Evaluation of laser tracheobronchoplasty for treatment of tracheobronchomalacia

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Abstract

Background: Despite different support techniques, the management of tracheobronchomalacia is still a challenging problem. The purpose of our study was to evaluate and to confirm the efficacy of a novel treatment by laser introduced for the first time in 2016 to treat this common disease.

Methods: A consecutive series of patients with a diagnosis of diffuse or segmental tracheobronchomalacia confirmed by transnasal flexible bronchoscopy under local anesthesia that showed excessive dynamic airway collapse during exhalation and or coughing, were treated with two to three holmium laser scarring surgeries of the hyperdynamic tracheal and bronchial walls for the purpose of stiffening them through fibrosis. Patients filled out a Dyspnea Index questionnaire before and after treatment.

Results: Twenty seven patients were treated for their tracheobronchomalacia with a mean age of 51 years. Symptoms included severe dyspnea, dry cough, recurrent pulmonary infections, and respiratory failure. Fifty percent of patients presented with wheezing refractory to traditional treatment. Tracheobronchomalacia was associated with gastroesophageal reflux disease (n=12), obstructive sleep apnea (n=7), and tracheobronchial stenosis (n=6). Only 35 % of patients presented with morbid obesity. All cases showed significant improvement of their respiratory symptoms with a mean postoperative difference of 25 out of a maximum impairment score of 40 (P <0.05) on the Dyspnea Index. The mean number of procedures was 2.1 per patient with the average laser energy delivered per procedure of 1500 joules.

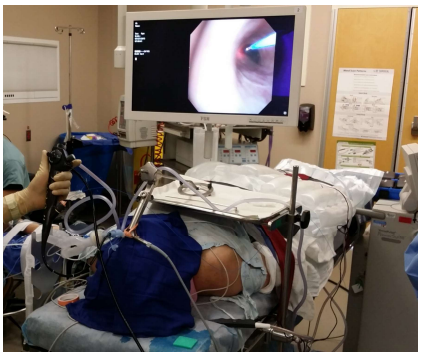
Conclusion: Laser tracheobronchoplasty is a safe, easy to adopt, and effective technique for the treatment of tracheobronchomalacia. It presents a simple alternative to the commonly used procedures like endoluminal stenting and open tracheobronchoplasty.

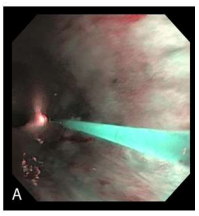
Introduction

There are no well-defined guidelines for diagnosing or treating tracheobronchomalacia. Positive-pressure ventilation can be helpful, especially in an acute setting, but it is not curative. Tracheostomy may stent the malacic airway and can provide invasive ventilatory support when necessary. However, it can be complicated by secondary tracheomalacia and stenosis at the stoma site. In addition, from a physiological standpoint, tracheostomy may exacerbate diffuse tracheobronchomalacia because it bypasses the physiological function of the glottis to maintain positive transmural pressure on exhalation that keeps the airway lumen patent. Endoluminal stent placement is a commonly used treatment option with many drawbacks. Other surgical treatment alternatives are laryngotracheal reconstruction with grafts or external tracheal supports, tracheal resection with a tightening of the posterior wall, and trans-thoracotomy tracheobronchoplasty using synthetic biocompatible meshes to strengthen the redundant posterior wall to prevent expiratory collapse into the airway; all of these treatment options may provide initial improvement in symptoms. However, they present a high rate of complications, including fatality. The purpose of this study is to evaluate a novel, endoscopic surgical approach described by us for the first time in 2017, using laser for the treatment of this challenging respiratory disease.

Methods and Materials

Patients diagnosed with tracheobronchomalacia underwent laser tracheobronchoplasty. The procedure is performed under general anesthesia. The laser (Holmium laser) is delivered via a quartz fiber which is introduced through the operating channel of a bronchoscope. The laser is used to strafe the mucosa of the posterior wall of the tracheobronchial tree longitudinally, transversely, and in a serpentine manner from distal to proximal. This technique produces relatively deep furrows into the submucosa while still preserving areas of intact mucosa between the strafes.





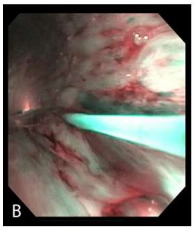


Figure: Laser tracheobronchoplasty. Suspension laryngoscopy is performed. An endotracheal tube is introduced through the laryngoscope and taped to the inlet of the laryngoscope system. The face of the patient is protected by wet towels. A bronchoscope is introduced into the airway of the patient through the endotracheal tube. A laser fiber is introduced through the operating channel of the bronchoscope to perform a laser tracheobronchoplasty. The figures on the right show the placement of the laser fiber into the mucosa during the laser treatment. (A) Depicts the contact of the fiber to the mucosa just prior to the firing of the laser beam. (B) Illustrates the fiber being pushed into the mucosa as it is dragged in the various directions; longitudinal, transverse, and serpiginous.

Results

Twenty seven patients were included. The preoperative mean patient dyspnea score was 36 (range 31 to 40) and post operatively it was 11 (range 9 to 18). All cases showed significant improvement of their respiratory symptoms; the preoperative to postoperative difference was 25 (P <0.001). The mean number of procedures was 2.1 per patient with the average laser energy delivered per procedure of ~1500 joules. The decision to proceed with additional treatments was based on the endoscopic appearance of the tracheal bronchial tree and the patient report of breathing comfort. In ten cases the scale of dyspnea reported was so much improved after the second laser as to obviate the need for a third treatment.
Five patients had invalidating cough preoperatively and showed improvement following lasertracheobronchoplasty. None to date have desired or required any additional treatment. No significant complications occurred in this series of patients. On interval bronchoscopies after surgery, most had small tufts of granulation tissue that were easily suctioned away by the bronchoscope. No cases of cicatricial scarring in the trachea or mainstem were encountered .

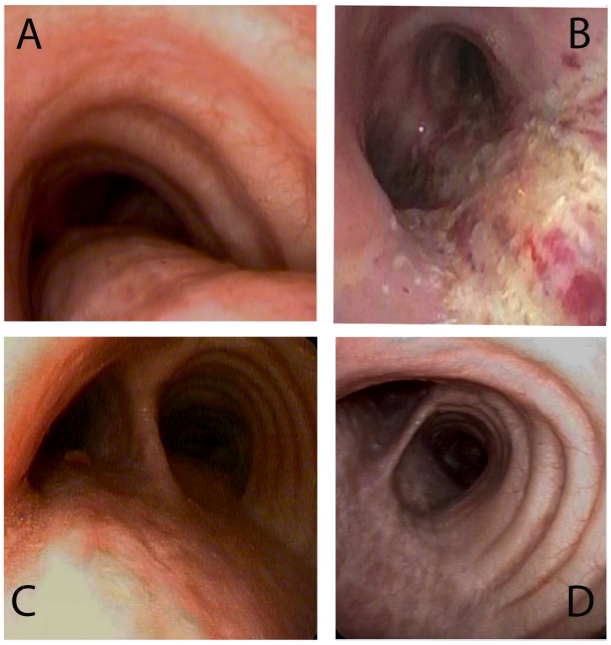


Figure: Endoscopic aspects of the trachea. (A) Preoperative collapse of the lower trachea and main stem bronchi during full exhalation. (B) Intraoperative view just after laser strafing of the mucosa of the posterior wall of the lower trachea and main stem bronchi. (C) Endoscopic view 2 weeks following laser tracheobronchoplasty showing granulation tissue. (D) Endoscopic view 12 weeks following the third stage of laser tracheobronchoplasty. Note that the posterior wall shows stiff fibrous tissue that does not collapse during full exhalation.

Discussion

Medical lasers are widely used in interventional pulmonology. In our study, we used the holmium laser because it is highly absorbed by hemoglobin, producing wounds with excellent hemostasis. It also has a shallow depth of penetration to approximately 0.4 mm. The depth minimizes collateral damage to the surrounding tissues. Based on our study, the holmium laser triggers a retractile fibrotic process that stiffens the posterior mucosal membrane with acute improvement in symptoms, and produces complete healing after 12 weeks. Additional stiffening of the posterior tracheobronchial wall is obtained by repeating the procedure once or twice. Our novel technique showed a high success rate in the treatment of tracheobronchomalacia without major complications. We think that this technique could significantly impact the management of patients with tracheobronchomalacia and look forward to performing prospective, multicenter studies.

Conclusions

Laser tracheobronchoplasty is a novel, safe, easy to adopt, and effective technique for the treatment of tracheobronchomalacia. It presents a simpler, safer alternative to open trans-thoracotomy tracheobronchoplasty and a durable alternative to endoluminal stenting.

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