



Milton Rochman. *Mindshift*. Acrylic on canvas, 30" × 40". Courtesy of Lewis-Atkinson Galleries, St. Petersburg, Fla.

Interventional pulmonology is now an integral part of optimal multimodal management of advanced lung cancer.

Endobronchial Management of Advanced Lung Cancer

Michael J. Simoff, MD, FCCP

Background: *Patients with lung cancer often have bulky endobronchial disease, endobronchial extension, or airway compression. Many endobronchial treatment modalities are available to supplement traditional therapies for advanced lung cancer.*

Methods: *The author reviews the use of several endobronchial treatment modalities that can augment standard antitumor therapies for advanced lung cancer, including rigid and flexible bronchoscopy, laser therapy, endobronchial prosthesis, and photodynamic therapy.*

Results: *Since the early 1980s, technical advances in interventional techniques have enhanced symptom-free survival and quality of life for patients with lung cancer. Although interventional procedures are not definitive therapies, they often relieve the strangling sensation produced by airway occlusion.*

Conclusions: *Endobronchial interventions are important adjuncts in the multimodality management of lung cancer and should become standard considerations in the management of patients with advanced lung cancer. For patients with respiratory symptoms associated with their disease, these interventions provide symptom palliation and improved quality of life.*

Introduction

Most of the estimated 169,500 new cases of lung cancer diagnosed in the United States in the year 2001

From the Division of Pulmonary and Critical Care Medicine, Allergy and Immunology, Henry Ford Hospital, Detroit, Michigan.

Address reprint requests to Michael J. Simoff, MD, Pulmonary and Critical Care Medicine, Henry Ford Hospital, 2799 West Grand Blvd, Detroit, MI 48202. E-mail: MSimoff1@hfhs.org

No significant relationship exists between the author and the companies/organizations whose products or services may be referenced in this article.

will be in an advanced stage.¹ More than 50% of these patients will have involvement of the central airways.² This can be in the form of bulky endobronchial disease, endobronchial extension, or extrinsic compression of the airways by the tumor or by lymphadenopathy. Many of these patients have respiratory symptoms due to their disease. Shortness of breath, hemoptysis, and cough are often the complaints that bring patients to a physician and to the complex treatment programs currently used for the management of lung cancer. Some of these patients may benefit from endobronchial intervention as part of the management of their disease.

Standard management techniques of lung cancer — surgery, radiation therapy, and chemotherapy — measure treatment response, 5-year survival, and recurrence rates. When treating endobronchial disease, the concepts of symptom-free survival, dyspnea indices, and quality-of-life scores also need to be evaluated. Some patients become incapacitated by their symptoms of dyspnea. Many studies not only demonstrate improvement in clinical symptoms and quality of life, but also suggest increased overall survival with the use of endobronchial management techniques.³⁻¹⁶

Not all endobronchial disease causes complete obstruction of the airways. Sometimes patients have partial obstruction, which often has a less severe symptom complex. As these patients enter treatment programs, the endobronchial component of their disease, in response to these treatments, can lead to more complicated concerns. External-beam radiotherapy can induce endobronchial inflammation and swelling, further compromising the airways. Radiation or chemotherapy can lead to necrosis of the endobronchial component of the cancer. The inflammation and necrotic tissue can cause further airway compromise by inducing airway obstruction, lung collapse, and possible postobstructive pneumonia. Therefore, endobronchial techniques should be considered throughout the management of lung cancer patients.^{17,18}

Lastly, when all management options have been used, end-stage patients will often develop compromise of their airways as the cancer continues to progress. Endobronchial management options may help to relieve some of their symptoms, allowing them freedom from shortness of breath as they go home in conjunction with hospice or other palliative therapies.¹⁷⁻¹⁹

Most endobronchial techniques are performed on an outpatient basis. Unless a patient presents with respiratory failure, many of the procedures performed provide immediate relief of symptoms. This rapid symptomatic improvement allows patients to return home with an improved quality of life or better prepares them to continue treatment at their local programs. Although interventional procedures are not definitive therapies, they often provide partial to total relief of the strangling sensation produced by complete airway occlusion.

Interventional pulmonary programs that include endobronchial procedures need an armamentarium of therapeutic modalities rather than a single invasive approach to manage patients with complicated lung cancer. As each patient's anatomy differs, the manner in which the patient's cancer leads to symptoms varies. Several procedures used in conjunction (eg, laser and

stenting) may be necessary to provide the most efficacious management of the disease. Offering a multitude of modalities allows the best selection of approaches for the patient.^{17,18}

The following sections discuss a variety of techniques and tools available to the interventionalist. In many cases, no one technique is better than the others, and some combination of these techniques often offers the greatest benefit to the patient.

Bronchoscopy

Since the inception of flexible fiberoptic bronchoscopy in the late 1960s in Japan and in 1970 in the United States, the flexible bronchoscope has become the most widespread tool for evaluating and diagnosing diseases of the airways and lungs.²⁰ The rigid bronchoscope, the flexible bronchoscope's predecessor, was in many regards forgotten as a tool until interventional pulmonology evolved in the 1980s. Interventional pulmonologists reevaluated this tool and found its properties advantageous to the procedures that are currently performed. A survey in 1991 by the American College of Chest Physicians reported that only 8% of responding pulmonologists used a rigid bronchoscope.²¹

Overall, the concurrent use of the flexible bronchoscope with the rigid bronchoscope is necessary for the practice of interventional pulmonology. The rigid bronchoscope offers many advantages to the interventional pulmonologist, one of which is the superior control of the airway achieved with its use. Ventilation is performed through the scope itself rather than around the flexible bronchoscope. The larger-bore rigid bronchoscopes allow optical systems, large caliber suction catheters, and the laser to pass through the scope simultaneously. Large biopsy forceps are used through the rigid bronchoscope, which can provide more significant tissue biopsies as well as assist in mechanical debulking of lesions. However, the rigid bronchoscope is a more difficult tool to use that requires additional training. In addition, rigid bronchoscopy is most commonly performed in the operating room with general anesthesia. Overall, in difficult airway conditions, rigid bronchoscopy is an excellent technique for the management of endobronchial disease.

The rigid bronchoscope itself can be used as a tool in the management of endobronchial disease. The distal end of the bronchoscope has a beveled end. This edge can be used to shear large sections of endobronchial tumor away from the airway wall in a technique often referred to as apple coring. In a report on 56 patients with endobronchial obstruction from the

trachea to the distal mainstem bronchi, Mathisen and Grillo²² described improvement in 90% of their patients. Only 3 of the 56 patients had more than minor bleeding with this procedure. Although this procedure is technically difficult, applectoring combined with the use of larger biopsy forceps allows tumor to be quickly resected from the obstructed airway.

Laser Therapy

Laser, an acronym coined from light amplification by stimulated emission of radiation, has many medical uses, including the endobronchial management of lung cancer. Several laser types are currently used within the bronchi: neodymium:yttrium-aluminum-garnet (Nd:YAG), potassium-titanyl-phosphate (KTP), and carbon dioxide (CO₂). The most common laser used endoscopically is the Nd:YAG, which delivers energy at a wavelength of 1,064 nm. The laser energy can be conducted via a quartz monofilament and thus can be easily used with either the rigid or flexible bronchoscope. Normally, Nd:YAG is used at 10-40 watts, but it has a wide range of power outputs, up to 100 watts. Depending on the energy level used, the laser can affect tissue several millimeters to several centimeters in depth.

The predominant tissue effects of Nd:YAG lasers are thermal necrosis and photocoagulation. Thermal necrosis uses higher energy levels to destroy tissue, causing the formation of eschar. The problem with this approach is the significant vascularity of most lung cancers. In destroying tissue with laser energy, large blood vessels can also be destroyed. These blood vessels can be perforated with the tissue destruction, leading to significant hemorrhage and an increase rather than a decrease in morbidity and mortality with this procedure.

The most commonly used effect of laser energy is photocoagulation. Using lower energy levels, the surface of the tumor is heated, causing shrinkage of the tumor and diminishing the blood flow to that region. By devascularizing the tumor, more rapid mechanical debulking can be performed with improved control of bleeding.

Laser therapy can be performed via either flexible or rigid bronchoscopy. The majority of interventionalists use rigid bronchoscopy as the predominate tool for the performance of laser procedures when possible. Nd:YAG laser fibers can be passed through the working channel of most flexible bronchoscopes. Using the flexible bronchoscope, laser energy can be delivered to areas that cannot be reached with the rigid bronchoscope.^{3-16,22}

The reported success rate of symptom palliation using laser energy in the endobronchial management of lung cancer is high. Reports of clinical improvement rates range from 84% to 92% following laser bronchoscopy.^{7,10,23-25} Further review of the literature identifies studies that demonstrate improved survival in patients treated with laser bronchoscopy.^{9,13,14,26} Brutilnel et al⁹ compared 25 historical controls (ie, patients who would have been candidates for laser management but did not receive it secondary to the unavailability of the procedure at the time of their management) to 71 patients treated with laser bronchoscopy as part of the treatment program. The authors reported 76% and 100% mortality rates at 4 months and 7 months, respectively, in the control population. In the group treated with laser bronchoscopy, survival rates at 7 months and 1 year were 60% and 28%, respectively. Although no definitive randomized studies are available, review of historical studies would suggest improved survival in patients treated with endobronchial techniques.

Endobronchial Prostheses

Endobronchial prostheses are stents that can be used in several clinical situations: intrinsic, extrinsic, or mixed endobronchial obstruction. Stents work well in conjunction with other modalities such as laser and mechanical debulking of tumors. Currently, stents are composed of silastic rubber and metal alloys. Advantages and disadvantages of each are noted in the Table.

Advantages/Disadvantages of Silastic and Metal Stents

Silastic Stents	
Advantages:	Disadvantages:
<ul style="list-style-type: none"> • Removable and replaceable • No growth through stent • Low cost • Low likelihood of granulation tissue formation 	<ul style="list-style-type: none"> • Potential for migration/dislodgment • Rigid bronchoscopy needed for placement • Possible secretion adherence
Metal Stents	
Advantages:	Disadvantages:
<ul style="list-style-type: none"> • Easy to place • Good wall/internal diameter relationship • Powerful radial force • Excellent conformity for irregular tracheal or bronchial walls • Good epithelialization 	<ul style="list-style-type: none"> • Permanent • Tumor regrowth (noncovered) • Possible migration of covered stents • Significant granulation tissue stimulation • Epithelialization affecting wall mechanics and secretion clearance • Radial force causing necrosis of bronchial wall, erosion, fistulas, perforation

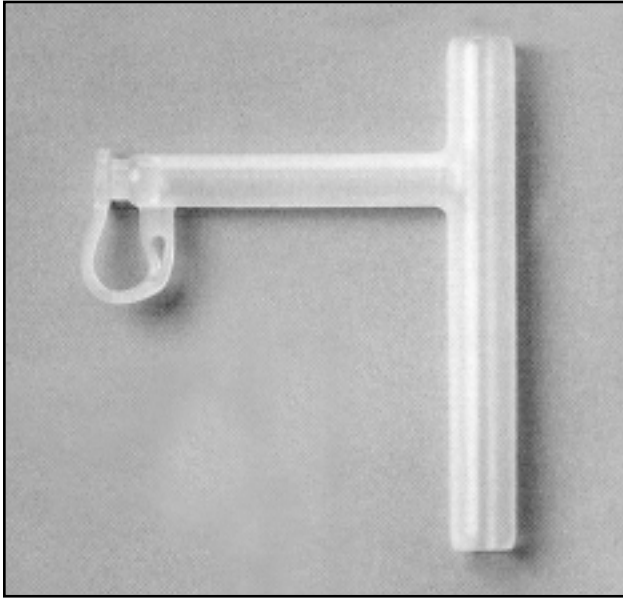


Fig 1. — Montgomery T-tubes.

Silastic Stents

Many of the silastic stents now in use evolved from the Montgomery T-tube, which was first used in the early 1960s. This T-shaped stent supports the entire trachea with an arm that extends through a permanent tracheostomy (Fig 1). In patients with a patent tracheostomy, the Montgomery T-tube remains an excellent tool for the management of endotracheal disease.²⁷⁻²⁹

In 1990, Dumon³⁰ reported the use of what is now referred to as the Dumon stent (Bryon Corp, Woburn, Mass). Developed in 1987, it is a silastic stent with evenly spaced studs along its outside walls (Fig 2). These studs not only assist in maintaining placement of the stent in the airway, but also allow the clearance of secretions around the walls of the stent. Although the use of expandable wire mesh stents is increasing, the Dumon stent probably is currently the most common stent currently used by interventionalists.

The Dumon stent is effective in maintaining the structural integrity when placed endobronchially. Its



Fig 2. — Dumon silastic stents.

solid walls prevent tumor growth from reobstructing airways. Endobronchial tumors are often debulked and then a stent is placed prior to the initiation of radiotherapy or chemotherapy, or both. Another advantage of the Dumon stent is the ease of removal. This can be significant when endobronchial procedures are used early in the management of cancer patients. After definitive therapies have been used (radiation, chemotherapy), re-evaluation of the airway can be performed, and the stent can be either left in place, removed (if deemed of no further clinical advantage), or replaced with a larger stent that would further improve the caliber and stability of the airway. The disadvantages of the Dumon stent are the potential for migration and the need for a rigid bronchoscope for placement. The migration issue, although often referred to, occurs less often when the stent is placed by an experienced interventional endoscopist.^{27,30-35}

Other silastic stents include the Hood stent (Hood Laboratories, Decatur, Ga) and the hybrid Rusch Y stent (Rusch Inc, Duluth, Ga). The Hood stent is similar to the Dumon stent in design and use. The Hood stent is placed in the same manner as the Dumon stent.³⁶ The Rusch-Y stent (Fig 3) is a silastic stent with stainless steel c-rings that artificially represent the cartilage. The posterior wall of the stent is made of a thinner silastic plastic to make it more functional, similar to the membranous trachea itself. The three available sizes of this stent are designed to traverse the entire length of the trachea with branches into the right and left mainstem bronchi. The Rusch Y stent requires rigid bronchoscopy and is difficult to place, remaining uncommon in clinical practice.

Metal Stents

Metal stents, such as the Gianturco (Cook Inc, Bloomington, Ind), the Palmaz (Johnson & Johnson Interventional Systems, Warren, NJ), the Wallstent (Schneider Inc, Minneapolis, Minn), and the Ultraflex (Boston Scientific, Natick, Mass), have been used in the endobronchial management of lung cancer. The advantage of metal stents is the relative ease for placement via a flexible bronchoscope with fluoroscopic

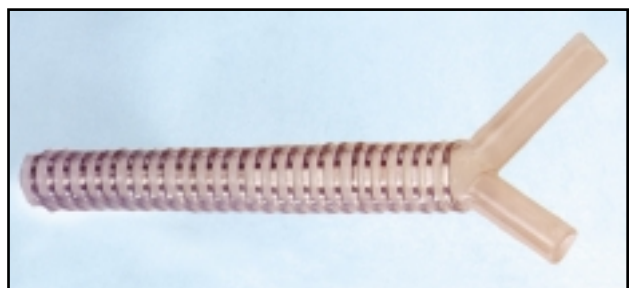


Fig 3. — Rusch Y stent.

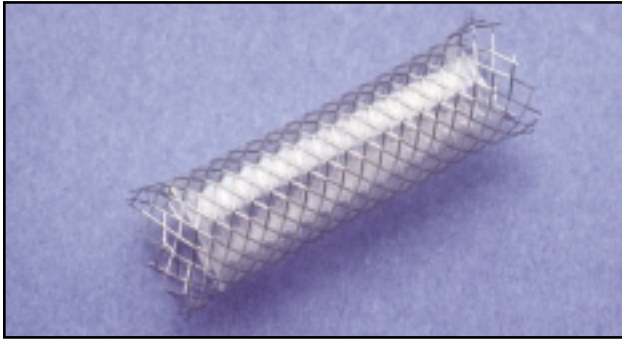


Fig 4. — Covered Wallstent.

assistance. This ease of placement allows some bronchoscopists to use these stents as their sole modality in the management of endobronchial disease. However, this practice limits the options to patients that may otherwise be available if all interventional modalities were offered. The wire mesh design of many of the original metal stents did not prevent the tumor from growing through the stent over time. The Wallstent and Ultraflex stents are now available in covered versions. A wrap is applied to the outside of the wire mesh to prevent tumor invasion through the stent. Data that support the use of both of these stents for the endobronchial management of lung cancer is available.^{27,31,37-39}

The Wallstent is composed of woven stainless steel wires with exposed proximal and distal ends (Fig 4). These exposed ends imbed in the endobronchial mucosa to fix the stent into place. Significant stimulation of granulation tissue development at both the proximal and distal ends of the exposed Wallstent is a concern for long-term endobronchial management. Studies using this stent demonstrate excellent initial outcomes, particularly with the release of the covered version.^{31,40}

The Ultraflex stent is made of nitinol, a titanium and nickel alloy, which has little bioreactivity. This stent has excellent inner to outer diameter and conforms well to various airway shapes, maintaining an equal pressure along the entire length of the stent. The Ultraflex stent is available in a variety of lengths and diameters. Overall the covered version of this stent is excellent for use in palliation of airway obstruction (Figs 5-6).

Metal stents epithelialize as they remain in the airways, thereby becoming incorporated into the wall of the bronchus. The epithelialization changes the mechanics of the airways with time by making them stiffer, which may lead to further airway complications.^{34,39} Another consideration with the use of metal stents is the fact that once they are endoscopically placed, their removal is difficult and often impossible. Although uncommon, the

risk with the use of metal stents is the erosion that can occur through bronchial/tracheal walls. This is particularly serious when erosion occurs into blood vessels, leading to massive uncontrollable hemoptysis.

Stents are effective tools for the endobronchial management of lung cancer. The choice of stent to use should be made carefully, weighing advantages and disadvantages of each, so the proper tool is used in all situations. Multiple stent types need to be available to the endoscopist to allow the proper choice for the clinical situation.

Photodynamic Therapy

Photodynamic therapy (PDT) has received increased attention in recent years. PDT is an important adjunctive modality to the management of endobronchial disease, but it does not replace Nd:YAG lasers, stents, and rigid bronchoscopy. PDT also can be used with bulky disease, but most interventionalists feel that it is of limited benefit in this role.^{41,42} The most

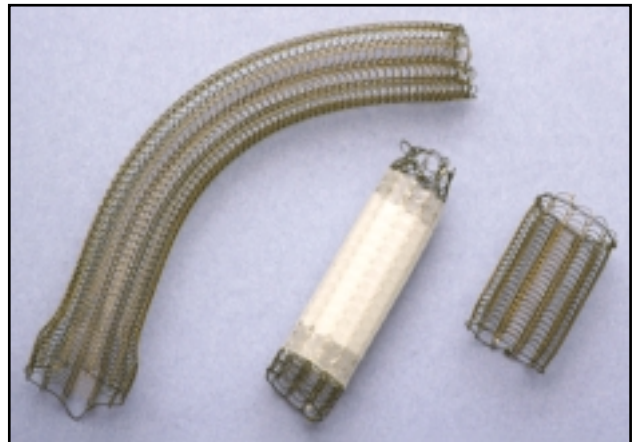


Fig 5. — Covered and uncovered Ultraflex stents.



Fig 6. — Proximal view of an Ultraflex stent in the right mainstem bronchi.

suitable lesions for PDT are in situ carcinomas or those limited to 4-5 mm of microinvasion.⁴³

A photosensitizing drug is intravenously administered to the patient 48 to 72 hours prior to the procedure. Porfimer sodium (Photofrin) is the most common agent currently used for this. This photosensitizer penetrates all cells systemically. It is not cleared as quickly in cancer cells as in other cells and is therefore found in higher concentrations in cancer cells as opposed to the endothelium surrounding the tumor.^{43,44} An argon dye laser is then used to provide the 630-nm wavelength light energy required to activate the intracellular porfimer sodium. The laser energy is transmitted via a flexible quartz fiber, which can be used through either a flexible or rigid bronchoscope. The fiber tip can be placed in close approximation to the tumor mass, or it can be imbedded into the tumor to provide the energy needed to start the intracellular activation of the porfimer sodium. This reaction leads to cellular destruction by a variety of mechanisms. Tissue necrosis then ensues as the cancer cells die.⁴³⁻⁴⁵

As the neoplastic tissue necrotizes, it must be removed by repeated bronchoscopies. Flexible bronchoscopy is commonly performed daily or every other day for up to 1 week to remove the necrotic tissue. The necrosis of bulky tumor can be dangerous to the patient if the necrotic tissue separates from the bronchial wall and occludes the airway. In some programs that use only PDT, patients remain intubated following the procedure for 1-2 days secondary to this concern. If necrotic tissue is removed over the first 24-48 hours, a second laser application to the cancer can be performed, thus improving the cancer tissue destruction.

PDT is an excellent therapeutic modality for patients with early-stage cancers. It destroys neoplastic tissue effectively and is an outstanding therapeutic modality in carcinoma in situ and microinvasive cancers. PDT is a necessary tool in our armamentarium of endobronchial treatments, but the time delays and multiple steps of management make it a more cumbersome therapy for the management of late-stage endobronchial lung cancer.⁴⁵

Cryotherapy

Cryotherapy is another modality for the endobronchial destruction of malignant tissue that obstructs the tracheobronchial tree. This technique uses cold instead of the heat used in laser-based technologies. A probe is placed onto or into an obstructing tumor mass. Liquid nitrogen (-196°C) or nitrous oxide (-80°C) cools the probe tip when performing cryo-

therapy. This tissue freezing leads to the destruction of all cells in an area of approximately 1 cm in diameter around the probe tip. Vascular thrombosis occurs with the super-cooling of tissue, minimizing the bleeding during resection of the tumor.

The limiting factor to using cryotherapy is that the tissues destroyed with the freezing procedure take time to die and necrose. This requires returning to the lesion to remove the necrosed material and, in some cases, repeating treatments. Although cryotherapy is effective at tumor destruction and management, the necessity of repeated procedures makes this a more time-consuming procedure to perform, limiting its usefulness in management of bulky endobronchial disease.⁴⁶

Electrocautery

Electrocautery uses electrical energy via one of several introducer devices to cut and/or destroy tumor cells. The various tools of electrocautery can be introduced through a flexible bronchoscope (one that is grounded and designed for this therapy) and can then debulk endobronchial disease using the electrical energy to cauterize tissue, thus minimizing the bleeding that occurs with tumor resection. Endobronchial electrocautery treatment can be used similarly to laser therapy and/or cryotherapy for managing advanced endobronchial lung cancer. Overall, this therapy holds great promise for endobronchial disease management.⁴⁷

Balloon Dilatation

Balloons used for intravascular procedures can also help to manage endobronchial stenosis secondary to both malignant and benign disease. At our institute, we are currently using the Cordis PTA Dilatation Catheter (Cordis Europa N.V., The Netherlands) for endobronchial narrowings. The Cordis balloon comes in a variety of diameters and lengths to help dilate areas of bronchial compromise. Occasionally, strictures are dilated prior to the placement of a stent or even used to fully expand a stent already in place.

The balloon is passed endobronchially via either a rigid or flexible bronchoscope. The appropriate diameter and length of the balloon are chosen for the particular lesion. Ideally, 5-10 mm of balloon should extend beyond the lesion both proximally and distally. The treatment should be performed as a series of dilatations with gradual increase in the balloon diameter to minimize the risk of tracheobronchial rupture. Once inflated to the prescribed pressure, this dilatation pressure should be maintained for 1-2 minutes. Two min-

utes is preferable if the patient can tolerate this without discomfort or hypoxia.

Although balloon dilatation is an adjunctive therapy to bronchoscopy, laser, and/or stenting, acquiring skills with this modality is beneficial to the interventionalist and important for the complete endobronchial management of patients with lung cancer.

References

1. *Cancer Facts and Figures, 2001*. Atlanta, Ga: American Cancer Society; 2001.
2. Luomanen RKJ, Watson WL. Autopsy findings. In: Watson WL, ed. *Lung Cancer: A Study of Five Thousand Memorial Hospital Cases*. St Louis, Mo: CV Mosby Co; 1968:504-510.
3. Hetzel MR, Millard FJ, Ayesh R, et al. Laser treatment for carcinoma of the bronchus. *Br Med J*. 1983;286:12-16.
4. Mehta AC, Golish JA, Ahmad M, et al. Palliative treatment of malignant airway obstruction by Nd-YAG laser. *Cleve Clin Q*. 1985;52:513-524.
5. McDougall JC, Corese DA. Neodymium-YAG laser therapy of malignant airway obstruction: a preliminary report. *Mayo Clin Proc*. 1983;58:35-39.
6. Toty L, Personne C, Colchen A, et al. Bronchoscopic management of tracheal lesions using the neodymium yttrium aluminum garnet laser. *Thorax*. 1981;36:175-178.
7. Dumon JF, Reboud E, Garbe L, et al. Treatment of tracheobronchial lesions by laser photoresection. *Chest*. 1982;81:278-284.
8. Arabian A, Spagnolo SV. Laser therapy in patients with primary lung cancer. *Chest*. 1984;86:519-523.
9. Brutinel WM, Cortese DA, McDougall JC, et al. A two-year experience with the neodymium-YAG laser in endobronchial obstruction. *Chest*. 1987;91:159-165.
10. Beamis JF Jr, Vergos K, Rebeiz EE, et al. Endoscopic laser therapy for obstructing tracheobronchial lesions. *Ann Otol Rhinol Laryngol*. 1991;100:413-419.
11. Sonett JR, Keenan RJ, Ferson PF, et al. Endobronchial management of benign, malignant, and lung transplantation airway stenosis. *Ann Thorac Surg*. 1995;59:1417-1422.
12. Macha HN, Becker KO, Kemmer HP. Pattern of failure and survival in endobronchial laser resection: a matched pair study. *Chest*. 1994;105:1668-1672.
13. Desai SJ, Mehta AC, Vanderbug Medendorp S, et al. Survival experience following Nd:YAG laser photoresection for primary bronchogenic carcinoma. *Chest*. 1988;94:939-944.
14. Stanopoulos IT, Beamis JF Jr, Martinez FJ, et al. Laser bronchoscopy in respiratory failure from malignant airway obstruction. *Crit Care Med*. 1993;21:386-391.
15. Cavaliere S, Foccoli P, Toninelli C, et al. Nd:YAG laser therapy in lung cancer: an 11-year experience with 2,253 applications in 1,585 patients. *J Bronchol*. 1994;1:105-111.
16. Ross DJ, Mohsenifar Z, Koerner SK. Survival characteristics after neodymium:YAG laser photoresection in advanced stage lung cancer. *Chest*. 1990;98:581-585.
17. Edell ES, Cortese DA, McDougall JC. Ancillary therapies in the management of lung cancer: photodynamic therapy, laser therapy, and endobronchial prosthetic devices. *Mayo Clin Proc*. 1993;68:685-690.
18. Cortese DA, Edell ES. Role of phototherapy, laser therapy, brachytherapy, and prosthetic stents in the management of lung cancer. *Clin Chest Med*. 1993;14:149-159.
19. Sutedja G, Schramel F, van Kralingen K, et al. Stent placement is justifiable in end-stage patients with malignant airway tumours. *Respiration*. 1995;62:148-150.
20. Ikeda S. Flexible bronchofiberscope. *Ann Otol Rhinol Laryngol*. 1970;79:916-923.
21. Prakash UB, Stubbs SE. The bronchoscopy survey: some reflections. *Chest*. 1991;100:1660-1667.
22. Mathisen DJ, Grillo HC. Endoscopic relief of malignant airway obstruction. *Ann Thorac Surg*. 1989;48:469-475.
23. Cavaliere S, Foccoli P, Farina PL. Nd:YAG laser bronchoscopy. A five-year experience with 1,396 applications in 1,000 patients. *Chest*. 1988;94:15-21.
24. Kvale PA, Eichenhorn MS, Radke JR, et al. YAG laser photoresection of lesions obstructing the central airways. *Chest*. 1985;87:283-288.
25. Eichenhorn MS, Kvale PA, Miks VM, et al. Initial combination therapy with YAG laser photoresection and irradiation for inoperable non-small cell carcinoma of the lung: a preliminary report. *Chest*. 1986;89:782-785.
26. Petrovich Z, Stanley K, Cox JD, et al. Radiotherapy in the management of locally advanced lung cancer of all cell types: final report of randomized trial. *Cancer*. 1981;48:1335-1340.
27. Colt HG, Dumon JF. Tracheobronchial stents: indications and applications. *Lung Cancer*. 1993;9:301-306.
28. Cooper JD, Pearson FG, Patterson GA, et al. Use of silicone stents in the management of airway problems. *Ann Thorac Surg*. 1989;47:371-378.
29. Montgomery WW. T-tube tracheal stent. *Arch Otolaryngol*. 1965;82:320-321.
30. Dumon JF. A dedicated tracheobronchial stent. *Chest*. 1990;97:328-332.
31. Tojo T, Iioka S, Kitamura S, et al. Management of malignant tracheobronchial stenosis with metal stents and Dumon stents. *Ann Thorac Surg*. 1996;61:1074-1078.
32. Dumon JF, Cavaliere S, Diaz-Jimenez JP, et al. Seven-year experience with the Dumon prosthesis. *J Bronchol*. 1996;3:6-10.
33. Diaz-Jimenez JP, Munoz EF, Ballarin JIM, et al. Silicone stents in the management of obstructive tracheobronchial lesions: 2-year experience. *J Bronchol*. 1994;1:15-18.
34. Freitag L, Eicker K, Donovan TJ, et al. Mechanical properties of airway stents. *J Bronchol*. 1995;2:270-278.
35. Clarke CP, Ball DL, Sephton R. Follow-up of patients having Nd:YAG laser resection of bronchostenotic lesions. *J Bronchol*. 1994;1:19-22.
36. Gaer JA, Tsang V, Khaghani A, et al. Use of endotracheal silicone stents for relief of tracheobronchial obstruction. *Ann Thorac Surg*. 1992;54:512-516.
37. Colt HG, Dumon JF. Airway obstruction in cancer: the pros and cons of stents. *J Respir Dis*. 1991;12:741-744, 746, 748-749.
38. Bolliger CT, Probst R, Tschopp K, et al. Silicone stents in the management of inoperable tracheobronchial stenoses: indications and limitations. *Chest*. 1993;104:1653-1659.
39. Gelb AE, Zamel N, Colchen A, et al. Physiologic studies of tracheobronchial stents in airway obstruction. *Am Rev Respir Dis*. 1992;146:1088-1090.
40. Tsang V, Williams AM, Goldstraw P. Sequential silastic and expandable metal stenting for tracheobronchial strictures. *Ann Thorac Surg*. 1992;53:856-860.
41. Lam S. Photodynamic therapy of lung cancer. *Semin Oncol*. 1994;21:15-19.
42. Sutedja T, Lam S, LeRiche JC, et al. Response and pattern of failure after photodynamic therapy for intraluminal stage I lung cancer. *J Bronchol*. 1994;1:295-298.
43. Furuse K, Fukuoka M, Kato H, et al. A prospective phase II study on photodynamic therapy with Photofrin II for centrally located early-stage lung cancer: the Japan Lung Cancer Photodynamic Therapy Study Group. *J Clin Oncol*. 1993;11:1852-1857.
44. Hayata Y, Kato H, Konaka C, et al. Photodynamic therapy (PDT) in early stage lung cancer. *Lung Cancer*. 1993;9:287-294.
45. Moghissi K, Dixon K, Stringer M, et al. The place of bronchoscopic photodynamic therapy in advanced unresectable lung cancer: experience of 100 cases. *Eur J Cardiothorac Surg*. 1999;15:1-6.
46. Maiwand MO, Homasson JP. Cryotherapy for tracheobronchial disorders. *Clin Chest Med*. 1995;16:427-443.
47. Gerasin VA, Shafirovsky BB. Endobronchial electrosurgery. *Chest*. 1988;93:270-274.