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Airway management and CO_2 laser treatment of subglottic and tracheal stenosis using flexible bronchoscope and laryngeal mask anesthesia

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Mitomycin C

Mild-to-moderate subglottic and tracheal stenosis can be effectively treated endoscopically, but safe airway management is a key concern. Options have included tracheotomy, jet ventilation, and intermittent apnea technique, each of which has limitations. This article presents the authors' endoscopic surgical technique using laryngeal mask anesthesia during CO_2 laser treatment of subglottic and tracheal stenosis. A flexible bronchoscope is passed through a laryngeal mask airway and permits continuous ventilation during treatment with a flexible CO_2 laser fiber or balloon dilator. This technique allows excellent airway control, access, and visualization during surgery and is easily mastered by anesthesiologists and otolaryngologists.

Treatment of subglottic and tracheal stenosis has come full circle from Chevalier Jackson's original rigid dilation in awake patients, to open approaches as general anesthesia became safer, and now back to largely endoscopic techniques. The current resurgence stems from the innovation of CO_2 and Nd:YAG laser incisions of the scarred tracheal segment[1,2] and has been strengthened by the technique of radial balloon dilation.[3,4] CO_2 laser energy is preferred for endoscopic treatment of subglottic and tracheal stenosis because it enables precise radial incisions with minimal lateral thermal damage, thereby preserving viable cells for reepithelialization of the injured area. However, intraoperative airway control remains a challenge in those patients who are not tracheostomy-dependent, because laser incisions cannot be made precisely and dilation cannot be accomplished in the presence of an endotracheal tube.

Airway management during endoscopic treatment of airway stenosis has been accomplished through 2 main approaches. The simplest is to perform the procedure during intermittent apnea or spontaneous shallow ventilation, with ventilation via face mask or repeated endotracheal intubations between brief treatment intervals. This approach necessitates prolonged waiting times in the operating room for preoxygenation, and the airway control is tenuous as intubation with an adequately sized endotracheal tube may not be possible in moderate or severe subglottic stenoses. In more difficult or severely stenotic airway, venturi jet ventilation via a small supraglottic needle catheter permits more continuous oxygen delivery.[5] This method does require an anesthesiologist who is comfortable with the technique. Jet ventilation also may carry a slight risk of hypoxemia or pneumothorax if the stenosis blocks adequate ventilatory exchange.[6]

As office-based procedures have become more common, awake or mildly sedated endoscopic treatments with spontaneous ventilation have been performed via flexible bronchoscopy.[7,8] Some authors advocate minimal sedation and airway manipulation in the difficult airway patients, but not all patients can tolerate such procedures. In particular, bal-

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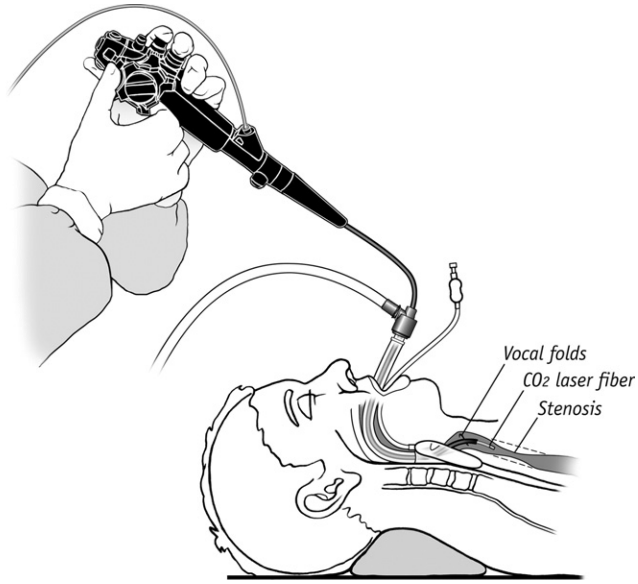

Figure 1 Operative setup using the laryngeal mask airway anesthesia for CO_2 laser treatment of airway stenosis. The flexible bronchoscope is inserted through the mask device, past the vocal folds, and into the trachea to visualize the stenotic segment. A flexible laser fiber is passed through the bronchoscope's working channel.

loon dilation necessitates a brief period of apnea regardless of the airway management method.

As an alternative to these approaches, we describe a method of continuous airway control under general anesthesia that does not compromise visualization or surgical access during endoscopic treatment of subglottic or tracheal stenoses. The recent invention of a hollow core fiber enables flexible delivery of CO_2 laser energy via the working channel of a flexible bronchoscope.[9] Laryngeal mask anesthesia maintains ventilation while flexible bronchoscopy is used to deliver fiber-based laser or balloon dilators. This technique treats airway stenoses with radial laser incisions and balloon dilation, while maintaining airway control and general anesthesia. The laryngeal mask airway has recently been advocated for airway management in patients with difficult airways, including for flexible endoscopic treatment of tracheal stenoses.[10]

Indications

The laryngeal mask anesthesia technique can be applied in all patients with subglottic or tracheal stenosis without a tracheostomy. Patients with tracheostomies do not benefit from this approach. Pediatric application is feasible, although the smaller internal diameter of the pediatric laryngeal mask airway may limit passage of a large-diameter bronchoscope. Patients with obesity and tracheomalacia have been successfully treated. As with all endoscopic airway techniques, short segment stenosis without concurrent tracheomalacia has improved outcome.

Technique

First, a laryngeal mask anesthesia (LMA North America, San Diego, CA) airway device is prepared. Some types of mask airways contain flexible polymeric bars on the laryngeal aperture, intended to prevent prolapse of the epiglottis into the airway device. Before use of this type of laryngeal mask airway, the aperture bars should be removed by cutting them with a scissors to open a wider passageway for the bronchoscope and instruments. Alternatively, an intubating mask airway with an unimpeded aperture may be selected.

After inducing adequate sedation, the anesthesiologist inserts the mask airway device into its standard position over the supraglottis. The larynx and trachea are then visualized by passing a flexible bronchoscope through the mask device (Fig. 1). Laryngospasm is prevented by spraying 4% lidocaine into the glottic airway before passing the bronchoscope through the vocal folds. The grade and length of stenosis are estimated by traversing the stenotic area with the bronchoscope. If the large-diameter interventional bronchoscope (usually about 6-mm outer diameter) cannot pass through the stenosis, a smaller diameter or a pediatric bronchoscope (as narrow as 2 mm) can be passed for complete inspection. Once the distal airway is examined, further intervention does require a bronchoscope with a working channel to approach the proximal aspect of the stenosis.

Radial incisions of the airway stenosis can then be performed with a flexible CO_2 laser fiber (OmniGuide, Cambridge, MA) passed through the bronchoscope's working channel (Fig. 2). Care is taken to follow routine laser safety precautions before use of the laser, including draping the patient with moist towels and eye pads, reducing the inspired oxygen content to less than 30%, having water available in a bulb syringe in case of airway fire, and supplying

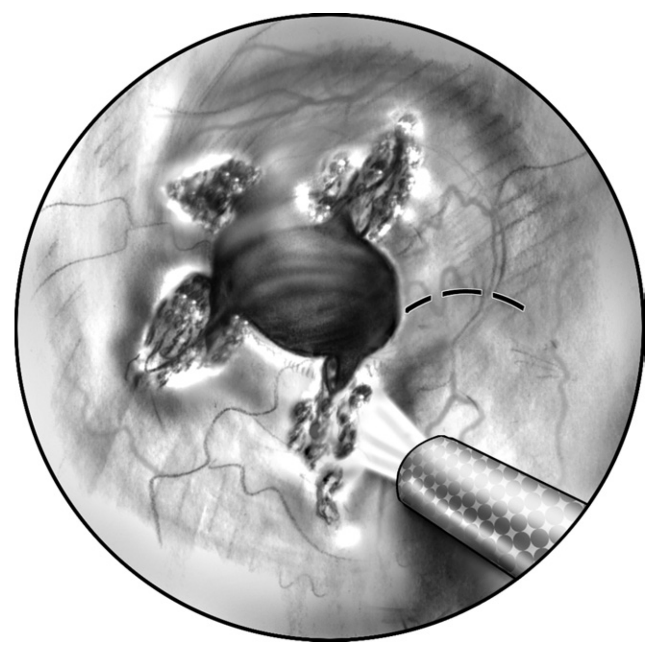

Figure 2 Flexible CO_2 laser fiber inserted through the working channel of a flexible bronchoscope is used to make radial incisions in the subglottic stenosis.

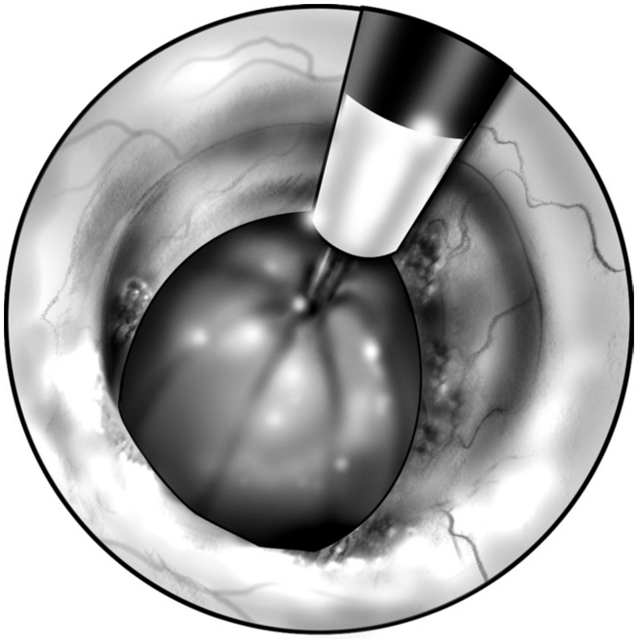

Figure 3 A balloon dilator is passed through the bronchoscope working channel and inflated to dilate the stenotic subglottic segment after the radial incisions have been made.

eye protection for all operating room personnel. Suction for smoke evacuation is not necessary as the anesthesia circuit continually exchanges airway gases. The CO_2 laser is applied at a power of 4-8 W. For circumferential stenosis, at least 5 radial incisions are made within the soft tissue of the stenosis, as has been described for traditional rigid bronchoscopic techniques.[2] The laser fiber is then removed from the bronchoscope.

After the laser treatment, further airway improvement can be achieved by dilation with a controlled radial expansion pulmonary balloon dilator (Boston Scientific Corporation, Natick, MA) passed through the working channel (Fig. 3). If the bronchoscope used has a working channel that does not allow passage of the balloon dilator, the dilator can be passed alongside the bronchoscope. Dilation is typically performed 2 or 3 times for 15 seconds each, until the intended radial diameter is reached (Fig. 4). If desired, locally active medications, such as mitomycin C, vasoconstrictive agents, or steroids, can be administered by spraying or injecting through the bronchoscope's working channel directed to the involved area. The treated area and the distal trachea are examined after dilation.

Costs

Cost of the laryngeal mask airway is similar to that of an endotracheal tube. Estimated current costs of the other disposables are about US$900 per laser fiber, and $200 per balloon dilator. Those disposable costs would also be incurred when using these techniques with traditional airway management methods. Cost savings also arise from decreased operating room time relative to the intermittent apnea technique and avoidance of a tracheostomy. Outcomes may be improved by improved visualization of the stenosis and treatment effects, because the bronchoscope tip is focused close to the stenotic site during laser incision and dilation.

Complications

To date we have not encountered any adverse events related to the use of the laryngeal mask airway device or the use of the flexible bronchoscope and the laser fiber. Potential complications include ventilatory challenge from severe stenosis or unrecognized severe tracheomalacia. Positive pressure ventilation may cause pneumothorax if high peak pressures are required. Overinflation of the laryngeal mask airway device can cause minor local irritation and potentially more serious nerve injury, which can be mediated by monitoring cuff inflation pressures.[11] Normal mask positioning places its posterior tip in the hypopharynx, which may result in excessive gas insufflation of the stomach or aspiration of gastric contents. Tracheal perforation may occur because of either laser injury to the tracheal wall or balloon dilation.

Airway laser fire is fortunately a rare occurrence but requires vigilance. An added benefit of the laryngeal mask airway is that there are no ventilating tubes beyond the laser fiber tip in the airway. However, similar to standard management with endotracheal intubation, the laryngeal mask airway device should be immediately removed in case of fire to remove the oxygen source.

To prevent inadvertent laser damage to the bronchoscope, the laser should not be fired unless the laser fiber tip is visualized in the video monitor. However, in cases of fiber failure, there is no risk of damaging the bronchoscope.

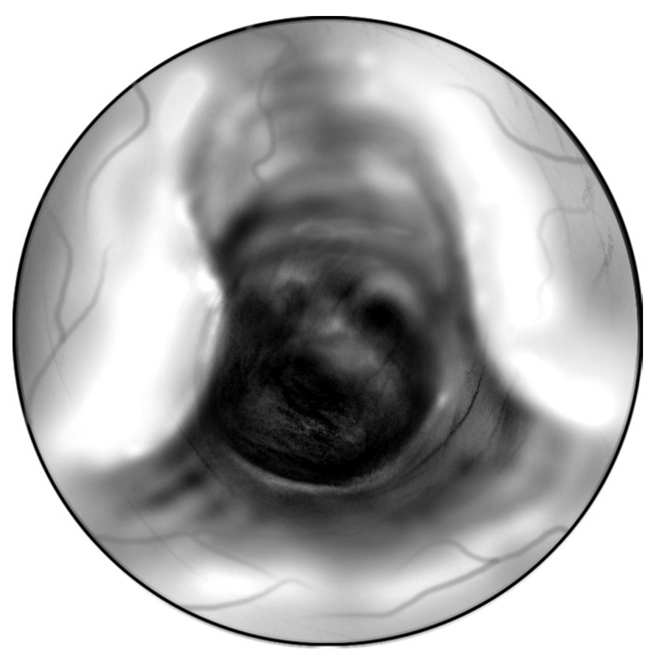

Figure 4 Bronchoscopic view of the subglottic stenosis after treatment with radial incisions and balloon dilation.

The fibers are made of tough, thermoplastic polymers that do not crack. Rather, when a fiber fails, its transmission is immediately stopped by a thermal mechanism that induces inward collapse of the polymer core and subsequent, instantaneous, cutoff of laser transmission.

Conclusions

Laryngeal mask anesthesia provides a simple, safe, and convenient means of continuous general anesthesia during endoscopic treatment of subglottic or tracheal stenosis. The laryngeal mask airway permits passage of a flexible bronchoscope for excellent visualization and subsequent delivery of a CO_2 laser fiber and balloon dilator for endoscopic treatment. This technique provides an excellent alternative to awake treatments, jet ventilation, or intermittent apnea technique for these challenging airway patients.

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