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Clinical Record

Electromyography of the cricoarytenoid unit during supracricoid laryngectomy with a cricohyoidoepiglottopexy procedure

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Abstract

Two patients who received supracricoid laryngectomy with cricohyoidoepiglottopexy to treat laryngeal cancers, underwent intra-operative electromyography analysis. After the lesion was removed and the electrodes were inserted into the remaining intrinsic laryngeal muscles, the depth of anaesthesia was carefully reduced. Gentle tactile stimulations were applied to the pharynx to trigger the reflex movement of the remaining arytenoids. Recordings were made when reflex movement was achieved.

Case one: Electromyography (EMG) of the remaining arytenoid demonstrated clear phase differences indicating reciprocal activities between the adductor group (lateral cricoarytenoid muscle, interarytenoid muscle) and the abductor muscle (posterior cricoarytenoid muscle). Case two: EMG of the remaining arytenoid demonstrated reciprocal activities between the interarytenoid muscle and the posterior cricoarytenoid muscle. Activity of the lateral cricoarytenoid muscle was not evident because the muscle was excised during removal of the paraglottic space. Mobility of the arytenoid was attributed to interaction between the interarytenoid muscle and posterior cricoarytenoid muscle. Reciprocal interaction between the interarytenoid muscle and posterior cricoarytenoid muscle alone is also capable of maintaining post-operative laryngeal functions after supracricoid laryngectomy with cricohyoidoepiglottopexy.

Key words: Laryngeal Neoplasms; Laryngectomy; Laryngeal Muscles; Electromyography

Introduction

Supracricoid laryngectomy with cricohyoidoepiglottopexy is an organ preservation surgery designed for T_2 and selected T_3, T_4 laryngeal cancers. After Majer first described the surgical concept in 1959,[1] the technique was refined and promoted by H Laccourreye and JJ Pique in France and other European countries in the 70s and 80s.[2,3] Supracricoid laryngectomy with cricohyoidoepiglottopexy gained further attention worldwide in the 90s due to the superior post-operative oncological and functional results reported in several English-language publications.[4–8] Together with conventional procedures for partial laryngectomy, this procedure has become one of the major surgical options in current laryngeal preservation strategies.

In this procedure, the entire thyroid cartilage is resected along with the tumour-bearing glottis; the remaining cricoid cartilage with one or two arytenoids is approximated to the hyoid bone thus forming a neo-glottis. Post-operative deglutition and phonation are achieved by the interaction of the arytenoids and the epiglottis.[9] The fundamental anatomical structure that allows speech and swallowing without a permanent tracheostomy is the cricoarytenoid unit.[10] The lateral cricoarytenoid (adductor), interarytenoid (adductor), and posterior cricoarytenoid (abductor) muscles are the three major intrinsic laryngeal muscles attached to the unit and hence known to be responsible for the mobility of the remaining arytenoids. However, there is no evidence showing whether these muscles actually interact with each other and contribute to the mobility of the arytenoids after supracricoid laryngectomy with cricohyoidoepiglottopexy. By analysing the electromyography (EMG) of the muscles associated with the cricoarytenoid unit during the surgical process, we intended to shed light on the mechanism of the cricoarytenoid unit, which sustains essential laryngeal functions after the procedure.

Case reports

Two patients, who received supracricoid laryngectomy with cricohyoidoepiglottopexy as a treatment for laryngeal cancer, underwent EMG analysis. A neuropack MEB-2208 (Nihon Kohden Corporation, Tokyo, Japan) was used for analysis.

As a routine surgical process, after the tumour-bearing larynx is removed, the key surgical margins were submitted as frozen sections for pathological diagnosis. EMG analysis was performed while waiting for the pathological findings. Three to four sets of bipolar electrodes plus the grounding electrode were inserted into the elected muscles (Figure 1). After these insertions and the wire connections to the detector were completed, the depth of anaesthesia was

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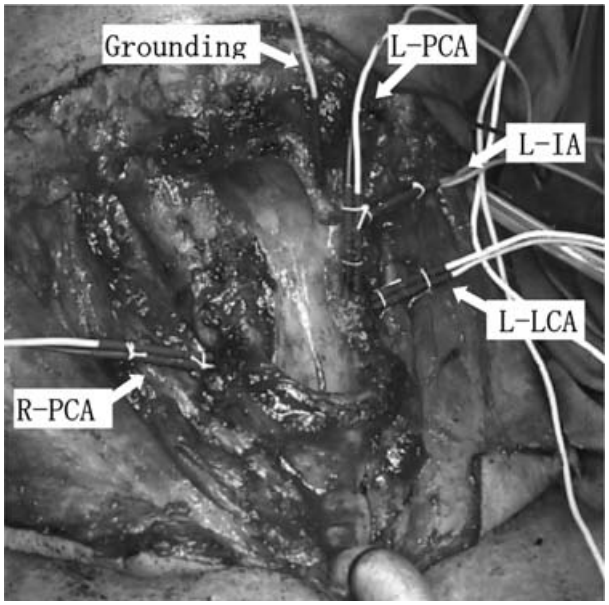

FIG. 1

Electromyographic analysis of the cricoarytenoid unit during the SCL-CHEP procedure (Case one). L-PCA = left posterior cricoarytenoid muscle; L-IA = left interarytenoid muscle; L-LCA = left lateral cricoarytenoid muscle; R-PCA = right posterior cricoarytenoid muscle

carefully reduced. During the evaluation, instillation of pain medication was continued to reduce adverse changes in vital signs. When a reduced level of anaesthetic depth was attained, gentle tactile stimulations were applied to the pharynx to trigger reflex movement of the remaining arytenoids in the form of repetitive opening and closing gestures of the glottis. EMG recordings were obtained when reflex was achieved.

The ethical aspect of this intra-operative EMG analysis was approved by the university hospital institutional review board. Before surgery, the purpose and whole process of EMG analysis was explained to the patients. Analysis was scheduled to be suspended if any adverse changes in medical conditions occurred or a recommendation of termination was advised by the anaesthesiologist.

Case one

Case one was a 70-year-old male with a $T_3N_0M_0$ glottic carcinoma. The tumour invaded the entire right fold and extended into the right paraglottic space with mobile folds. Supracricoid laryngectomy with cricohyoidoepiglottopexy was performed and the anterior half of the right arytenoid cartilage was removed along with the tumour-bearing larynx. The entire left arytenoid posterior to the vocal process was preserved along with three surrounding intact intrinsic laryngeal muscles. Four sets of EMG bipolar electrodes were inserted into the 1) left lateral cricoarytenoid muscle, 2) left interarytenoid muscle, 3) left posterior cricoarytenoid muscle, and 4) right posterior cricoarytenoid muscle (Figure 1).

EMG analysis of the reflex movement of the left arytenoid demonstrated a certain extent of activities that were associated with muscle contractions of all four muscles. The amplitudes of EMG activity were between 150 and 200 uV for the posterior cricoarytenoid muscle and the lateral cricoarytenoid muscle, and between 25 to 50 uV for the interarytenoid muscle. The apparent duration of each contraction was between 1.5 to 2 seconds for each of the four muscles. Clear phase differences indicating reciprocal activities were observed between the adductor group (lateral cricoarytenoid muscle, interarytenoid muscle) and abductor muscle (posterior cricoarytenoid muscle) (Figure 2).

The patient's post-operative course was uneventful and he achieved satisfactory laryngeal functions for phonation and deglutition two months post-operatively. In this case, the mobility of the remaining arytenoid was fully attributed to the three intrinsic laryngeal muscles attached to the cricoarytenoid unit.

Case two

Case two was a 69-year-old male patient with an untreated $T_3N_0M_0$ glottic carcinoma. The tumour invaded the bilateral vocal folds and extended deeply into both paraglottic spaces with mobile folds. Supracricoid laryngectomy with cricohyoidoepiglottopexy was performed and the anterior two thirds of the right arytenoid cartilage was resected along with the tumour-bearing larynx. The left arytenoid cartilage posterior to the vocal process was preserved together with two intact intrinsic laryngeal muscles; the interarytenoid muscle and the posterior cricoarytenoid muscle. Most of the left lateral cricoarytenoid muscle was excised as a result of the complete removal of the bilateral paraglottic spaces. Three sets of EMG bipolar electrodes were inserted into the 1) remaining portion of the left lateral cricoarytenoid muscle, 2) left interarytenoid muscle, and 3) left posterior cricoarytenoid muscle.

EMG analysis of the reflex movement of the left arytenoid demonstrated activation of the two muscles; the interarytenoid muscle and the posterior cricoarytenoid muscle. Only minimal activity could be observed from the left lateral cricoarytenoid muscle throughout the analysis. The amplitudes of the contraction activities were approximately 1 mV for the interarytenoid muscle and 2 mV for the posterior cricoarytenoid muscle. Apparent duration of each contraction was approximately 0.8 to 1 second for both the interarytenoid muscle and posterior cricoarytenoid muscle. Clear phase differences indicating reciprocal activities were observed between the interarytenoid muscle and the posterior cricoarytenoid muscle (Figure 3).

The patient's post-operative course was prolonged by local infection but satisfactory laryngeal functions were eventually achieved nine months post-operatively. A fibrescopic view of the neo-glottis 20 months after surgery demonstrated excellent mobility of the only remaining left arytenoid (Figure 4). In this case, the mobility of the arytenoid was attributed to the interaction between the interarytenoid muscle and posterior cricoarytenoid muscle.

Discussion

Due to the large proportion of early stage glottic carcinoma and the well established treatment options, such as radiotherapy and total laryngectomy, laryngeal cancer has become one of the head and neck cancers with an excellent prognosis. Clinical attention has gradually shifted from the prognostic to the functional aspects of this particular disease. Over the past several decades, efforts have been made to find better treatment options capable of preserving the natural airway, while avoiding permanent tracheostomy. Supracricoid laryngectomy with cricohyoidoepiglottopexy has become one of the major organ-preservation surgeries because of the stable and reliable oncological and functional results. Although an intensive rehabilitation process is needed, most patients are able to restore normal swallowing within a year without requiring gastrostomy or tracheostomy.[11,12] The voice after the procedure is rough and less efficient compared with that of

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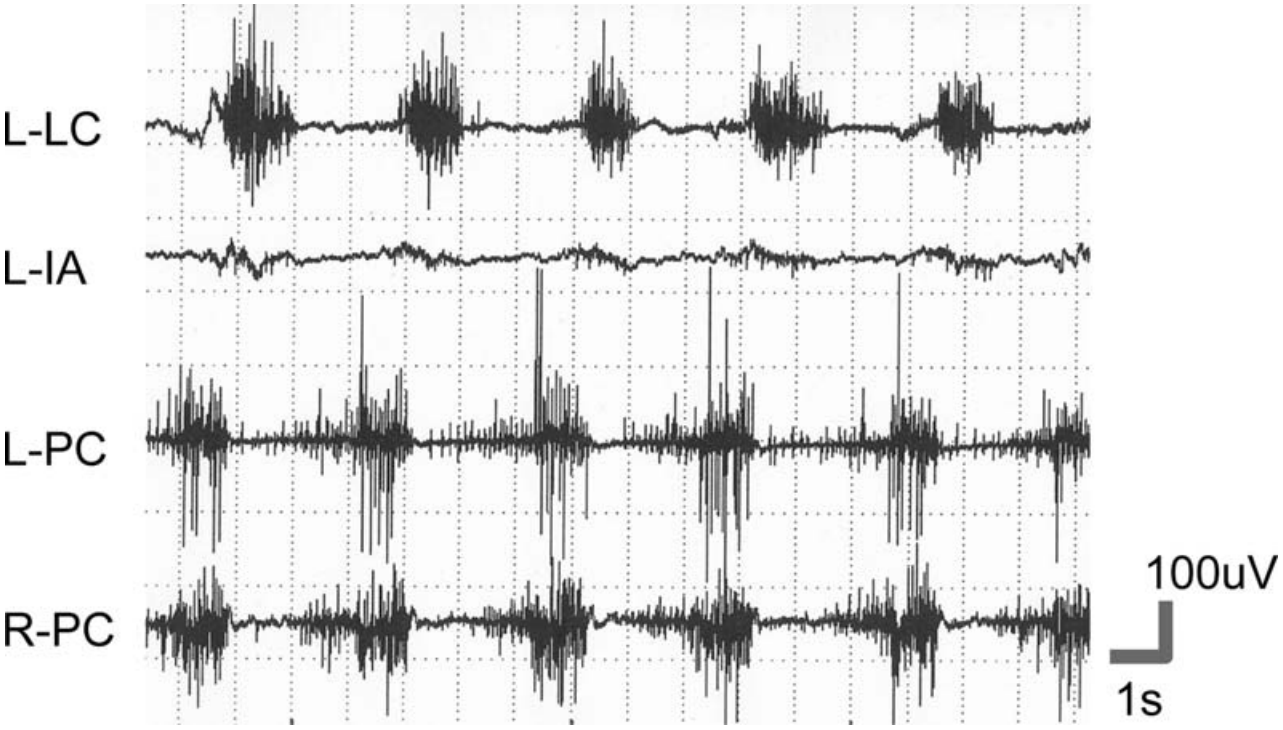

FIG. 2

Results of EMG analysis from Case one. Clear phase differences indicating reciprocal activities were observed between the adductor group and the abductor muscle. L–LCA = left lateral cricoarytenoid muscle; L–IA = left interarytenoid muscle; L–PCA = left posterior cricoarytenoid muscle; R–PCA = right posterior cricoarytenoid muscle

normal speakers but it is adequate for most social interactions.[13,14]

The cricoarytenoid unit composed of the arytenoid cartilages, cricoid cartilage, cricoarytenoid muscles, and recurrent laryngeal nerves is the basic functional unit that allows speech and swallowing after supracricoid laryngectomy with cricohyoidoepiglottopexy.[10] Based on the anatomical dispositions, the three intrinsic laryngeal muscles,

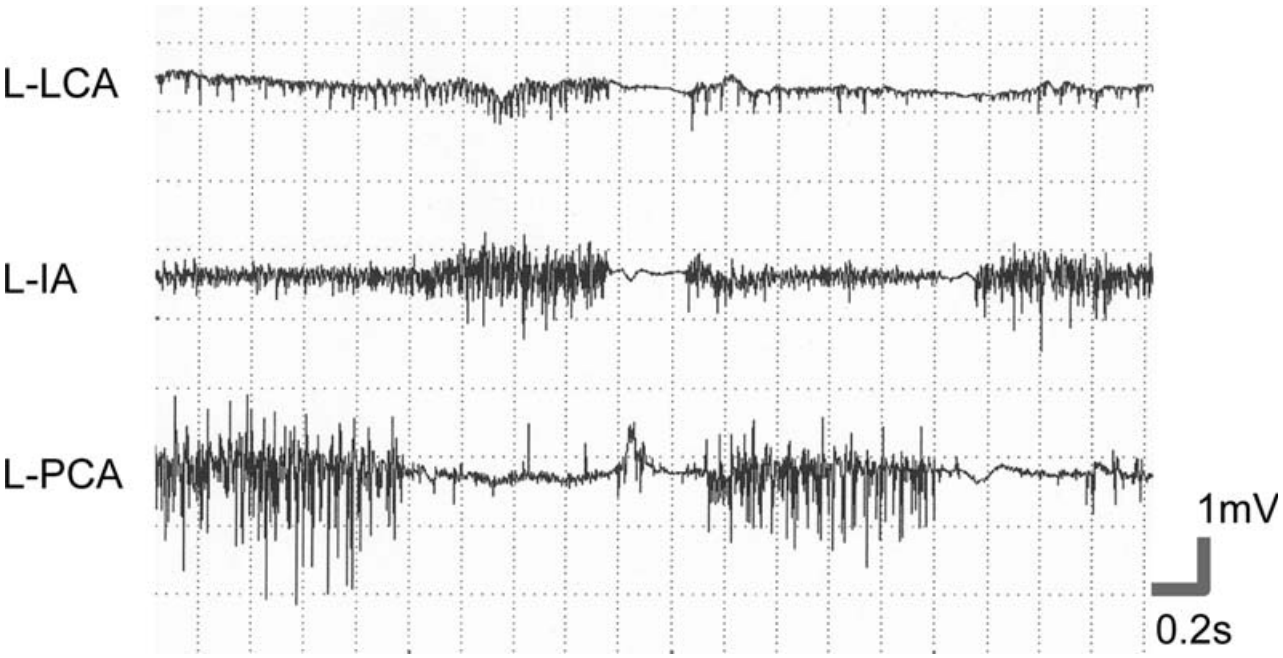

FIG. 3

Results of EMG analysis from Case two. Clear phase differences indicating reciprocal activities were observed between the interarytenoid and the posterior cricoarytenoid muscle. L–LCA = left lateral cricoarytenoid muscle; L–IA = left interarytenoid muscle; L–PCA = left posterior cricoarytenoid muscle

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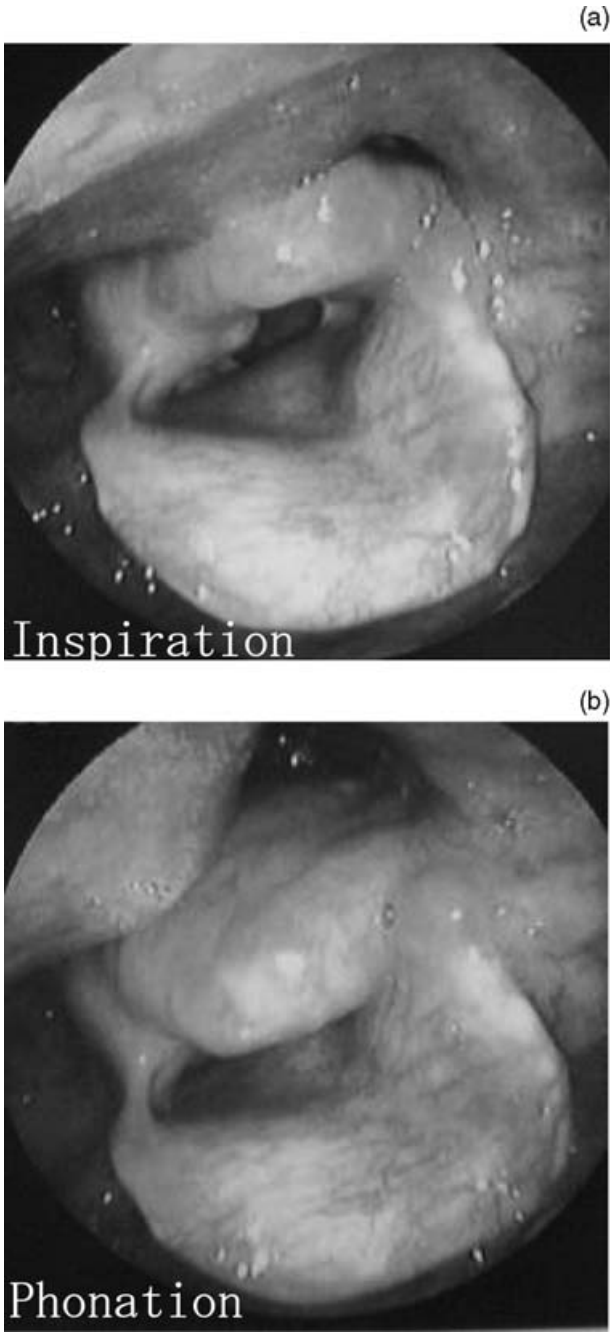

FIG. 4
Fibrescopic view of the neo-glottis 20 months after supracricoid laryngectomy with cricohyoidoepiglottopexy in Case two. Excellent mobility of the sole remaining left arytenoid can be observed.

interarytenoid, posterior cricoarytenoid and lateral cricoarytenoid, are considered responsible for sustaining the essential function of the unit. However, there is no evidence showing whether these intrinsic laryngeal muscles actually interact with each other and contribute to the mobility of arytenoids after supracricoid laryngectomy with cricohyoidoepiglottopexy. There is also limited information on how much of the lateral cricoarytenoid muscle can be excised without interfering with the mobility of the remaining arytenoid. Since the lateral cricoarytenoid muscle is often excised in order to completely remove the paraglottic space adjacent to it, this information is crucial, especially when the arytenoid is the only unit remaining after excision. EMG analysis is ideal to document the essential functions of these intrinsic laryngeal muscles.

Over the past several decades, EMG analysis has provided important perspectives on laryngeal physiology, especially laryngeal participation in voice and speech production.[15–20] The contribution of each intrinsic laryngeal muscle, three adductors (lateral cricoarytenoid, interarytenoid and vocalis or thyroarytenoid) and one abductor (posterior cricoarytenoid), to voicing distinction is well documented.[16–18] The interarytenoid muscle provides finer adjustments of the glottic aperture for various speech sounds with the supportive action of the lateral cricoarytenoid and vocalis or thyroarytenoid muscle; all adductors are generally associated with suppression of the posterior cricoarytenoid muscle.[16,17] Reciprocal activations between the lateral cricoarytenoid, the interarytenoid and the posterior cricoarytenoid muscle could be clearly observed in the EMG activities of Case one. It is clear that the three muscles attached to the cricoarytenoid unit fully attributed to the mobility of the remaining arytenoid in this case. In the normal larynx, the anterior glottis plays the most important role in phonation and the posterior glottis in respiration.[20] In the neo-glottis after supracricoid laryngectomy with cricohyoidoepiglottopexy the posterior glottis alone plays an important role in both phonation and respiration.

Case two showed clear reciprocal EMG activities between the interarytenoid and the posterior cricoarytenoid muscles. In this case, the lateral cricoarytenoid muscle was excised for oncological control. The typical incision for supracricoid laryngectomy with cricohyoidoepiglottopexy transects the lateral cricoarytenoid muscle, especially when complete removal of the ipsilateral paraglottic space is required. In Case two, the mobility of the arytenoid was attributed to the interactions of the interarytenoid and the posterior cricoarytenoid muscles only. In other words, the reciprocal interaction between the interarytenoid muscle and posterior cricoarytenoid muscle alone is capable of maintaining post-operative laryngeal functions after the procedure.

- **Two patients undergoing supracricoid laryngectomy with cricohyoidoepiglottopexy underwent intra-operative electromyography analysis**
- **Mobility of the arytenoid following surgery was attributed to interaction between the interarytenoid and posterior cricoarytenoid muscles**
- **Reciprocal interaction between these muscles is sufficient to maintain laryngeal function after supracricoid laryngectomy**

This is the first report documenting muscular activities related to the cricoarytenoid unit after supracricoid laryngectomy with cricohyoidoepiglottopexy. Technical refinements and accumulation of data are needed to further elucidate the post-operative mechanism of the cricoarytenoid unit.

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