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## Original research

Current therapeutic prospectives in the functional rehabilitation of vocal fold paralysis after thyroidectomy: CO<sub>2</sub> laser aritenoidectomyDomenico Testa <sup>a,\*,1</sup>, Germano Guerra <sup>b,1</sup>, Pasquale Gianluca Landolfo <sup>a</sup>, Michele Nunziata <sup>a</sup>, Giovanni Conzo <sup>c</sup>, Massimo Mesolella <sup>d</sup>, Gaetano Motta <sup>a</sup><sup>a</sup> Department of Anesthesiologic, Surgical and Emergency Sciences, Otolaryngology, Head and Neck Surgery Unit, Second University of Naples, Italy<sup>b</sup> Department of Medicine and Health Sciences, University of Molise, Campobasso, Italy<sup>c</sup> Department of Anesthesiologic, Surgical and Emergency Sciences, VII Division of General and Endocrine Surgery, Second University of Naples, Italy<sup>d</sup> Department of Neuroscience Reproductive and Dentistry Sciences, Otolaryngology Unit, University of Naples "Federico II", Naples, Italy

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## ABSTRACT

A frequent complication of thyroid surgery is laryngeal nerve palsy with transitory or permanent deficiency of cordal motility. Peripheral mono- or bilateral palsy in these cases may either occur, in adduction or abduction, and be complete or not complete. Bilateral vocal cords paralysis cause a persistent dyspnoic symptomatology with worsening during physical exercise or flogistic episodes of the upper airway: true vocal cords adduction, in median or paramedian position reduce the glottic space and increases respiratory resistances. Several surgical procedures have been proposed for the treatment of respiratory distress secondary to bilateral cord palsy. The aim of this study is to value the role of CO<sub>2</sub> laser aritenoidectomy in 93 patients affected by bilateral paralysis in adduction of true vocal cords. Pre and postoperative evaluations included clinical results, spirometry, aerodynamics studies and evaluation of foniatric performance (MPT, H/N Ratio, Jitter and Shimmer) with a mean follow-up of 12 years. CO<sub>2</sub> laser aritenoidectomy induces a complete resolution of respiratory failure, maintaining a good vocal quality, minimum surgical stress with low percentage of complications and a short hospitalization.

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## 1. Introduction

A very frequent cause of laryngeal paralysis is total thyroidectomy performed for pathological eutopic and ectopic thyroid gland [1]. Bilateral vocal cords paralysis cause a persistent dyspnoic symptomatology with worsening during physical exercise or flogistic disease of the upper airway: true vocal cords adduction, in median or paramedian position, reduce the glottic space and increases respiratory resistances. The inferior laryngeal nerve paralysis need surgical treatment to restore glottic space and give a sufficient respiratory space and, meantime, a good vocal performance. The first surgical approaches to bilateral vocal cords paralysis have been realized at the beginning of '900: tracheotomy was the only available procedure for these patients. In 1939, King presented arytenoidopexy: mobilization of the arytenoid, by

external approach, and suturing the vocal process to the thyroid cartilage. Kelly, in 1941, proposed the arytenoidectomy making a window in the thyroid cartilage and fixation the vocal cord in abduction. In 1946, De Graf-Woodman proposed a new surgical procedure which remove the arytenoid cartilage and preserve the vocal process [2]. Only in 1948 Thornell performed an arytenoidectomy by endoscopic approach with poor surgical trauma but the electrocoagulation determined the formation of scar tissue [3]. In 1968 Kleinsasser proposed a variant of this procedure, with the realization of aritenoidectomy with submucosal resection of the posterior third of omolateral vocal fold [4]. CO<sub>2</sub> laser introduction immediately looked be useful in treatment of a lot of otolaryngological pathologies [5]. The introduction of microlaryngoscopy with CO<sub>2</sub> laser allowed new surgical procedures. After experiments done by Strong, Jako, Eskew and Bailey on aritenoidectomy with CO<sub>2</sub> laser, many authors have described numerous surgical techniques in order to restore the respiratory space widening the posterior area of glottis [6–13]. Our school, ever since the '80s, has been treating in adduction vocal cord paralysis in microlaryngoscopy with CO<sub>2</sub> laser [14–16]. The aim of this study is to value the role of CO<sub>2</sub> laser aritenoidectomy in the

\* Corresponding author. Department of Anesthesiologic, Surgical and Emergency Sciences, Otolaryngology, Head and Neck Surgery Unit, Second University of Naples, Largo Madonna delle Grazie, 80138 Naples, Italy.

E-mail address: [domenico.testa@unina2.it](mailto:domenico.testa@unina2.it) (D. Testa).

<sup>1</sup> These authors equally contributed at this work.

bilateral vocal cord paralysis to resolve the respiratory injury, preserve vocal capacity after surgery and maintain good results in time.

## 2. Material and method

The our experience concern 93 patients – 33 male (33.7%) and 60 female (66.3%), average age 48.7 – affected by bilateral vocal cords paralysis observed in the ENT Clinic – Second University of Naples, in the period between 1987 and 2010. All patients presented obstructive respiratory symptomatology. The etiopathogenesis of paralysis was: 85 cases (91.6%), bilateral injury of the recurrent laryngeal nerve after thyroid surgery; in 6 cases (6%), lesion of the skull base; in 2 cases (2.4%), central pathology (Gerhardt's paralysis). Of the 93 patients treated, 37 (39.7%) underwent previously to tracheotomy; 4 (4.3%) have had aritenoidectomy in other ENT Unit performed with external approach with poor results. The 93 patients underwent to aritenoidectomy, in microlaryngoscopy with CO<sub>2</sub> laser, the laser is focalized in superpulse modality with a power of 9–10 W. It is connected to a surgical microscope with a 400 mm lens. Patients have had a follow-up for a period between 1 and 24 years (average 12 years) with periodical fibrolaryngoscopy examination: in the first month every week. After, every month for six months, than every three months for the following year and, finally, every six months for two more years and once a year thereafter. The surgical results have been evaluated by: 1) clinical results; 2) the study of foniatric capacity evaluating Maximum Phonation Time (MPT) in seconds, Harmonic to Noise Ratio (H/N ratio) of the vocal spectrum expressed in dB; Jitter and Shimmer have been evaluated, they indicate the vocal signal perturbation in frequency and intensity; 3) aerodynamics studies which evaluate the vocal functionality: by Aerophon II we registered the average flux (liters in second) during the emission of the vowel “a” and acustic intensity (in dB SPL).

## 3. Results

All patients have been discharged after 2–4 day from surgery (average time 3.1/days). In 32 patients tracheotomised, the tracheal tube has been removed after 7–15 days (average time 9.6/days). In 90 patients there was a complete restoration of respiratory function. In 3 cases (2.8%) has been a moderate dyspnea (for incomplete remove of posterior part of true and false fold): in them was not necessary reoperation. In the days following surgery, all patients presented fibrin scar tissue in the surgical site: in 9 cases (8.47%) it determined respiratory disorders, 2/3 days after surgery. These patients underwent to surgery for remove the fibrin in microlaryngoscopy, with a complete resolution of the breathing difficulty. How concern the functional results we refer to the 90 patients.

A) In the days immediately following surgery we observe:

- A complete resolution of respiratory difficulty evaluated through the spirometry;
- The spectrography shows an alteration of the phonatory activity compared to the preoperative;
- Aerodynamic evaluation shows a phonatory flow significantly increased but a significant reduction of acoustic intensity.

B) At follow-up after three months we register:

- A further and progressive improvement of spirometric index;
- An increase of the parameters TMF an H/N with appearance of the fundamental tone;

- A modest decrease in the phonatory flow and a moderate increase of acoustic intensity compared to the immediate postoperative.

C) At follow-up after six and eight months:

- The spirometry confirms the excellent respiratory results;
- The spectrography shows an improvement of all parameters (TMF, H/N, Jitter and Shimmer) for the appearance of the fundamental tone and a discrete number of harmonics (Table 1);
- Aerodynamic evaluation shows a further reduction of phonatory flow and an increase of acoustic intensity compared to the previous control (Table 2).

## 4. Discussion

Total thyroidectomy procedure show as frequent complication a laryngeal nerve palsy with transitory or permanent deficiency of cordal motility. Many surgical procedures have been advocated for the treatment of bilateral vocal cord paralysis. Techniques based on tissue resection represent the standard therapy today, although they create an unphysiologic situation where the fonatory function of the larynx is more or less sacrificed for the air-way function. An important point in all glottis-enlarging interventions is the determination of optimal amount of tissue to be resected to achieve sufficient airway lumen with a reasonably preserved voice. External approach to larynx has had lots of variable contradictions in many trials. Using the endoscopic technique have been reported also many cases not homogeneous: Whicker and Devine reported successfully surgical results in 87% of 147 patients analyzed; de Campora hasn't had any failure in the 12 patients he operated with the Kleinsasser technique; Nassar registered 67% failure with Thornell technique; De Vincentis treated 11 patients with aritenoidectomy, with or without cordectomy, registering in 6 cases (55%) no improvement of dyspnea [8,17–25]. Gorphe performed, in 20 patients, a medial arytenoidectomy (bilateral in 18 cases) with CO<sub>2</sub> laser reporting in 6 cases no significant difference in pre and postoperative spirometry [8]. Segas performed a partial posterior cordectomy using the CO<sub>2</sub> and KTP-532 lasers in 20 patients, but 9 underwent to revision surgery and 2 of these patients continued with a tracheotomy with a speaking valve [12]. Suleyman, with the same technique, registered a 24% of reintervention and, in addition, a 6% underwent contralateral posterior cordotomy for an insufficient airway performance [13]. Since from 1981 our group have been using microlaryngoscopy with CO<sub>2</sub> laser in order to resolve bilateral paralysis in adduction of vocal fods we perform aritenoidectomy with removal of the posterior half omolateral true and false fold [14–16]. We prefer to remove half or twothirds of the true and false fold so that the post-surgery hypertrophy and the

**Table 1**

Pre- and postoperative acoustic analysis result.

	Subjective evaluation	TMF (s) v.n. (16–18 s)	H/N (dB) v.n. 7 dB ± 1	Jitter v.n. 0.1% ± 1	Shimmer (dB) v.n. 0.2 ± 1
Preoperative	Slight dysphonia Normal tone of voice	12	2.1	3.4	3.8
Postoperative 5 days	Severe dysphonia Veiled voice	4	–8.2	5.8	6.4
Postoperative 90 days	Medium dysphonia Veiled/raucous voice	5	–6.2	5.4	6.2
Postoperative 180 days	Slight dysphonia Raucous voice	7	–4.4	5.1	6.1
Postoperative 240 days	Slight dysphonia Raucous voice	7	–4.4	5.1	6.1

**Table 2**  
Comparison of pre- and postoperative aerodynamic results.

	FEV 1	FEF max (average value in l/s)	FIF max	FIF max	FIF 50%
Preoperative	Slight dysphonia Normal tone of voice	1.64	2.38	0.97	0.85
Postoperative 5 days	Severe dysphonia Veiled voice	1.9 (+15.8%)	3.98 (+67%)	1.1 (+14.4%)	0.97 (+14%)
Postoperative 90 days	Medium dysphonia Veiled/raucous voice	2.13 (+12%)	4.81 (+20.8%)	2 (+80%)	1.69 (+74%)
Postoperative 180 days	Slight dysphonia Raucous voice	2.13 (+0%)	4.81 (+0%)	2 (+0%)	1.69 (+74%)
Postoperative 240 days	Slight dysphonia Raucous voice	2.13 (+0%)	4.81 (+0%)	2 (+0%)	1.69 (+74%)

reduction of breathing space would be avoided; this last factor could be the cause of failure in some other trials. We recommend to preserve the integrity of the anterior and posterior commissure so that scar tissue doesn't form.

## 5. Conclusion

In conclusion endoscopic CO<sub>2</sub> laser medial arytenoidectomy for treatment of bilateral vocal fold paralysis has been performed by several otolaryngology surgeons. The vantages of technique proposed by our group are:

1. Resolution of symptoms: patients show a rapid decrease of dyspnea confirmed by spirometry.
2. Maintainance of a good vocal quality: after three months dysphonia bettered, logopedic therapy has been demanded only in some patients who weren't satisfied of their own vocal quality or if they had special demands due to the type of job they had.
3. Minimum surgical stress: tracheotomy is usually avoided and post-surgical edema is poor; tracheal cannula could be removed in few days if the patient had previously been tracheotomized.
4. Low incidence of surgical complications: in 5 patients (5.3%) we observed, in the first three days after surgery, a healing of thickening tissue in the surgical site that was causing dyspnea. In these cases we removed the fibrous tissue with micro-laryngoscopy. We had post-surgical dysphagia, particularly for liquid, in 20% of cases. This problem was solved usually after 3–4 days.
5. The hospitalization is short with health care costs reduction.

## Ethical approval

Ethical approval was requested and obtained from the "Second University of Naples" ethical committee.

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## Author contribution

**Domenico Testa:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also participated substantially in the drafting and editing of the manuscript.

**Germano Guerra:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also participated substantially in the drafting and editing of the manuscript.

**Pasquale Gianluca Landolfo:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

**Michele Nunziata:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

**Giovanni Conzo:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

**Massimo Mesoella:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

**Gaetano Motta:** Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also participated substantially in the drafting and editing of the manuscript.

## Conflict of interest

The authors have no conflict of interest or any financial support.

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