

# Flexible Laser Bronchoscopy for Subglottic Stenosis in the Awake Patient

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**Objective:** To describe our technique and experience of treating adult subglottic stenosis using the Nd:YAG laser through a flexible bronchoscope via a fiberoptic delivery system.

**Design:** Retrospective chart review.

**Patients:** This study included 16 patients with subglottic stenosis who presented to the senior surgeon (M.R.R.) for laser bronchoscopy from January 2000 to December 2006.

**Main Outcome Measures:** Progression toward decannulation and preoperative and postoperative symptoms were assessed.

**Results:** Four of 7 patients who required tracheostomy tubes at the start of laser bronchoscopy underwent decannulation. None of the remaining 9 patients required tracheostomy tubes during treatment. All patients had improvement in their symptoms. Complications of the procedure were minimal.

**Conclusions:** Bronchoscopy with the Nd:YAG laser is a well-tolerated and effective treatment for subglottic stenosis. Laryngotracheal trauma caused by an endotracheal tube and/or rigid bronchoscope is avoided. This procedure may be useful to achieve and maintain a patent airway.

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**S**UBGLOTTIC STENOSIS IS A CONGENITAL or acquired narrowing of the trachea below the true vocal cords. Causes of acquired subglottic stenosis include endotracheal intubation, trauma, burns, inflammation, neoplasms, autoimmune disorders, and collagen vascular disease.<sup>1</sup> Gastroesophageal reflux disease has also been implicated in the pathogenesis of subglottic stenosis.<sup>2</sup> Management of adult subglottic stenosis is complex and challenging. Treatment consists of observation, endoscopic treatment with laser and dilation, application of antifibrotic agents such as mitomycin C, airway expansion procedures, and tracheostomy.<sup>3</sup> The ultimate goal of any treatment is to increase the patency of the airway, while maintaining an acceptable voice and a competent larynx.<sup>4</sup>

The Nd:YAG laser, which was developed in 1964, produces light with a wavelength of 1.064  $\mu\text{m}$  in the near-infrared range of the electromagnetic spectrum. It causes thermal coagulation and necrosis and, because of its deep penetration in tissue, provides adequate hemostasis.<sup>4</sup> It can be applied both through an open, rigid bronchoscope and through a flexible bron-

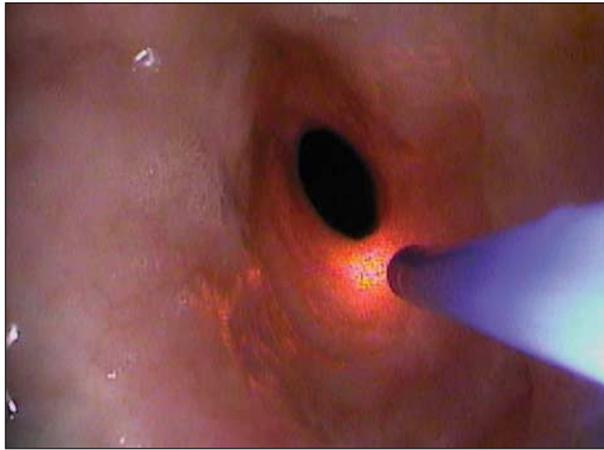
choscope via fiberoptic delivery systems. The use of a rigid bronchoscope requires deeper anesthesia, which may further decrease respiratory function.<sup>5</sup> Furthermore, mucosal trauma can result from endotracheal intubation. In our series, we used the Nd:YAG laser through a flexible bronchoscope in patients who were spontaneously breathing, thus eliminating the need for general anesthesia and endotracheal intubation.

## METHODS

After obtaining permission through the institutional review board, we conducted a retrospective chart review of 16 adult patients with subglottic stenosis who underwent laser bronchoscopy by the senior author (M.R.R.) between January 2001 and December 2006. The follow-up period ranged from 1 to 20 months (mean, 6.75 months). Preoperative data included the patient's age, underlying cause of the subglottic stenosis, and symptoms, including wheezing, dyspnea at rest, dyspnea on exertion, and stridor. It was also noted whether the patient had a prior or existing tracheostomy on presentation to our office. We documented the number of procedures each patient underwent and the reported symptoms at each postoperative office visit. Patients were

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**Figure 1.** The flexible fiberoptic laser wire is shown with the beam focused on the stenotic area.



**Figure 2.** A wedge of the stenotic segment was removed using the Nd:YAG laser.

divided into 3 groups: group 1 consisted of 4 patients who had never had a tracheostomy; group 2 was composed of 5 patients who had required a tracheostomy in the past but underwent decannulation before undergoing any laser bronchoscopy procedures; and group 3 comprised 7 patients who were tracheostomy dependent before undergoing endoscopic laser excision.

### TECHNIQUE

When performing a laser bronchoscopy for subglottic stenosis, the senior author uses the SLT Nd:YAG Contact Laser (Surgical Laser Technologies, Sigmacon Medical Products, North York, Ontario, Canada) with a flexible endoscopic fiber (outer diameter, 1.8 mm) delivery system. The laser may be used on a pulse or continuous setting, while the power and internal coaxial fiber coolant system can be adjusted as necessary to cause appropriate tissue destruction.

Before the patients enter the operating room, an oxy-metazoline spray is administered to decongest the nasal mucosa and to facilitate passage of the bronchoscope. Patients are also given 4 mL of lidocaine, 4%, in a nebulized form to provide topical anesthesia. On entering the oper-

ating room, the patients are given dexamethasone (8-10 mg intravenously) and midazolam (1-2 mg intravenously), and placed on a remifentanyl infusion (starting at 0.05-0.10  $\mu\text{g}/\text{kg}/\text{min}$ ) titrated to light sedation. Therefore, they are adequately sedated, yet still spontaneously breathing. The back of the operating room table is raised approximately 60° to 75° so that the patient is sitting almost upright. At this point, the flexible bronchoscope is passed intranasally through the nasopharynx to the level of the epiglottis. One milliliter of lidocaine, 4%, with 4 mL of air in a 10-mL syringe is then administered through the instrument port on the flexible bronchoscope. Once this area is sufficiently anesthetized, the bronchoscope is passed to the level of the glottis and subglottis. These regions are anesthetized in a similar fashion. The bronchoscope is then carefully advanced through the true vocal cords until the stenotic area is identified. If possible, the bronchoscope is passed through the stenotic segment to evaluate the distal trachea.

At this point, the flexible bronchoscope is withdrawn, and a flexible video bronchoscope (EB-1970; Pentax Medical Co, Montvale, New Jersey) with a 6.2-mm insertion tube, a 3.2-mm biopsy channel, and a 60-cm working length is placed into the subglottic larynx. After all persons in the operating room have complied with the laser safety protocol, the laser fiber is passed through the instrument port. Pictures are taken of the stenotic segment before surgery (**Figure 1**), and the procedure may be videotaped. Once the laser is placed on the appropriate power and cooling settings (15 W continuous with 0.3-L/min of carbon dioxide gas coolant), the fiber is placed against the surface of the stenotic segment. Depending on the location of the narrowed area, the laser is used to coagulate and excise a wedge of tissue to increase the airway diameter (**Figure 2**). Although the procedure is performed with the patients awake and spontaneously breathing, laryngoscopy and tracheostomy trays are always available in the operating room.

The patients are then brought to the postanesthesia care unit, monitored with continuous pulse oximetry, and given 2 more doses of intravenous dexamethasone (8-10 mg) every 8 hours while in the hospital. After the first procedure, the patients without tracheotomy tubes typically stay overnight in the hospital for airway monitoring and are discharged home on postoperative day 1. The patients with tracheotomy tubes are discharged the same day. All patients are sent home on a tapered course of oral steroids (methylprednisolone).

### RESULTS

The patient population consisted of 7 men and 9 women with a mean age of 57.8 years (age range, 35-80 years). The total number of procedures for all the groups was 66, yielding an average of 4.1 procedures per patient. Underlying causes of the subglottic stenosis included the following: previous endotracheal intubation (n=6), previous endotracheal intubation and tracheostomy (n=8), and inhalation injury (n=1); 1 case was considered idiopathic. Cases involving stenosis of considerable vertical length (>1 cm) were not treated with laser bronchoscopy. The results are shown in **Table 1**.

## GROUP 1

Four patients underwent a total of 10 endoscopic laser procedures (mean, 2.5 treatments per patient). Before surgery, all patients had dyspnea at rest and on exertion and 1 patient had stridor. After each procedure, there was improvement in each of these symptoms. No patients required a tracheostomy during treatment.

## GROUP 2

All 5 patients had undergone previous tracheostomy, but at the time of their first endoscopic procedure, 4 patients had already undergone decannulation and 1 patient had a Montgomery stent in place. These 5 patients underwent a total of 14 procedures (mean, 2.8 treatments per patient). Before surgery, 1 patient had wheezing, 3 patients had dyspnea at rest, 5 patients had dyspnea on exertion, and 1 patient had stridor. After each procedure, there was complete resolution of these symptoms. The 1 patient who initially had a Montgomery stent in place underwent decannulation after his first laser bronchoscopy. All patients remained decannulated during treatment.

## GROUP 3

Seven patients who were tracheostomy dependent underwent 42 laser procedures (mean, 6 treatments per patient). Before surgery, 3 patients had dyspnea at rest and on exertion and stridor. After each procedure, all these symptoms resolved. Four of the 7 patients (57%) subsequently underwent decannulation. Among these 4 patients, a mean of 4 treatments were needed before decannulation. Two patients were able to have their tracheostomy removed after 1 and 2 procedures, respectively. One patient required 5 procedures before he could have the tracheostomy replaced with a Montgomery stent and 10 procedures before he could be completely decannulated. This patient had presented with severe subglottic stenosis. After he underwent multiple laser bronchoscopic procedures, his airway was patent enough to allow decannulation (**Figure 3**). One patient underwent 2 procedures before having his tracheostomy replaced with a Montgomery stent and 3 procedures before having the stent removed. One patient underwent decannulation after 2 procedures but subsequently required reinsertion of the tracheostomy tube, on which he is currently dependent.

Among the 66 total procedures performed on 16 patients, there was 1 complication of bleeding, which was unable to be controlled with the laser. The patient subsequently underwent intubation, and with the use of electrocautery, hemostasis was achieved. There were no complications related to airway obstruction or perforation.

## COMMENT

Many authors maintain that surgical management is the treatment of choice for laryngotracheal stenosis.<sup>6-8</sup> Although there are numerous different surgical treatments for subglottic stenosis, no single treatment modality, short of tracheostomy, appears to be universally

**Table 1. Results in Cases Treated With Flexible Laser Bronchoscopy**

Group No.	No. of Patients	No. of Patients With Tracheostomy During Treatment	Mean No. of Treatments
1 (Patients with no history of tracheostomy)	4	0	2.5
2 (Patients with history of tracheostomy; decannulated before start of treatment)	5 <sup>a</sup>	0	2.8
3 (Tracheostomy dependent at start of treatment)	7	3	6.0

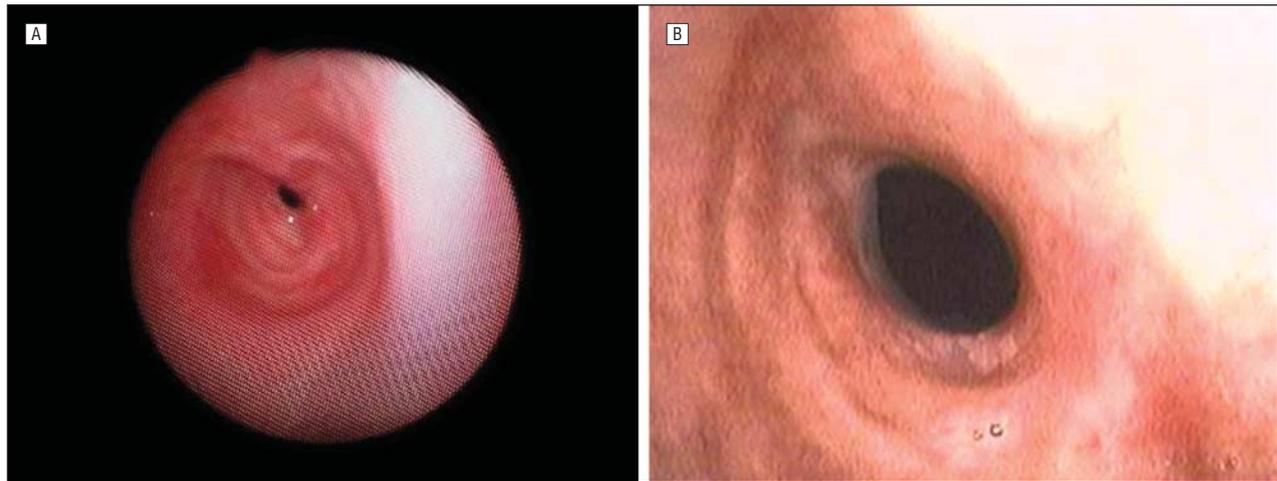
<sup>a</sup>One patient had a Montgomery stent in place at the start of treatment.

effective. While surgery may offer good results in many cases, mortality rates have been reported ranging from 1.8% to an alarming 19%.<sup>9,10</sup> Many patients are ineligible for open surgery owing to local active inflammation or comorbid conditions.<sup>6</sup> Therefore, endoscopic management of subglottic stenosis has been used as an alternative. Endoscopic treatment is associated with minimal complications, low morbidity, and short operative time and hospitalization.<sup>11</sup> Endoscopic laser treatment, most commonly with the carbon dioxide or Nd:YAG laser, has been used, with variable success. **Table 2** summarizes documented success rates in studies in which various lasers were used to treat subglottic stenosis.

We were able to successfully decannulate 4 of 7 patients (57%). Of the 3 patients who remained tracheostomy dependent, 2 had evidence of tracheomalacia and have experienced numerous episodes of tracheitis and bronchitis. These clinical features are similar to endoscopic failures that have been observed in other studies.<sup>7,12</sup> The remaining patient, after 2 failures of decannulation, has elected to stop further attempts at the present time. Furthermore, 5 of the 5 patients (100%) who required prior tracheostomy tubes remained decannulated during the treatment period.

Our technique of flexible bronchoscopy using the Nd:YAG laser provides numerous benefits. First, by using sedatives and narcotics but still allowing spontaneous ventilation, the technique does not require endotracheal intubation. Also, the Nd:YAG laser is flexible and does not necessitate the use of a rigid bronchoscope. Therefore, the patients avoid further circumferential trauma due to the bronchoscope and endotracheal tube, which may have been the initial inciting event of the disease process. We used the Nd:YAG laser because it was compatible with a flexible bronchoscope, but carbon dioxide lasers (OmniGuide Inc, Cambridge, Massachusetts) may be used as well. Further studies are needed to compare the efficacy of the flexible carbon dioxide laser with that of the Nd:YAG laser.

Furthermore, our technique may be safer than the standard surgical therapies for subglottic stenosis, which typically require general anesthesia. This patient population is challenging in that ventilation may be difficult because of the airway stenosis. Standard techniques for subglottic stenosis can be even more difficult to perform in cases in-



**Figure 3.** Preoperative (A) and postoperative (B) views of a patient with severe subglottic stenosis and the marked improvement in airway caliber after multiple treatments with Nd:YAG laser.

**Table 2. A Summary of Studies in Which Different Lasers Were Used to Treat Subglottic Stenosis**

Source	No. of Patients	Laser	Bronchoscopy	Additional Treatment	Success Rate, %
Ciccione et al, <sup>6</sup> 2004	4	Nd:YAG	Rigid	Stent	100
Mehta et al, <sup>7</sup> 1993	9	Nd:YAG	Rigid	Dilation	71
Mandour et al, <sup>8</sup> 2003	13	CO <sub>2</sub>	Rigid	Dilation, stent	87
Simpson et al, <sup>12</sup> 1982	31	CO <sub>2</sub>	Rigid	Stent	81
Koufman et al, <sup>13</sup> 1981	13	CO <sub>2</sub>	Rigid	Stent, steroids	77
Present study	16	Nd:YAG	Flexible	None	81

Abbreviation: CO<sub>2</sub>, carbon dioxide.

volving preexisting conditions such as obstructive sleep apnea or difficult airways as a result of body habitus. Moreover, our technique avoids the lingering effect of general anesthesia after surgery in patients who have compromised airways at baseline.<sup>14</sup>

Otolaryngologists are quite familiar with the flexible bronchoscope, and the facility of its use allows shorter operative time. The flexible bronchoscope also has the ability to suction any debris or pieces of coagulated tissue. Furthermore, with the flexible bronchoscope, the physician is capable of documenting the procedure via real-time video or still photographs, which provide an objective means to evaluate ongoing response to therapy.

Patients are counseled on the potential adverse effects of laser bronchoscopy, which include bleeding, tracheal perforation, tissue edema, and reformation of stenosis. Hemorrhage, which is the most frequent intraoperative complication of laser bronchoscopy, is effectively controlled with the Nd:YAG laser because of its deep thermal coagulation.<sup>4</sup> Airway edema in reported cases is thought to be related to excessive power and prolonged exposure.<sup>5</sup> We are very judicious in determining the fluency needed to increase tracheal patency without creating major edema. By removing only a focal area or wedge of the stenotic segment, we theoretically avoid circumferential inflammation and tracheal edema. Among the 66 procedures performed, we had only 1 complication, which was an episode of bleeding that could not be controlled with the laser. The patient subsequently underwent intuba-

tion; the bleeding was controlled with electrocauterization; and there were no further adverse sequelae. We have not experienced any situations of airway compromise; however, we always have a rigid bronchoscope and tracheostomy tray available in the operating room.

The main drawback of this technique is that, in some cases, multiple laser treatments are required to improve and maintain airway patency, which may impair a patient's quality of life. Therefore, flexible laser bronchoscopy is an ideal therapeutic modality for the motivated patient in whom laryngotracheal reconstruction is not an option. This procedure may be indicated for individuals with medical contraindications to surgery who do not wish to undergo a more involved and complex surgery or who have mild to moderate stenosis that does not warrant an open procedure. Contraindications include glottic stenosis, tracheal stenosis, and a vertical scar length of greater than 1 cm.

Many different treatments have been advocated for the management of subglottic stenosis, attesting to the notion that no single modality is universally accepted. Novel techniques such as balloon dilation have recently emerged as safe and effective methods with which to treat adult subglottic stenosis.<sup>14,15</sup> We are currently investigating the use of flexible Nd:YAG laser bronchoscopy followed by endoscopic balloon dilation using a the pulmonary balloon dilation catheter (CRE Pulmonary Balloon Dilator; Boston Scientific, Natick, Massachusetts) in this patient population. Further studies are needed to determine which treatment or combination of treatments is the most effective.

In conclusion, adult subglottic stenosis is one of the most challenging problems in the field of head and neck surgery. Endoscopic laser procedures have been developed to manage this condition without subjecting the patient to an open surgical procedure. Flexible bronchoscopy using the Nd:YAG laser is a relatively quick and safe technique that has shown promising results for the treatment of subglottic stenosis. Patients tolerate the procedure extremely well as they do not experience the aftereffects of general anesthesia or oropharyngeal and laryngeal trauma due to endotracheal intubation. Further studies are needed to evaluate the long-term results of this treatment.

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**Author Contributions:** Drs Leventhal and Rosen had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Leventhal and Rosen. *Acquisition of data:* Leventhal. *Analysis and interpretation of data:* Leventhal and Krebs. *Drafting of the manuscript:* Leventhal and Krebs. *Critical revision of the manuscript for important intellectual content:* Rosen. *Administrative, technical, and material support:* Leventhal and Rosen. *Study supervision:* Rosen.

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