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Case Report

Intraoperative Mapping and Monitoring of Sensory Vagal Fibers During Vagal Schwannoma Resection

Catherine F. Sinclair, Bsc (Biomedical), MBBS (Hons)*; Maria J. Téllez, MD*; M. Angeles Sánchez Roldán, MD; Mark Urken, MD; Sedat Ulkatan, MD*

Vagal schwannomas are rare, benign tumors. Intermittent intraoperative neuromonitoring via selective stimulation of splayed motor fibers running on the schwannoma surface to elicit a compound muscle action potential has been previously reported as a method of preserving vagal motor fibers. In this case report, vagal sensory fibers are mapped and continuously monitored intraoperatively during high vagus schwannoma resection using the laryngeal adductor reflex (LAR). Mapping of nerve fibers on the schwannoma surface enabled identification of sensory fibers. Continuous LAR monitoring during schwannoma subcapsular microsurgical dissection enabled sensory (and motor) vagal fibers to be monitored in real time with excellent postoperative functional outcomes.

Key Words: Neurolaryngology, swallowing/dysphagia, schwannoma, neural monitoring.

INTRODUCTION

The vagus nerve is a mixed cranial nerve with sensory, motor, and autonomic fibers. Injury to the nerve or its peripheral branches during surgical procedures can result in significant patient morbidity affecting voice, swallowing, and respiration.

Established intraoperative neuromonitoring (IONM) techniques for the vagus nerve have played a critical role in identifying and monitoring vagal motor fibers by eliciting a compound muscle action potential (CMAP) that manifests as vocal fold contraction. This contractile activity is detected by surface electrodes on the endotracheal tube (ETT). Motor fiber activation within the vagus or recurrent laryngeal nerves (RLN) is usually performed by intermittent, direct nerve stimulation with a handheld probe in the surgically exposed field. Monitoring of motor fibers can be performed by continuous electrical stimulation (continuous intraoperative nerve monitoring, CIONM) of the vagus nerve using a circumferential nerve electrode. Although motor fibers can be identified and monitored by these techniques, there has been no way of identifying and monitoring sensory vagal fibers.

In 2017, a novel methodology was introduced to continuously monitor vagal and RLN motor fibers using the laryngeal adductor reflex (LAR), termed LAR-CIONM.1-3 The LAR is a brainstem reflex initiated by supraglottic irritation. Afferenent information is carried by the internal branch of the superior laryngeal nerve (IBSLN) to the medulla oblongata, with motor fibers of the vagus nerve (via the RLN) activating laryngeal adductor musculature to initiate vocal fold contraction and airway protection. Previous publications have reported on the utility of this technique for continuously monitoring vagus nerve motor fibers during neck endocrine, cervical spine, and lower brainstem procedures.1,2,4,5 Due to the anatomical separation of afferent and efferent limbs of the reflex, it was hypothesized that mapping and monitoring of vagus nerve sensory fibers may also be possible using the LAR.

Vagal schwannomas are rare, benign tumors of the head and neck. Although surgical resection for large or symptomatic lesions is the standard of care, nerve sacrifice at the time of resection is associated with significant morbidity. A subcapsular microsurgical technique of schwannoma excision has been developed to improve patient functional outcomes, with schwannoma recurrence rates reportedly similar to traditional en bloc resection techniques.6 Intermittent intraoperative nerve monitoring with selective stimulation of splayed motor fibers running over the surface of the schwannoma has been used to map and preserve vagal nerve motor fibers prior to subcapsular microsurgical tumor removal.7,8 In this case report of a high vagal nerve schwannoma, the LAR was utilized to identify, map, and monitor sensory (in addition to motor) nerve fibers on the surface of the tumor prior to capsule incision and tumor enucleation.
METHODS

For detailed methodology of LAR-CIONM for vagal and RLN motor fibers, please refer to prior publications on this topic.1–3 For LAR-CIONM of sensory nerve fibers, the methodology varies somewhat because the LAR is elicited by ETT electrode stimulation of supraglottic mucosa ipsilateral to the IBSLN at risk and is recorded from the contralateral/vocal fold supplied by RLN motor fibers not at risk running in the contralateral neck. This setup minimizes the risk of coincident efferent pathway impairment being a possible cause for LAR amplitude changes, ensuring that any observed intraoperative LAR amplitude variations are due to changes in afferent input at the level of the larynx or supraglottic mucosa.
to afferent pathway impairment from ipsilateral IBSLN stress. For sensory fiber mapping using the LAR, visualized nerve fibers are directly stimulated with a handheld neuroprobe, and LAR responses are recorded from bilateral ETT electrodes.

This study received institutional review board exemption (Program for Protection of Human Subjects, Icahn School of Medicine at Mount Sinai, New York, NY).

CASE REPORT

A 46-year-old female presented with a progressively enlarging right vagal schwannoma at cervical vertebra (C)1/C2 to C4/C5 levels (Fig. 1A). Preoperative laryngeal examination showed grossly normal laryngeal sensation with decreased motion of the right vocal fold. Intraoperatively, the schwannoma extended high into the neck with involvement of the IBSLN origin. Visible nerve fascicles running on the schwannoma surface were mapped using a bipolar probe (Inomed Medizintechnik GmbH, Emmendingen, Germany) at 1 mA intensity and 1 Hz repetition rate. RLN motor fibers were identified when stimulation elicited a CMAP from laryngeal muscles, recorded with the electromyographic endotracheal tube (EMG-ETT) (Fig. 1B). Sensory fibers were identified when LAR responses were recorded on the EMG-ETT and were distinguished from RLN CMAPs by latency and morphology. When stimulating the vagus nerve proximal to the IBSLN branch point, both CMAP and LAR responses were obtained (Fig. 1B). The course of both motor and sensory fibers of the vagus nerve that supply laryngeal structures were thereby identified on the surface of the tumor and secured. An incision into the schwannoma capsule was made away from the identified nerve fibers. Using microsurgical techniques, the schwannoma was carefully dissected free from its capsule in a 360-degree manner and removed en bloc. During schwannoma dissection, sensory and motor functions of the vagus nerve were continuously monitored using LAR-CIONM by alternately eliciting the LAR in the right and left vocal folds (Fig. 1C). Transient declines in amplitude were managed with procedure cessation, tissue relaxation, and irrigation until amplitude recovery occurred. At completion of the surgery, nerve fascicles within the thin schwannoma capsule remained functionally intact to direct stimulation. Closing LAR amplitudes were comparable to opening amplitudes. Postoperative modified barium swallow test showed no dysphagia, laryngeal penetration, or aspiration. Fiberoptic laryngoscopy revealed preservation of vocal fold mobility and a strong cough reflex on ipsilateral supraglottic stimulation.

DISCUSSION

This case report demonstrates the feasibility of identifying, mapping, and continuously monitoring peripheral sensory vagus nerve fibers during vagal schwannoma resection. By intermittent direct nerve fiber stimulation, sensory fibers were mapped on the surface on the schwannoma and differentiated from motor fibers within the vagus nerve. By mucosal LAR elicitation, sensory and motor vagal fibers were continuously monitored in real time. To our knowledge, this is the first report of sensory vagus nerve monitoring, either intermittent or continuous, during head and neck surgical procedures. This patient had excellent functional outcomes; however, a prospective trial is necessary to prove correlation between functional outcome and sensory vagus nerve fiber preservation.

Sensory LAR mapping and monitoring may be applicable to other surgeries in which sensory vagal fibers and IBSLN are at risk of injury. During high anterior cervical spine approaches involving C2 and C3 vertebral levels, the IBSLN is at risk of injury either from direct trauma during the anterior approach or from traction secondary to retractor placement. Mapping for IBSLN location prior to retractor placement and continuously monitoring IBSLN function throughout the procedure are two techniques frequently utilized by our group to prevent iatrogenic nerve damage. Prospective studies are needed to assess the utility of sensory LAR monitoring in optimizing patient functional swallowing outcomes after high cervical spine surgeries. Sensory LAR mapping may also be useful in brainstem surgeries to identify sensory vagal nuclei during proximate neurosurgical procedures. This hypothesis remains to be clinically tested.

CONCLUSION

This case report demonstrates that peripheral mapping and continuous monitoring of vagus nerve sensory fibers is possible during surgeries in which the fibers are at risk of injury. By mapping, IBSLN sensory fibers on the tumor surface could be identified and spared. By continuous monitoring, real-time information about functional sensory nerve integrity was gained. Sensory vagus mapping and monitoring using the LAR is an advance in the field of intraoperative vagus nerve monitoring. Future prospective studies will determine whether this advance translates into improved patient functional outcomes.

BIBLIOGRAPHY