Systematic Ultrasound Identification of the Dorsal Scapular and Long Thoracic Nerves During Interscalene Block

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Background and Objectives: The use of ultrasound for in-plane interscalene block shifts needle insertion to a more posterior approach through the middle scalene muscle, when compared with classic nerve stimulator techniques. Branches from the brachial plexus, including the dorsal scapular and long thoracic nerves, are often anatomically located within the middle scalene muscle. The aim of this study was to use ultrasound to identify and characterize the frequency and position of the dorsal scapular and long thoracic nerves located in the middle scalene muscle.

Methods: We recruited 50 subjects who presented for shoulder surgery. Before block placement, ultrasound was used to evaluate the area posterior to the brachial plexus for visible segments of the long thoracic and dorsal scapular nerves. If nerves were identified, a stimulating Tuohy needle was advanced in close proximity. Current was then applied through the needle, and motor response confirmed the visualized nerve as being either the dorsal scapular nerve or long thoracic nerve.

Results: Ninety percent of the subjects had a nerve visible under ultrasound assessment within or superficial to the middle scalene muscle. The nerves were located at similar depth as the perceived C6 nerve root, at 1.1 ± 0.4 cm from skin and 0.7 ± 0.4 cm posterior from the brachial plexus. Stimulation revealed that the nerve identified on ultrasound was the dorsal scapular nerve (77%) or the long thoracic nerve (23%).

Conclusions: This descriptive study revealed that the dorsal scapular and long thoracic nerves routinely could be identified with ultrasound.

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A common approach to performing an ultrasound-guided interscalene block is to image the brachial plexus at the level of the midneck in short axis and to insert the needle using the in-plane approach.[1] This ultrasound approach has created a shift in the classic insertion point described by Winnie,[2] from the groove between the anterior and middle scalene muscles, to a more posterior or anterior puncture site.[3] Based on the work by Kessler and colleagues,[4] the anterior approach may come into direct contact with the phrenic nerve. This posterior approach to the brachial plexus through the middle scalene muscle should theoretically avoid unintentional trauma to the phrenic nerve. However, descriptions of this technique do not take into consideration the small branches of the brachial plexus that are closely associated with the middle scalene muscle, such as the dorsal scapular and long thoracic nerves. Our aim was to use ultrasound to identify, locate, and describe the location of the dorsal scapular and long thoracic nerves in the context of performing an interscalene block.

METHODS

After institutional review board approval by the Benaroya Research Institute at Virginia Mason Medical Center, written informed consent was obtained from a convenience sample of 50 consecutive American Society of Anesthesiologists physical status I-III patients undergoing shoulder surgery requiring continuous peripheral nerve blockade for postoperative analgesia. Exclusion criteria included age younger than 18 years, pregnancy, localized infection, preexisting coagulopathy, neuromuscular disorders, or allergy to local anesthetics.

Before placement of the interscalene catheter, 2 investigators independently scanned each patient with a linear 15-6 MHz ultrasound probe (SonoSite M-Turbo, Bothell, Washington), then came to a consensus on what they believed to be neural tissue within the middle scalene muscle. Images were electronically captured and were used to characterize the presence of the dorsal scapular or long thoracic nerves within or superficial to the middle scalene. Once the brachial plexus was identified at the nerve root insertion of the vertebral transverse process level, the C5 and C6 nerve roots were traced caudad, where the brachial plexus was clearly identified at the root to trunk level (Fig. 1).

After obtaining an interscalene image of the brachial plexus, the screen was frozen, and electronic calipers were used to measure the distance from skin to the top of what were most likely the C5 and C6 nerve roots. Then, the area posterior to the plexus was analyzed for the presence of the dorsal scapular and long thoracic nerves located within or around the middle scalene muscle. The investigators considered neural tissue to appear within the middle scalene muscle as a discrete hyperechoic structure containing a hypoechoic center. Once nerve(s) were identified, the 2 investigators measured the depth from skin to nerve and horizontal distance from the brachial plexus to nerve. Perceived nerve origin was then determined by tracing the nerve back to its origination point from the brachial plexus (Fig. 2 and Video 1 in Supplemental Digital Content, http://links.lww.com/AAP/A55). Cervical nerve root levels were determined by moving the transducer cranially and counting the transverse processes from C7. C7 is easily identifiable as not having an anterior tubercle.[5]

To confirm the nerve(s) visualized on ultrasound, an insulated stimulating Tuohy needle (arrow) was placed in close proximity to the identified nerve(s) (Fig. 3). Current was then slowly increased from 0.1 mA to a maximum current of 3.0 mA until a muscular contraction was elicited. Stimulator pulse width was 100 microseconds with a frequency of 2 Hz. During stimulation, direct palpation of the serratus anterior, rhomboids, and levator scapulae confirmed the muscle twitch. These contractions helped identify the dorsal scapular (rhomboids and levator

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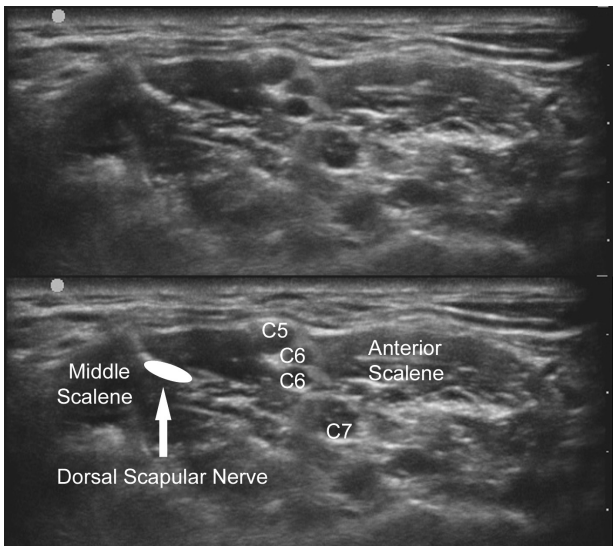


FIGURE 1. Sonogram showing ''classic'' interscalene image of the brachial plexus, as well as a dorsal scapular nerve identified in the middle scalene muscle (indicated by large arrow). Right side of the image is medial/anterior.

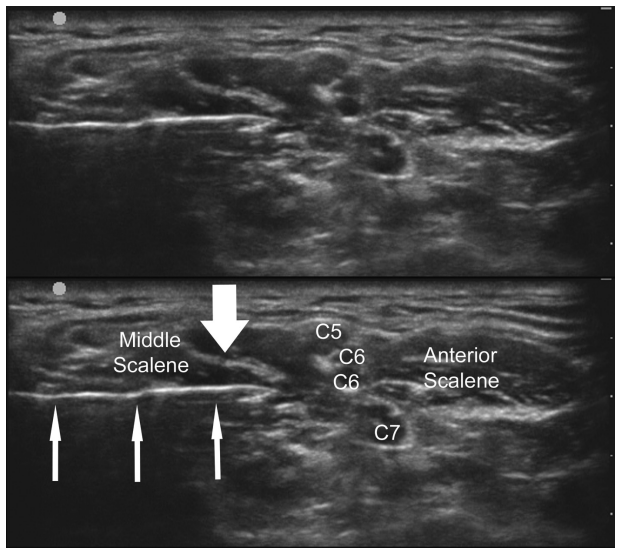


FIGURE 3. Sonogram showing stimulating Tuohy needle (small arrows) inferior to a dorsal scapular nerve (large arrow), within the middle scalene muscle, and posterior to the brachial plexus. Right side of the image is medial/anterior.

scapulae muscle) or long thoracic (serratus anterior muscle) nerves visibly on ultrasound. If contraction of any of the aforementioned muscles required greater than 3.0 mA of current, or if any contraction consistent with stimulation of the main roots or trunks of the brachial plexus was obtained, the needle was readjusted under ultrasound guidance until a specific, isolated motor response was obtained. If no small nerves could be located posterior to the brachial plexus on ultrasound assessment by either investigator, the brachial plexus location was still characterized by recording perceived depth to C5 and C6. During needle advancement to the brachial plexus, the current of the insulated Tuohy needle was set at 3.0 mA with a pulse width of 100 microseconds and frequency of 2 Hz. The needle was advanced through the middle scalene muscle toward the brachial plexus with ultrasound guidance in standard fashion. Any motor responses of the serratus anterior, rhomboids, or levator scapulae were recorded. Once the needle was in close proximity to the brachial plexus, the current would be discontinued, and the study portion of the procedure deemed complete.

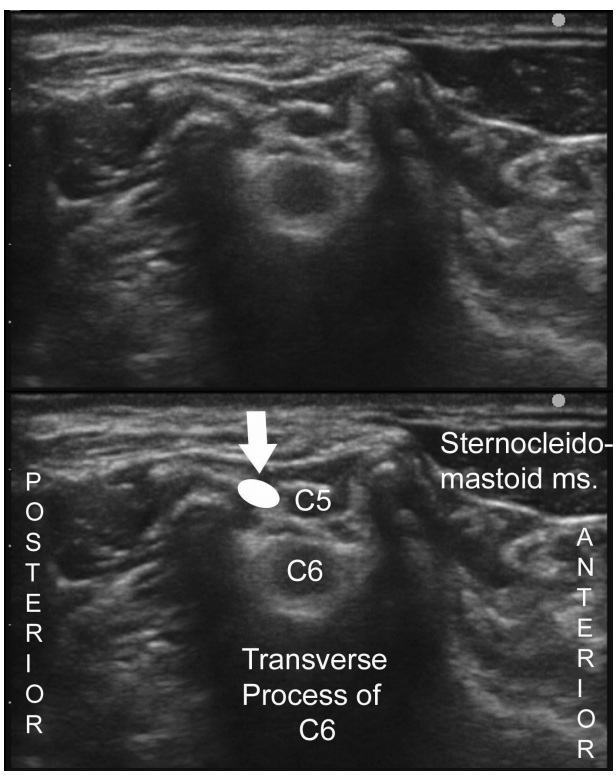


FIGURE 2. Sonogram showing emergence of a dorsal scapular nerve from C5 nerve root.

RESULTS

Fifty consecutive subjects meeting eligibility criteria and agreeing to participate were enrolled for this study. Demographic data appear in Table 1; 45 (90%) of 50 subjects had the dorsal scapular nerve, long thoracic nerve, or both nerves visible with ultrasound posterior to the brachial plexus. Of those 45 subjects, 7 had both the dorsal scapular and long thoracic nerves visible in the same imaging plane (Fig. 4). In these subjects, with both nerves visible within the middle scalene muscle, the

TABLE 1. Baseline Demographics (n = 50)

Sex, n (%)	
Male	29 (58)
Female	21 (42)
Age, mean (SD), y	58 (12)
American Society of Anesthesiologists physical status, n (%)	
I	6 (12)
II	34 (68)
III	10 (20)
BMI, mean (SD), kg/m^2	28.7 (5.1)

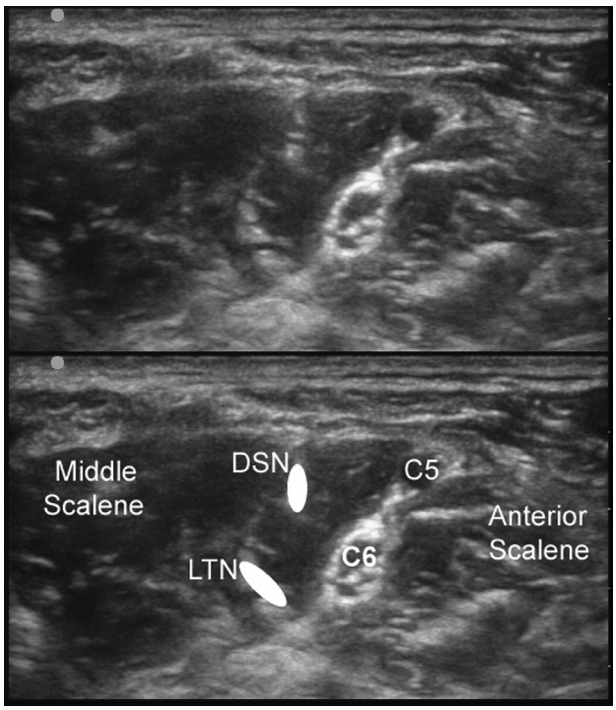


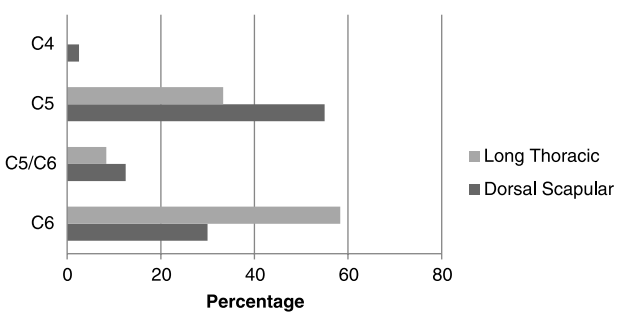
FIGURE 4. Sonogram showing "classic" interscalene image of the brachial plexus with both the dorsal scapular nerve and long thoracic nerve identified in the middle scalene muscle. Similar images of both nerves were identified in 14% of study subjects. Right side of the image is medial/anterior.

more superficial was always the dorsal scapular nerve, and the deeper always the long thoracic nerve.

The dorsal scapular and long thoracic nerves had an ultrasound appearance of predominantly hyperechoic tissue, with small areas of hypoechoic fascicles within. The mean distance of these ultrasonographically identified nerves to the brachial plexus was found to be 0.7 ± 0.4 cm, and the depth from the skin was demonstrated to be 1.1 ± 0.4 cm. Average depth of the perceived C5 nerve root to the skin on all patients was 0.8 ± 0.3 cm and 1.1 ± 0.4 cm for C6. The dorsal scapular nerve was shown to originate from nerve roots C4, C5, and/or C6, whereas the long thoracic nerve had origins from C5 and/or C6 (Table 2).

Of all nerves identified within the middle scalene muscle, 77% were the dorsal scapular nerve, whereas 23% were the long thoracic nerve (Table 3). The average current used to elicit these contractions was 1.28 ± 0.59 mA. Of the 5 subjects where neither observer could identify a small nerve posterior to the plexus with ultrasound, only 1 subject had an elicited contraction of the rhomboids while the needle was advanced toward the brachial plexus with a constant current of 3.0 mA. Therefore, a nerve that was not identified using ultrasound was identified with stimulation in only 1 of the 5 subjects.

TABLE 2. Perceived Nerve Branch Root Origins



Compiled origins of the dorsal scapular and long thoracic nerves located within or superficial to the middle scalene muscle at the interscalene level.

DISCUSSION

This observational study reveals that the dorsal scapular and long thoracic nerves of the brachial plexus are frequently located within the middle scalene muscle, less than 1 cm posterior to the brachial plexus and at similar depth as the perceived C6 nerve root. Because of variability in subject size, imaging plane, and pressure applied to the transducer, absolute distances to these nerves may not be applicable in all patients. However, we correlated our findings to the location of brachial plexus, so clinicians can have an estimate of potentially important regions to identify the dorsal scapular and long thoracic nerves.

In our study, ultrasound visualization of these nerves was approximately 90%. In most cases, the dorsal scapular nerve will be identified (77%), followed by the long thoracic nerve (23%) at the interscalene level. A small subset of patients (14%) showed both the dorsal scapular and long thoracic nerves in the same imaging plane. With these data, we hope to improve the sonoanatomic knowledge of this area and encourage identification of these nerves during an in-plane ultrasound-guided interscalene nerve block.

No outcome data describe unintentional injury of the dorsal scapular or long thoracic nerve in the context of performing ultrasound-guided interscalene blocks, although there is literature on brachial plexus injury.[6,7] We speculate that it is important to proactively identify and describe these nerves as a potential means of preventing injury.

Contrary to anatomic textbooks showing that the dorsal scapular nerve is derived solely from the C5 nerve root,[8] we found that the dorsal scapular nerve had contributions from the C6 nerve root. Recent cadaver studies have shown similar dual innervation to the dorsal scapular nerve.[9] We also found that 1 subject had contributions to the dorsal scapular nerve directly from C4, something that has been previously described in cadaver dissections.[10] The dorsal scapular nerve has also been described as having contributions from the superficial cervical plexus. Therefore, it is not surprising that there is a small cohort of subjects (8%) who had no posterior branch from C5 or C6 visible on ultrasound examination.

One of the limitations of this observational study is that ultrasound resolution and image quality may not be sufficient to

TABLE 3. Identification of Dorsal Scapular and Long Thoracic Nerves

Nerve	Ultrasound + Nerve Stimulation	Nerve Stimulator Alone
Dorsal scapular	40 (75)	1 (2)
Long thoracic	12 (23)	0

Values are presented as n (%).

visualize and trace the dorsal scapular and long thoracic nerves. These nerves were identified and traced by 2 independent observers to increase reproducibility in results. In addition, the highest-frequency ultrasound probe and ultrasound frequencies were used, with focal zones set as appropriately as possible. As technology and image resolution improve, the identification of these nerves using ultrasound should be even more straightforward.

The stimulation currents to confirm the nerves were relatively high (average, 1.28 mA). Our goal was to place the Tuohy needle only as close to the nerve as necessary to produce appropriate muscle contraction. Undoubtedly, we could have manipulated the needle to achieve lower current, but this would not have added to the study because the contractions produced were always isolated and never included the major muscles of the upper extremity.

In summary, this study demonstrates the close proximity of the dorsal scapular and long thoracic nerves posterior to the brachial plexus in vivo and that these nerves can be regularly identified at the interscalene level. Prior to this study, the majority of the literature has identified these nerves in cases of anatomic dissections only; there has yet to be any published clinical ultrasound characterization of these brachial plexus nerve branches. Further outcome studies on nerve injury should include analysis of direct needle trauma to the dorsal scapular and long thoracic nerves.

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