

Endoscopic Treatment of Central Airway Stenosis: Five Years' Experience

A. Cosano Povedano, L. Muñoz Cabrera, F.J. Cosano Povedano, J. Rubio Sánchez, N. Pascual Martínez, and A. Escribano Dueñas

Servicio de Neumología, Hospital Universitario Reina Sofía, Córdoba, Spain.

OBJECTIVE: To describe our experience with interventional bronchoscopy in the treatment of central airway stenosis.

PATIENTS AND METHODS: We reviewed patient records and bronchoscopic findings. Clinical data, findings from computed tomography, techniques performed, complications, and results were recorded.

RESULTS: One-hundred and thirty-six patients (90 males and 46 females) were treated. The mean (SD) age was 57 (7) years (range, 3-81). A total of 320 therapeutic interventions were performed: 145 laser treatments, 33 balloon or mechanical dilatations, 26 electrocauterizations, and 116 stent insertions. Pathogenesis varied: in 64 (47%) patients, the stenosis was caused by a tumor (48 were bronchopulmonary and 16 nonpulmonary); in 72 (53%) patients, stenosis was secondary to a nontumor-related process, of which the most common was prolonged intubation (42% of these cases). Central airway patency was achieved in 92% (59/64) of the tumor-related stenoses and 96% (69/72) of those unrelated to tumors. Improvement in dyspnea was observed in 96% of all patients. Two deaths (due to hemoptysis and to acute myocardial infarction) occurred in the first week, for a 1.4% mortality rate. The most common complications were stent migration (8%; 9/116 cases) and the formation of granulomas (9%; 11/116).

CONCLUSIONS: Interventional bronchoscopy is an effective technique to resolve life-threatening obstructions of the central airways. Dyspnea improves immediately and there is no significant morbidity or mortality.

Key words: Airways. Interventional bronchoscopy. Stents.

Cinco años de experiencia en el tratamiento endoscópico de las estenosis de la vía aérea principal

OBJETIVO: Describir nuestra experiencia en estenosis de la vía aérea principal (VAP) tratadas mediante broncoscopia intervencionista.

PACIENTES Y MÉTODOS: Se han revisado las historias clínicas e informes de broncoscopia y se han registrado los datos clínicos, informe de tomografía axial computarizada, técnicas realizadas, complicaciones y resultados.

RESULTADOS: Se trató a 136 pacientes (90 varones y 46 mujeres), con una edad media \pm desviación estándar de 57 \pm 7 años (rango: 3-81), en quienes se realizaron 320 procedimientos terapéuticos, que incluyeron 145 tratamientos con láser, 33 dilataciones con balón o mecánicas, 26 tratamientos mediante electrocauterio y la colocación de 116 prótesis. La etiología de la estenosis fue diversa: hubo 64 (47%) de causa tumoral (48 de origen broncopulmonar y 16 tumores extrapulmonares), mientras que en 72 pacientes (53%) la estenosis fue secundaria a una enfermedad no tumoral; de éstas, la causada por intubación prolongada fue la más frecuente (el 42% de los casos).

La permeabilidad de la VAP se logró en el 92% (59/64) de las estenosis de etiología tumoral y en el 96% de las no tumorales (69/72), y se observó mejoría de la disnea en el 96% de todos los pacientes. En la primera semana hubo 2 fallecimientos (por hemoptisis e infarto agudo de miocardio), lo que representa una mortalidad del 1,4%. Las complicaciones más frecuentes fueron la migración de prótesis en un 8% (9/116) y en un 9% la formación de granulomas (11/116).

CONCLUSIONES: La broncoscopia intervencionista es una técnica eficaz para resolver las situaciones de riesgo vital de la VAP, con mejoría inmediata de la disnea y sin morbimortalidad significativa.

Palabras clave: Vías aéreas. Broncoscopia intervencionista. Prótesis.

Introduction

The quality of life of most patients with significant central airway stenosis is seriously impaired by severe

dyspnea, although stridor, a sense of suffocation, or even respiratory failure may be present as well.

Endoscopy is widely used to treat obstructive lesions in stenosis of the central airway.¹⁻³ Endoscopic treatment can help to palliate dyspnea in certain cases with malignant obstruction and may even be curative when pathogenesis is a benign tumor or inflammation. A variety of therapeutic modalities are used to achieve optimal results in the treatment of central airway stenosis.⁴ Dilatation

Correspondence: Dr. A. Cosano Povedano.
Servicio de Neumología. Hospital Universitario Reina Sofía.
Avda. Menéndez Pidal, s/n. 14004 Córdoba. España.
E-Mail: andr539@separ.es

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—combined or not with laser treatment or electrocautery—may be sufficient to treat stenoses of benign origin. Treatment options for malignant lesions include tumor resection, laser vaporization, photodynamic treatment, brachytherapy, cryotherapy, and electrocautery.¹⁻³ Stenting is also commonly used to maintain airway patency in nonresectable benign stenoses^{5,6} or as a palliative for malignant tumors.⁷

Our objective was to describe the experience of the interventional bronchoscopy unit at our hospital in the treatment of central airway stenosis.

Patients and Methods

In order to evaluate the endoscopic treatment of central airway stenoses, we reviewed the patient records, imaging techniques used, and bronchoscopic findings for all patients sent to our unit from January 1999 to January 2004. All therapeutic procedures were performed at the Bronchoscopy Unit of the Respiratory Medicine Service at our hospital in Cordoba, Spain. Our hospital serves a population of approximately 850 000 people and is also a referral hospital for lung transplants and interventional bronchoscopy in the Autonomous Community of Andalusia, Spain. In addition, we treat pediatric patients who require bronchoscopic evaluations or removal of foreign bodies from the bronchi. As a result, we perform approximately 1100 bronchoscopies per year and over the last 2 years a mean of 78 of these procedures were performed with a rigid bronchoscope.

The bronchoscopic interventions were performed as follows: a video-assisted fiberoptic bronchoscope with image recording was used to evaluate the lesion; then, in addition to x-rays, the following procedures were performed to determine the appropriate treatment indication: spiral computed tomography, standard laboratory workup, a coagulation study, arterial blood gas analysis, and electrocardiogram. In addition, 2 packed red blood cell reserves were collected from patients whose hematocrit was less than 30% or who had a well-vascularized lesion or one likely to bleed profusely. All patients signed an informed consent form. All patients met the basic criteria for endoscopic treatment: central airway stenosis greater than 50%, underlying lung amenable to reexpansion, and severe respiratory symptoms—primarily dyspnea.¹⁻³ After completion of the preanesthetic evaluation, the most appropriate treatment modality for each patient was selected.

Improvement of dyspnea and the degree of central airway patency recovered were the main outcome measures. Dyspnea was considered to have improved when it decreased by at least 1 point on the Medical Research Council dyspnea scale. Stenosis resolution was defined as the recovery of more than 75% of tracheal or bronchial lumen patency.

Immediate complications—those that presented during surgery or in the first 72 hours—and late complications were recorded. Immediate complications included hemorrhage, significant desaturation, vocal cord lesions, and perforation of the tracheal or bronchial wall. Bronchial tree hemorrhage was considered severe if accompanied by a significant fall in arterial oxygen saturation, hemodynamic instability, or a failure to respond to standard methods used to achieve hemostasis. A significant fall in arterial oxygen saturation was defined as a decrease greater than 4% or the need for the anesthesiologist to adjust the ventilation or oxygenation parameters. Late complications for stenoses without tumor involvement included stent migration, formation of granulomas, mucous hypersecretion and stent blockage, and stenosis recurrence.

The following equipment was used: a rigid bronchoscope (Efer[®] Endoscopy; La Ciotat, France) with optical system, probes, stent introducer, and stenting forceps; fiberoptic bronchoscopes (Olympus[®] BF-B30 and BF-1T240 video-assisted bronchoscope; Olympus Optical Co., Japan) with lighting system for both endoscopes, and video-recorder; a surgical laser (Diomed[®] 30, Diomed Ltd., Cambridge, United Kingdom) with separate light delivery systems for both contact and noncontact fibers; and an electrocautery system (Olympus[®] PSD-20, Olympus Optical Co., Japan). Both systems had to be previously calibrated and programmed for the appropriate power output and duration.

Rigid bronchoscopy, performed according to currently accepted guidelines,^{1,2,8} was carried out by nursing staff and 2 pneumologists with extensive experience with this technique. The procedure was performed under general anesthesia with the appropriate degree of sedation and muscle relaxation monitored closely by an expert anesthesiologist.⁹ Depending on the clinical and functional situation of the patient and the location of the lesion, the procedure was performed under spontaneous breathing or mechanical ventilation. For patients with subglottic tracheal stenosis or severe functional deterioration, mechanical ventilation was used.

All patients were given oxygen therapy for a minimum of the first 24 hours and aerosolized mesna every 6 to 8 hours. Nebulized saline solution and salbutamol were prescribed to control bronchospasm, when necessary. The patients were examined endoscopically between the first and third days after the intervention and, when appropriate, the stent was checked for proper placement and functioning. If no complications emerged and the treatment was effective, the patients were discharged. All patients were prescribed broad spectrum antibiotics, with the addition of aerosols for those with stents. For inflammation-related stenoses, the therapeutic regimen included the use of nonsteroidal antiinflammatory drugs for 2 weeks. All patients were reminded of the need for self-care to prevent secretions from obstructing the stent; in addition, daily use of aerosolized mesna and/or salbutamol was recommended and patients were advised to carry an emergency medical card with this information.

Results

Over the study period, 136 patients (46 women and 90 men) were treated, with a mean (SD) age of 59 (7) years (range, 3-81 years). In total, 320 therapeutic procedures were performed and 116 stents inserted (Table 1).

TABLE 1
Procedures Performed During Bronchoscopy to Resolve Central Airway Stenosis

Procedure	Number
Laser	145
Dilatation	33
Electrocautery	26
Stenting	116
Dumon cylindrical stent	66
Dumon y-stent	19
Polyflex cylindrical stent	13
Montgomery stent	8
Coated Ultraflex stent	8
Freitag dynamic stent	2
Total	320

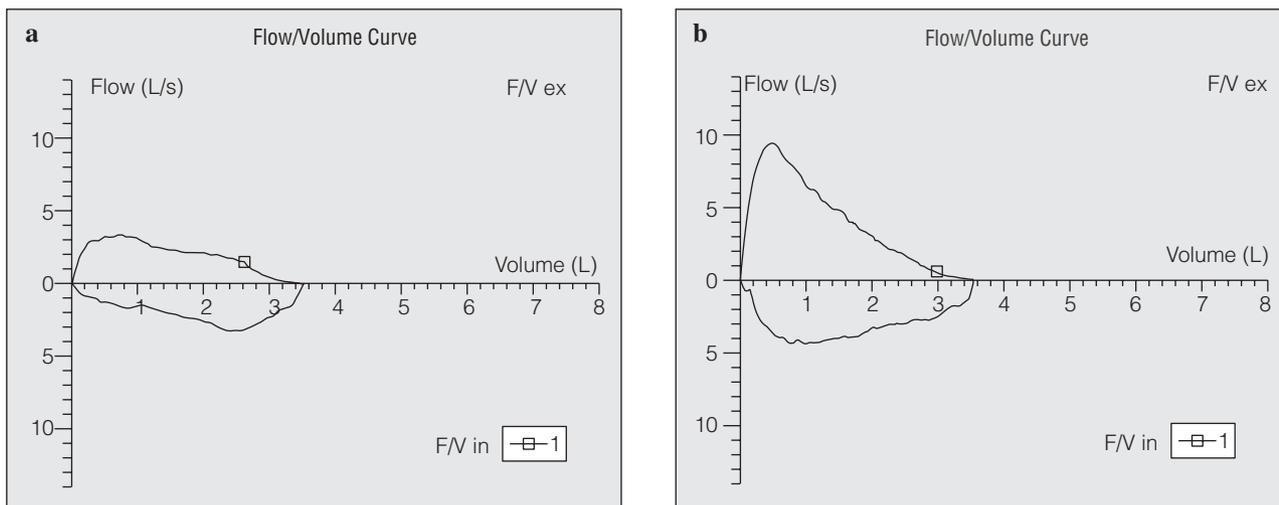


Figure 1. Postintubation (a) and postdilatation (b) stenosis.

Pathogenesis was tumor-related in 64 patients (47%) and, of these, 75% (48/64) were of bronchopulmonary origin (Table 2). Squamous cell carcinoma was the most common (52%) cell type. The location of the neoplasm in the remaining 16 tumor-related cases (25%) was extrapulmonary. The most common cause of stenosis—72 cases (53%)—was nontumor-related. Stenosis was secondary to prolonged orotracheal intubation or tracheotomy in 30 (42%) of these cases, secondary to lung transplant in 13 (18%) cases, idiopathic in 7 (10%), caused by malacia in 4 (5.5%), and of miscellaneous causes in the rest (Table 3). As shown in Table 1, the therapeutic procedures performed were as follows: 145 laser treatments, 33 mechanical or balloon dilatations, 26 electrocauterizations, and 116 stent insertions.

In the 64 patients with tumor-related stenoses, 58 laser treatments, 8 electrocauterizations, and 60 tracheal or bronchial stent insertions were performed. Two stenoses caused by benign lung tumor (hamartoma and leiomyoma) required surgical intervention due to extensive tumor dissemination. The 72 patients without tumor involvement were treated by 87 laser treatments, 18 electrocauterizations, and 56 stent insertions. Thirteen patients who had undergone lung transplant were treated for stenosis and, in some of these cases, several endoscopic interventions were necessary.

Eight Montgomery stents—inserted through the patients' existing tracheotomy tubes—were placed with the assistance of the thoracic surgery team. Only 2 patients required surgery with resection and end-to-end anastomosis of the tracheal stenosis. There were 4 cases of tracheal malacia, resolved by the insertion of a Polyflex stent in 3 cases and a Dumon stent in the other.

In 92% of the tumor-related stenoses, symptom improvement was observed immediately, although 5 patients failed to show improvement. In 96% (69/72) of the nontumor-related cases (Figures 1a and 1b), satisfactory improvement of the stenosis of the central airway and dyspnea was noted.

TABLE 2
Causes and Location of the Central Airway Stenoses

Cause of Stenosis	Location	Number
<i>Tumor</i>		64
Lung cancer		34
	Trachea	3
	Bronchi	10
	Both trachea and bronchi	21
Neoplastic infiltration of contiguous areas		13
	Trachea	11
	Bronchi	1
	Both trachea and bronchi	1
Metastasis		3
	Trachea	2
	Bronchi	1
Low/intermediate grade malignancy		14
	Trachea	10
	Bronchi	4
<i>Nontumor</i>		72
Postintubation		30
	Trachea	30
Posttransplant		13
	Bronchi	13
Idiopathic		7
	Trachea	5
	Bronchi	2
Bronchial disruption		3
	Bronchi	3
Malacia		4
	Trachea	4
Anastomosis		3
	Bronchi	3
Granulomas		3
	Trachea	2
	Bronchi	1
Other causes		9
	Trachea	2
	Bronchi	6
	Both trachea and bronchi	3

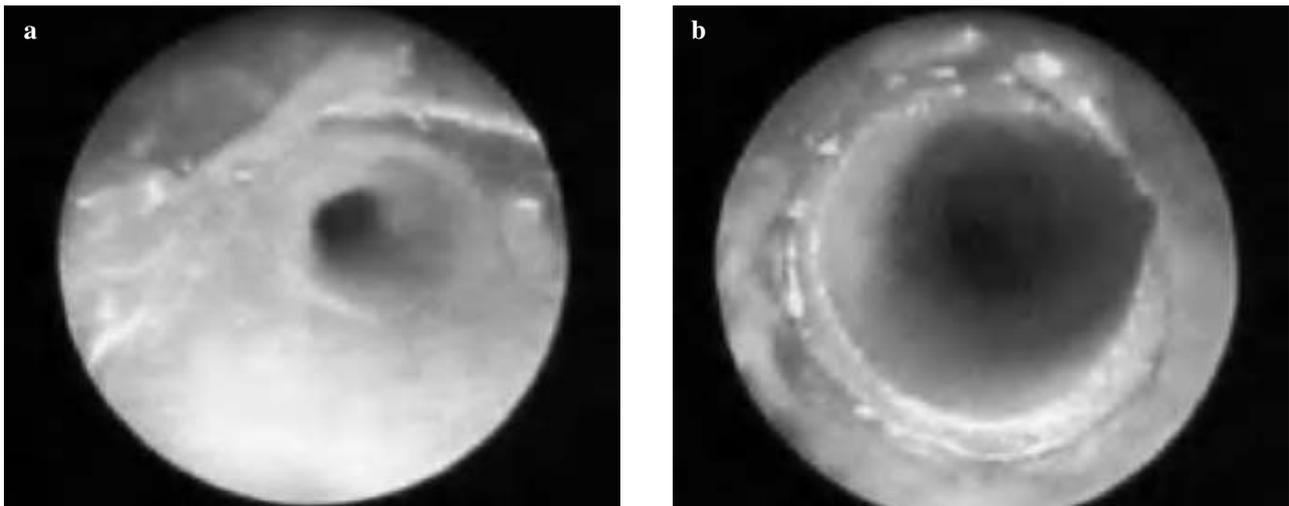


Figure 2. After intubation (a) and after insertion of a tracheal stent (b).

Of the 320 procedures carried out, 11 (3.4%) perioperative complications were observed. The following complications were noteworthy due to their severity: 2 episodes of temporary hypoventilation leading to a severe, life-threatening desaturation, although both patients were able to recover; 4 (1.2%) cases of severe hemorrhaging accompanied by significant desaturation; 1 case in which the tip of the laser fibers ignited, although with no harm to the patient; 4 (1.2%) bronchial perforations involving 1 lung cancer patient and 3 lung transplant patients with stenosis at the bronchial suture. Of these last 3 cases, 1 was resolved by immediate surgery and the other 2 by insertion of a self-expanding coated metal stent (Ultraflex), after which both patients progressed without complications; closure of the bronchial disruption was confirmed at 3 weeks.

Late complications were observed in 25 (34%) of the 72 patients without tumor involvement: 11 (15.30%) patients developed granulomas at the stent ends; 9 experienced stent migration requiring a second procedure under general anesthesia (most of the stent migrations, however, occurred in patients treated when we had less experience with this technique); 3 (4%) had stenosis recurrence; and 2 required fiberoptic bronchoscopic aspiration due to secretion accumulation or blockage.

Although 2 (1.4%) deaths occurred in the postoperative period, the cause was not directly related to the procedure. The first patient had ischemic heart disease and suffered an acute myocardial infarction and cardiogenic shock, resulting in death on the fourth day after bronchoscopy. The second patient had a highly-malignant lymphoma and died in the first 48 hours after treatment due to a stubborn bronchial hemorrhage secondary to a severe thrombocytopenia. The remaining patients (98.5%) recovered without incidents in the recovery room and had satisfactory progress in the immediate postoperative period.

Mean survival for patients with malignant tumors was 98.5 days and the endoscopic intervention was curative in 3 of the 4 patients with hamartoma, in the patient with benign schwannoma, and in the patient with a polypoid carcinoid tumor.

Discussion

In our experience interventionist bronchoscopy is a very effective way to resolve central airway stenosis, with few deaths and only minor complications in most cases.

Laser therapy and stenting are used for palliative purposes to improve the patient's quality of life in cases of stenosis of the trachea or main bronchi caused by a nonresectable tumor.¹⁻³ However, to perform this technique properly, the following conditions must be met: the bronchoscopist must be able to see the bronchial lumen beyond the tumor, the lung parenchyma beyond the obstruction must be functional, and the symptoms of tumor-related disease should be predominantly respiratory. The presence of an anesthesiologist is essential to monitor ventilation during the procedure⁹ and to assess anesthetic risk and possible intraoperative complications.¹⁰

One of the most common causes of benign tracheal stenosis is postintubation injury,^{5,6} resulting from a pressure ulcer caused by the balloon or the tip of the endotracheal tube lying on the mucosa, although benign tracheal stenosis has also been associated with inflammatory or infectious processes,⁸ and even with gastroesophageal reflux.^{9,10} Such postintubation injuries can probably be minimized or prevented by carefully monitoring the pressure applied to the endotracheal tube cuff or by assessing any such injuries endoscopically.¹¹ In fact, noninvasive techniques are increasingly used for follow up, with good results in the diagnosis of central airway stenosis.^{12,13}

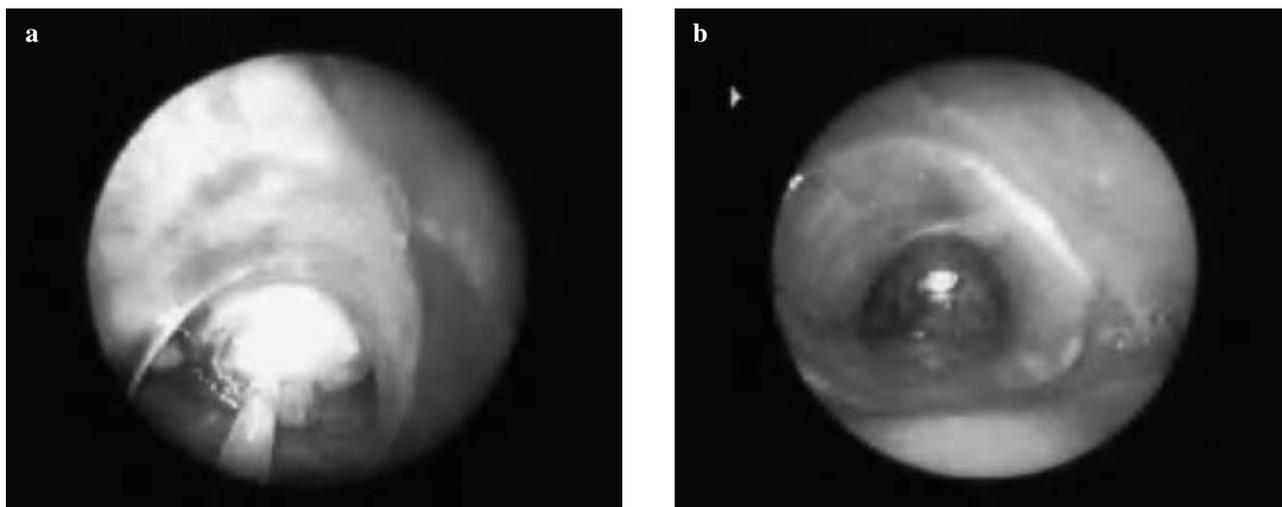


Figure 3. Squamous cell carcinoma of the tracheal carina (a), after laser treatment and Y-stent insertion (b).

The accepted indication for focal tracheal stenoses with significant damage to the structure of the tracheal wall—despite the well-known complexity of this type of surgery and the seriousness of its complications—is surgical resection with end-to-end anastomosis.² However, if the structure of the tracheal wall is intact, dilatation and/or stent insertion offers an effective alternative (Figures 2a and 2b).

In stenoses caused by inflammation, stent removal should be considered from 12 to 18 months after insertion because the inflammatory lesion will probably have stabilized,¹² although vigilance must be maintained given the possible recurrence of the stenosis or the emergence of malacia.⁷⁻¹³ Stenoses that develop at the site of the bronchial sutures in lung transplant patients are among the most complicated. Although uncommon,¹⁴ these stenoses are usually accompanied by malacia and they tend to recur^{6,15,16}; moreover, they are associated with a higher death rate.¹⁶ The cause of these stenoses is still not clear although several possibilities have been proposed, including ischemia of the donated bronchus, the use of mattress sutures, and the need for mechanical ventilation more than 6 days after the transplant.^{16,17} Treatment includes laser vaporization of the granulomas or sutures, electrocautery or laser resection of fibrotic stenoses, hydraulic balloon dilatation, and stenting.¹⁷ Five stents (3 silicone and 2 coated Ultraflex stents) were inserted in our transplant patients. In another 3 patients, a false passage—an uncommon though serious complication—was created while attempting to insert a silicone stent.¹⁶ Clearly, resolution of a stenosis associated with the bronchial suture of a lung transplant patient requires special care. Surgical reconstruction is an option for those patients who do not respond to endoscopic treatment, who have bronchial necrosis, or stenosis dissemination to the lobar bronchi.¹⁸

Stent migration is one of the most common complications and, in our study, occurred in 8% of patients, a rate similar to that reported in other case

series.^{5,18} Stent migration is commonly associated with benign stenoses because of the shape of the stenosis and the occasional coexistence with malacia.

Granulation tissue often forms in the bronchial tree in response to stent insertion. In our case series, this occurred in 12.5%, similar to rates reported by other authors.⁵ These complications are easily treated by electrocautery or cryotherapy, although in 2 cases in our series a resection with end-to-end anastomosis of the injury had to be performed.

As Table 1 shows, we used the Dumon stent most often because fewer spontaneous migrations occur and it is easier to reinsert if necessary. Nevertheless, for early stenoses at the bronchial suture in lung transplant patients, coated metal Ultraflex stents are easier and safer to insert because less manipulation of the affected area is necessary during the insertion procedure.

Interventional bronchoscopy may be indicated prior to chemotherapy or radiotherapy—or when such treatments fail—in central airways affected by a nonresectable tumor (Figures 3a and 3b). However, a few cases have been described of nonresectable lung cancers which became operable after laser treatment.¹⁹ Endoscopic treatment may be an alternative to surgery in cases in which an otherwise resectable tumor is deemed inoperable due to the high functional or anesthetic risk to the patient.²⁰ Although low-malignancy polypoid tumors are uncommon, treatment by laser resection or diathermy may be curative, as it was in 5 of our patients (Figures 4a and 4b).^{1,21} Good results have been achieved with electrocautery and in some cases it appears to offer a potential alternative to the bronchoscopic laser—especially to make radial cuts in stenoses caused by inflammation and to resect polypoid tumors, or to biopsy tumors that are likely to hemorrhage, such as carcinoid tumors.²²

The mean survival time—more than 3 months—achieved in cases with malignant tumors is promising. Moreover, immediate extubation and dyspnea

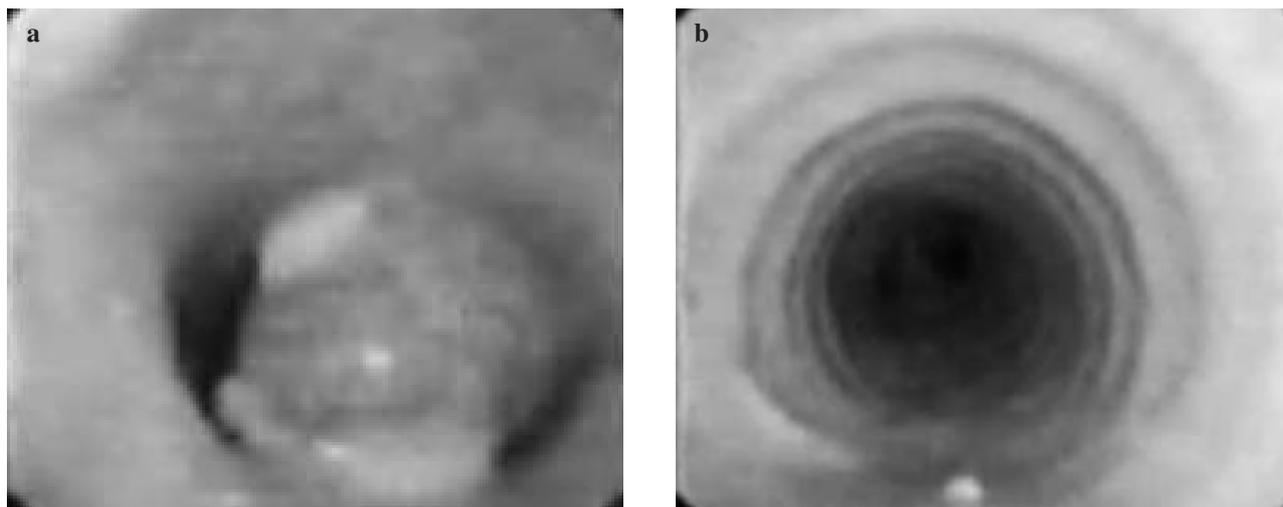


Figure 4. Benign polypoid schwannoma before (a) and after extirpation (b).

improvement in more than 90% of cases gives patients better quality of life.^{1,19,23}

Interventional bronchoscopy is a therapeutic advance that provides an effective response to life-threatening events of the central airways. It is palliative in malignant cases^{7,19-21,23} and may even be curative when the origin is benign.^{5,6,16,17,23} Given that the incidence of lung cancer in our country is likely to rise, we can expect that such life-threatening situations in the central airways will become increasingly common. Nevertheless, interventional bronchoscopy requires appropriate training and study, as well as the essential support of the thoracic surgery unit.

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