Surgical anatomy of the cervical and infraclavicular parts of the long thoracic nerve

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Object. There is insufficient information in the neurosurgical literature regarding the long thoracic nerve (LTN). Many neurosurgical procedures necessitate a thorough understanding of this nerve’s anatomy, for example, brachial plexus exploration/repair, passes for ventriculoperitoneal shunt placement, pleural placement of a ventriculopleural shunt, and scalenotomy. In the present study the authors seek to elucidate further the surgical anatomy of this structure.

Methods. Eighteen cadaveric sides were dissected of the LTN, anatomical relationships were observed, and measurements were obtained between it and surrounding osseous landmarks.

The LTN had a mean length of 27 ± 4.5 cm (mean ± standard deviation) and a mean diameter of 3 ± 2.5 mm. The distance from the angle of the mandible to the most proximal portion of the LTN was a mean of 6 ± 1.1 cm. The distance from this proximal portion of the LTN to the carotid tubercle was a mean of 3.3 ± 2 cm. The LTN was located a mean 2.8 cm posterior to the clavicle. In 61% of all sides the C-7 component of the LTN joined the C-5 and C-6 components of the LTN at the level of the second rib posterior to the axillary artery. In one right-sided specimen the C-5 component directly innervated the upper two digitations of the serratus anterior muscle rather than joining the C-6 and C-7 parts of this nerve. The LTN traveled posterior to the axillary vessels and trunks of the brachial plexus in all specimens. It lay between the middle and posterior scalene muscles in 56% of sides. In 11% of sides the C-5 and C-6 components of the LTN traveled through the middle scalene muscle and then combined with the C-7 contribution. In two sides, all contributions to the LTN were situated between the middle scalene muscle and brachial plexus and thus did not travel through any muscle. The C-7 contribution to the LTN was always located anterior to the middle scalene muscle. In all specimens the LTN was found within the axillary sheath superior to the clavicle. Distally, the LTN lay a mean of 15 ± 3.4 cm lateral to the jugular notch and a mean of 22 ± 4.2 cm lateral to the xiphoid process of the sternum.

Conclusions. The neurosurgeon should have knowledge of the topography of the LTN. The results of the present study will allow the surgeon to better localize this structure superior and inferior to the clavicle and decrease morbidity following invasive procedures.

Key Words • anatomy • peripheral nerve • nerve injury • iatrogenicity • brachial plexus

A paucity of information regarding the LTN, external respiratory nerve of Bell, in the neurosurgical literature. This nerve, with approximately 1800 nerve fibers, arises from the ventral rami of C5–7. The first two roots of the nerve are said to enter the middle scalene muscle, unite, and then join the C-7 root. The united nerve then travels deep to the clavicle, posterior to the axillary artery, and then inferiorly extends almost vertically, superficial to the serratus anterior muscle, which it innervates. Although the LTN contains very few sensory fibers, once it is injured there can be deep, ill-defined scapular pain. The nerve’s long and superficial course makes it susceptible to damage at various levels.

Long thoracic nerve injury has been reported following trauma, exposure to toxins, surgery (for example, mastectomy and breast augmentation, and cardiac surgery), and various sports activities (for example, wrestling, tennis, weight lifting, and archery). Occupations in which heavy tools are carried on the shoulder (for example, miners with heavy picks or hammers) may involve damage to this nerve. Other iatrogenic causes include transaxillary first rib removal for thoracic outlet syndrome, scalenotomy, chest tube placement, infraclavicular anesthesia, sympathectomy, internal jugular vein cannulation, and surgical positioning. Although not reported on as yet, other neurosurgical procedures that may injure the LTN include pleural placement of a ventriculopleural shunt, creation of pockets for vagus nerve stimulator generators, and harvesting of intercostal nerves for neurotization procedures. Entrapment syndromes involving the LTN have occurred as the nerve passes through the middle scalene muscle in the posterior cervical triangle or as it passes between the clavicle and first two ribs.

Injury to the LTN results in varying degrees of a winged scapula. Pain around the shoulder perhaps due to inappro-
propriate scapulothoracic motion may also be described by the
patient. Resistance to protraction as in attempting push-ups
will exaggerate scapula alata.

Materials and Methods

The LTN was dissected from nine formalin-fixed cadavers (com-
posing 18 sides) in the supine position. The five female and four
male cadavers had ranged in age from 59 to 88 years at the time of
death (mean 75 years). We noted the relationships and measure-
ments of this nerve both superior and inferior to the clavicle. Mea-
surements included the length and diameter of the nerve and dis-
tances between it and the angle of the mandible, carotid tubercle,
xiphoid process, and jugular notch (Figs. 1 and 2). Noted relation-
ships included the course of the nerve through the scalene muscles,
root composition, and potential bands within the posterior cervical
triangle that might contribute to nerve compression. No cadaveric
specimen had signs of previous surgery to the neck or lateral chest
wall. The Student t-test was used to analyze statistically significant
differences between male and female sexes, as well as left and right
sides. Values are presented as the means ± standard deviations.

Results

There was no statistically significant difference in the
nerve between sexes or sides (p > 0.05). The LTN’s length
ranged from 23 to 30 cm (mean 27 ± 4.5 cm) and its main
trunk diameter from 2.5 to 3.5 mm (mean 3 ± 2.5 mm).
Two to three branches were noted to leave the main trunk of
this nerve and enter each digitation of the serratus anterior
muscle. No pre- or postfixed brachial plexuses were noted.
The distance from the angle of the mandible to the most
proximal portion of the LTN ranged from 4 to 8.5 cm (mean
6 ± 1.1 cm). The distance from this proximal portion of
the LTN to the carotid tubercle ranged from 2 to 5 cm (mean
3.3 ± 2 cm). The LTN was situated 2 to 3.5 cm (mean
2.8 ± 1.2 cm) posterior to the clavicle. The contributions
from the ventral rami of the C-5 and C-6 spinal nerves to the
LTN were 1 to 1.5 mm in diameter, and these conjoined
fibers traveled 4 to 6.5 cm distally before fusing with the
C-7 contributions, which were approximately 2 mm (range
1.5–2.8 mm) in diameter and 4 to 7 cm (mean 5.5 ± 2.2 cm)
in length. In the majority of sides (11 sides [61%]), the C-7
component of the LTN joined the C-5 and C-6 components
at the level of the second rib posterior to the axillary artery.
In six sides (33%), these nerve components joined more su-
periorly at the level of the first rib posterior to the middle
trunk of the brachial plexus; in two of these sides, the C-5
and C-6 portions of the LTN were split by the dorsal scap-
ular artery originating from the third part of the subclavian
artery. In one right-sided specimen, the C-5 component of
the LTN did not join the C-6 and C-7 parts of this nerve but
traveled directly to the upper two digitations of the serratus
anterior muscle. This same isolated branch provided mo-
tor fibers to the posterior scalene and levator scapulae mus-
cles. The LTN traveled posterior to the axillary vessels and
trunks of the brachial plexus in all specimens. In 10 sides
(56%) the LTN (C-5 and C-6 components) lay between the
middle and posterior scalene muscles. In six sides, the C-5
and C-6 components of the LTN coursed through the mid-
dle scalene muscle and then combined with the C-7 con-
tribution. In two sides, all contributions of the LTN were situ-
ated between the middle scalene muscle and brachial plexus
anteriorly and thus did not travel through any muscle fibers.
The C-7 contribution to the LTN was always located ante-
or to the middle scalene muscle. In all specimens the LTN
was found within the axillary sheath superior to the clavicle.
One specimen had a branch to the subscapularis muscle that originated from the upper trunk of the brachial plexus. Distally, the LTN was found to lie 13 to 16 cm (mean 15 ± 3.4 cm) lateral to the jugular notch and 19 to 23 cm (mean 22 ± 4.2 cm) lateral to the xiphoid process of the sternum. We noted no anomalous bands that might compress the LTN.

Discussion

The serratus anterior muscle arises from the superior seventh, eighth, ninth, and 10th ribs in 13, 48, 26, and 13% of the population, respectively.2 The insertion site of this muscle is the vertebral border of the scapula. The serratus anterior muscle is involved in protraction of the scapula, as occurs in maneuvers used in boxing and fencing.17 This muscle also fixes the scapula to the chest wall, acts as a secondary muscle of respiration, and rotates the scapula for movements such as reaching above the head.3 The LTN supplies the serratus anterior muscle and extends as far inferior as the eighth or ninth rib. Resolution of injury to this nerve may take as many as 2 years.11

Variations in the LTN were noted in 5% of cases in which the C-5 root coursed independently to the superior digitations of the serratus anterior muscle, 8% of cases in which the C-7 root was absent, and 3% of cases in which the union between the fifth and sixth roots was delayed for a variable distance.12,16 The C-8 root may contribute to the LTN in 8% of individuals.15 Rarely, the C-4 root may contribute to the LTN even when the brachial plexus is not prefixed.8 Some authors have stated that the lower part of the serratus anterior muscle is often innervated by the intercostal nerves.7,16 Although we did not observe this phenomenon in any specimen in our study, Erdogmus and Govsa3 have noted its occurrence in as many as 25% of cadavers. Note, however, that other investigators have stated that the LTN is the sole means of innervation of the serratus anterior muscle.17

As previously noted, the LTN may become entrapped in the middle scalene muscle. Indeed, Disa and colleagues3 have decompressed this nerve at this anatomical level in four patients with an idiopathic winged scapula. All patients in their series experienced resolution of the scapular deformity following this procedure. Note that many of these patients also demonstrated entrapment of the LTN between the middle and posterior scalene muscles. We found that most often the C-5 and C-6 components of the LTN passed between the middle and posterior scalene muscles and not through the middle scalene muscle. Interestingly, Ramamurthy and associates12 have described seven patients with intractable pain of the lateral chest wall, which was thought to be due to spasm of the serratus anterior muscle. The majority of this cohort experienced pain resolution following supraclavicular nerve block of the LTN.

Sunderland18 has stated that the LTN is usually situated approximately 2 cm posterior to the clavicle. This finding roughly corresponds to the 2.8-cm mean distance in the present study. Salazar and coworkers13 have asserted that to avoid the LTN, incision sites for transaxillary thoracotomies should be at least 7.5 cm anterior to the scapular tip (inferior scapular angle) and those for posterolateral thoracotomies should be approximately 6 cm anterior to this osseous landmark. We chose not to use the scapular tip as an osseous landmark given that this bone is too mobile and hence does not make a reliable surgical marker. We chose immobile bone landmarks for making measurements to the infracavicular part of the LTN, that is, the xiphoid process and jugular notch. We found that the LTN was a mean 15 cm lateral to the jugular notch and 22 cm lateral to the xiphoid process of the sternum.

Lurje2 has stated that often with traumatic sectioning of the upper trunk of the brachial plexus, the LTN is left intact. In fact, this author has used the LTN distal to its innervation to the superior two digitations of the serratus anterior muscle for neurotization of a transected suprascapular nerve; the patient in this case regained full function of her spinati muscles. Likewise, Narakas8 has used the LTN for neurotization procedures to the distal C-6 and C-8 nerve roots as well as to the lateral cord, with varying results.

Schultes, et al.,14 have noted the similarity between the spinal accessory nerve and the LTN and have suggested that the functional deficits associated with the loss of trapezius muscle function are much greater than those with the loss of serratus anterior muscle function. Thus, these authors have performed neurotization of the damaged spinal accessory nerve using the LTN. Furthermore, these authors compared the use of the LTN with the thoracodorsal nerve for spinal accessory nerve regeneration and concluded that the LTN was the superior choice. Note, however, that Novak and Mackinnon10 have performed neurotization using the thoracodorsal nerve for injuries to the LTN in a patient who demonstrated resolution of scapular winging at the long-term follow-up evaluation. Schultes and colleagues15 have used the LTN for reinnervation of the lower lip in patients who underwent resection of oral cavity carcinomas. Quantitatively, Ebraheim, et al.,4 have found that the mean length of the LTN was 24 cm; we found this mean distance to be 27 cm.

Conclusions

We believe our data will aid the neurosurgeon who wishes to find the LTN for potential neurotization or nerve release procedures or to avoid this nerve while performing other surgical procedures in its vicinity. We hope that these data will perhaps decrease surgical complications involving the LTN.

References

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Manuscript received June 28, 2005. Accepted in final form January 20, 2006.

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