The Laryngoscope

How I Do It

Selective Reinnervation for Bilateral Vocal Cord Paralysis Using the Superior Laryngeal Nerve

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INTRODUCTION

Bilateral vocal fold paralysis is an uncommon but potentially life-threatening condition that can be very difficult to treat. Thyroidectomy remains the most common cause of bilateral vocal fold paralysis.[1] Current treatments can be divided into two groups: static and dynamic reconstruction. The vast majority of techniques currently performed are static techniques, which often trade increased airflow for decreased voice and potential aspiration.[2] Dynamic reconstruction utilizing the phrenic nerve has been performed in humans; however, the potential risks to the hemidiaphragm are often unacceptable to patients who have already compromised respiratory function[3]

It is well known that the cricothyroid muscle is active in respiration,[4] although its role is not entirely clear. Previous reports have demonstrated that the muscle contracts simultaneously with the posterior cricoarytenoid muscle (PCA). Furthermore, the ability of the external branch of the superior laryngeal nerve (EBSLN) to drive the PCA has been previously demonstrated in a feline model.[4,5] Here, we report the first two cases of selective reinnervation of the PCA utilizing the EBSLN with good postoperative results.

MATERIALS AND METHODS

Two patients with bilateral vocal fold paralysis elected to undergo this procedure. The first patient had a history of MEN-1 and had undergone four separate parathyroidectomies for treatment of hyperparathyroidism and presented to us with increasing dyspnea on exertion. The second patient underwent a total thyroidectomy for papillary thyroid carcinoma, resulting in severe dyspnea and stridor, and was diagnosed with bilateral vocal cord paralysis. Both patients desired an improved airway without sacrificing voice and potential for aspiration associated with static procedures. However, neither was willing to accept the potential risk of hemidiaphram paralysis secondary to phrenic nerve transfer.

Surgical Technique

A horizontal skin incision was made at the level of the cricoid, and the larynx was exposed.

Isolation of the Ansa Cervicalis

The ipsilateral ansa cervicalis was exposed where it runs along the surface of the internal jugular vein. The branches to the omohyoid and sternothyroid branches were dissected free and tagged. Stimulation of both the anterior and posterior roots was performed at 1 mA to ensure proper sternothyroid function and viability of the nerve for reinnervation.

Isolation of the External Branch of the Superior Laryngeal Nerve

The external branch of the superior laryngeal nerve is located just inferior to the oblique line, running just deep to the sternothyroid muscle attachment. After identifying the nerve and stimulating it at 1 mA with an observed cricothyroid muscle twitch, the nerve was dissected into the cricothyroid muscle belly. The nerve was cut and tagged (Figure 1).

Exposure of the Intralaryngeal Portion of the Recurrent Laryngeal Nerve

The thyroid cartilage was exposed. The inferior constrictor and cricopharyngeus was sectioned to expose the entire posterior aspect of the thyroid cartilage. The piriform sinus was mobilized to expose the posterior cricoarytenoid muscle to the muscular process, and the space up and above the muscular process of the arytenoid was exposed as well. The intralaryngeal portion of the recurrent laryngeal nerve (RLN) is located just posterior to the cricothyroid joint, medial to the edge of the PCA. In both cases, a previously cut nerve was identified below the cricopharyngeus muscle, with positive identification of a free nerve ending at the level of the cricothyroid joint (Figure 1).

Additional Supporting Information may be found in the online version of this article.

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Editor's Note: This Manuscript was accepted for publication May 18, 2015.

Presented at the Fall Voice Conference, San Antonio, Texas, October 25, 2014

The authors have no funding, financial relationships, or conflicts of interest to disclose.

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DOI: 10.1002/lary.25430

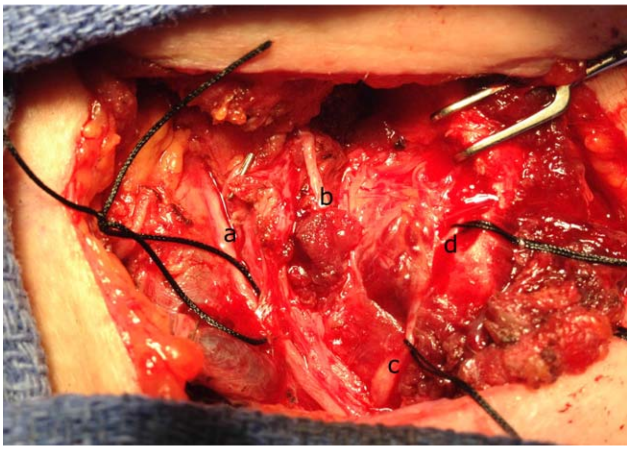

Fig. 1. Nerve dissection. (a) Ansa cervicalis, (b) external branch superior laryngeal nerve with cuff of cricothyroid muscle, (c) main trunk recurrent laryngeal nerve, and (d) adductor branch of the recurrent laryngeal nerve. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Exposure of the Branches to the Lateral Cricoarytenoid and Thyroarytenoid Muscles

The intralaryngeal portion of the RLN was dissected superiorly, staying between the PCA muscle and the posterior border of the thyroid cartilage. Removal of a portion of the thyroid cartilage can be performed to improve exposure. The nerve changes course from vertical to horizontal just below the muscular process of the arytenoid at the level of the superior border of the cricoid. At this point, it had given off branches to the posterior cricoarytenoid muscle and interarytenoid muscles and was only supplying the lateral cricoarytenoid and thyroarytenoid muscles.

Sectioning of the Interarytenoid Muscle or Nerve

Because it is difficult to isolate the nerve branch to the interarytenoid muscle, the muscle can either be denervated by sectioning all the nerve fibers travelling superior to the superior aspect of the posterior cricoarytenoid or by physically cutting the interarytenoid (IA) muscle. The latter can be performed by further dissecting the hypopharyngeal mucosa superiorly and identifying the muscle belly of the interarytenoid as is crosses from one arytenoid to the other. The muscle can be then be divided. Care must be taken to avoid entry into the posterior larynx.

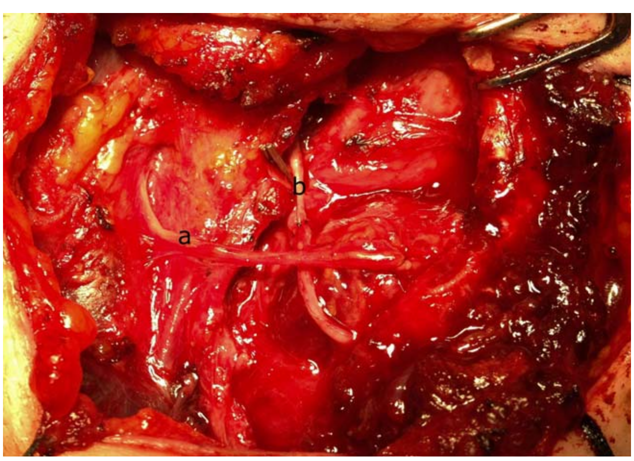

Fig. 2. Nerve anastomosis. (a) Ansa cervicalis to adductor branch of the recurrent laryngeal nerve. (b) External branch superior laryngeal nerve to main trunk of the recurrent laryngeal nerve. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Microsurgical Anastomosis of the Nerves

The cut end of the recurrent laryngeal nerve, now only innervating the PCA, and the distal adductor nerve trunk, with branches to the lateral cricoarytenoid and thyroarytenoid muscles, were trimmed and the edges freshened. The donor nerves were prepared similarly. They were both tunneled under the strap muscles, and then the EBSLN was anastomosed to the RLN and the ansa cervicalis was anastomosed to the distal adductor nerve trunk using 8-0 nylon under magnification (Figure 2).

RESULTS

Both patients had excellent outcomes, eventually resulting in decannulation and restoration of adequate glottis opening. Both had improved physiologic positioning of the vocal folds at 3 months, with posterior rotation of the prolapsed arytenoid and improvement in abduction at 7 months (Supp. video S1, S2). The second patient had some increased abduction on the contralateral side shortly after the surgery. The motion improvement in the second patient appeared greater than the first Supp video S2. Both had excellent vocal quality, although the second

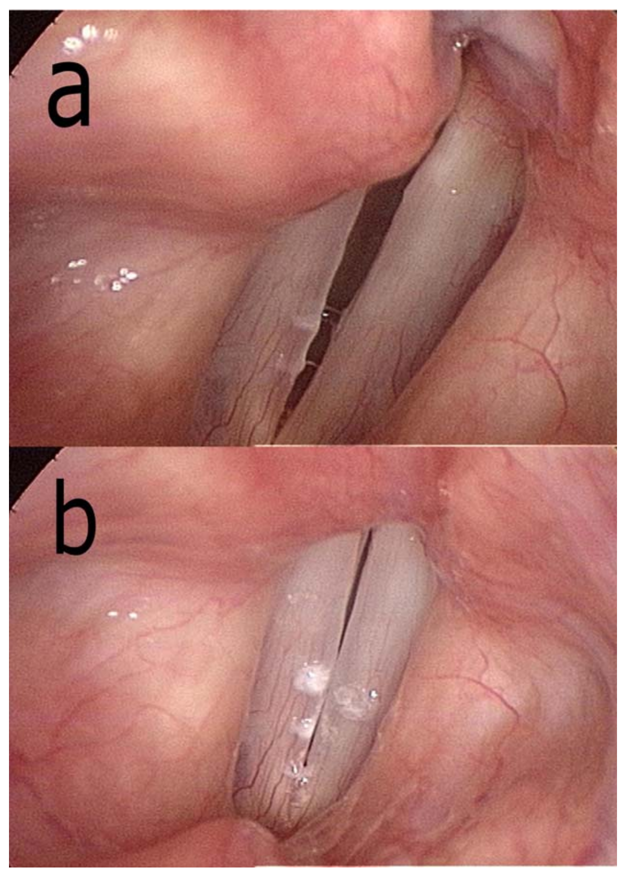

Fig. 3. Preoperative examination. (a) Maximal abduction. (b) Maximal adduction. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

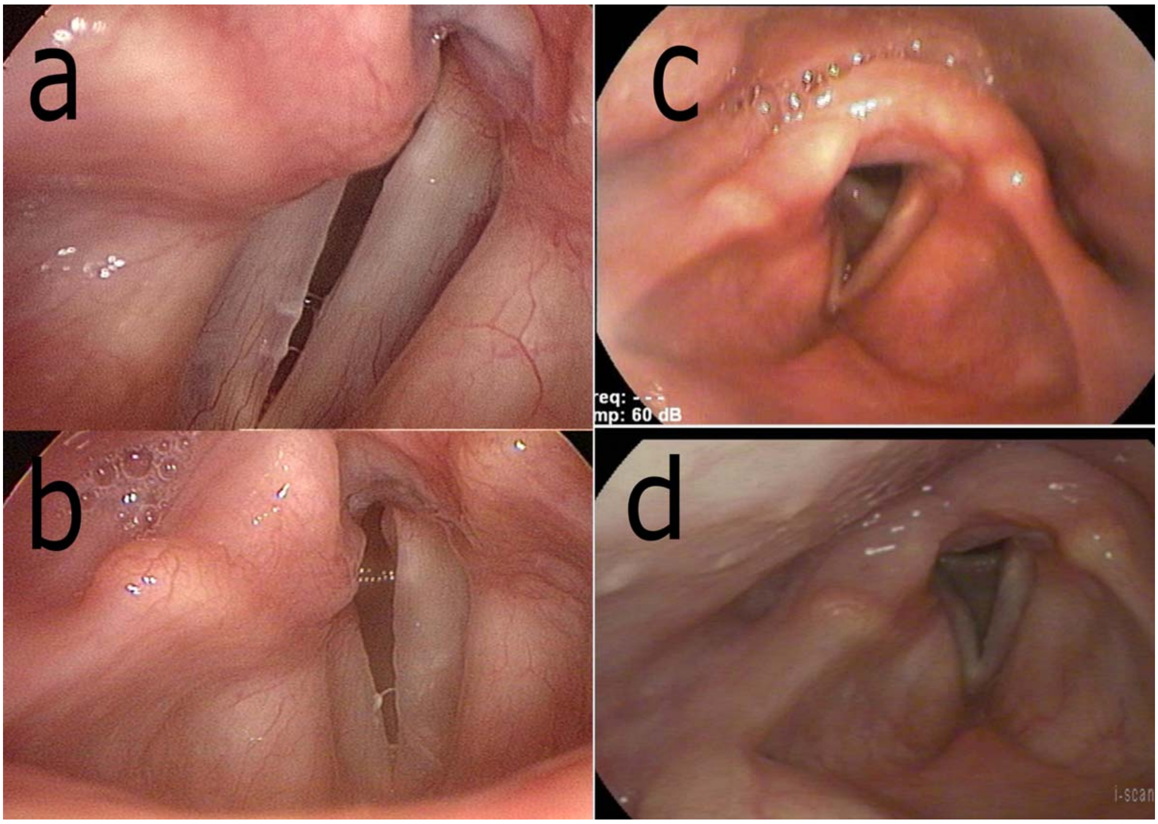

Fig. 4. Postoperative examination showing maximal abduction at 3 (b), 7 (c) and 11 months (d). Preoperative examination showing maximal abduction shown for reference (a). [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

patient required speech therapy. Figures 3 and 4 show the preoperative and postoperative laryngeal function of the second patient.

DISCUSSION

Properly performed, a dynamic reinnervation has the potential to give the patient with bilateral vocal fold paralysis a far superior outcome than a static reconstruction because both airway and voice can be preserved. However, the benefits of the surgery require the patient to wait about 6 months or more, and the surgery is more technically challenging to perform as well. It is often difficult to interest the patient in a surgery for which the dividends arrive in the long-term future. Results from phrenic nerve reinnervation have been promising[6]; however, risks to the hemidiaphram and need for a cable graft to reach the larynx are significant limitations of the surgery

Reinnervation of the PCA to restore dynamic glottal opening has some important requirements: First, an adequate donor nerve must be selected that can adequately reach (or be connected utilizing a cable graft) the target muscle. Second, the donor nerve must be active during inspiration to physiologically activate the muscle. Third, inadvertent reinnervation of the adductor musculature must be avoided to prevent synkinetic motion.

The EBSLN is active in respiration and directly corresponds with PCA activity.[4,7] Woodson (1990)[4] demonstrated that the cricothyroid is activated in awake humans both during airway occlusion and deep respiration. Furthermore, the EBSLN is within the immediate area of the larynx and can be dissected back to the common trunk of the superior laryngeal nerve deep to the carotid artery if additional length is needed. The size and caliber of the nerve is an excellent match for the intralaryngeal portion of the recurrent laryngeal nerve.[8]

Finally, a direct connection from the EBSLN into the PCA branches is extremely difficult due to the complex anatomy of the intralaryngeal RLN contributions to the PCA. Nguyen et al. (1989)[9] described multiple variations of the PCA branch, demonstrating that in some cases the IA and one of the PCA branches share a common trunk. However, Prades et al. (2005) and Maranillo et al. (2005)[10,11] noted that the PCA branch shares a common trunk with the IA in up to 88% of the cadavers that they studied. Furthermore, the division of the IA branch from the intralaryngeal component of the RLN typically occurs deep to the PCA muscle,[12] and although dissection in a cadaver is feasible, dissection in a live human may disrupt the function of the muscle. Given the difficulty, we elected to simply section the nerve in the first case and the muscle in the second case, with good results. Sectioning of the muscle presents an additional advantage of disrupting any synkinetic contraction from the contralateral injured recurrent laryngeal nerve. In fact, we noted some improvement in the motion of the contralateral side in our second patient almost immediately after surgery.

CONCLUSION

The method presented here represents a novel surgical procedure for bilateral vocal fold paralysis that produces results equal to or superior to phrenic reinnervation. The immediate availability of the superior laryngeal nerve eliminates the need for an interposition graft, and there is no risk of hemidiaphragm paralysis. Compared to a posterior cordotomy, the achievable airway diameter is far larger, without risk of aspiration or significant vocal changes. A significant disadvantage is that an intact EBSLN may not be available in patients who have undergone thyroid surgery, although in both cases reported here an intact nerve was present. Furthermore, like all reinnervation surgery, time is required to see improvement. This results in a delay in decannulation for several months, which is a strong deterrent to many patients.

Acknowledgment

The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

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