The Heat Is On*

Impact of Endobronchial Electrosurgery on the Need for Nd-YAG Laser Photoresection

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Study objectives: **Advances in bronchoscopic electrosurgery have allowed its application in the outpatient setting in patients who otherwise would have required Nd-YAG laser photoresection (LPR) in the operating room. We intended to evaluate the impact of endobronchial electrosurgery (EBES) on the need for Nd-YAG LPR on patients with symptomatic airway lesions.**
Design: **Prospective observational case series.**
Participants: **One hundred eighteen evaluations for LPR were performed. Forty-seven evaluations (40%) were considered to be amendable to EBES and were treated during the initial bronchoscopy. The remaining patients underwent LPR.**
Setting: **Outpatient bronchoscopy suite at the Cleveland Clinic Foundation, Cleveland, OH.**
Results: **Of the 47 procedures, 42 (89%) were successful in alleviating the obstruction, thus eliminating the need for LPR. No major complications were encountered.**
Conclusion: **EBES can be performed safely in the outpatient setting and is an effective procedure in treating select endobronchial lesions. EBES eliminated the need for LPR in 36% of such procedures with a potential for significant time and cost savings.**

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Key words: bronchoscopy; electrosurgery; endobronchial; LPR

Abbreviations: EBES = endobronchial electrosurgery; FB = flexible bronchoscope; LPR = laser photoresection

Tracheobronchial obstruction from benign or malignant lesions can cause significant morbidity in affected patients. Acute respiratory distress, postobstructive pneumonia, atelectasis, asphyxia, or even death can result from various degrees of airway obstruction. Some patients may benefit from curative or palliative therapeutic interventions that can alleviate their obstruction.[1,2] Nd-YAG laser photoresection (LPR) is the most effective therapy for treating obstructive lesions; however, the widespread use of this technique is limited by the perceived need for rigid bronchoscopy, expensive equipment, and special training, and by the fear of major complications. Advances in flexible bronchoscopy (FB) have allowed for the development of other techniques directed at alleviating airway obstruction, including cryotherapy, brachytherapy, and photodynamic therapy.[3] Although cost-effective, their effects are delayed and may require repeat treatments.

The use of electrocautery through the bronchoscope was first reported in the early 1980s with varying degrees of success.[4,5] Despite its low cost, endobronchial electrosurgery (EBES) failed to gain popularity due to cumbersome delivery systems and complications associated with the power units. Since the evolution of a new generation of electrosurgical devices used in GI endoscopy, there has been renewed interest in its application in the endobronchial tree. Labeled as "the poor man's laser," electrosurgery has equivalent "laser-like" tissue effects at a fraction of the cost. Herein, we prospectively evaluated the usefulness of EBES in selected patients with malignant or benign causes of tracheobronchial obstruction who otherwise would have been candidates for LPR.

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Materials and Methods

Nd-YAG LPR has been available to patients with surgically unresectable exophytic lesions at our institution since 1983. All LPR procedures are performed in the operating room under general anesthesia using the FB. Since August 1997, patients referred to our department for evaluation for LPR also were considered for EBES. During the study period, 118 evaluations were performed. Forty-seven of these (40%) were considered amendable to EBES, and, thus, the procedure was performed during the initial bronchoscopy. The remaining patients underwent LPR.

The risks and benefits of FB, as well as those of EBES, were discussed with eligible patients. During the initial bronchoscopy, if an endobronchial lesion amenable to LPR was encountered, then EBES was attempted. Lesions considered suitable for the procedure were required to have < 50% luminal obstruction, a visualized size that was < 2 cm in its greatest dimension, limited vascularity, and an estimated procedure time of < 1 h.

A flexible bronchoscope (model BF 240; Olympus America; Melville, NY) was utilized for all procedures. This instrument has an inherent feature that eliminates the need for separate grounding. The diameter of the working channel of the scope is 2.6 mm, which allows the insertion of most therapeutic accessories. An electrosurgical unit (model PSD-10; Olympus America) was the power source for the procedure (Fig 1). This unit is approximately 1 cubic foot in volume and produces the three following current modes: cut, coagulate, and blend. The cut mode utilizes high electrical current with low voltage. This allows for the vaporization of tissue due to a dense concentration of electrical energy with minimal lateral thermal spread. The coagulation mode produces low current with high voltage along a dampened waveform causing slow heating that is dispersed over a larger area. Protein is denatured, forming a viscous coagulum leading to hemostasis. The blend mode combines the effects of the two and is best used during a snare polypectomy procedure. Electric current is delivered at 10 different levels of settings, from 0 to 80 W, depending on the chosen mode. The endobronchial accessories consisted of polypectomy snare, coagulation probe, forceps, and a cutting blade (Fig 2).

All procedures were performed in the outpatient bronchoscopy suite with the patient under conscious sedation. Patients were premedicated with IM meperidine, hydroxyzine, and atropine unless contraindicated. For sedation, IV morphine sulfate and midazolam hydrochloride were administered in 2-mg boluses as needed. Topical anesthesia was achieved by endobronchial instillation of 2% lidocaine (limited to 7 mg/kg body weight over a 45-min period). Supplemental oxygen was delivered via nasal cannula or face mask at concentrations titrated to maintain a saturation > 92%. Arterial oxygen saturation, ECG, and BP monitoring were performed throughout the procedure. The bronchoscope was introduced transnasally, orally, or through a preexisting tracheotomy stoma. No elective intubation was performed for the procedure. Once a lesion amenable to EBES was identified, the procedure was carried out according to the method previously published.[6] The selection of endobronchial accessories was at the discretion of the bronchoscopist.

The intent of the procedure was the total removal of the exophytic lesion. This was achieved by cutting the stalk of a pedunculated lesion using a snare or by vaporization of a sessile lesion using a coagulation probe (Fig 3, 4). The cutting blade was used to make radial incisions on concentric web-like strictures involving either the trachea or the main bronchi (Fig 5). Following the incision, these lesions were dilated using an angioplasty balloon of the appropriate size. The procedure was considered successful if the obstruction was relieved, thus eliminating the need for LPR. If the patient could not tolerate the procedure due to excessive bleeding or coughing, or if the procedure time exceeded 1 h, then the procedure was considered unsuccessful. Diagnostic tissue samples were obtained when indicated.

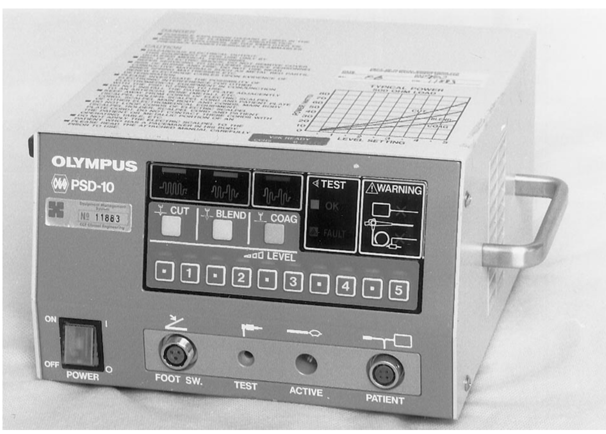


FIGURE 1. An electrosurgical unit (model PSD-10; Olympus America).

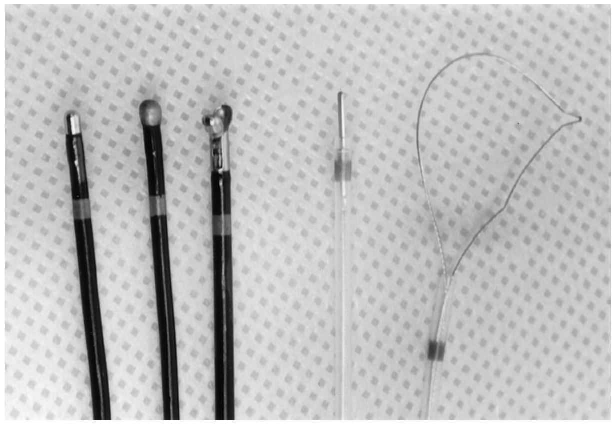


FIGURE 2. Electrosurgical accessories (left to right: small coagulation probe, large coagulation probe, cup forceps, blade, and loop snare).

Results

Thirty-eight patients, 22 men and 16 women, between the ages of 24 and 85 years were treated with EBES. A total of 47 procedures were performed to treat 68 different lesions. One patient required four separate procedures, another required three, and three patients required two procedures for the recurrent nature of their disease. Primary abnormalities and the location of the endobronchial lesions are listed in Tables 1 and 2, respectively. A single lesion involving a tracheotomy stoma was treated with the direct application of the probe without using the bronchoscope.

Successful results were seen in 42 procedures (89%), thus eliminating need for the LPR. Unsuccessful results were encountered in patients who had lesions larger than initially anticipated. These lesions appeared polypoid on first inspection; however, while debulking with a polypectomy snare, it became

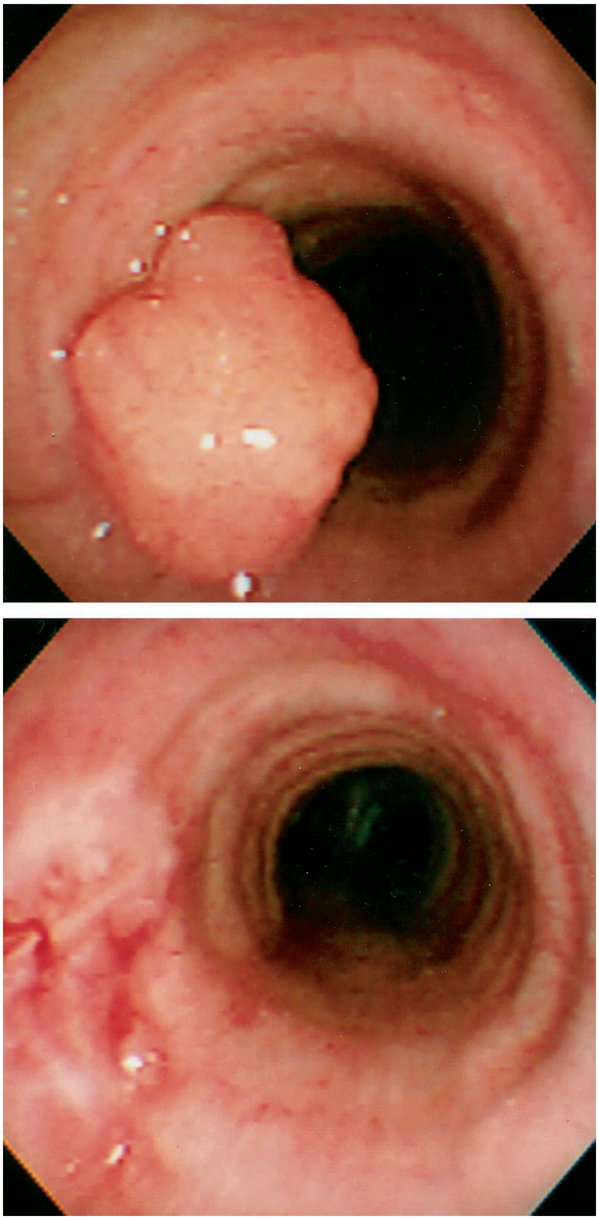


FIGURE 3. Endotracheal hamartoma before (*top*) and after (*bottom*) excision with the loop snare.

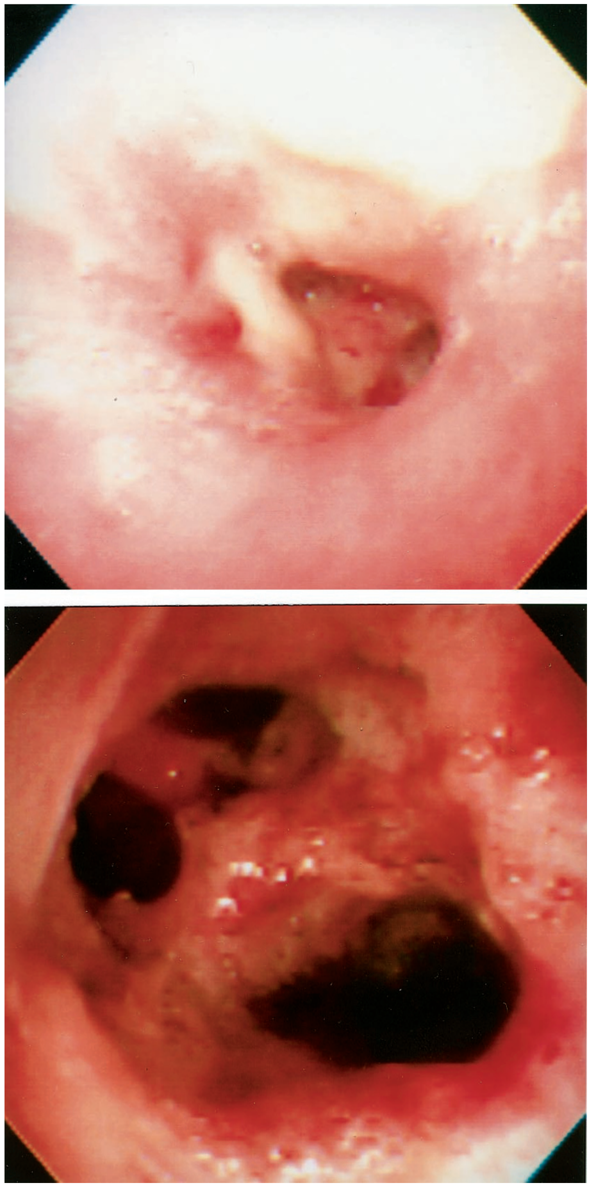
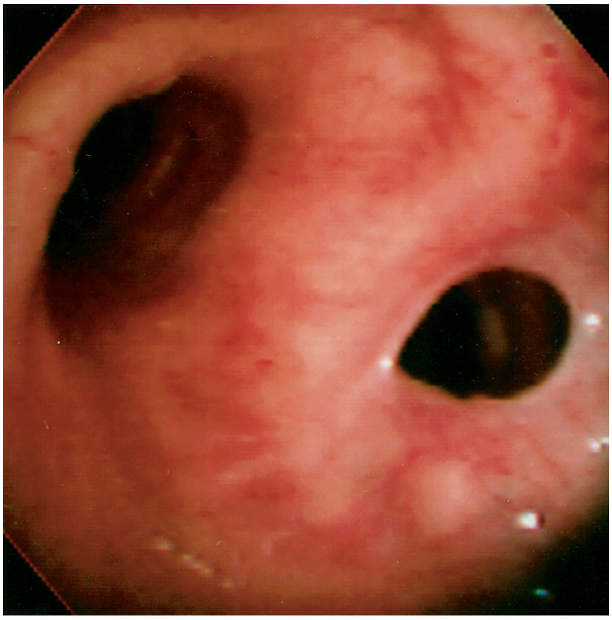


FIGURE 4. Right upper lobe orifice before (*top*) and after (*bottom*) probe ablation of an endobronchial posttransplant lymphoproliferative disorder lesion causing obstruction in a lung transplant recipient.

apparent that the distal extension of the tumor deemed them too large for electrosurgical resection. Complications were few (Table 3). Bleeding was encountered in four patients. Transient oxygen desaturations were seen in one patient, while the other three patients had repeatedly obscured fields of vision for the bronchoscope. One patient had persistent coughing that hindered, but did not limit, the outcome. No other adverse events were encountered. No patients required hospitalization or endotracheal intubation as a consequence of the procedure.

DISCUSSION

This series demonstrates that EBES is a safe and effective alternative for treating benign or malignant tracheobronchial lesions. Although the initial reports were small in number and had variable outcomes,[4,5] more recent series have validated this procedure.[7,8] This success is attributable to the skills and equipment borrowed from GI endoscopic procedures. Gastroenterologists have been using electrosurgery to remove colonic polyps and to control GI bleeding for years, and it is the application of their techniques to the tracheobronchial tree that has allowed for these advances.[9]



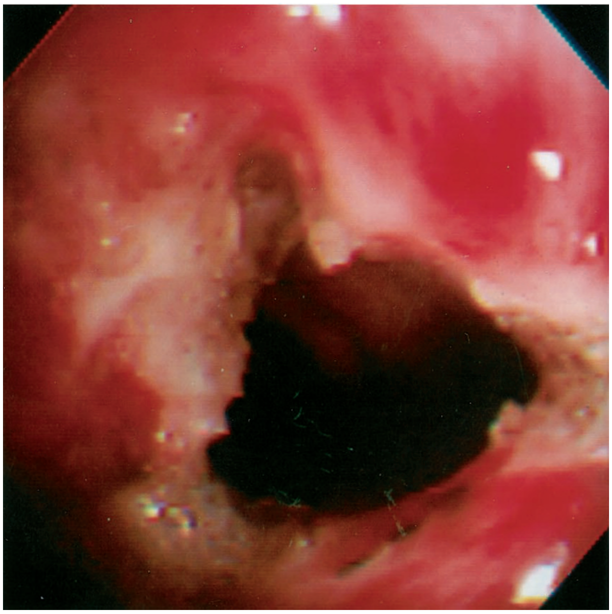


FIGURE 5. Image of the carina demonstrating the right mainstem bronchus with a 50% stricture due to scaring from resolved endobronchial tuberculosis (*top*). The cutting blade was used to make radial incisions followed by balloon bronchoplasty (*bottom*).

Both benign and malignant lesions were proven to be amendable to EBES. The total or near-total removal of benign endobronchial lesions was accomplished in all of our cases. Although some patients required repeated procedures due to the nature of the disease (papillomas or stent granulomas), these were not considered therapeutic failures. None of the procedures for malignant obstruction were intended to be curative but, rather, were palliative. Most of these patients also had adjuvant therapy such as external beam radiation, brachytherapy, or chemotherapy.

Table 1—*Diagnosis, Patients, and Number of Lesions Treated*

Diagnosis	Patients, No.	Lesions Treated, No.
Benign		
Papillomatosis	6	21
Granulation tissue	12	24
Lipoma	3	3
Hamartoma	2	2
Stenosis	2	2
Malignant		
Bronchogenic carcinoma	7	8
Renal cell carcinoma	2	3
Colon adenocarcinoma	1	1
Sarcoma	1	1
Lymphoma	1	2
Carcinoid	1	1

Lesions found to be most favorable to EBES were polypoid in morphology and were attached to the airway by a stalk. This allowed for the total ensnarement of the lesion with complete removal in one piece. At times, the tissue was too large to be removed through the working channel of the bronchoscope, so it was removed *in toto*. This was accomplished by anchoring the tissue with grasping forceps or applied suction, and removing the bronchoscope while visualizing the secured tissue as the bronchoscope passes through the upper airway. An alternative method was to allow the patient to expectorate the piece of tissue when the procedure was complete.

The technique of removing an endobronchial polypoid lesion follows the same principles as removing a colonic polyp. A wire snare was passed beyond the lesion and opened in the distal lumen. It was then slowly pulled proximal with the open loop passing over the lesion head. Once the wires were around the lesion, the bronchoscope was flexed toward the base of the lesion allowing the loop to drop to the base of the stalk. The loop was closed with gentle pressure to assure ensnarement. Appropriate current selection with the blend mode was chosen and applied. The operator slowly closed the snare as the wire advanced through the tissue allowing for simul-

Table 2—*Location and Number of Lesions Treated*

Location	Lesions, No.
Trachea	24
Mainstem bronchi	27
Lobar bronchi	16
Stoma	1

Table 3—*Complications During Electrosurgery*

Type	Complications, No.
Bleeding	4
Limited field of view	3
Transient desaturation	1
Excessive cough	1
Hospital admissions	0

taneous cutting and coagulation. This procedure was relatively bloodless if performed correctly. The application of high currents led to rapid cutting without adequate time for coagulation. Likewise, excessive pressure while closing the snare led to unwanted bleeding. The right "feel" for the snare and knowledge of current setting were acquired through experience.

Flat or sessile lesions were not amendable to snare removal. These lesions were better treated by attempting fulguration with the coagulation probe. This was best achieved with the blend or cut mode. Although the principal effect was vaporization of the tissue, we found it did not achieve the results seen with LPR. Tissue was destroyed, however, not as much vaporization occurred. This led to the accumulation of carbonized tissue that required frequent irrigation and debridement. In addition, carbonized tissue adhered to the probe tip, thus decreasing the effectiveness of electrical conduction. Bleeding was common while using the higher-wattage blend or cut mode, which limited the field of vision. One way to enhance the effectiveness of ablating tissue with the probe was not to "bury" the tip in the tissue, but rather lightly "kiss" the tissue. This allowed the current to be applied to a small area of tissue, thus concentrating electrical conduction and thermal effects. An easy way to assess this was to look for "sparks" between the probe tip and tissue.

In addition to the immediate difficulties of treating sessile lesions, late complications can occur as well. The various settings of mode, power, and duration of application make it difficult to predict the depth of tissue destruction. Although not seen in our series, tracheal perforation and pneumothorax are potential complications.[10] The circumferential treatment of lesions should be avoided as this may lead to cartilaginous damage, fibrosis, and subsequent stenosis.[11] If structural support is compromised, tracheobronchomalacia can occur.

Endotracheal fire was not encountered in our series. This was likely due to the lack of an igniting substance, such as an endotracheal tube. In several patients, the procedure was performed while the patients received 100% oxygen that was administered via a face mask. Special attention was made keeping the distal line mark on the various accessories visible during the procedure (Fig 2). This assured an adequate distance from the tip of the bronchoscope, a potential source of ignition,

The most common cause for EBES failure was due to the misleading endoscopic appearance of some lesions. While the initial morphology appeared polypoid, on attempted removal it became apparent that the lesion extended down the lumen. When such large bulky tumors were encountered, the snare was used to remove or debulk the tumor in a piecemeal fashion. However, it became apparent that these lesions were more remediable by LPR. Other difficult lesions were those that were vascular and, hence, very hemorrhagic. Blood in the field of work provided a wet surface that diffused the contact point and limited the effectiveness of electrosurgery. If an endobronchial lesion is known to be extensive or vascular, it would be prudent to utilize LPR over EBES.

The use of EBES in removing the granulation tissue caused by metallic stents has been a successful alternative to LPR. When patients with stents were being evaluated, the grounded bronchoscope was used in the anticipation of granulation tissue polyps. While ablating these lesions, special care not to touch the wires was taken since electrical conduction can be carried throughout the wire mesh. Although the energy was quickly dissipated, the effect on the target lesion was decreased. The success with EBES has markedly reduced the need for LPR at our institution in patients with metallic stents. With a growing number of pulmonologists now placing stents, EBES may become a necessary skill to treat this anticipated complication.

EBES has been utilized in place of costly photodynamic therapy or brachytherapy on patients with radiologically occult carcinoma. In a pilot study, Boxem et al[12] reported a complete response to EBES in 10 of 13 patients with endobronchial lesions that were < 1 cm^2. Their study suggests that EBES may be an effective alternative in the treatment of carcinoma *in situ*.

Last, an attractive advantage of EBES is that it is relatively inexpensive compared to LPR.[13] The newer line of production bronchoscopes is now standardized to be compatible with and internally grounded for the use of electrosurgery. The cost of setting up electrosurgery, excluding the bronchoscope, can now be obtained for < $10,000, whereas that of setting up the Nd-YAG laser can approach $200,000. Additional cost savings occur by not requiring operating room time, general anesthesia, and additional personnel. EBR can be performed safely in the outpatient setting, without the need for these extraneous costs.

In conclusion, EBR is a safe and effective treatment of benign or malignant endobronchial lesions. Our series has demonstrated that the need for LPR was reduced by 36%. The ability of EBES to be performed in the outpatient setting is more accommodating for patients as well as time saving for physicians, and it is associated with a potential for significant cost savings. As more pulmonologists become adept with interventional bronchoscopy, EBES likely will evolve as an effectual procedure.

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