CO₂ Laser in the Diagnosis and Treatment of Early Cancer of the Vocal Fold

Jae-Gu Cho
Min Woo Park
Seung-Kuk Baek
Soon-Young Kwon
Kwang-Yoon Jung
Jeong-Soo Woo

*Department of Otolaryngology-Head and Neck
Surgery, Korea University College of Medicine,
Seoul, Korea*

Received November 22, 2012
Revised December 11, 2012
Accepted December 12, 2012

Correspondence

Jae-Gu Cho
Department of Otorhinolaryngology-Head and
Neck Surgery, Guro Hospital, Korea University
College of Medicine, 80 Guro-dong, Guro-gu,
Seoul 152-703, Korea
Tel: +82-2-2626-3189
Fax: +82-2-868-0475
E-mail: jgcho@korea.ac.kr

© Korean Society for Laser Medicine and Surgery

© This is an open access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background and Objectives

We report on our experiences with the CO₂ laser in the diagnosis and treatment of early cancer of the vocal fold, as well as the voice quality produced after this type of treatment.

Materials and Methods

A total of 74 patients underwent cordectomy using a CO₂ laser for either diagnosis or treatment of an early cancer of the vocal fold. Type I cordectomy consisted of the resection of the entire epithelium, while leaving the vocal ligament intact. Type II cordectomy involved removal of the vocal fold from the vocal process to the anterior commissure and passing through the inferior thyroarytenoid muscle. Type IIIA required vocal fold resection along the internal side of the thyroid ala, while type IIIB included removal of the anterior commissure.

Results

Type I cordectomies were performed using an Acuspot micromanipulator, which provided a 250-gm-diameter beam for a working distance of 400 mm, and in the shot-by-shot cutting mode with 3 W power superpulse. This cordectomy was performed in 39 patients and a dysplasia or an early carcinoma was detected in 45.9% of cases. Type II and type III procedures were performed using the Microslad micromanipulator having a 700 micrometer-diameter beam in the continuous cutting mode, with 7 W power superpulse. Fifteen cases were treated with type II cordectomy; of these, three patients with T1aN0M0 tumors underwent postoperative radiotherapy due to insufficient resection and two patients with T1aN0M0 tumors later underwent reconstructive laryngectomy. A type III cordectomy was performed in 14 patients with T1aN0M0 carcinomas and three patients with severe dysplasia. The margins of resection were found to be positive histologically in 23.5% of these cases, making frozen section examinations mandatory at the time of surgery.

Conclusion

Results of all procedures showed that voice was best after a type I cordectomy where only the epithelium was resected. In type II and type III cordectomies, the quality of voice depended on development of a fibrous fold and the absence of anterior synechia in the healed larynx.

Key words

Glottic carcinoma; Laser cordectomy; Quality of voice; Acoustic voice analysis

INTRODUCTION

It is now a generally accepted principle of clinical laryngology that any chronic hypertrophic laryngitis requires histological examination and appropriate treatment in order not to overlook an early glottic cancer. The risk of neoplastic transformation is not, however, directly proportional to the amount of keratosis present.^{1,2} This is why it can be difficult to orient biopsied tissues despite the possible aid of vital staining with toluidine blue, which is fixed preferentially by abnormal epithelial cells³ or by stroboscopy to reveal "silent" vibratory zones suggestive of tumoral infiltration.⁴

The surest solution to the occurrence of neoplasia is total resection of the epithelium of the vocal fold. If histological examination reveals only hyperplasia or dysplasia, then treatment has been administered at the same time. If, on the other hand, a specimen is found to be positive, further treatment must be decided upon after taking into account the pathologist's report. We describe our experiences with the CO₂ laser in the diagnosis and treatment of early cancer of the vocal fold, as well as the voice quality produced after this type of treatment.

MATERIALS AND METHODS

From April 1989 until the end of December 1993, we used an Acuspot micromanipulator (Sharplan Laser Industries, Tel Aviv, Israel) to carry out endoscopic surgery with a CO₂ laser on 74 patients either for the diagnosis or treatment of early cancer of the vocal fold. For simplification, we classified our resection procedures of the vocal fold into three types of cordectomies. Type I cordectomy consisted of total resection of the epithelium of the vocal fold. Type II cordectomy was carried out by passing through the vocalis muscle or inferior thyroarytenoid muscle. Type III cordectomy involved removal of the entire vocal fold, which was resected as far as the internal side of the thyroid ala. Type I cordectomy was undertaken in cases with "red" or "white" hypertrophic laryngitis with keratosis. Dysplasia was classified according to the system described by Friedman and Ferlito.¹ Its main role was diagnostic to allow histological examination of the entire epithelium of the vocal fold. Its role could also be therapeutic if histological results confirmed a chronic laryngitis without neoplastic transformation or signs of microinvasion. If signs of tumoral growth were found, another procedure was required. The cutting effect of the laser was produced shot-by-shot (each shot lasting 0.1 s) using 2-3 W power.

The wave was superpulsed, with very high peaks of energy (400-500 W) produced for a nanosecond, but the mean power remaining at 2-3 W. Thus, the cutting effect of the laser was increased with respect to the coagulation effect. During surgery, the vocal fold was stretched towards the median line of the larynx with Bouchayer forceps (Micro-France, Paris, France). Preliminary palpation of the vocal fold allowed assessment of whether or not it was superficial. The cutting mode used allowed meticulous control during the dissection while ensuring integrity of the vocal ligament. A small swab dipped in saline solution containing adrenaline was also applied to the resection area if minor superficial bleeding occurred. Type II cordectomy extended from the vocal process to the anterior commissure and could include partial or entire resection of the ventricular fold so as to expose the entire vocal fold. This procedure was indicated in cases of recurrent chronic laryngitis following resection of the epithelium but without defining malignancy, cases with thickened vocal folds and suspect neoplastic transformation, as well as cases of a small superficial cancer of the mid-third of the vocal fold. This operation was carried out with the Microslad micromanipulator (Sharplan Laser Industries, Tel Aviv, Israel). Hemostasis was obtained by either laser coagulation or electrocoagulation with the help of a suction tube. Type IIIA cordectomy extended from the vocal process to the anterior commissure and in depth up to the internal side of the thyroid ala. If needed, the resection could go as far as 1 cm beneath the glottis to bare the cricoid cartilage. This procedure was used for curative resections of previously diagnosed T1a cancers of the vocal fold.^{5,6} If the anterior commissure was obstructed due to the volume of the lesion, the resection could be extended to the anterior third of the contralateral vocal fold as a type IIIB cordectomy. This resection had to follow the cartilage at the anterior commissure and thus remove Broyle's ligament. To do this, cutting started above the insertion plane of the vocal folds, passed through the ligament and was continued, if necessary, towards the subglottis. During this procedure, hemostasis of the endolaryngeal vessels on the internal side of the thyroid cartilage and branches of the arytenoid artery was obtained by the suction-coagulation tube. Towards the end of a type III cordectomy, the volume of the tissue being resected could obstruct the surgeon's visualization of the procedure. Although it was sometimes necessary to cut the specimen in two in order to continue with the operation, we tried to avoid this as much as possible so as to eliminate the problems of orienting the excised fragment for histological examination of resection

margins. High-frequency jet ventilation was used for type I cordectomies but not for type II and III cordectomies because of the risks of perioperative hemorrhage. In the event of bleeding, the blood was pulsed towards the laryngoscope in very fine droplets and could quickly dirty the optics. A flexible metal endotracheal tube was used that was adapted for laser surgery (Maltinckrodt Medical, Athlone, Ireland). The tube's balloon was filled with saline solution colored with methylene blue. This was also protected from an accidental perforation by a swab soaked in saline. Whenever possible, a Steiner adjustable laryngoscope (Wolf, Knittlingen, Germany) was used. If the open mouth did not give sufficient vision, a Kramer laryngoscope was employed (Wolf). Once the excised tissue was completely detached, it was positioned and fixed on a cork plate and sent for frozen section examination. If necessary, the margins of the resection were revised with the Acuspot beam under the same conditions as in the type I cordectomy. By agreement with the pathologist, the margin of the resection was considered to be situated at the spot where microscopic examination of the specimen was not affected by coagulation due to the laser beam. If the histological examination revealed a positive margin, the resection was extended until healthy margins were obtained. If it was necessary to go further than an endoscopic cordectomy, a second-stage reconstructive laryngectomy was performed as described by Tucker et al.⁷ Such surgery was carried out at a later stage after further assessment of the patient's clinical condition (age, cardiopulmonary condition, etc.) and discussion of alternative therapies. At the end of the initial laser operation, the resection surfaces of the larynx were covered with slow-setting fibrin glue from pooled blood (Tissucol; Immuno, Vienna, Austria). Although this was empirical, edema and bleeding of the postoperative surfaces were seen to be reduced and the formation of granulomas was noted to be inhibited. In our experience, tracheotomy was not required. The patient was extubated in the operating room, and could eat normally the next day. The patient was allowed to leave the hospital on the 4th or 5th postoperative day and received antibiotics for 10 days. Aerosol therapy comprising steroids, antibiotics and saline solution was also maintained 2-3 times daily for 8-10 days. Speech therapy was then started as soon as cicatrization was seen. Follow-up examinations were performed every 6 months in cases of chronic laryngitis with only dysplasia. In patients with a carcinoma, a check-up was performed every 3 months for 3 years and then every 6 months for 2 years. Examinations included videostroboscopy with

rigid optics at 70° or 90°. Vocal quality was assessed by measuring the maximum phonation time (MPT: normal = 15-20 s); the phonation quotient (PQ: VC/MPT: normal = 150-200 ml/s) and intensity (normal = 60 dB). Voice was then evaluated qualitatively on a predetermined scale from 0 to 4 by high-resolution spectral analysis. All data were expressed in median values. Comparisons among the three types of cordectomies used the Kruskal-Wallis analysis of variance and chi-square test for numerical and categorical variables, respectively. In case of heterogeneity, 2 × 2 comparisons were performed by the Wilcoxon rank-sum test or Fisher exact test.

RESULTS

A total of 74 patients underwent CO₂ laser endoscopic surgery for the diagnosis or the treatment of early cancer of the vocal folds (Table 1). In 3 patients, a type I procedure was carried out on one side and a type II procedure on the other. The procedure was carried out on both sides in 70% of type I cordectomies, 33% of type II cordectomies and was unilateral for the type III cordectomies. The median follow-up was 29 months for patients after type I cordectomies and 28 months for type II procedures. Median follow-up for type III procedures was 13 months but these cordectomies were carried out at a much later time (explaining the time difference present). The histological findings are summarized in Table 2. Overall, 45.9% of patients were diagnosed as suffering from dysplasia (12 cases) or carcinoma (5 cases) in the type I cordectomy group. Two patients with T1aN0M0 carcinoma received radiotherapy to 60 Gy and 1 patient later underwent a type III cordectomy. The patient with the T1bN0M0 carcinoma was treated by a Tucker reconstructive laryngectomy. The other cases of hyperplasia or dysplasia were monitored only and received speech therapy during follow-up treatment. The patient with tuberculosis received chemotherapy, consisting of isoniazid, rifampicin and pirazinamide. Three patients (2 cases of hyperplasia and 1 case of LIN III

Table 1. Demographics of enrolled patients undergoing CO₂ laser cordectomies

Procedures	No.	Age (mean, years)	Sex	
			Male	Female
Type I	39	49	31	8
Type II	15	64	15	-
Type III	17	66	17	-

Table 2. Result of histopathology after endoscopic CO₂ laser cordectomies

Histopathology	Procedures		
	Type I	Type II	Type III
Hyperplasia	19	3	-
Dysplasia			
Mild (LIN I)	6	-	-
Moderate (LIN II)	1	-	-
Severe (LIN III)	5	6	3
Squamous cell carcinoma			
pT1aN0M0	3	6	14
pT1bN0M0	1	2	-
Verrucous carcinoma	1	1	-
Miscellaneous			
Reinke's edema	4	-	-
Angiectic polyp	2	-	-
Sulcus glottidis	1	-	-
Tuberculosis	1	-	-

dysplasia) continued to smoke after surgery and suffered recurrences. A second type I cordectomy was performed and histological examination now revealed that one of the former hyperplasias had also become a LIN III dysplasia while the LIN III dysplasia had changed into a T1aN0M0 carcinoma. The cases of dysplasia continue to be monitored and the patient with carcinoma underwent a type III cordectomy. Of the 15 patients who underwent type II cordectomies (Table 2), surgery was required for 3 cases that were initially diagnosed as hyperplasias but then developed recurrences of keratoses. The second histological examination revealed that pathology was still LIN III dysplasia. Three patients with T1aN0M0 carcinoma received complementary radiotherapy to 60 Gy because of incomplete resections. Two patients with T1bN0M0 tumors underwent Tucker reconstructive laryngectomies. Of the 17 patients undergoing type III cordectomies, 2 had macroscopic recurrences of keratoses after having undergone previous conventional resections of the epithelium: 1 patient had LIN III dysplasia. Thirteen patients had T1aN0M0 epidermoid carcinomas while 1 patient developed a recurrence of a rT1aN0M0 epidermoid carcinoma after radiotherapy. Resection margins were found to be positive in 4 of the 17 patients (23.5%). Three of these patients, with previously untreated T1aN0M0 epidermoid carcinomas, were given adjunctive radiotherapy while the case of LIN III dysplasia underwent endoscopic resection with the CO₂ laser. No major complication due to any procedure was observed. Two cervical emphysemas developed through a breach in the cricothyroid ligament but neither caused any dyspnea and then resolved with a lightly compressive dressing.

One patient continues to have endolaryngeal crusts after receiving postoperative radiotherapy after a type II cordectomy. The development of small granulomas was not uncommon but usually resorbed within a few weeks without needing any further surgery. Healing varied from 2 to 4 weeks depending on the extent of the resection done. Type I cordectomies aimed at maintaining the vocal ligament, with follow-up stroboscopy showing a fold return to a normal vibratory amplitude, but with a possible in phase vibratory asymmetry and a diminished mucosal wave motion. After type II and III resections, the excised vocal fold was replaced by a fibrous fold which made re-establishment of vocal function easier. This fibrous fold improved voice quality in cases of type II cordectomy but synechias developing at the anterior commissure resulted in a voice of poor quality. The median value of the spectral voice analysis was 3 after type I and type II cordectomies but was 2 after a type III cordectomy. This difference was significant with respect to type I ($p = 0.030$) and type II cordectomies ($p = 0.003$). The median value of MPT was 12 s following a type I cordectomy, 17 s after a type II cordectomy and 8 s after the type III cordectomy. The median PQ was 238 ml/s after type I cordectomy, 205 ml/s after type II cordectomy and 395 ml/s after type III cordectomy. The median value of conversational voice intensity varied from 60 to 64 dB for all types of cordectomies. The values for the MPT, PQ and vocal intensity did not differ significantly among cases undergoing the three types of cordectomies.

DISCUSSION

The Acuspot micromanipulator provides a 250- μ m-diameter beam for a 400-mm working distance. By concentrating the energy delivered on a much smaller area, less power is needed to produce the same effect. This can be expressed by the formula PD (power density) = Watt/ πR^2 . The thermal effect around the impact of the beam is reduced and the macroscopic cutting effect of the laser is improved, especially in obtaining vessel coagulation. In contrast, the Microslad micromanipulator provides a 700 micrometer-diameter beam for a working distance of 400 mm in a continuous mode with 7 W power and the superpulse. The use of the Microslad and superpulse offers a compromise between macroscopic cutting and coagulation by the laser beam. The use of the Acuspot micromanipulator improved cutting quality, allowing for the resection of the entire vocal epithelium for histological examination. The procedure was certainly much easier than with microscissors, especially if an

inflammatory lesion was present that could become hemorrhagic. The identification and thus preservation of the integrity of the vocal ligament was possible during the entire resection. The formation of notches, causing permanent dysphonia,⁹ was avoided. Coagulation of the edges of the excised fragment was only a few microns and did not therefore hinder tissue examination by our pathologist. Nevertheless, lesions must be approached with the same precautions as in phonosurgery. Working shot-by-shot is therefore certainly to be recommended. In our view, the Acuspot is the instrument of choice to ensure the diagnosis and treatment of patients with chronic laryngitis as well as to ensure voice quality as much as possible. This micromanipulator may of course be used in type II and type III cordectomies but is less indicated since the vocal ligament is resected and a greater hemostasis is desirable.

The conventional micromanipulator with a 400-mm working distance is therefore quite adequate in these circumstances and the instrument's cutting effect will be sufficient in the superpulse mode. Furthermore, it is necessary to defocus the Acuspot from 250 gm to 700 gm if it is to be used in these two indications. The coagulation produced by a conventional micromanipulator is much greater than with the Acuspot.

Thus, the fragment of tissue excised from the larynx is considered to be healthy if the zone next to the coagulated area is not infiltrated by abnormal cells. It is important, however, to correctly orient any specimen removed and to specify the anatomical limits of the resection, especially since the thermal effect of the conventional laser beam causes retraction of the tissue and may give a false impression that a resection was insufficient. Since approximately one-fourth of the margins in our resected type III cordectomy specimens were positive, we now carry out systematic further resections of margins for frozen section examination, as usually done in "openfield" surgery. Our finding of 45.9% of dysplasias or carcinomas in type I cordectomies reaffirmed our need to check the histological nature of any chronic keratotic laryngitis whatever its macroscopic aspect. Since the procedure is both simple and safe, the type I cordectomy for diagnostic purposes was often carried out bilaterally.

A type II cordectomy was often considered to be sufficient tumor surgery if a carcinoma was limited to the midthird of a vocal fold. This approach was used at the beginning of our experience with CO₂ laser endoscopic cordectomies. However, the frequency of positive margins (5 cases out of 9 carcinomas) has led us to reserve this procedure at present to microinvasive carcinoma of the

mid-third of the vocal fold. When confronted with an infiltrating T1aN0M0 carcinoma, we now prefer a type III cordectomy. The extension of the neoplasm can reach as far as, but not involve, the anterior commissure. Indeed, at this point, the distance between the mucosa and the cartilage is no more than 2-3 mm, with no internal perichondrium present to bar the extension of the cancer throughout the thyroid cartilage.^{5,6}

During preoperative endoscopy, it is advisable to ensure correct exposure of the larynx for possible total resection. In order to expose adequately and reach the internal wall of the thyroid cartilage, it is best not to position the laryngoscope along the axis of the larynx, but rather to turn it towards the thyroid ala at an angle of 15-20° with respect to the median axis. Here, the internal perichondrium is easily peeled away from the cartilage, together with the inferior thyroarytenoid muscle, using a small metal suction tube as a peeler. On the other hand, there is no internal perichondrium at the anterior commissure, so that Broyle's ligament ensures a firm insertion for the vocal folds. However, the cutting procedure at this point is more difficult and more irregular, and thus endoscopic cordectomy is contraindicated in the case of neoplastic extension to the anterior commissure.

Laser cordectomies are not simple operations and require considerable experience in endoscopic microsurgery. This technique is considerably more painstaking for the surgeon than an external cordectomy, but the results are better for the patient since a tracheotomy is not required. The principal difficulties arise from the need to have good visibility, the volume of resected tissue to be manipulated in the lumen of the larynx and possible bleeding arising from the endolaryngeal arteries.¹⁰ The limits of the resection must be respected as for an external cordectomy. If good visibility is not possible for anatomical reasons, then an external cordectomy is preferable.

In our experience, external surgery is uncommonly needed and was found to be less than 1% in Steiner's cases.¹¹ If a lesion is vaporized without taking any histological specimen and without any real certainty of being able to treat an entire lesion,¹² more extensive procedures are required, even when dealing with superficial lesions or assessing the degree of infiltration by stroboscopy. If frozen section or complementary histological examination reveals that a lesion extends beyond the limits of the endoscopic cordectomy, partial laryngectomy, at the least, is required. If a patient refuses this procedure or is in no condition to undergo external

surgery, we offer radiotherapy. The use of fibrin glue is empirical, but it seems to us that its use has prevented the development of major granulomas that could impede breathing and swallowing. Indeed, we have never had to reoperate any patient due to a granuloma, nor have we ever observed any disease (such as hepatitis or HIV) which could have been induced by the fibrin glue. We also use it systematically in phonosurgery and its use also seems to reduce the risks of synechia in these cases. Fibrin glue, however, has not been approved by the Foods and Drugs Administration because it is obtained from pooled blood. Although the follow-up of our patients is quite satisfactory to date, it is still too early to draw any definite conclusions from our data as to survival rates. Nevertheless, because we apply the same indications and limits for vocal fold tumors as for external cordectomies, we are confident as to long-term follow-up. We propose the same therapeutic approach regardless of our patients' genders. The absence of women in the type II and type III cordectomy groups is not due to their being directed towards radiotherapy. It is more likely the consequence of increased smoking by women and an earlier diagnosis of chronic keratotic laryngitis before its evolution to cancerization.

The vocal results obtained in our series have been good after a type I cordectomy. In our opinion, this procedure is comparable to that of phonosurgery, and can be used in all cases of chronic keratotic laryngitis. Good voice conservation is possible while reducing the risk of worsening the condition. This seems to us to be a better approach than simple monitoring, even if using stroboscopy for laryngoscopic evaluations.

The statistically better vocal results after a type II cordectomy than a type III procedure arise from the ease in which a fibrous fold develops in the former. Vocalization after a type III cordectomy is satisfactory in as much as a patient is able to compensate for the endolaryngeal opening through speech therapy, especially when there are no anterior synechiae and the contralateral vocal fold is intact. The question of vocal quality after laser cordectomy has not been resolved, but it is better than after external cordectomy.¹³ This can be explained by the possible avoidance of anterior synechiae with the endoscopic procedure than via the external route, which requires an anterior thyrotomy.

Laser cordectomy is now preferably limited by us to the management of T1a carcinomas. A T1b carcinoma of the vocal fold does not seem to us to be a good indication, because of the difficulty of resection around the anterior commissure,^{5,6} unless dictated by specific

circumstances (such as, age and general health). In the event of failure, these particular cases may be directed towards radiotherapy. While some authors appear to be able to treat T2 glottic carcinomas efficiently with the CO₂ laser,¹⁴⁻¹⁶ the difficulties of local control have led us to prefer partial or reconstructive laryngectomy for the treatment T1b and T2 glottic cancers. When confronted with a chronic keratotic laryngitis with an altered stroboscopic image, we suggest a type I cordectomy and repeat this if the keratosis persists. If hyperplasia or dysplasia are found on histological examination, treatment stops but we continue to follow the patient at regular intervals. If a T1a epidermoid carcinoma is diagnosed after a type I cordectomy (or if previously diagnosed), a type II cordectomy can be used in cases with superficial cancers of the mid-third of the vocal fold or recurrent severe keratosis. The type IH procedure is reserved for more extensive lesions (if warranted clinically). A type IIIA cordectomy is carried out if the commissure is clearly visible; otherwise the type IIIB is undertaken. If a positive margin is detected by the frozen section examination or by the usual histological examination, the cordectomy is extended when possible or else partial or reconstructive surgery is undertaken. Should the patient refuse or be in no condition to undergo external surgery, radiotherapy is given.

REFERENCES

1. Friedman I, Ferlito A. Precursors of squamous cell carcinoma. In: Ferlito A, editor. Neoplasms of the larynx. Edinburgh: Churchill Livingstone; 1993. p.97.
2. Hirano M, Hirade Y, Kawasaki H. Vocal function following carbon dioxide laser surgery for glottic carcinoma. *Ann Otol Rhinol Laryngol* 1985;94:232-5.
3. Lundgren J, Olofsson J, Hellquist H. Toluidine blue. An aid in the microlaryngoscopic diagnosis of glottic lesions? *Arch Otolaryngol* 1979;105:169-74.
4. Kitzing P. Stroboscopy--a pertinent laryngological examination. *J Otolaryngol* 1985;14:151-7.
5. Krespi YP, Meltzer CJ. Laser surgery for vocal cord carcinoma involving the anterior commissure. *Ann Otol Rhinol Laryngol* 1989;98:105-9.
6. Wetmore SJ, Key JM, Suen JY. Laser therapy for T1 glottic carcinoma of the larynx. *Arch Otolaryngol Head Neck Surg* 1986;112:853-5.
7. Tucker HM, Benninger MS, Roberts JK, Wood BG, Levine HL. Near-total laryngectomy with epiglottic reconstruction. Long-term results. *Arch Otolaryngol Head Neck Surg* 1989;115:1341-4.
8. Laccourreye H, Laccourreye O, Weinstein G, Menard M, Brasnu

- D. Supracricoid laryngectomy with cricohyoidoepiglottopexy: a partial laryngeal procedure for glottic carcinoma. *Ann Otol Rhinol Laryngol* 1990;99:421-6.
9. Bouchayer M, Cornut G. Microsurgical treatment of benign vocal fold lesions: indications, technique, results. *Folia Phoniatr (Basel)* 1992;44:155-84.
10. Andrea M. Vasculariza~ao arterial da laringe. Distribuicao macro e microvascular [dissertation]. Lisbon: University of Lisbon; 1975.
11. Steiner W. Experience in endoscopic laser surgery of malignant tumours of the upper aero-digestive tract. *Adv Otorhinolaryngol* 1988;39:135-44.
12. Mahieu HF, Patel P, Annyas AA, van der Laan T. Carbon dioxide laser vaporization in early glottic carcinoma. *Arch Otolaryngol Head Neck Surg* 1994;120:383-7.
13. Pia F, Gonella ML, Boggero R, Ponzo S, Giordano C. Vocal function after cordectomy (traditional surgical treatment vs CO₂ laser): a comparative objective-instrumental evaluation. *Acta Otorhinolaryngol Ital* 1994;14:329-38.
14. Eckel HE, Thumfart WF. Laser surgery for the treatment of larynx carcinomas: indications, techniques, and preliminary results. *Ann Otol Rhinol Laryngol* 1992;101:113-8.
15. Motta G, Villari G, Motta S, Ripa G, Cuzzocrea R. Use of CO₂ laser in conservative surgery of glottic tumors. *Acta Otorhinolaryngol Ital* 1991;11:25-34.
16. Steiner W, Aurbach G, Ambrosch P. Minimally invasive therapy in otorhinolaryngology and head and neck surgery. *Minim Invasive Ther* 1991;1:57-70.