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CO_2 laser subtotal arytenoidectomy and posterior true and false cordotomy in the treatment of post-thyroidectomy bilateral laryngeal fixation in adduction

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Abstract A total of 39 patients with bilateral post-thyroidectomy vocal cord paralysis in adduction underwent CO_2 laser subtotal arytenoidectomies with removal of the posterior third of the false and true vocal cords. Total airway resistance (R_{tot}) evaluated before and 4–10 months after surgery showed marked preoperative impairment before and significant improvement after surgery ($P < 0.05$). In five patients revision surgery was performed due to a progressive impairment of respiratory function. A variable degree of voice breathiness was observed after surgery; the maximum phonation time mean values were lower than normal and peak sound pressure levels 63 ± 5 dB. In three cases aspiration was present in the first postoperative days, but swallowing dysfunctions disappeared within 1 week. Subtotal arytenoidectomy with removal of the posterior third of the true and false vocal folds was found to be a satisfactory surgical treatment for bilateral vocal cord paralysis in adduction. However, further research is still needed to define the surgical procedure able to balance respiratory, phonatory and sphincteric functions optimally.

Key words Airway obstruction · Vocal cord palsy · CO_2 laser surgery · Transoral arytenoidectomy

Introduction

Surgical treatment of bilateral vocal cord palsy in adduction is still considered to be controversial, as none of the proposed surgical treatments can totally preserve respiratory, phonatory and sphincteric functions. In general, clinical symptoms are characterized by marked dyspnea and an almost normal voice due to the paramedian fixation of the two hemilarynges [38]. The most frequent causes in adults are summarized in Table 1. Previous reports show that it occurs in 0.5–58% of procedures involving the thyroid gland [4, 14–16, 20, 28, 29, 48, 49, 53, 56, 57]. This is not necessarily due to direct anatomical lesions (nerve sections, cauterization, etc.), but often simply to stretching, compression or ischemia of the recurrent nerves [9, 14, 15, 44, 49, 53]. Terminal branches of the recurrent nerves can show very different anatomical configurations [30, 33, 45, 46, 55], as illustrated in Figs. 1 and 2, while "non-recurrent" nerves (Fig. 2) can be present in 0.5–1% of cases [19, 45, 46, 50].

Table 1 Causes of recurrent nerve paralysis

Etiology	%	Source	Year
Congenital	55	Holinger and Holinger [16]	1976
Surgical (thyroidectomy or thoracic surgery)	13	Thompson and Harness [52]	1970
	41	Maisel and Ogura [28]	1974
	58	Holinger and Holinger [16]	1976
	46	Tucker [57]	1980
Compression or infiltration	18	Maisel and Ogura [28]	1976
	22	Tucker [57]	1980

Clinical signs can occur immediately after surgery or progressively in the first postoperative days. In general, a diagnosis can be made by means of laryngoscopy, stroboscopy, respiratory function investigations and electromyography.

Tracheostomy was considered to be the only surgical treatment until 1922 when one vocal cord with the homolateral ventricle was removed for the first time [18]. In 1932 a submucous resection of the vocal cord was proposed [17].

Since then, mainly external surgical procedures have been employed to treat adductor cord paralysis. Arytenoidectomy was carried out through a small opening of the thyroid cartilage, followed by suture fixation in abduction of the homolateral vocal fold [22] or a suture fixing the vocal process to the inferior process of the thyroid

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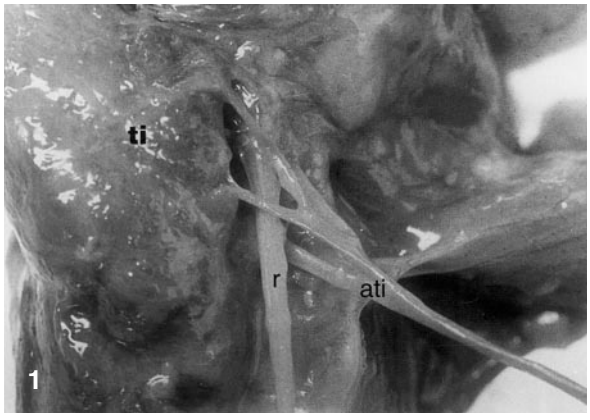

Fig. 1 Anatomical specimen showing the recurrent nerve passing through the branches of the inferior thyroid artery (*ti* thyroid gland, *r* recurrent nerve, *ati* inferior thyroid artery; figure published previously in ref. [31]

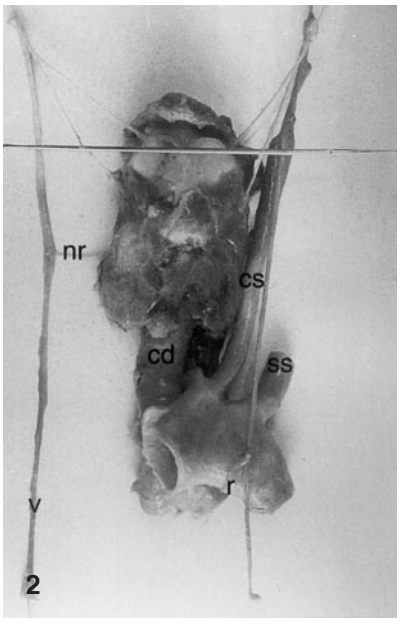

Fig. 2 Anatomical specimen showing a right inferior laryngeal nerve originating from the vagus nerve (*v* vagus nerve, *r* left recurrent nerve, *nr* "non-recurrent" right inferior laryngeal nerve, *cd* right carotid artery, *cs* left carotid artery, *ss* left succlavian artery; figure published previously in ref. [31]

cartilage [58]. More recently, the validity of an arytenoidectomy performed via a median thyrotomy has been shown [13]. Several types of arytenoidopexies [23] with mobilization and lateralization of the arytenoid and fixation along the posterior margin of the thyroid cartilage [1] have been described.

Some surgeons perform different types of cordpexies or cordectomies [10, 11]. Surgical procedures on the cricoid cartilage to create posterior enlargements of the larynx are mainly indicated in laryngotracheal stenosis [42].

More recently, endoscopic surgery has allowed the same and even better results to be obtained without damaging most laryngeal structures and markedly reducing recovery time and the patient's discomfort. Endoscopic procedures in the past have included arytenoidectomy by means of electrocautery [54], arytenoidectomy with submucous resection of the posterior third of the ipsilateral vocal fold [25], and vocal cord lateralization [24]. Newer techniques have involved reinnervation using the vagus nerve, descending branch of the hypoglossal nerve or the phrenic nerve [2, 6, 43], neurorraphy and neurotization, which seem still to be in the experimental stage.

The aim of our present paper was to describe the results we obtained in cases of post-thyroidectomy adductor vocal cord paralysis by performing a subtotal arytenoidectomy with removal of the posterior third of the false and true vocal folds using the CO_2 laser following the suggestions of Ossoff et al. [35–37] and Remacle et al. [40].

Materials and methods

Thirty-nine patients, 31 females and 8 males between 30 and 75 years of age, had bilateral post-thyroidectomy vocal cord adductor paralysis and were evaluated between November 1993 and June 1998. Seven had already been tracheotomized prior to being seen at Catholic University of the Sacred Heart. Clinical signs were evident immediately after thyroidectomy in all patients (Figs. 3, 4). After careful clinical and videolaryngoscopic investigation showing fixation of the vocal cords in a paramedian position (Fig. 3 a, 4 a), all patients underwent voice investigations and respiratory function measurements.

Patients underwent laryngeal surgery only 6–12 months after their primary thyroid surgery when no signs of cord motility were observed during the following period. Subtotal arytenoidectomy and ipsilateral true and false medial-posterior cordotomies were carried out with the CO_2 laser (using continuous-pulse and 7.5 W power). A 1-cm-long incision was made at the level of the corniculate cartilage of the arytenoid parallel to the aryepiglottic fold. The arytenoid and its vocal process were carefully freed from the mucosa. The arytenoid body was sectioned preserving a thin posterior cartilagineous shell. Its removal was completed by splitting the joint between the cricoid cartilage and the resected part of the arytenoid. The posterior third of the true and false vocal cords were then removed, preserving carefully the interarytenoid region in order to avoid retraction and synechiae. Accurate hemostasis was carried out and no patient required a tracheotomy. During the first 20–30 days following surgery, patients underwent several sessions of fibrin removal under in local anesthesia.

In order to evaluate the surgical results objectively, voice characteristics and respiratory parameters were determined 4–10 months after surgery. Postoperative voice evaluation was performed in 35/39 patients and included psychoacoustic and electroacoustic studies, maximum phonation time (MPT) and peak sound-pressure-level (PSP) measurements.The evaluation of phonetically balanced sentences and spontaneous speech was performed by a phoniatrist and speech therapists.

Electroacoustic analysis was carried out by means of a narrow-band filter of the prolonged vowels "a" and "i" and the word "aiuole," using the "Speech Station" spectrograph. The fundamental frequency ($F°$), distribution of the harmonics and the presence of an aperiodic signal were evaluated.

The MPT was analyzed by asking each patient to vocalize the vowel "a" as long as possible after a deep inspiration. The test was performed three times and the highest value considered.

The PSP was measured by positioning a Bruel and Kjaer 2231 phonometer 30 cm from the patient's mouth and asking him to pronounce the vowel "a" at the maximum intensity following a deep inspiration. In order to evaluate the postoperative increase in the laryngeal space as well, 24/39 patients had total airway resistance (R_{tot}) measured by body plethysmography using the Gould 2000-Sensor Medics System. Results were compared to those obtained preoperatively by means of the paired Student's *t*-test.

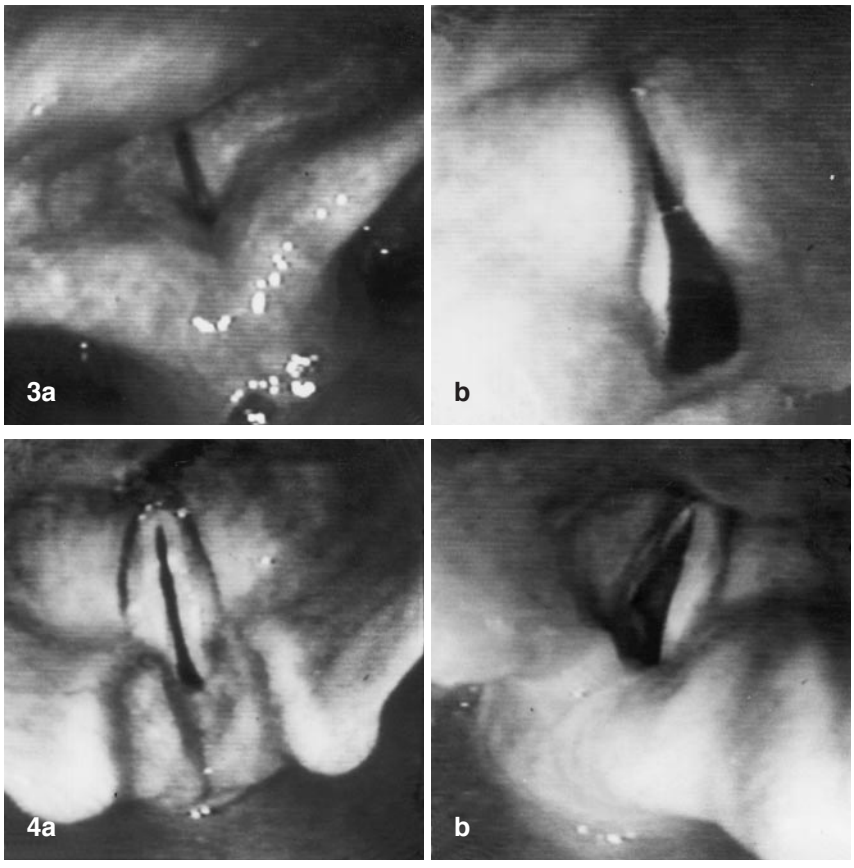

Fig. 3 **a** Example of bilateral post-thyroidectomy vocal cord adductor paralysis with marked reduction of the respiratory space in a 55-year-old male. **b** Twenty-eight months after arytenoidectomy and removal of the posterior third of the true and false vocal cords, stable improvement of the respiratory space can be observed. The posterior region shows correct re-epithelialization

Fig. 4 **a** Bilateral post-thyroidectomy vocal cord adductor paralysis with reduction of respiratory space to 2–3 mm. **b** Two months after arytenoidectomy and removal of the posterior third of the true and false vocal cords, a stable respiratory space has been obtained

Results

Clinical follow-up ranged from 2 to 30 months. The seven tracheotomized patients were successfully decannulated 15–30 days following surgery.

Results of the 24 patients who underwent evaluation of respiratory function showed that preoperative measurements had a marked impairment in the mean R_{tot} (8.7 ± 3.3 cm H_2O × s/l) compared to a normal value of 3 cm H_2O × s/l. A significant improvement after surgery was found in all but three subjects (4.8 ± 3.9 cm H_2O × s/l; $P < 0.05$).

In these three subjects and in two others who did not have respiratory function studies performed, progressive impairment of respiratory function from granulation tissue and scarring resulted in revision surgery that had final good functional results. In the remaining 34 patients, the improved respiratory conditions and enlarged glottic space remained stable over time (Figs. 3b, 4b).

In all 35 patients in whom voice characteristics were evaluated before and after surgery, a variable degree of breathiness was present. Spectrographic analysis showed the presence of a wide aperiodic signal overwhelming or replacing the harmonic component. In 20 patients the fundamental frequency was shifted towards higher values if compared to normal, considering age and sex, but the harmonic structure was poor in the high-frequency region in which the aperiodic signal was stronger. In 14 patients the fundamental frequency could not be evaluated and the periodic component was completely replaced by an aperiodic signal, showing its stronger intensity in the high-frequency region. The MPT mean value was always lower than normal (7 ± 2 s), while the PSP mean value was 63 ± 5 dB HL.

In three cases aspirations of liquids occurred during the first few postoperative days, but this problem rapidly improved, so that after 1 week none of the patients operated upon had swallowing problems.

Discussion

All thyrotomy approaches to the larynx consistently damage its cartilaginous framework. Even though postoperative respiratory function is satisfactory, voice is strongly affected, ranging in incidence from 62% [47] to 78% [5, 8, 27, 34] and 80% [3] of cases. However, lateral approaches seem to be less invasive, with a greater respect for the static and dynamic characteristics of laryngeal structures. Furthermore, a tracheotomy is often needed and postoperative courses are commonly longer and more troublesome.

There are now a number of reports concerning the value of CO_2 laser arytenoidectomy as treatment for bilateral vocal cord adductor paralysis [30–32, 51]. Although satisfactory results have been described in arytenoidectomies and cordectomies performed without the laser

[12], we believe that its use allows very precise incisions to be made with reduced edematous reactions, guaranteeing good hemostasis of vessels smaller than 2 mm, making this kind of surgery quicker and easier, markedly reducing periods of hospitalization and patient discomfort.

Still, when one arytenoid is removed, voice quality is quite often impaired. Therefore, less invasive surgical approaches have been proposed periodically [5, 7, 39, 41]. While voice quality has been better preserved, respiratory function has been unsatisfactory, and more invasive revision surgery is often needed [21]. For this reason, our experience has shown that the arytenoid cartilage needs to be removed partially or totally in order to ensure satisfactory respiratory function. Remacle et al. [40] proposed a procedure that provides a subtotal arytenoidectomy with preservation of a thin posterior cartilagineous shell and removal of the posterior third of the true and false vocal folds. We removed a slightly greater part of the true and vocal folds in our patients in order to reduce possible recurrences of dyspnea due to scarring, granulation tissue and compensatory hypertrophy of the false vocal cord.

Remacle et al. [40] believe that simple posterior cordotomy needs only a very short time (almost 10 min) and at best could be indicated in elderly patients for whom anesthesia has to be short. Nevertheless, functional results can often be unsatisfactory. In our experience, the time needed to perform an arytenoidectomy with cordotomy never exceeded 35 min.

Postoperative courses in our patients have been free of complications and well accepted by the patients. Possible complications are represented by postoperative granulomas, perichondritis of the cricoid cartilage, and ipsilateral false cord hypertrophy (if not removed), causing inspiratory dyspnea.

In the cases presented, significant and stable improvement in respiratory function was obtained in 34 patients, while progressive impairment was observed in 5 cases.

In terms of voice quality, MPT and PSP were variably impaired in all cases, but it appeared to be acceptable, as intelligibility was fairly good even though a variable degree of breathiness was present in all cases. The results presented seem to be somewhat worse than those obtained by Remacle et al. [40], but quite similar to those of Eckel et al. [10]. We fully agree with Eckel et al. [10], who state that assessment of voice quality cannot be performed by measuring individual phonatory parameters and that the standard of voice assessment remains the auditory perception of a patient's voice by a well-trained laryngologist or voice pathologist. In only three cases was aspiration of liquids observed and this lasted for 2–3 days. Results remained stable over time for 34 patients. In only five cases (12.8%) was it necessary to carry out revision surgery. While Lannigan et al. [26] performed revision cordectomy at periods varying from 6 to 7 months from primary surgery (using CO_2 laser arytenoidectomy and cordectomy in 50% of the patients), Remacle et al. [40] obtained sufficient and stable respiration and a satisfactory voice in all patients without the need for any revision surgery. Removal of the arytenoid could cause excessive intralaryngeal scarring [36], but this was not seen in our results.

In post-thyroidectomy vocal cord paralysis a quite important question to answer is when to operate. Jatzko et al. [19] observed post-thyroidectomy bilateral vocal cord paralysis in 29 out of 797 patients. In all, 86% recovered spontaneously within 6 months and only 0.5% had a permanent bilateral paralysis. Therefore, we believe that surgery modifying the anatomy of the laryngeal framework should not be performed earlier than 6–12 months after the occurrence of a laryngeal palsy. If severe dyspnea is present, a temporany tracheotomy should be performed in order to protect the airway while monitoring possible recovery of laryngeal motility. Our experience has shown that subtotal arytenoidectomy with posterior true and false vocal cord cordotomies represents a satisfactory surgical treatment of bilateral adductor vocal cord paralysis due to an almost stable and significant improvement of respiratory function and an acceptable voice quality without aspiration. Still, further research is needed in order to define a surgical procedure able to balance respiratory, phonatory and sphincteric functions optimally.

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