Novel Method for Laryngotracheal Reconstruction: Combining Single- and Double-Stage Techniques

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Objectives: Traditional open techniques for laryngotracheal reconstruction are either single- or double-stage procedures. Some patients may benefit from the presence of a long, single-tube stent, such as an endotracheal tube, but their predicted need for a 2-stage procedure and a persistent tracheostomy is high. We describe a novel technique for airway reconstruction that combines the methods of both single- and double-stage procedures.

Methods: We present a retrospective review of 4 patients. All patients underwent laryngotracheal reconstruction by a single surgeon. After the operation, the airway was stented with nasotracheal intubation. A small stent, fashioned from an endotracheal tube, was placed in the tracheostoma to keep it patent. The patients subsequently underwent extubation and replacement of the tracheostomy tube.

Results: The study included 1 patient with grade 4 subglottic stenosis, 2 patients with grade 3 subglottic stenosis, and 1 patient with a posterior glottic scar. All were tracheostomy tube–dependent. Serial bronchoscopy was used to follow the patients for a minimum of 9 months after the operation. All 4 patients have since met the criteria for decannulation.

Conclusions: This hybrid reconstruction merges the advantages of both the single- and double-stage procedures. It adds versatility to the surgical toolbox for airway reconstruction.

Key Words: airway surgery, laryngotracheal reconstruction, pediatrics, subglottic stenosis, tracheostomy.

INTRODUCTION

The problem of laryngotracheal stenosis remains a significant burden on the pediatric population. Numerous methods have been attempted to treat stenosis, but open techniques endure as a mainstay of therapy despite the development of endoscopic techniques. Laryngotracheal reconstruction (LTR) with cartilage grafting was initially described as double-stage LTR (dsLTR). As such, it allows the tracheostomy tube to remain in place throughout the duration of the reconstruction and recovery, with decannulation planned at a later date. This technique may be useful in patients with high-grade stenosis, for combined glottic and subglottic stenosis, or when there are significant comorbidities that prevent immediate decannulation. Nevertheless, by definition, it necessitates postoperative continued tracheostomy dependence. Additional problems inherent to this technique are the need for an above-stoma stent that rests immediately adjacent and superior to the tracheostomy tube in the airway lumen. There are significant risks of suprastomal granulation tissue development and, at times, frank stenosis development due to rubbing of the inferior edge of the stent onto the top of the tracheostomy tube and onto the airway mucosa itself. Also, there is the risk of either aspiration or supraglottic granulation tissue or stenosis if the top limb of the stent is fashioned either too long or too short.

Single-stage LTR (ssLTR) was developed as means of reconstructing the airway without a tracheostomy tube, and therefore allows for decannulation at the time of reconstruction or avoidance of a tracheostomy altogether. Although this may seem more advantageous, it also comes with a risk of having to rely solely on the reconstructed airway after the operation. For younger children, when muscle relaxants and sedatives are used while the child remains intubated, there may be a prolonged recovery resulting from withdrawal of sedation, as well as the need for physical therapy to help with the ensuing hypotonia. A single-stage reconstruction poses the additional risk that a child may need emergent reintubation and replacement of the tracheostomy tube after the operation. Such airway crises may be dangerous for children and psychologically traumatic for their families. In spite of their limitations, both dsLTR and ssLTR have been developed and refined over time to allow for excellent patient outcomes.
Surgical management of the stenotic airway relies not only on the surgeon's technique, but also on careful patient selection and preoperative planning. Consequently, once it has been determined that a patient requires an open procedure, it can be difficult to choose between dsLTR and ssLTR, as the benefits and risks of each may not be clear-cut. We have developed a novel technique that allows the surgeon to combine the advantages of both dsLTR and ssLTR. The hybridization of LTR can continue to improve patient outcomes after open airway surgery for laryngotracheal stenosis.

METHODS

Institutional Review Board approval was obtained to perform a retrospective medical record review of all patients who underwent LTR with cartilage grafting at a tertiary care children's hospital. All procedures were performed by a single surgeon. The patients underwent anesthetic induction via their existing tracheostomy tubes. Once they were asleep, diagnostic rigid bronchoscopy was performed. Next, the tracheostomy tube was removed and replaced with an endotracheal tube (ETT) secured to the chest. A transverse skin incision was made to expose the superior portion of the trachea and the cricothyroid cartilage complex. This incision was kept separate from the tracheostomy site. The specifics of reconstruction were tailored according to the bronchoscopy findings.

After reconstruction, the patients were then nasotracheally intubated and the reconstructed airway was closed over the ETT. The ETT was then removed from the tracheostoma. The length of the patient's preexisting tracheostomy tube was measured, and a size 3.0 ETT was cut to match (Fig 1). The external portion of this tube was sutured closed with 3-0 Prolene (Ethicon, Somerville, New Jersey; Fig 2). This was placed into the tracheostoma and secured to the neck with cloth ties (Figs 3 and 4). The
transverse neck incision was then closed in a layered fashion over a rubber-band drain.

At the conclusion of the procedure, the patients were taken to the pediatric intensive care unit, in which a chest radiograph confirmed the placement of both the ETT itself and the fashioned stent. The neck was dressed in such a way as to prevent significant air leak from the tracheostoma. The children remained intubated and sedated until postoperative day 7, at which time they returned to the operating room. The ETT was removed, and diagnostic rigid bronchoscopy was performed. Once bronchoscopy was completed, the tracheostomal stent was removed and replaced with the patient’s tracheostomy tube.

RESULTS

A total of 4 patients underwent the hybrid LTR procedure (see Table). All patients were tracheostomy tube–dependent at the time of reconstruction. All patients were male, and the mean age was 6.3 years (range, 1.5 to 14 years). Two patients carried a diagnosis of grade 3 subglottic stenosis with glottal involvement, 1 patient had grade 4 stenosis, and 1 patient had bilateral vocal fold paralysis and a posterior glottic scar. The degree of stenosis was graded according to the Cotton-Myer system for subglottic stenosis. Three of the 4 patients underwent anterior laryngofissure and placement of a posterior graft, and 1 patient underwent anterior and posterior laryngofissures with debridement and excision of scar tissue from the airway lumen.

Three patients were deemed candidates for this procedure because of high-grade glottic or subglottic stenosis and the need to rely on the tracheostomy for postoperative airway support. The fourth patient was truly a candidate for T-tube placement, but was too young for this. Each of the families was educated as to the risks and benefits of each technique, and they opted for the novel technique. None of the patients experienced accidental extubation, alar necrosis, or postoperative infection or pneumonia. Each patient was placed on a narcotics weaning schedule after extubation. All underwent a modified barium swallow study to assess for possible aspiration, and all were approved for a regular diet without restriction or risk of aspiration.

The patients were followed for a minimum of 9 months after the operation with serial bronchoscopy. One patient required balloon dilation to maintain the reconstructed airway lumen at 1 month after the operation (patient 4). The remaining patients did not require airway manipulation. Two of the patients have been successfully decannulated. Another patient is ready for decannulation, but his parents have not opted for this yet. This patient could have been a candidate for either sLTR or dLTR, but the family had reservations about a single-stage procedure because of concern for recannulation. They remain too fearful to consider decannulation despite a stable airway. During the follow-up period, no patients had evidence of supraglottic or suprastomal granulation tissue.

DISCUSSION

Surgical management of the patient with laryngotracheal stenosis requires the surgeon to possess an extensive toolbox that offers versatility to the patient. A combination of dLTR and sLTR can prove very useful when applied to the correct patient population. Because the plan is to leave the patient with the tracheostomy after the reconstruction, patients who undergo hybrid LTR should be those who the surgeon predicts will be tracheostomy-dependent. According to dLTR selection criteria, this includes patients with high-grade stenosis, multilevel stenoses, or other comorbidities that prevent successful decannulation. With the tracheostomy tube in place, the airway remains secure in the critical postoperative period. Additionally, this method is useful when emergent postoperative access to the airway may be difficult or impossible, as may be the case for patients with craniofacial or vertebral anomalies.

Typically, patients who are candidates for a hybrid, or one-and-a-half–stage, reconstruction are those who would benefit from the placement of a long-segment but short-term stent in the airway, as described for the sLTR. This allows the reconstructed airway to heal and grafts to take. Where-
as strict single-stage procedures make the postoperative management of the airway difficult and are best for patients with lower-grade stenosis requiring a single graft, the presence of a stent in the tracheostoma in the hybrid LTR allows for emergent airway access, thereby allowing ssLTR to become applicable to patients with higher-grade or complex stenoses.9,14

In performing airway surgery on children with complex stenoses, safety in the perioperative period is of the utmost importance, particularly during single-stage procedures. The success rates are affected not only by careful preoperative planning and patient selection, but also by events that may not be directly under the surgeon’s control.11,13 Events such as plugging of the ETT or unplanned extubation may occur. Although it is convenient to have pediatric intensivists on hand to aid in the management of these events, we recognize that this is not always a possibility. In instances in which staffing of the intensive care unit may be limited, we advocate the use of the hybrid reconstruction, as the tracheostomal stent offers the team emergent access to the airway, while treating underlying sedation or ventilation issues.

Experience with ssLTR has shown that not only is it important to formulate a plan in case of airway loss, but that it is also important to use nasotracheal intubation.16 This has been incorporated into the hybrid LTR in an effort to improve patient outcomes. Prior studies have shown that nasotracheal intubation can be well tolerated in children, and can lead to reduced requirements of sedatives and paralytics.16,17 As such, the incidence of adverse sequelae such as atelectasis, sedation withdrawal syndrome, and neuromuscular weakness can be reduced.18 Of particular interest is the applicability of this technique to patients with glottic or subglottic stenosis who may be best served by T-tube placement but are too young for such treatment. The period of intubation allows the glottic airway to be stented after reconstruction, but offers the tracheostomy as additional support once the stent is removed. The glottic airway can then be monitored for patency while the tracheostomy is in place for airway protection.

This combined technique may be of particular benefit to children whose parents are apprehensive about sudden airway compromise after ssLTR and have a significant fear of emergent decannulation. In our study, we had one set of parents who felt that neither they nor their child was ready for decannulation simultaneous with airway reconstruction (patient 1). The child had an underlying autistic condition, and his parents were concerned that the child would find it hard to cope with a complex surgery and removal of the tracheostomy tube. Our hybrid technique allows time not only for the reconstructed airway to heal and be monitored for patency, but also for the family to prepare themselves for subsequent decannulation.

Furthermore, performing a hybrid LTR offers the advantage of repairing anterior tracheal collapse. Frequently, a component of suprastomal tracheal collapse is a sequela of tracheostomy dependence, and may hinder decannulation.19 In instances in which the tracheostomy tube is replaced immediately after reconstruction, the repair of the anterior tracheal wall may be put at risk of failure. The hybrid technique allows for adequate manipulation of the anterior tracheal wall, followed by a period of immobility to allow for healing.

The hybrid LTR method combines the advantages of dsLTR and ssLTR and results in a novel approach that is highly versatile. However, we do acknowledge that there are limitations. Consultation with a pediatric intensivist is essential for postoperative ventilation management. If the neck and peristomal area are not dressed appropriately to minimize air leak, determining adequate ventilator settings can be a significant challenge. Consequently, it may be hard to calculate the patient’s true ventilation requirements and weaning needs. As a last resort, the tracheostomal stent has the option of being removed. We have found that careful attention to the neck dressing with daily changes is the best management option for a peristomal air leak and have not yet had to remove the stent.

The one-and-a-half–stage technique combines many of the advantages of the 1- and 2-stage procedures together. One of the drawbacks of ssLTR that we know of is the relatively high rate of reintubation after planned extubation, due to subglottic swelling, oversedation, or withdrawal issues. The hybrid procedure allows the child to recover from being sedated without the need for sudden, semi-urgent or urgent reintubation that may result in laryngeal trauma. It has been our experience that many parents are more comfortable with hybrid reconstruction than with ssLTR, in which there is a sudden transition of the airway that can affect the child, the parents, and general family life. That is, children who have been living with their tracheostomy tubes for a long time either succeed or need revision tracheostomy, which may be psychologically traumatizing. The hybrid procedure provides a smoother transition.

As compared to dsLTR, hybrid reconstruction offers the distinct advantage of a single smooth stent (the ETT) without the granuloma formation possible at the junction of the tracheostomy tube and a su-
prastomal stent. The relative disadvantage of a hybrid procedure as compared to dsLTR is that in children too young to tolerate awake nasotracheal intubation (generally those younger than 3 years of age), there may be problems related to long-term sedation or muscle relaxation. Therefore, a one-and-a-half-stage procedure is the best option for children who otherwise might be candidates for a possible single-stage procedure.

We have offered a small case series, but hope to expand this in the future. Our goal was to focus on the hybrid technique as one that allows quicker postoperative weaning from ventilatory support, reduced anesthesia needs, and an overall reduced length of stay.

REFERENCES
