Management of Pediatric Subglottic Stenosis with Bipolar Radiofrequency Ablation

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Abstract

Background
To describe a case series of pediatric patients with subglottic stenosis who were managed primarily with a microlaryngeal bipolar radiofrequency device.

Methods
Retrospective chart review of pediatric cases of subglottic stenosis for which bipolar radiofrequency ablation, using a microlaryngeal wand, was utilized endoscopically to address the stenosis. The setting was a pediatric otolaryngology private practice with academic affiliation.

Results
Three cases of pediatric Grade II subglottic stenosis were identified for which bipolar radiofrequency ablation was utilized (ages 5 to 12 years old). The stenosis was either acquired (n=2) or idiopathic (n=1). A single endoscopic procedure with the microlaryngeal bipolar radiofrequency device was successful in resolving the stenoses. Tracheostomy decannulation was achieved in the subject who had been tracheostomy-dependent, and resolution of stridor was achieved in the other 2 subjects. There were no procedural complications.

Discussion
Endoscopic management of Grade II subglottic stenosis provides a less-invasive management approach compared to open laryngeal framework surgery. Bipolar radiofrequency ablation is known to transmit less heat than laser therapy and yields a lower risk of ignition of an airway fire, and the microlaryngeal wand is long and thin enough to allow delivery of energy endoscopically to the pediatric subglottis.

Conclusion
For Grade II pediatric subglottic stenosis, the technique of endoscopic bipolar radiofrequency ablation was found to be effective and safe as a primary treatment modality.

Keywords
Subglottic Stenosis; Pediatric; Coblation; Endoscopic; Airway; Larynx

Introduction
Endoscopic surgical techniques such as balloon dilatation and laser therapy have often been utilized for the management of pediatric subglottic stenosis. Such procedures are beneficial due to their less invasive nature, but they can have limits with regards to their effectiveness in higher-grade stenoses, and since there are many
techniques to choose from, a universally-accepted management algorithm does not exist [1-4].

Pediatric subglottis stenosis is most often acquired in nature, developing as a result prolonged endotracheal intubation of premature infants, which can lead to pressure necrosis and mucosal injury, local infection, granulation tissue development, and eventual maturation into fibrosis [5]. Post-intubation stenosis rates among neonatal intensive care unit graduates ranges from 0.9% to 3.0% [6, 7].

Open surgical techniques, such as laryngotracheal reconstruction with costal cartilage grafting, or cricotracheal resection, have traditionally been employed to repair laryngotracheal stenosis, with more extensive approaches being utilized for more severe stenoses. The long-term decannulation rates in patients with tracheostomies have been reported to be >90% with these open surgical approaches, with multiple procedures being required in some cases [2].

Endoscopic techniques have been used successfully as an initial treatment of lower-grade (Cotton-Myer Grade I or II) subglottic stenosis. However, such techniques show decreasing decannulation rates with increasing SGS severity [1, 3, 8].

Although less invasive with faster recovery, endoscopic techniques are not without their risks and downfalls. Laser therapy can cause tissue necrosis and chondritis with subsequent worsening of stenosis [1], and is associated with intra-operative airway fire risk [9]. Endoscopic balloon dilatation procedures can require multiple procedures and yield an overall longer time to tracheostomy decannulation [3, 10]. Monnier et al. showed that endoscopic laser treatment of subglottic stenosis was most successful in treating Grade I stenosis, with a success rate of >90% [1]. However, the success rate declined with increasing severity of stenosis to 46% with Grade II stenosis, and 13% with Grade III stenosis [1].

An alternative technique that can be used for endoscopic treatment of laryngotracheal stenosis is bipolar radiofrequency ablation. The saline medium used with microlaryngeal bipolar radiofrequency is activated by the electrode at the tip of the wand and becomes a focal plasma field that divides organic molecular bonds in tissue. The low temperature of the instrument may reduce the risk of collateral thermal injury to the surrounding tissue, giving it a potential advantage over laser therapy [11]. Another advantage over laser therapy is that bipolar radiofrequency ablation yields a lower risk of ignition of airway fires [12]. When compared to endoscopic balloon dilatation, the bipolar radiofrequency ablation device has the advantage of being able to remove tissue, including hypertrophic cartilage. A variety of wands with specialized tips are available. One of these utilizes a “microlaryngeal” tip, with a small, shielded electrode that can fit into pediatric larynx and trachea, and this is the tool that was utilized in the current study.

There are previous reports of successful treatment of subglottic stenosis, sternal and suprastomal granulation tissue in adults using bipolar radiofrequency ablation, either through a pre-existing tracheostomy site, or bronchoscopically [13, 14]. The technique has also been described in children, to assist in removal of suprastomal tracheal granulation tissue [11, 15] and as an adjunct for treatment of laryngeal stenosis after open framework surgery [15]. In this study, we review a case series of pediatric patients who underwent endoscopic bipolar radiofrequency ablation as the primary treatment modality for Grade II subglottic stenosis, to assess clinical effectiveness and safety.

Methods

A retrospective study from January 2010 to December 2016 was conducted at the Center for Pediatric ENT (Boynton Beach, FL), a private practice consisting of four fellowship-trained pediatric otolaryngologists. This study was IRB-approved under 45CFR56.101(b) (Exempt Category 4). An electronic medical records search was performed for all patients in the practice who underwent laryngeal and tracheal procedures, with CPT codes 31750, 31641, 31588, 31541 and 31588. Patients were excluded if they solely underwent open surgical repair of SGS, or an endoscopic technique that did not include microlaryngeal bipolar radiofrequency ablation. Data collected included subject age at the time of each procedure, etiology, location and severity of laryngotracheal stenosis, comorbid medical conditions, number of procedures performed, types of procedures performed, age at resolution of stenosis if resolution was achieved, presence of tracheostomy, success rate of tracheostomy decannulation, and procedural complications.

The microlaryngeal bipolar radiofrequency ablation instrument used was the Coblation Precise MLW laryngeal wand (Smith & Nephew, Andover, Massachusetts, USA). The ablation setting used was 7 and the coagulation setting used was 3. The instrument has a small, eccentric electrode on one edge of the tip of the wand, and is shielded on the other side of the tip, such
that the opposite side of the tip can contact tissue and even retract it without injuring the tissue, while the electrode side can ablate tissue. Saline is automatically applied to the electrode through a small channel on the instrument, and there is also a small suction port.

The larynx was exposed using suspension laryngoscopy and the airway was examined using a rigid 0-degree Hopkins-rod telescope or an operating microscope. Subglottic stenosis was assessed using the Cotton-Myer staging system, with Grade II defined as 51-75% stenosis [8]. The MLW microlaryngeal bipolar radiofrequency ablation device was used to eliminate the stenosis with an ablation setting of 7.

If the stenosis was circumferential, the instrument was used to remove hypertrophic cartilage and fibrosis in one quadrant only, in order to minimize the chance of iatrogenically worsening the stenosis during the healing process. Patients were returned to the operating room at 6 to 12 weeks later to endoscopically re-assess the status of the airway, with preparations made to perform another endoscopic procedure if stenosis had persisted.

Resolution of stenosis was defined based on clinical and functional status during rest and with activity, achievement of tracheostomy decannulation (if a tracheostomy tube had been present), and confirmed by operative direct laryngoscopy and bronchoscopy.

Results

Three pediatric patients underwent bipolar radiofrequency ablation as a primary treatment modality for subglottic stenosis. The patient ages at the time of treatment ranged from 5 to 12 years old. One case was diagnosed as idiopathic, and the other 2 cases were acquired from prior neonatal endotracheal intubation. Two patients presented with exercise-induced stridor and had not undergone prior tracheotomy; one patient presented with a tracheostomy tube already in place. The stenosis was endoscopically calculated to be Grade II in all three cases.

In the 2 cases without a tracheostomy tube present, a single bipolar radiofrequency ablation procedure was performed, in which a shelf of fibrotic tissue was removed from one side of the subglottis; the entire stenosis was not treated, in order to minimize the chance of recurrence of stenosis due to circumferential scarring (Figure 1). Patient 1 was 5 years old with acquired stenosis due to prior endotracheal intubation, and Patient 2 was 12 years old with idiopathic stenosis. Neither patient had undergone any prior airway procedures. Stenosis improved afterwards to allow for resolution of stridor in both subjects, with no sign of recurrence with over 1 year of follow-up.

Figure 1: Microlaryngeal Bipolar Radiofrequency Ablation of Congenital Subglottic Stenosis. Left Frame: Idiopathic Subglottic Stenosis (No Prior History of Endotracheal Intubation). Middle Frame: Microlaryngeal Bipolar Radiofrequency Ablation of the Stenosis. Right Frame: Post-Ablation Appearance of Subglottis

Patient 3 was a 9-year-old with tracheostomy-dependence and acquired Grade II subglottic stenosis, who underwent removal of fibrotic subglottic tissue in one quadrant (left antero-lateral subglottis) with the MLW bipolar radiofrequency device, followed by removal of fibrotic tissue in another quadrant (right antero-lateral subglottis) 3 months later. At follow-up endoscopy 3 months later, Patient 3 had demonstrated enough improvement that he was able to undergo successful tracheostomy decannulation, and has had no stridor or recurrence of disease in over 2 years since then.

There were no intra-operative adverse patient outcomes associated with use of the microlaryngeal bipolar radiofrequency wand, but some technical issues with the wand were noted intra-operatively. For example, the wand is long, semi-rigid, and very thin, with a diameter of 2.8mm at the tip; if it is bent significantly, it may kink and become unusable, as saline can no longer flow through it. Bending the neck back to its original position can cause it to break completely.

Additionally, the small suction lumen of the device can easily become clogged with soft tissue during ablation. To try to unblock the device, the tip of the wand can be submerged in a canister of saline and ablation activated on the highest setting, level 9. If that does not successfully eliminate the blockage, the instrument can be disconnected from the saline tubing and forcibly flushed with saline via a syringe.

Discussion

This case series describes the endoscopic use of a microlaryngeal bipolar radiofrequency device as a primary method of management for Grade II pediatric subglottic stenosis.
stenosis. For the three patients in this series, resolution of disease was experienced following treatment with the technique. Two of the patients had resolution after one procedure, and the other patient, who had a tracheostomy tube in place, required two procedures and experienced successful decannulation after the second procedure.

New and important aspects of the technique described in this case series are the following: 1) there is less risk of ignition of an airway fire when compared to endoscopic laser therapy in the pediatric airway; 2) cartilage and fibrosis can be removed with the technique, which is an advantage over endoscopic balloon dilatation of the airway; and 3) for Grade II subglottic stenosis, the technique shares the benefit of other endoscopic techniques in that open laryngeal framework surgery, with its associated longer recovery and hospital stays, can be avoided.

Successful use of bipolar radiofrequency ablation for subglottic stenosis in adults has been reported [13]. Also, in a case series by Fastenberg et al., bipolar radiofrequency ablation was used in an 8-year old patient to help manage a case of persistent subglottic stenosis after failed open laryngotracheal reconstruction, in combination with balloon catheter dilatation and planned further open framework surgery [15]. The current case series adds to the literature on this subject, including three new cases of pediatric subglottic stenosis in which the technique successfully resolved the disease process in a minimally-invasive manner.

The current study found bipolar radiofrequency ablation to be a feasible tool, single-modality tool for the minimally-invasive management of pediatric Grade II subglottic stenosis. Future research would involve determine whether or not this technique would yield success in resolving higher-grade subglottic stenoses in pediatric patients, and determining the role of the instrument as part of a more comprehensive subglottic stenosis algorithm.

References