2 cadavers). The C6 perforated the ASM in the left side of 1 cadaver, with the C5 passing anteriorly to the ASM and joining with the C6 to form the UT [14].

Leonhard et al. [9] reported 8 cadavers with bilateral perforation of the ASM by the UT. In their study, the C5 perforated the ASM in 2 cadavers, with the C6 passing through the interscalene triangle. The authors suggest that the UT perforating the ASM may cause TOS even with minimal muscular hypertonicity [9]. Sakamoto [18] conducted a study on 26 cadavers and reported the C5 perforating the ASM bilaterally in 1 cadaver. These papers do not contain descriptions of the C5 and C6 perforating the ASM simultaneously. Instead, the ASM was perforated by the formed UT or by a single ventral ramus (i.e. the C5 or the C6). Harry et al. [5] performed a study on 51 cadavers (102 sides) and reported the UT perforating the ASM in 15% of total number of sides, with 6% showing the C5 and C6 piercing the ASM simultaneosly. However, their paper lacks the photographs of the actual cadavers, and the schematic representation shows the C5 and C6 perforating the muscle at distant points. Based on the data from reports in the literature, it is concluded that the variation presented herein may be considered new.

Thoracic outlet syndrome is a condition caused by compression or irritation of the BP and the subclavian vessels in the thoracic outlet due to a bony or soft tissue abnormality [8]. Nerve entrapment is characterised by a reduced blood supply to the mesoneurium and the endoneurium, leading to nerve oedema and damaged axonal transport [1]. TOS affecting the UT causes symptoms based on the dermatomes and myotomes of the C5 and C6, including sensory deficit of the lateral arm, forearm, thumb and index finger, as well as diminished biceps and brachioradialis reflexes [9]. Roos reported five types of variations of the ASM and the BP as possible culprits behind the TOS: (1) ASM fibres attached to the perineurium of the BP's trunks; (2) fibres connecting the ASM to the MSM, traversing between the BP's trunks; (3) C5 and C6 passing anteriorly to the ASM; (4) ASM and MSM fusion into a single muscle perforated by the BP; (5) fibrous bands passing posteriorly to the ASM and perpendicularly to the BP. The suggested treatment is complete anterior scalenectomy through a supraclavicular approach [16]. Furthermore, applying regional anaesthesia to the upper extremity requires a precise understanding of the BP anatomy [17]. Ultrasound-guided localisation of the trunks and fascicles of the BP is a useful diagnostic tool in the BP block, with the possibility of evaluating individual anatomical variations [3, 17].

CONCLUSIONS

In conclusion, the anatomical variations of the BP may provide a basis for the development of TOS. The variation presented herein is previously unreported, and this description may help to expand what is known of the anatomy of the neck, providing better orientation in the diagnosis and treatment of TOS.

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