Surgical Anatomy of the Extralaryngeal Aspect of the Superior Laryngeal Nerve
Julio C. Furlan, MD, PhD; Lenine G. Brandão, MD, PhD; Alberto R. Ferraz, MD, PhD; Aldo J. Rodrigues, Jr, MD, PhD

Objectives: To describe the topography of the superior laryngeal nerve (SLN) and to evaluate the influence of gender, ethnicity, side of the neck, and individual height on the topography of the SLN.

Design: Anatomical study of human cadavers.

Subjects: Fifty fresh human cadavers (19 female subjects and 31 male subjects; age range, 22-89 years; mean age, 61 years) were randomly selected for this study. The subjects were divided into nonwhite (n=18) and white (n=32) ethnic groups. The t test and linear regression were used for statistical analysis of data.

Results: All SLNs emerged medially to the vagus nerve. The SLNs mostly divided into internal (ibSLN) and external (ebSLN) branches distally from their origin (94%). The mean±SE length of the SLN trunk was 16.7±0.9 mm and was affected by gender (P=.01) but not ethnicity (P=.57), side of the neck (P=.96), or individual height (R^2=0.01; P=.33). The length of the ibSLN reached 44.9±1.0 mm and was unaffected by gender (P=.91), ethnicity (P=.24), side (P=.40), or height (R^2<0.01; P=.71).

Conclusions: The topography of the SLN has a few anatomical variations and is unaffected by gender, ethnicity, side of the neck, and individual height, except that the SLN is longer in males than in females. These findings are important in that they can help in the prevention of SLN injuries during operations such as laryngectomy and neck dissection, as well as in the planning of laryngeal reinnervation and transplantation.


ANATOMICAL KNOWLEDGE of the superior laryngeal nerve (SLN) is crucial for helping anatomists and surgeons to prevent intraoperative injury and to improve rehabilitation or reinnervation techniques in cases of laryngeal paralysis. However, “the anatomy of the SLN continues to be misrepresented, and this ‘error’ persists in journals as well as the most recently published textbooks,” as Kambrick et al wrote in 1984. Also, anatomy and physiology are mutually collaborative scientific fields, and progress in either one is potentially helpful for the other.

The functions of the internal (ibSLN) and external (ebSLN) branches of the SLN are not well recognized. According to Rueger, the current understanding is that the ibSLN and the ebSLN are mixed nerves, as was the popular view before 1850. In fact, sensorial neurons were mostly found within the ibSLN; fewer were observed within the ebSLN. Other studies demonstrated that sympathetic fibers may reach the larynx through both branches of the SLN. Moreover, not only has ebSLN motor function on cricothyroid muscle, but also stimulation of the ibSLN can provoke tonic contraction in the vocal cord and ventricular folds, probably using the nervous connection with the recurrent laryngeal nerve: the so-called Galen anastomosis. Finally, other functions such as olfactory acuity and respiratory control have been associated with the SLN.

The focus of this study was to describe the topography of extralaryngeal aspect of the SLN and its branches, as well as to evaluate the influence of gender, ethnicity, side of the neck, and individual height on the topography of the SLN.
METHODS

Fifty fresh human adult cadavers were randomly selected for the study, which was approved by the Ethics Board Committee of the Faculty of Medicine, University of São Paulo, São Paulo, Brazil. Bilateral neck dissections were performed as follows: The cadavers were placed in a supine position on the necropsy table with a rolled pad behind the shoulders to extend the neck. The head was slightly rotated to the contralateral side as in a lateral neck operation. The vagus nerve was dissected to their entrances into the larynx (the trunk of the SLN; subsequently, the ebSLN and ibSLN were carefully dissected from the jugular foramen to the origin of the cranial side as in a lateral neck operation. The vagus nerve was dissected to their entrances into the larynx (the trunk of the SLN; subsequently, the ebSLN and ibSLN were carefully dissected from the jugular foramen to the origin of the cranial nerve, hypoglossal nerve, common carotid artery; and 7, submandibular gland).

For every element studied, groups divided into gender, ethnicity, or side of the neck (mean ± SE, 62.6 ± 1.2 mm) and was unaffected by gender, but not by ethnicity or side of the neck (Table 1). The angle between the ibSLN and the tracheoesophageal sulcus ranged from 18° to 75° (mean ± SE, 49° ± 1°) and was unaffected by gender, ethnicity, or side of the neck (Table 4). The angle between the ibSLN and tracheoesophageal sulcus ranged from 18° to 75° (mean ± SE, 49° ± 1°) and was unaffected by gender, ethnicity, or side of the neck (Table 4).

Most SLNs showed a trunk arising from the inferior (no dose) ganglion of the nerve vagus, just caudal to the jugular foramen of the skull. However, in 6% of the SLNs, the bifurcation occurred at their origin, just below the inferior ganglion of the nerve vagus. The SLN and its branches always assumed an anterior, medial, and caudal direction before reaching the larynx. Their paths of descent initially began posteriorly and proceeded medially to the carotid arteries, and the ibSLN was always located medially to the lingual and facial arteries. Furthermore, the ibSLN was mostly observed in a parallel and medial position to the superior laryngeal artery (89%), but in 11% of the dissections it was located inferiorty and medially to that artery. The ibSLN was adjacent to the wall of pharynx, swung medially caudal to the greater horn of hyoid bone, and passed beneath the thyrohyoid membrane. The ebSLN descended lying on the inferior pharyngeal constrictor and curved anteriorly and medially close to the lower edge of the thyroid cartilage before the ebSLN innervated the cricothyroid muscle.

The length of the trunk of the SLN ranged from 0 to 41.8 mm (mean ± SE, 16.7 ± 0.9 mm). This element was affected by gender, but not by ethnicity or side of the neck (Table 1). The length of the ibSLN ranged from 21 to 84.9 mm (mean ± SE, 44.9 ± 1.0 mm) and was unaffected by gender, ethnicity, or side of the neck (Table 2). The length of the ebSLN measured between 31.5 and 90.3 mm (mean ± SE, 62.6 ± 1.2 mm) and was unaffected by gender, ethnicity, or side of the neck (Table 3). The angle between the ibSLN and tracheoesophageal sulcus ranged from 18° to 75° (mean ± SE, 49° ± 1°) and was unaffected by gender, ethnicity, or side of the neck (Table 4). Moreover, the length of the trunk of the SLN, the ibSLN, and the ebSLN was not significantly correlated to indi-
Table 4. Angle Between Internal Branch of the Superior Laryngeal Nerve and the Tracheoesophageal Sulcus (N = 100)

<table>
<thead>
<tr>
<th>Variable Pairs</th>
<th>No. of Dissections</th>
<th>Mean ± SE Angle, Degrees</th>
<th>t-Test</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>62</td>
<td>51 ± 2</td>
<td></td>
<td>.35</td>
</tr>
<tr>
<td>Female</td>
<td>38</td>
<td>48 ± 2</td>
<td></td>
<td>.11</td>
</tr>
<tr>
<td>White</td>
<td>64</td>
<td>48 ± 2</td>
<td></td>
<td>.26</td>
</tr>
<tr>
<td>Nonwhite</td>
<td>36</td>
<td>52 ± 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right side</td>
<td>50</td>
<td>51 ± 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left side</td>
<td>50</td>
<td>48 ± 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Knowledge of the topography of the SLN and its branches is essential for diverse surgical procedures. However, the neuroanatomy of the larynx is still a controversial issue. Most anatomical studies have emphasized the importance of preservation of the ebSLN during thyroidectomy.10 Nevertheless, knowledge of localization and anatomical variations of the ibSLN is a prerequisite for surgeons who perform operations such as sensorial denervation of the larynx for odynophagia or superior laryngeal neuralgia, preservation of the ibSLN during supraglottic laryngectomy and cervical spine procedures, restoration of laryngopharyngeal sensation by neural anastomosis between the greater auricular nerve and the ibSLN, conservation of the ibSLN in the lateral pharyngotomy, and, more recently, laryngeal transplantation.11-17

The classic description of the SLN is a constant and short trunk that divides into the internal and external branches.2,18-21 However, Kambic et al2 reported that in 5% of their dissections the ebSLN and ibSLN arose from the lower pole of the inferior ganglion of the vagus nerve. Our study demonstrated a 6% incidence of absence of the trunk of the SLN. The internal and external branches of the SLN constantly descend toward and pierce the lateral aspect of the thyrohyoid membrane and cricothyroid muscle, respectively. This pathway was observed in all our dissections and was a consensual finding in other studies.2,18-22 Nonetheless, both ibSLNs in 1 subject (2% of dissections) were characterized by a long loop caudal to the hyoid horn, followed by an ascending pathway up to penetration at the ostium of the thyrohyoid membrane.

COMMENT

The classic description of the SLN is a constant and short trunk that divides into the internal and external branches.2,18-21 However, Kambic et al2 reported that in 5% of their dissections the ebSLN and ibSLN arose from the lower pole of the inferior ganglion of the vagus nerve. Our study demonstrated a 6% incidence of absence of the trunk of the SLN. The internal and external branches of the SLN constantly descend toward and pierce the lateral aspect of the thyrohyoid membrane and cricothyroid muscle, respectively. This pathway was observed in all our dissections and was a consensual finding in other studies.2,18-22 Nonetheless, both ibSLNs in 1 subject (2% of dissections) were characterized by a long loop caudal to the hyoid horn, followed by an ascending pathway up to penetration at the ostium of the thyrohyoid membrane. During surgical procedures such as partial laryngectomies, this anatomical variation could result in an injury of the ibSLN owing to its unexpected course.

In our specimens, both the ibSLN and the ebSLN were always located medially to the carotid arteries. This seems to be the most common description of their relationship,18 even though Kambic et al2 for instance, reported that the ebSLN “descends from behind the internal carotid artery.” However, anatomical variations of this topographic relationship, such as an anterior position of the SLN on the internal carotid artery,19,20 have also been reported.21 Also, in our study, the ibSLN was always located medially to the lingual and facial arteries. Drouillas et al19 reported that the ibSLN passed laterally to the hyoid bone, followed by an ascending pathway up to penetration at the ostium of the thyrohyoid membrane. During surgical procedures such as partial laryngectomies, this anatomical variation could result in an injury of the ibSLN owing to its unexpected course.
were in a parallel and medial position to the superior laryngeal artery, whereas they were located inferiorly and medially to the superior laryngeal artery in 11% of dissections.

The length of SLN trunk was, on average, 44.9 mm, and there was no statistically significant difference regarding ethnicity (P = .57), side of the neck (P = .96), and individual height (R² = 0.01; P = .33). Durham and Harrison mentioned a limit of 20 mm for the length of the SLN trunk, and Kambic et al reported that the SLN trunk was approximately 15 mm long, but in 5% of the dissections, the 2 branches of the SLN originated from the ganglion itself. In our study, the length of the ibSLN was, on average, 44.9 mm, and there was no statistically significant difference with regard to gender (P = .91), ethnicity (P = .24), side of the neck (P = .40), and individual height. Moreover, the length of the ebSLN measured, on average, 62.6 mm and was unaffected by gender (P = .69), ethnicity (P = .42), side of the neck (P = .26), and individual height (R² = 0.01; P = .85). Thomassini described an ebSLN that was 65 mm long, whereas Kambic et al mentioned an average of 80 mm for the ebSLN. Also, in our specimens, there was no considerable difference between the right and left sides of the neck in the course of the SLN and its branches, whereas Kambic and colleagues usually found differences between the 2 sides in their dissections. Finally, the angle between the ibSLN and the tracheoesophageal sulcus was, on average, 49°, and, to our knowledge, no previous study has cited this parameter. Also, to our knowledge, this is the first study to statistically analyze the influence of gender, ethnicity, side of the neck, and individual height on the length of the trunk of the SLN, the ibSLN, and the ebSLN, as well as the angle between the ibSLN and the tracheoesophageal sulcus.

The topography of the SLN has a few anatomical variations and is unaffected by gender, ethnicity, side of the neck, and individual height, except that the SLN is longer in males than in females. These findings are important in that they can help the surgeon to prevent SLN injuries during operations such as laryngectomy, neck dissection, thyroidectomy, anterior cervical spine approach, and parathyroidectomy, as well as to plan laryngeal reinnervation and transplantation.

Moreover, this study reinforced the need for further investigation with focus on the anatomy of the SLN and its branches. Greater awareness by anatomists and surgeons regarding misrepresentation of the anatomy of the SLN and its branches would be beneficial to reduce risk of iatrogenic injury to those nerves.

Accepted for publication August 29, 2002.

This study was presented at the annual meeting of the American Head and Neck Society, Boca Raton, Fla, May 11-13, 2002.

The dissections were performed at the Obit Verifying Service of the Faculty of Medicine, University of São Paulo, São Paulo, Brazil.

We thank Margaret Allen for her assistance with the preparation of the manuscript for this article.

Corresponding author: Julio C. Furlan, MD, PhD, Mount Sinai Hospital, 600 University Ave, Suite 1521, Toronto, Ontario, Canada MSG 1X5 (email: juliofurlan@idirect.com).

REFERENCES

13. Hill JH, Olson NR. The surgical anatomy of the spinal accessory nerve and the internal branch of the superior laryngeal nerve. Laryngoscope. 1979;89:1935-1942.

CONCLUSIONS