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Scalenus muscle and the C5 root of the brachial plexus: bilateral anatomical variation and its clinical significance.

Gagandeep Kaur Aheer, BSc, MSc, PhD[1]
Joey Villella, HBSc (Kin)[2]

Objective: *To describe an anatomical variant wherein, bilaterally, the C5 ventral root passes anterior to the anterior scalene muscle.*

Clinical Implications: *This and other variants in the anatomy of brachial plexus may complicate diagnosis of thoracic outlet syndrome, by producing unconventional signs and symptoms. Additionally, the passage of C5 ventral root anterior to the anterior scalene muscle, as in this case, may render the nerve root more susceptible to injury, including injury during manual therapy directed to this region.*

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KEY WORDS: thoracic outlet syndrome, anatomical variant, C5 ventral root, cadaver

Scalène antérieur et racine nerveuse C5 du plexus brachial : variation anatomique bilatérale et sa signification en clinique

Objectif : *Décrire une variante anatomique selon laquelle, bilatéralement, la racine ventrale de C5 passe en avant du scalène antérieur.*

Incidence clinique : *Cette variante et d'autres dans l'anatomie du plexus brachial peuvent compliquer le diagnostic du syndrome du défilé thoracique, parce qu'elles produisent des signes et des symptômes inhabituels. Par ailleurs, le passage de la racine ventrale de C5 en avant du scalène antérieur, comme c'est le cas ici, peut rendre la racine nerveuse plus exposée aux blessures, notamment pendant des manipulations dans cette région.*

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MOTS CLÉS : syndrome du défilé thoracique, variante anatomique, racine ventrale de la C5, cadavre

[1] Department of Anatomy, Canadian Memorial Chiropractic College
[2] Undergraduate Program, Canadian Memorial Chiropractic College

Corresponding author: Gagandeep Kaur Aheer, Department of Anatomy, Canadian Memorial Chiropractic College, 6100 Leslie Street, Toronto, ON M2H 3J1
Tel: 647-863-1300
E-mail: gaheer@cmcc.ca

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Introduction

Thoracic outlet syndrome is not a rare presentation and may be seen as a concomitant of whiplash associated disorders and athletic injuries.[1-3] The practitioner therefore needs to be able to recognize this syndrome for what it is, and institute appropriate care. These responsibilities would be made lighter if the relevant anatomy were immutable. However, the physical diagnosis of thoracic outlet syndrome is not trivial[4] and various anatomical variants, including cervical ribs and unusual muscle attachments, mean both the underlying mechanisms and the clinical constellation may be quite variable (for examples, see [5-7]). Hence, for example, what are essentially neurological manifestations may masquerade as cardiovascular complaints[8,9], complicating diagnosis and leading to the implementation of inappropriate treatment. Therefore, anatomical variations of the brachial plexus are of significant interest to clinicians[10].

The brachial plexus is formed by the union of the ventral rami of the C5-C8 and T1 nerves. The C5 and C6 rami join at the lateral border of scalenus medius as the superior trunk (ST), the C8 and T1 rami join behind scalenus anterior as the inferior trunk, and the C7 ramus becomes the middle trunk. After exiting the intervertebral foramen, these ventral rami usually pass through the interscalene triangle, bounded anteriorly by the anterior scalenus muscle (ASM), posteriorly by the middle scalenus muscle (MSM), and below by the first rib.[11] The ASM arises from the transverse process of the C3 to C6 vertebrae, and it inserts into the scalene tubercle of the first rib, between the grooves for subclavian artery (SA) and subclavian vein (SV). The MSM arises from the transverse process of the C2 to C7 vertebrae, and it attaches to the first rib posterior to the attachment of ASM.[12]

There are few studies which evaluate the relations between the roots of the brachial plexus and the scalenus

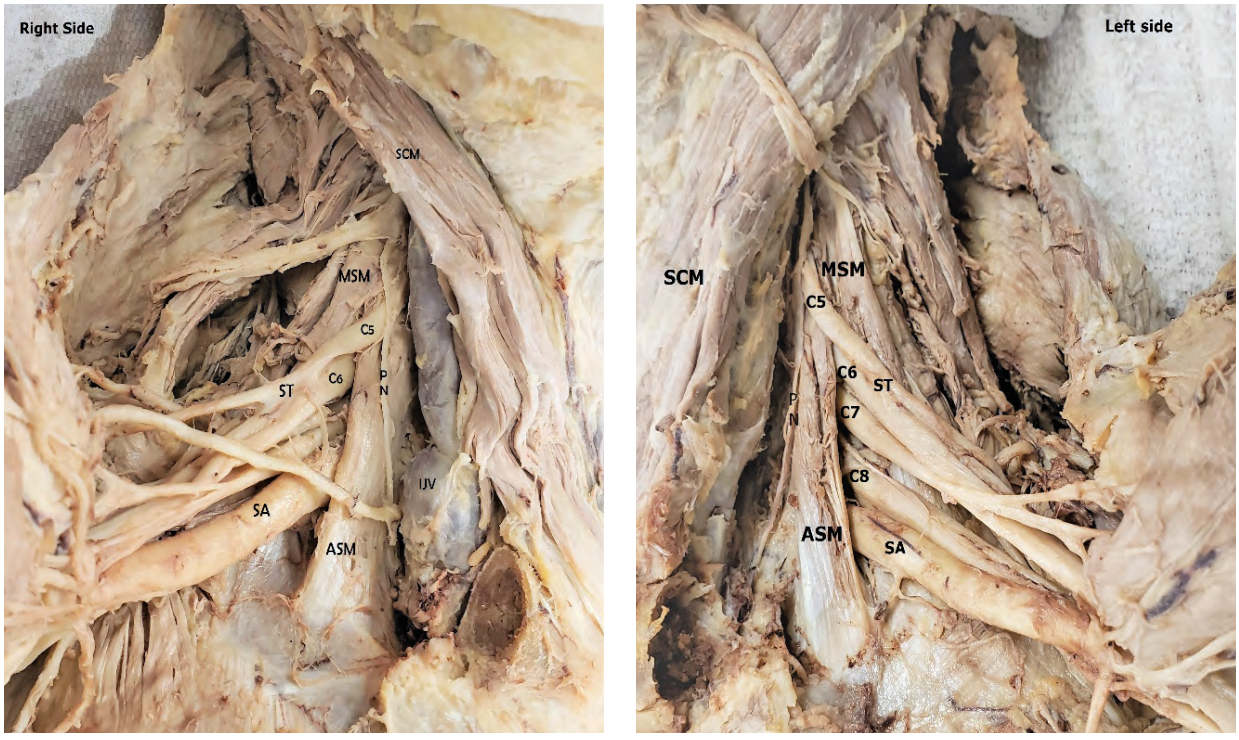

Figure 1.

Bilateral variation of the C5 root of the brachial plexus; Anterior right side and Anterior left side; ASM – anterior scalene muscle; MSM – middle scalene muscle; PN – phrenic nerve; ST – superior trunk; C5 – ventral ramus of the fifth cervical nerve; C6 – ventral ramus of the sixth cervical nerve; C7 – ventral ramus of the seventh cervical nerve; C8 – ventral ramus of the eight cervical nerve; SA – subclavian artery; IJV – internal jugular vein.

muscles. Knowledge of the relations between the roots of the brachial plexus and the scalenus muscles is clinically significant for anesthetists, surgeons, radiologists, and manual therapists, as these variations are a constant challenge, for example during surgical investigation.[13] This study introduces an additional complication to which clinicians should be alert in formulating their diagnosis – a variant passage of the C5 spinal nerve anterior to the anterior scalenus muscle. This variation would likely modify the presentation of thoracic outlet syndrome; for example by sparing the C5 nerve root from compression in the interscalene triangle, and hence sparing, for example, deltoid muscle strength, At the same time, however such superficial passage might render the C5 nerve root vulnerable to forces applied during manual therapies to the neck and so could account for some adverse response to treatment as detailed below.

Case report

During a routine educational dissection for the first-year chiropractic students, we came across a variation in the brachial plexus in a female cadaver. The neck was dissected to expose the posterior triangle. A midline incision was made, followed by lateral reflection of the skin, superficial fascia and the platysma muscle, exposing the sternocleidomastoid muscle. The omohyoid muscle was reflected and the clavicle was disarticulated at the sternoclavicular joint, exposing the scalene muscles, as well as the supraclavicular and infraclavicular parts of the brachial plexus. Prevertebral fasciae and the carotid sheath were cleared from the surface of the anterior and middle scalene muscles, as well as from the root and trunk of the brachial plexus. In our case, bilaterally, the C5 nerve root passed anterior to the anterior scalene muscle (ASM) and inferior to the phrenic nerve, deep to the sternocleidomastoid muscle (Figure 1). After its descent over the anterior scalene muscle, C5 joined C6 on the lateral border of the ASM to form the Superior Trunk. The subclavian artery (SA) and the middle and inferior trunks of the brachial plexus (BP) passed through the interscalene triangle on both sides, with the subclavian vein passing anterior to the ASM. Further dissection of the neck and the axilla proved the branches of the BP trunks and the vascular anatomy to be normal.

Discussion

The current study sheds further light on anatomical variations presenting in the brachial plexus region and cause us to consider potential clinical implications. The presence of anatomical variation is often used to explain the etiology of symptoms that might not otherwise be obvious. Our report of the variant position of the C5 ventral root anterior to the anterior scalene muscle demonstrates yet another brachial plexus variation. C5 and C6 roots forming the superior trunk of the brachial plexus normally run between the anterior and middle scalene muscles, and so they are somewhat protected from superficial trauma.

Variations of the BP and scalene muscles are embryologically determined. The interaction of the neural primordium with the scalene muscles and blood vessels is considered the key factor in the anatomical variations of the neck and the axilla. The development of the BP may orchestrate the cited variation in its relation to the ASM, owing to its formation prior to scalene muscle development.[12]

The C5 root has been described in the literature as piercing the anterior scalene, or more rarely, passing anterior to the muscle. According to a study by Harry *et al*.[10] on 51 cadavers, in 3% of cases the C5 root was located anterior to ASM unilaterally, but never bilaterally. Leonhard *et al*.[13] assessed the brachial plexus variations in 95 cadavers and only found this unilateral variation in two cadavers. Natsis *et al*.[14] who studied 93 cadavers, observed the C5 root passing anterior to ASM and C6 piercing the muscle in one individual. However, Gutton *et al*.[15] observed this unilateral variation in 8%, Kessler and Gray[16] in 6.5%, and Loukas *et al*.[17] in 1% of cadavers. Bilateral occurrence of this variant has not been previously reported.

This superficial location of the C5 ventral root could result in significant neurological deficits, if the nerve were damaged. The superficial position of the superior trunk, and the reduction in protective overlying musculature could render it more vulnerable to injury rather than prolonged compression. Individuals with this variation would be more likely to present with neurogenic symptoms following temporary pressure on the anterior and lateral neck, for example, from carrying a heavy backpack or purse.[18] Others have reported 'pack palsy' defined as impairment of the superior trunk or suprascapular nerve, a proximal branch of superior trunk, due to pressure on the shoulder girdle, and this complaint is commonly seen

in military personnel and hikers.[19] The anterior scalenus muscle produces rotation of the cervical spine to the same side and maximum stretching of the anterior scalene muscles occurs with rotation to the opposite side. Therefore, the variant course of C5, as seen in our case, could be a possible source of neuropathic pain or neuritis with neck musculature strain or hyper-abduction injuries.

From a medical perspective, there are also implications for variation in the position of roots of the brachial plexus relative to the anterior scalenus muscle when performing an interscalene brachial plexus block. In cases where the roots are located outside of the interscalene groove, which is the injection site for this block, the block may not adequately anesthetize the upper limb.[20] However, variation in position of the root and trunk in relation to the scalene muscle can be easily identified on ultrasound imaging. Ultrasound guided visualization of the root can be employed, and if variations are identified, the interscalene approach can be utilized with anesthetic injected into adjacent areas in addition to the interscalene groove, ensuring that these variant nerves are blocked and adequate anesthesia is obtained.[21]

Awareness of anatomical variation in the cervico-brachial region is of increasing importance in the chiropractic profession. The etiology of compressive syndromes in this region (such as TOS) typically involves a combination of flexed head posture, anteriorly rounded shoulders and protracted scapulae.[22] Owing to the life-style trends of the 21st century, there is a growing burden of TOS in full-time students as well as in occupations that require repetitive overhead reaching. A cascade of neuromuscular events can develop secondary to faulty posture, ergonomics, trauma, or even muscular hypertrophy.[23]

When evaluating patients with TOS, the clinician will complete a standard evaluation procedure that consists of a history, and physical and regional assessment of the thoracic outlet and shoulder girdle.[24] The patient interview will aim to discuss the mechanism of injury and a well-rounded health history is required in order to devise a working diagnosis. To confirm or rule out clinical suspicions, the chiropractor will then conduct an orthopedic assessment with an attempt to reproduce the chief complaint through a series of provocative tests. With prior knowledge of neurovascular variants and confirmatory advanced imaging studies, the clinician may, in addition to routine procedures, attempt to provoke or amplify the patient's symptoms by applying pressure to the anterior margin of the ASM. Subsequently, the clinician may consider this anatomical variant in the diagnostic process and adjust the treatment plan accordingly.

The foundation of chiropractic management for many compressive syndromes is to adopt a holistic approach in re-establishing proper function, giving focus to neurological innervation by offloading impingements.[25] In practice, the challenge to manual therapy is to facilitate this decompression without further irritating the relevant neurovascular supply.[23] For patients presenting with a suspected cervico-brachial compression syndrome, treatment options might include myofascial release therapy of scalene musculature, first rib adjustments and cervical joint mobilization or manipulation. In reference to the current case study, the bilateral superficial location of the C5 ventral roots could result in significant unexpected neurological deficits following otherwise conventional manual therapy, such as trigger point therapy or stripping massage applied to the ASM. As a result, clinical manifestations of varying severity may refer as C5 nerve root dermatomal and myotomal patterns. The patient may experience ipsilateral numbness and tingling in the lateral arm following manual pressure to the anterolateral neck.[22] However, due to individual differences, it is not possible to forecast the exact implications in all cases.

Conclusion

Clinicians should be aware that variants, as described in this paper, exist and have clinical implications. Awareness of relevant neurovascular anatomy allows chiropractors to derive more specific differential diagnoses and develop appropriate treatment plans. Without careful consideration, certain treatment modalities would be ineffective, or even exacerbate symptoms in some patients. The mere presence of anatomical variation does not imply that symptoms will become manifest. However, the etiology of compressive syndromes in the cervico-brachial junction typically involves a combination of predisposing risk factors including faulty posture and congenital anatomical variants. These individual differences can often explain symptoms that might not otherwise be obvious. Therefore, the most reliable way to correlate structure and function of the thoracic outlet is through a good medical history, physical examination and periodic reassessments.

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