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A Multicenter Review of Superior Laryngeal Nerve Injury Following Anterior Cervical Spine Surgery

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Abstract

Study Design: A retrospective multicenter case-series study; case report and review of the literature.

Objective: The anatomy and function of the superior laryngeal nerve (SLN) are well described; however, the consequences of SLN injury remain variable and poorly defined. The prevalence of SLN injury as a consequence of cervical spine surgery is difficult to discern as its clinical manifestations are often inconstant and frequently of a subclinical degree. A multicenter study was performed to better delineate the risk factors, prevalence, and outcomes of SLN injury.

Methods: A retrospective multicenter case-series study involving 21 high-volume surgical centers from the AO Spine North America Clinical Research Network. Medical records for 17 625 patients who received subaxial cervical spine surgery from 2005 to 2011 were reviewed to identify occurrence of 21 predefined treatment complications. Descriptive statistics were provided for baseline patient characteristics. A retrospective review of the neurosurgical literature on SLN injury was also performed.

Results: A total of 8887 patients who underwent anterior cervical spine surgery at the participating institutions were screened, and 1 case of SLN palsy was identified. The prevalence ranged from 0% to 1.25% across all centers. The patient identified underwent a C4 corpectomy. The SLN injury was identified after the patient demonstrated difficulty swallowing postoperatively. He underwent placement of a percutaneous gastrostomy tube and his SLN palsy resolved by 6 weeks.

Conclusions: This multicenter study demonstrates that identification of SLN injury occurs very infrequently. Symptomatic SLN injury is an exceedingly rare complication of anterior cervical spine surgery. The SLN is particularly vulnerable when exposing the more rostral levels of the cervical spine. Careful dissection and retraction of the longus coli may decrease the risk of SLN injury during anterior cervical surgery.

Keywords

superior laryngeal nerve, cervical spine, anterior approach, corpectomy

Introduction

The anatomy and function of the superior laryngeal nerve (SLN) are well described; however, the consequences of SLN injury remain variable and ill defined. The prevalence of SLN injury as a consequence of cervical spine surgery is difficult to discern, as its clinical manifestations are often inconstant and frequently of a subclinical degree.[1] SLN injury is best characterized in the head and neck surgery literature, where its prevalence has been reported to occur in up to 60% of conventional procedures such as total thyroidectomy.[2-4] As it pertains to cervical spine procedures, specifically anterior cervical discectomy and fusion (ACDF), SLN injury remains poorly characterized.

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Vocal cord paralysis following ACDF is traditionally attributed to recurrent laryngeal nerve (RLN) traction. However, SLN injury may also produce vocal cord paralysis in addition to reduced laryngeal sensation, dysphagia, and decreased laryngeal cough reflex predisposing to aspiration and impaired vocal quality.[2,4-8] Thus unrecognized SLN injury may be an underappreciated cause of persistent dysphonia following anterior cervical spine surgery.

The SLN is vulnerable to injury when operating at the rostral levels of the cervical spine, thus understanding its detailed anatomy and vascular supply remains critical to avoiding its stretch or ligation during cervical spine procedures.

Methods

We have conducted a retrospective multicenter study involving 21 high-volume surgical centers from the AOSpine North America Clinical Research Network, selected for their excellence in spine care and clinical research infrastructure and experience. Medical records for 17 625 patients who received cervical spine surgery (levels from C2 to C7) from January 1, 2005 to December 31, 2011, inclusive, were reviewed to identify occurrence of 21 predefined treatment complications. The complications included reintubation requiring evacuation, esophageal perforation, epidural hematoma, C5 palsy, recurrent laryngeal nerve palsy, superior laryngeal nerve palsy, hypoglossal or glossopharyngeal nerve palsy, dural tear, brachial plexopathy, blindness, graft extrusion, misplaced screws requiring reoperation, anterior cervical infection, carotid artery injury or cerebrovascular accident, vertebral artery injuries, Horner's syndrome, thoracic duct injury, tetraplegia, intraoperative death, revision of arthroplasty and, pseudomeningocele. Trained research staff at each site abstracted the data from medical records, surgical charts, radiology imaging, narratives, and other source documents for the patients who experienced one or more of the complications from the list. Data were transcribed into study-specific paper Case Report Forms (CRF). Copies of CRF forms were transferred to the AOSpine North America Clinical Research Network Methodological Core for processing, cleaning, and data entry.

Descriptive statistics were provided for baseline patient characteristics.

This study was ethically approved by the institutional ethics committees at all participating sites.

Results

In the current study involving 21 centers and 17 265 cases of cervical spine surgery, 8887 patients underwent an anterior cervical operation. In this subset of patients, 258 complications were identified. This population consisted of 141 males and 117 females with a mean age of 57.1 years (SD = 13.2) and a mean body mass index (BMI) of 28.8 kg/m^2 (SD = 6.5). The mean operative time was 212.7 minutes (SD = 110.8) and mean blood loss was 461.1 mL (SD = 725.5). A total of 139 patients (53.9%) underwent anterior surgery, 101 patients (39.1%) underwent posterior surgery, and 18 patients (7.98%) underwent combined anterior/posterior surgery. One confirmed case of transient SLN palsy was identified. The prevalence ranged from 0% to 1.25% across the various centers involved in the study.

Case Report

The SLN palsy occurred in a 51 year-old man with a BMI of 30.4 kg/m^2 who presented with severe degenerative cervical spondylosis and diffuse disc pathology at C3/4 and C4/5. Clinically, the patient endorsed neck pain, radiculopathy, and early signs of myelopathy. He underwent a C4 corpectomy and C3-5 fusion via a left sided approach. The operation lasted 357 minutes, and total blood loss was 300 mL. Although the patient was noted to have a short neck, cervical traction was not used, and his neck was not manipulated intra-operatively. Postoperatively, he complained of dysphagia and a significant alteration in voice quality. Formal otolaryngology evaluation with laryngoscopy, strobovideolaryngoscopy, and a modified barium swallow test confirmed the diagnosis of SLN palsy. The patient underwent placement of a temporary percutaneous gastrostomy tube and was discharged from the hospital 8 days later with the tube still in place. He experienced significant improvement with outpatient voice and swallowing therapy. A repeat barium swallow test 6 weeks later demonstrated normal swallowing function suggesting resolution of his SLN palsy, and the gastrostomy tube was removed.

Discussion

There are limited data regarding SLN palsy in the neurosurgical literature. Retrospective studies by Bulger et al[5] and Ballotta et al[6] reported a 1% prevalence of permanent and transient SLN palsy following ACDF and carotid endarterectomy respectively. Another study from China by Zhao et al[9] found 3 patients in 282 (1.1%) who developed SLN palsy after ACDF; all 3 cases resolved within 1 week after surgery. In this multicenter study, the prevalence ranged from 0% to 1.25%. The current study supports previous findings that SLN injury as a consequence of anterior cervical spine surgery is an extremely rare phenomenon.

Diagnosis and Treatment

The diagnosis of SLN palsy is challenging and cannot be made on clinical suspicion alone. SLN injury is almost certainly underdiagnosed. Initial evaluation of impaired phonation and dysphagia may include laryngoscopy; however, it provides variable results and may be insufficient as a stand-alone test for the diagnosis of SLN palsy. In cases where laryngoscopy is inconclusive, a definitive diagnosis requires evaluation with strobovideolaryngoscopy and laryngeal electromyography.[10] Laryngeal electromyography is also used to measure recovery and guide therapy.[10]

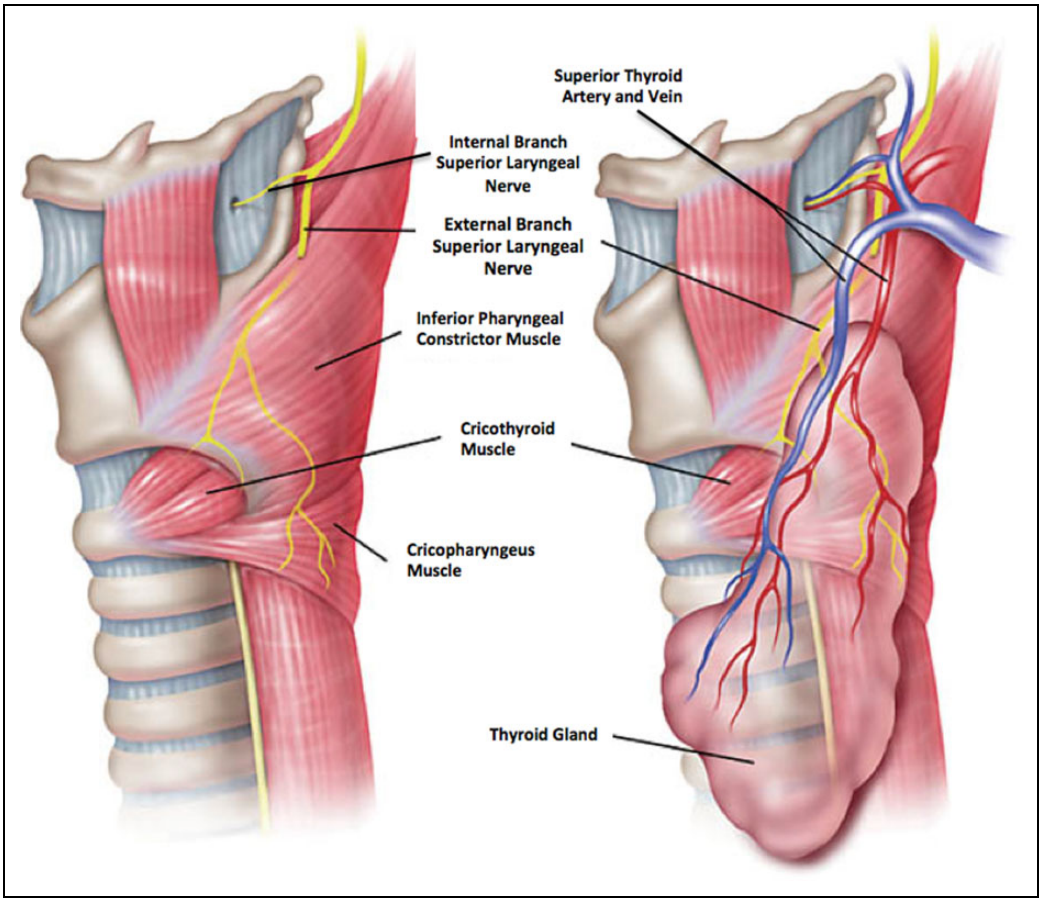

Figure 1. An overview of the superior laryngeal nerve anatomy (http://www.shifrinmd.com/sites/all/images/ebsln.jpg).

The most common therapy recommended for SLN palsy is voice therapy targeted at strengthening the cricothyroid muscle. Several surgical procedures have been described in the literature ranging from laryngoplasty and cricothyroid muscle approximation to nerve-muscle pedicle techniques for reinnervation.[2,5,11] However, most of these studies are small series that lack long-term data and require further research to delineate the role of these procedures in the treatment of SLN palsy. In cases of vocal cord paralysis, injection therapy, although temporary, is often effective in restoring the cough reflex, preventing aspiration and improving voice quality.

Early diagnosis and treatment often results in good clinical outcomes, as SLN palsy following anterior cervical surgery is transient in most cases. Patients with injury to the SLN bilaterally may have worse outcomes.[12,13] It is important to note that the prognosis of SLN injury is difficult to determine because it is extremely uncommon following anterior cervical spine surgery and the symptoms are often subclinical in nature and extent. Confirmed cases requiring treatment are likely more severe and may predispose to observational bias.[2]

Anatomic Considerations

Figure 1 provides an overview of SLN anatomy. The SLN arises from the nodose ganglion as a branch of the vagal nerve within the carotid sheath midway between the jugular foramen and the carotid bifurcation (at the level of the C2 vertebra).[2,7,12-14] It then runs medially and caudally approximately 1.5 cm toward the thyrohyoid membrane before dividing into the internal and external branches.[12]

The internal branch of the SLN is the larger of the 2 branches and continues medially with the superior laryngeal artery, which most commonly arises from the superior thyroid artery.[12] It follows a transverse trajectory as it courses inferior to the hyoid bone, pierces the thyrohyoid membrane and divides into 3 terminal branches.[2,7,12,14] The internal branch of the SLN provides sensory and parasympathetic innervation from the larynx to the level of the vocal folds in addition to a small motor branch to the interarytenoid muscle.[13] These are critical pathways mediating the afferent limb and subsequent recruitment of the laryngeal cough reflex. Parenthetically, the prevalence of aspiration pneumonitis as a consequence of anterior cervical spine surgery remains low due to the laryngeal mucosa's bilateral SLN innervation.[12,13]

The smaller external branch maintains a course medial to the carotid arteries as it runs distally toward the superior thyroid. The external branch is consistently located posterior to the superior thyroid artery, thus serving as a potential landmark.[12] It is a purely motor branch providing innervation to the inferior pharyngeal constrictor muscles and most important, the

cricothyroid. The cricothyroid muscle plays an important role in phonation by regulating tension of the vocal folds. Injury to the external branch of the SLN results in impairment of high-pitched tone and early fatiguability, an important consideration when performing anterior cervical surgery in singers.[15]

Complication Avoidance

The course and divisions of the SLN are essentially symmetric between the right and left sides of the neck, thus neither side imposes an increased risk of injury when compared with the other.[7] The trunk of the SLN and proximal divisions are at greater risk of injury during high-cervical exposures. The SLN consistently originates at the C1 or C2 level and the internal branch pierces the thyrohyoid membrane, entering the surgical field at the level of the C4 vertebral body in the majority of cases.[12,14]

After exiting the carotid sheath, the SLN courses medially and lies within the pretracheal fascia overlying the longus colli en route to the thyrohyoid membrane.[7] When exposing the higher levels of the cervical spine above the carotid bifurcation, division of the longus colli and fascia deep to the carotid arteries must be cautiously performed to avoid inadvertent injury to the trunk of the SLN. Prior to placement of self-retaining retractor blades in the upper cervical spine, it is important to adequately dissect the longus colli muscles laterally on either side of the vertebral bodies in order to ensure that the blades remain beneath the muscle layer. If the retractor blades are positioned superficial to the longus colli, they may create significant traction on one or both branches of the SLN as they course from the carotid sheath to the larynx within the pretracheal fascia.[7] As the external branch takes an aggressive medial course, it is less vulnerable to injury during this portion of the exposure compared with the internal branch, which takes off at a more acute angle from the trunk of the SLN.

The superior thyroid artery serves as a useful landmark for the SLN, as both internal and external branches arise near it. Therefore, aggressive dissection near the artery or bipolar cautery may cause injury to the proximal portions of one or both divisions of the SLN.[7,12] The external branch is more vulnerable to injury than the internal branch during ligation of the superior thyroid artery, as the distal portions lie immediately deep to the artery.[16] Identification of the cricothyroid muscle and the upper lobe of the thyroid gland are useful landmarks for the external branch.[7] Once the self-retaining retractor blades are appropriately placed, care should be taken to limit dissection and electrocautery to the confines of the blades to avoid injury to the distal divisions of the SLN, especially the internal branch. The cricrothyroid artery and superior laryngeal arteries run closely with the external and internal branches, respectively.[7] Excessive distraction of the retractor blades medially may cause bleeding from either of these arteries prompting excessive use of bipolar electrocautery along the pretrachial fascia, that could lead to injury to either division of the SLN.[7]

Exposing the anterior cervical spine is more challenging in patients who have undergone prior neck surgery due scar tissue formation and altered anatomy. Patients who undergo multilevel spine surgery or a corpectomy require additional tissue dissection that may increase the risk of SLN injury. Intraoperative neuromonitoring with electromyography may be useful in avoiding SLN injury during difficult cases or those requiring a more difficult exposure.[17,18] Jonas and Bahr[18] described a technique for monitoring the external branch of the SLN during thyroid surgery by placing a bipolar electrode in the cricothyroid muscle and stimulating the nerve or suspected nerve with a nerve stimulator. They found the technique 97% effective in both positive and negative identification of the external SLN.[18]

Conclusion

SLN injury following anterior cervical surgery is an extremely rare phenomenon. However, the true prevalence is likely higher than reported in the spine literature as the signs and symptoms of SLN palsy are often subtle and transient. Meticulous dissection, thoughtful retraction, and a comprehensive understanding of anatomic constraints are suggested to minimize prevalence of SLN injury.

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