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Study of the cervical plexus innervation of the trapezius muscle

Laboratory investigation

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Object. There is conflicting and often anecdotal evidence regarding the potential motor innervation of the trapezius muscle by cervical nerves, with most authors attributing such fibers to proprioception. As knowledge of such potential motor innervations may prove useful to the neurosurgeon, the present study aimed to elucidate this anatomy further.

Methods. Fifteen adult cadavers (30 sides) underwent dissection of the posterior triangle of the neck and harvesting of cervical nerve fibers found to enter the trapezius muscle. Random fibers were evaluated histologically to determine fiber type (that is, motor vs sensory axons).

Results. In addition to an innervation from the spinal accessory nerve, the authors also identified cervical nerve innervations of all trapezius muscles. For these innervations, 3 sides were found to have fibers derived from C-2 to C-4, 2 sides had fibers derived from C-2 to C-3, and 25 sides had fibers derived from C-3 to C-4. Fibers derived from C-2 to C-4 were classified as a Type I innervation, those from C-2 to C-3 were classified as a Type II innervation, and those from C-3 to C-4 were classified as a Type III innervation. Immunohistochemical analysis of fibers from each of these types confirmed the presence of motor axons.

Conclusions. Based on the authors' study, cervical nerves innervate the trapezius muscle with motor fibers. These findings support surgical and clinical experiences in which partial or complete trapezius function is maintained after injury to the spinal accessory nerve. The degree to which these nerves innervate this muscle, however, necessitates further study. Such information may be useful following nerve transfer procedures, denervation techniques for cervical dystonia, or sacrifice of the spinal accessory nerve due to pathological entities. *(DOI: 10.3171/2011.1.SPINE10717)*

Key Words • **trapezius** • **innervations** • **nerve supply** • **injury** • **neurosurgery**

There is debate regarding the innervation of the trapezius muscle in humans. It has long been held that this muscle is unusual in that its sensory pathways (afferent) travel via the third and fourth cervical nerves, whereas its efferent pathways are entirely supplied by the spinal accessory nerve. Various cadaveric and animal studies have been performed to elucidate the innervations of the trapezius,[3,5,7,11–13,24] and clinical observations have been mixed.[1–4,6,8–10,14,15–21,23,26,28] Based on investigations of the spinal accessory nerve and its musculature, some authors have concluded that there is a "strong phylogenetic inclination for this nerve to lose its sensory cells by their migration onto the dorsal roots of adjacent cervical nerves."[25] Although most agree that the spinal accessory nerve is the primary innervation of the trapezius, the additional contribution from cervical nerves has yet to reach a general consensus.[6,9,14,17,19,21,23,26]

As there are essentially no data regarding this topic in the neurosurgical literature, the aim of the present study was to shed light on the types of fibers found in a sampling of cervical nerve fibers innervating the trapezius muscle.

Methods

In the supine position, 15 adult cadavers (30 sides) underwent dissection of the posterior triangle of the neck

Abbreviation used in this paper: SCM = sternocleidomastoid muscle.

and harvesting of cervical nerve fibers found to enter the trapezius muscle. Cervical nerve fibers found entering the substance of the trapezius muscle were followed proximally to verify their vertebral level of origin, and this necessitated reflection of the SCM. Of the specimens, 8 were male and 7 were female with no signs of pathology or past surgery to the areas dissected. No specimen had a known myopathy or neuropathy involving the trapezius muscle. Ages at death for this group ranged from 40 to 98 years (mean 74 years). Ten specimens were formalin fixed, and 5 were unembalmed. When identified, cervical fibers to the trapezius muscle were evaluated with routine staining and immunohistochemistry (for example, H & E, Luxol fast blue–periodic acid-Schiff, and carbonic anhydrase) to observe for fiber types (that is, motor vs sensory axons). Control stains were performed on sural nerve specimens. Statistical analysis between sides and sexes was performed using Statistica for Windows with significance set at $p < 0.05$.

Results

In addition to an innervation of the trapezius muscle from the spinal accessory nerve in all specimens, we also identified cervical nerve innervations of all trapezius muscles (Fig. 1 left). These latter fibers all entered the deep surface of the muscle and traveled within its substance. Fibers from the cervical nerves either ran independently to the trapezius or formed a plexus with the spinal accessory nerve before entering this muscle. Cervical nerve fibers that combined with the spinal accessory nerve prior to entering the trapezius muscle usually did so deep to the SCM. However, this rarely occurred in the posterior cervical triangle. Additionally, fibers derived from C-2 and C-3 usually joined the spinal accessory nerve before its penetration into the trapezius muscle, whereas fibers containing just C-3 and C-4 innervations generally entered this muscle separately. For these innervations, 3 sides were found to have fibers derived from C-2 to C-4; 2 sides had fibers derived from C-2 to C-3; and 25 sides had fibers derived from C-3 to C-4. All cervical fibers were found to contain motor axons. Fibers derived from C-2 to C-4 were classified as a Type I innervation; those from C-2 to C-3 were classified as a Type II innervation; and those from C-3 to C-4 innervations were classified as a Type III innervation.

Staining with H & E confirmed neural histology of all samples. Myelin staining with Luxol fast blue–periodic acid-Schiff and carbonic anhydrase analysis demonstrated motor fiber content of the analyzed fibers (Fig. 1 right). Samples from Types I through III innervations each confirmed motor fiber types. All control stains were appropriate. No statistical difference was noted between which levels contributed to the cervical innervation (that is, Types I–III) of the trapezius and side or sex.

Discussion

We found that all cervical fibers innervating the trapezius muscle contained motor fibers as exemplified by positive carbonic anhydrase activity although the simultaneous presence of sensory fibers was not excluded.[9] Through their dissections, Stacey et al.[24] demonstrated that cervical nerve contributions to the trapezius are present, isolated from the spinal accessory nerve, and play a potential role in motor control. Krause et al.[13] concluded that the cervical contribution is "not insignificant." However, some researchers have stated that the cervical motor

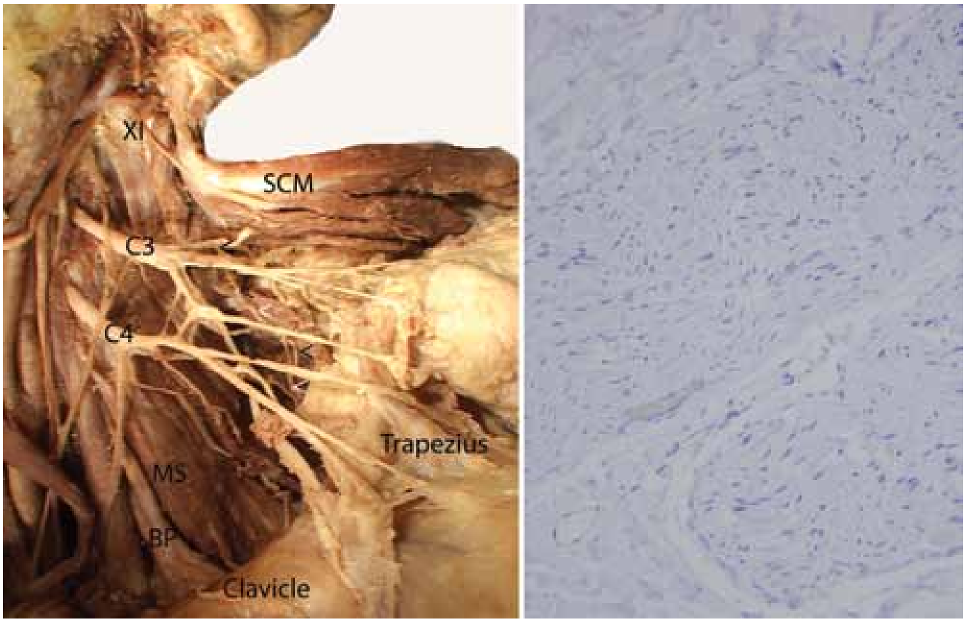

Fig. 1. **Left:** Left cadaveric neck dissection noting cervical fibers (C-3 and C-4) terminating in the trapezius muscle. Note the spinal accessory nerve (XI) innervation of the SCM and the spinal accessory nerve innervations of the trapezius *(arrowheads)*. Based on our study, this represents a Type III innervation. BP = brachial plexus; MS = middle scalene muscle. **Right:** Sample of cervical nerves innervating the trapezius muscle stained with carbonic anhydrase. Note the complete lack of staining, indicative of motor function of these nerves. Original magnification × 25.

supply is present but of limited significance.[3,5,11,12,22] To confound this, there is evidence that the cervical plexus and spinal accessory nerve innervate the transverse and ascending portions of the trapezius muscle, but only a single branch of the spinal accessory nerve supplies the descending portion of this muscle.[1,2] To address this conundrum, Krause et al.[14] and Kierner et al.[10] described using electromyography to determine an individual's unique nervous anatomy to aid in making surgical decisions.

The most common sequelae of injury to the spinal accessory nerve involves paralysis of the trapezius muscle, a dull pain in the neck and back, and limited range of motion in the shoulder.[16,26,28] This is of postoperative functional importance as this muscle is considered by Straus and Howell[25] to be the most important muscle in the back and shoulders, and allows multiple unique movements that are important in day-to-day life.[17] The simultaneous contraction of the upper and lower parts of the trapezius muscle help to upwardly rotate the scapula during arm abduction. Paralysis of the trapezius muscle results in a downward displacement of the scapula and often in shoulder pain that is described as resembling that of a toothache.[17]

We found that fibers derived from C-2 and C-3 usually joined the spinal accessory nerve prior to its penetration of the trapezius muscle, whereas fibers containing just C-3 and C-4 innervations generally entered this muscle separately. These findings are in agreement with those of Straus and Howell.[25] Interestingly, long-necked ungulates (for example, giraffes, llamas, and camels) may have absence of the spinal accessory nerve with complete innervation of their trapezius by cervical nerves.[27] Other animals without a spinal accessory nerve include lampreys and snakes.[27] Most mammals, birds, sharks, skates, and some amphibians do have a spinal accessory nerve.[22,25] Regarding a cervical nerve innervation of the trapezius muscle in humans, some surgeons hope for such a contribution so that this innervation can be used to "take over" control of the muscle after damage to the spinal accessory nerve, for example, after radical neck dissections.[4,5,11,13,28]

Conclusions

Based on our human cadaveric study, cervical nerves innervate the trapezius muscle with motor fibers and should be preserved if at all possible during surgery of the cervical region. These findings support surgical and clinical experiences where partial or complete trapezius function is maintained after injury to the spinal accessory nerve. The degree to which these nerves innervate this muscle, however, necessitates further study. Such information may be useful after nerve transfer procedures, denervation techniques for cervical dystonia, or sacrifice of the spinal accessory nerve due to pathological entities.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Cohen-Gadol, Tubbs. Acquisition of data: Tubbs, Lancaster, Mortazavi. Analysis and interpretation of data: all authors. Drafting the article: Tubbs, Lancaster. Critically revising the article: all authors. Reviewed final version of the manuscript and approved it for submission: all authors. Study supervision: Tubbs.

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