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COMPLETE TRACHEAL TRANSECTION IN A 3-YEAR-OLD AFTER BLUNT NECK TRAUMA: A CASE REPORT

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Abstract

Pediatric laryngotracheal injuries from blunt force trauma are rare but can lead to significant morbidity and mortality. In pediatric patients with severe laryngotracheal disruption, extracorporeal membrane oxygenation has been used to improve oxygenation and ventilation until definitive repair can be performed. We describe the case of a 3-year-old girl with blunt neck trauma secondary to an all-terrain vehicle accident in which her neck was clotheslined against a fence, leading to a complete tracheal transection at the C7-T1 level. Emergent extracorporeal membrane oxygenation cannulation was initiated. We discuss the evaluation and management of tracheal injuries and the requisite multidisciplinary team approach. Pediatric patients with laryngotracheal trauma require definitive airway management, which should be performed by skilled personnel.

Keywords

Extubation • extracorporeal membrane oxygenation • laryngeal trauma • pediatric • trachea

Introduction

Pediatric laryngotracheal injuries from blunt force trauma are extremely rare but can lead to significant morbidity and mortality. The pediatric larynx is positioned more superiorly than in adults, which allows the mandibular arch to partially shield the larynx from injury. The laryngeal cartilage is also more flexible in pediatric patients, which also decreases the likelihood of laryngotracheal injuries. However, when these injuries occur, the narrower lumen of the pediatric airway and the loose attachment of the mucosa to the underlying tissues predispose children to rapidly progressing airway edema and obstruction.[1,2] In pediatric patients with severe laryngotracheal disruption, extracorporeal membrane oxygenation (ECMO) has been used to improve oxygenation and ventilation until definitive repair can be performed. We describe the case of a 3-year-old girl with blunt neck trauma secondary to an all-terrain vehicle accident in which her neck was clotheslined against a barbed-wire fence. This led to a complete tracheal transection at the C7-T1 level. Emergent ECMO cannulation was initiated to improve her oxygenation and to repair her trachea. We discuss the initial evaluation and management of tracheal injuries and the multidisciplinary team approach required for successful treatment. We obtained written consent from the patient's biological mother for this case presentation.

Case

A 3-year-old girl presented to the emergency department after she was struck in the neck by barbed wire while riding an all-terrain vehicle. On arrival to the trauma bay, she had a blood pressure of 121/61 mmHg, a heart rate of 133 beats per minute, a respiratory rate of 30 breaths per minute, and an oxygen saturation of 84% on a non-rebreather. On examination, she had a cervical collar in place, obvious facial trauma with severe periorbital edema, neck swelling, and absent lung sounds bilaterally. Immediate plans were made for endotracheal intubation. Direct laryngoscopy was performed by the emergency room physician and a 4.5-cuffed endotracheal tube (ETT) was placed through the vocal cords with only slight improvement in oxygenation. A bedside chest X-ray revealed bilateral pneumothoraxes, so bilateral chest tubes were placed. Her oxygenation improved and she was taken to a computed tomography (CT) scanner. CT imaging revealed subcutaneous

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emphysema extending from the level of the occiput to the flanks, as well as substantial pneumomediastinum. The trachea was completely transected at the C7-T1 level and the tip of the ETT was free in the mediastinum (Figure 1).

On arrival in the operating room (OR), the patient had been paralyzed with rocuronium and was intubated as described above. Vital signs were as follows: blood pressure 96/53 mmHg, heart rate 125 beats per minute, ventilator rate 40 breaths per minute, SPO_2 100%. A left radial arterial line and two peripheral intravenous lines were placed. The anesthesiologist and the pediatric otolaryngologist attempted to advance the ETT from its current position beyond the tracheal transection site, but with each attempt, the patient's oxygen saturation immediately dropped to the 50s and several minutes of handbag ventilation were required to recover appropriate oxygenation; therefore, this approach was abandoned. We decided to place the patient on ECMO. ECMO was initiated and she underwent open repair of the tracheal injury. Upon incision, the distal end of the ETT was found free in the superior portion of the mediastinum at the base of the neck (Figure 2). The tracheal injury was a clean transection with no destruction of the tracheal rings. The tracheal transection was the only serious injury suffered; all other nearby structures were uninjured. An end-to-end

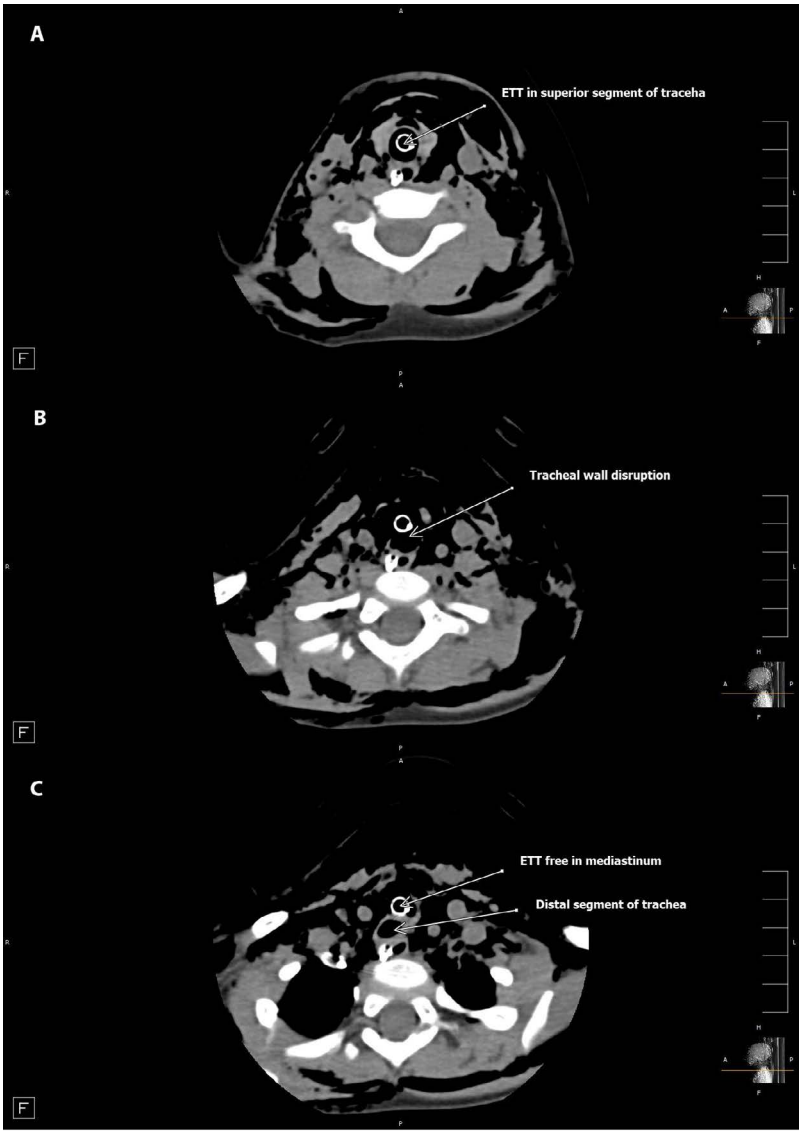

Fig. 1. Computed tomography images demonstrating the position of the endotracheal tube in the superior segment of the trachea (A), the injury to the tracheal wall (B), and the distal end of the endotracheal tube free in the mediastinum and the distal segment of the trachea (C). The patient's trachea was completely transected at the C7T1 level.

anastomosis was performed for primary repair of the trachea (Figure 3). At the end of the case, a new nasotracheal tube was placed so the patient could remain intubated postoperatively to protect the anastomosis and allow time for healing. After ETT replacement, the patient was successfully weaned from ECMO and transferred to the pediatric intensive care unit. One week later, she returned to the OR for rigid bronchoscopy and esophagoscopy, which showed bilateral true vocal cord mobility, glottic edema, and a well-healing tracheal anastomosis (Figure 4). The patient remained intubated and returned to the OR 2 weeks postoperatively for a second rigid bronchoscopy, esophagoscopy, and extubation, all of which proceeded uneventfully (Figure 5). The patient was discharged home 5 days later, 19 days after admission. Three weeks postoperatively, her glottic edema had largely resolved and her tracheal anastomosis appeared well healed, apart from a small suture granuloma (Figure 6). She continues to do well and has no detectable neurologic deficits.

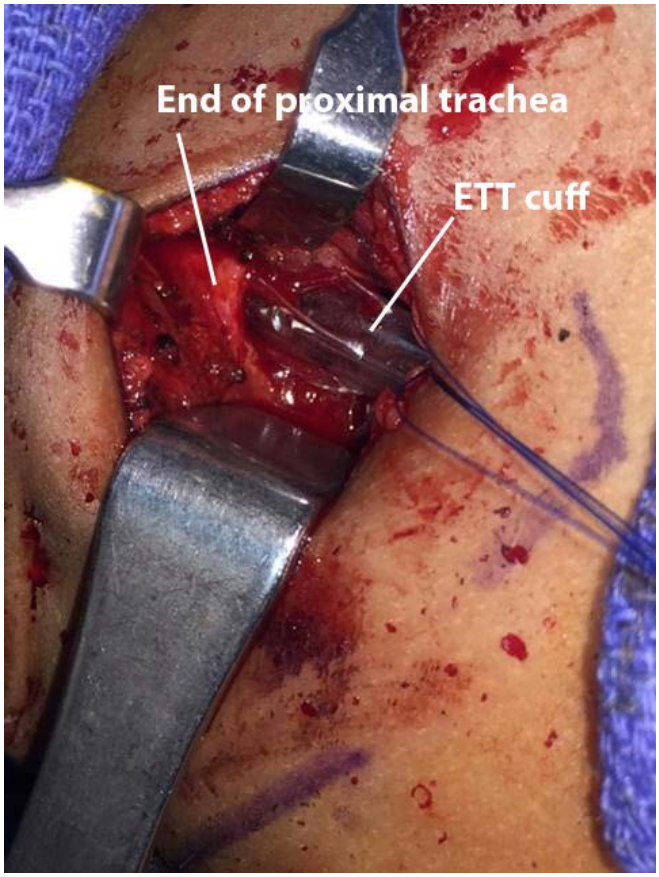

Fig. 2. Photograph of the distal end of the endotracheal tube free in the mediastinum after incision. The patient's injury did not cause destruction of the tracheal rings and all other nearby structures were intact.

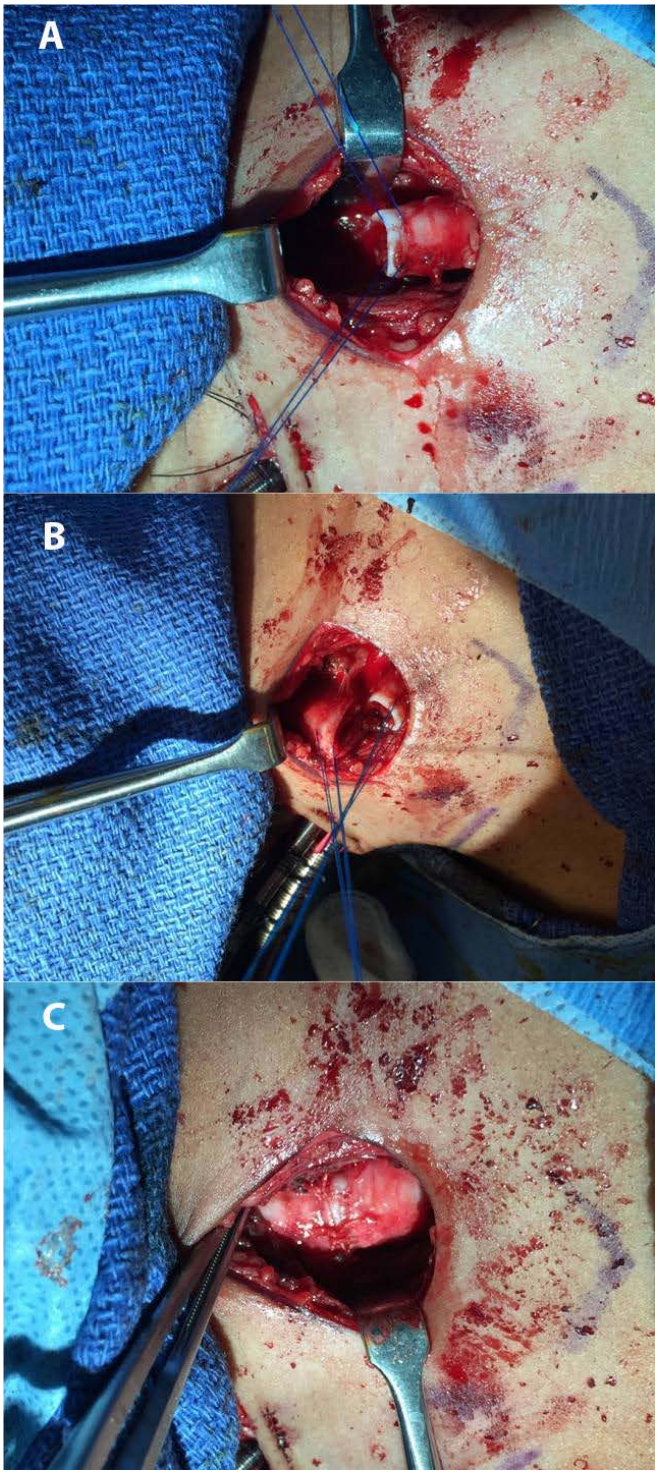

Fig. 3. Intraoperative findings. The distal segment of the trachea after retrieval from behind the sternum with stay sutures in place (A). The tracheal ends as the anastomosis is beginning (B). Note the clean end of the trachea without any tissue destruction. The completed anastomosis (C).

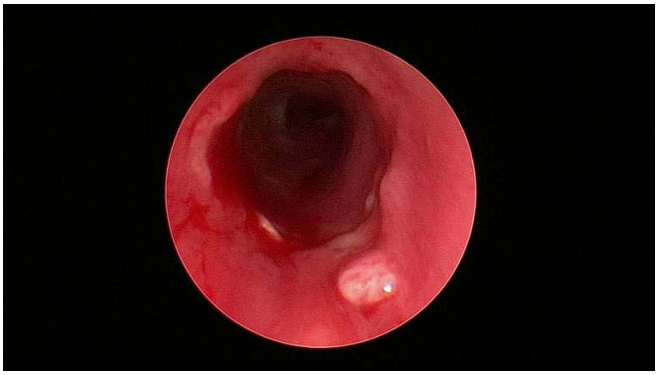

Fig. 4. Endoscopic view of the tracheal anastomosis 1 week post-operatively, which showed bilateral true vocal cord mobility, glottic edema, and a well-healing tracheal anastomosis.

Discussion

Less than 1% of all adult patients with significant blunt trauma suffer laryngeal injuries.[3,4] Laryngotracheal injuries are estimated to be found in approximately 1 to 12 per 30,000 emergency department admissions.[2–5] There are no pediatric-specific data about the incidence of laryngeal trauma, but it is accepted that these cases are much rarer. The rarity of pediatric airway trauma can be attributed to behavioral factors that tend not to put children at the same risk of blunt trauma to the neck. In addition, there are also anatomic factors that make laryngeal trauma less likely.[2,6] Pediatric patients have shorter necks, and this helps to shield the larynx behind the arch of the mandible. Pediatric patients also have

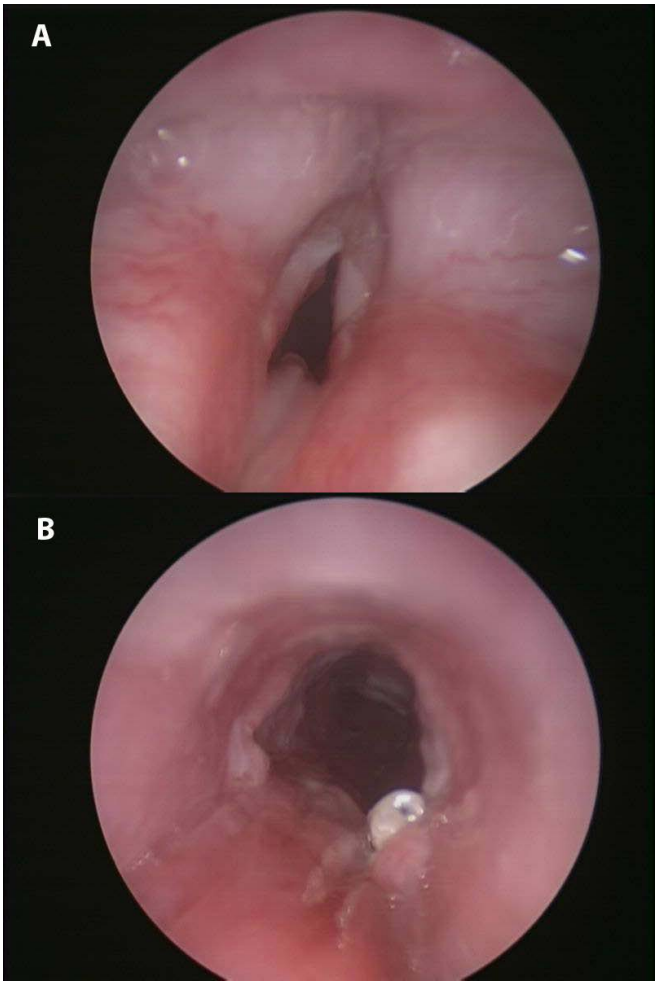

Fig. 5. Endoscopic view of the glottis (A) and tracheal anastomosis (B) 2 weeks postoperatively. The patient was discharged home 19 days after admission.

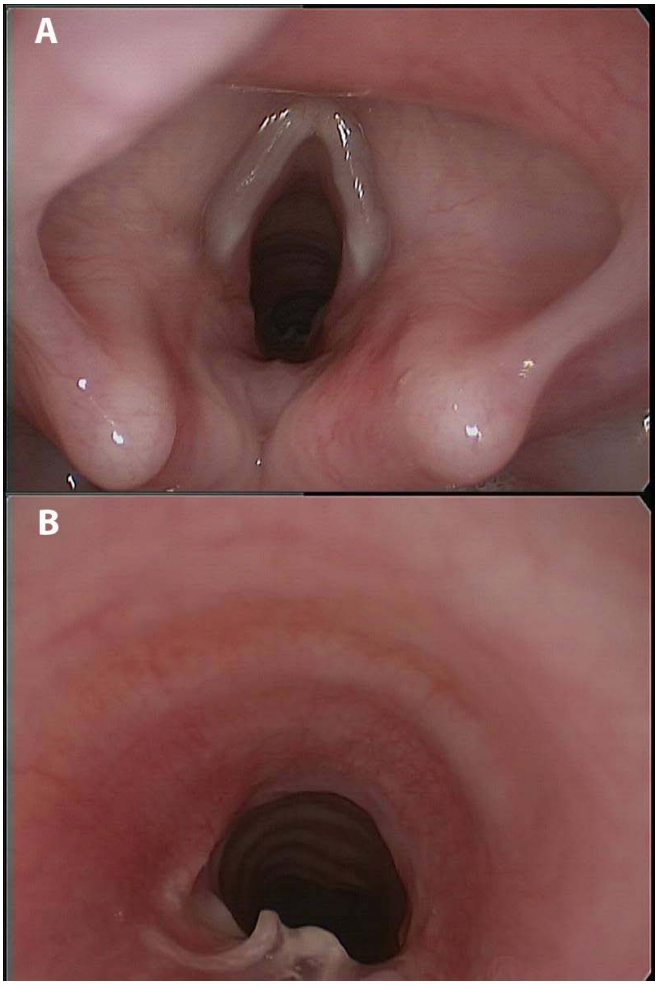

Fig. 6. Endoscopic view of the glottis (A) and tracheal anastomosis (B) 3 weeks postoperatively, at which time her glottic edema had mostly resolved and her tracheal anastomosis was healing well.

greater pliability of their laryngeal cartilages, which reduces the likelihood of fractures and the severity of tracheal injury. [3,7] Unfortunately, when children experience laryngotracheal trauma, the consequences are often catastrophic. Given the narrower lumen of the pediatric airway, children poorly tolerate edema and hematoma formation, often leading to airway compromise.[6,7]

Laryngotracheal injuries are classified into five groups based on severity (Table 1). These range from minor endolaryngeal laceration or hematoma (group 1) to complete laryngotracheal separation (group 5).[6] The presenting signs and symptoms of children with laryngotracheal injuries can range from a mild sore throat and dysphonia to unconsciousness, stridor, and frank respiratory distress.[3,7–9] It is vital to understand that children with blunt laryngeal trauma can often present relatively asymptomatically but can rapidly progress to complete airway obstruction. Providers must be highly vigilant in their initial evaluation to mitigate the high lethality associated with laryngotracheal injuries. It has also been suggested that early recognition and prompt treatment improves prognosis.[2,3,10] On examination, anterior neck ecchymosis, loss of laryngeal landmarks, edema, subcutaneous emphysema, and palpable cartilage fractures are ominous signs and should alert the treating physician to the possibility of laryngotracheal injury. [3,8]

Initial management of children with laryngotracheal injuries varies based on how stable the patient's airway is. Children deemed to have unstable airways require placement of a definitive airway, but whether this should be an ETT placement or surgical tracheostomy remains contested. [5,7,8,11,12] Proponents of surgical tracheostomy argue that ETT placement risks exacerbating mucosal lacerations, further disrupting displaced structures and leading to complete laryngotracheal separation, creation of false passages, or inadvertent placement of the ETT into the mediastinum or pleura, as occurred in our case.[5,8] The most significant consideration regarding ETT placement is failed endotracheal intubation, which requires emergent surgical airway access, with potentially disastrous consequences. Under the correct conditions, however, ETT placement can be performed safely. This requires an expert physician, excellent visualization of the airway, and a small ETT.[2,5,12] Gold et al.[5] recommend using a rigid bronchoscope to secure the airway under direct visualization in the operating room. For patients with stable airways, an otolaryngologist should be consulted as soon as possible for flexible laryngoscopic examination followed by microlaryngoscopy and bronchoscopy as indicated.[10]

Imaging

Radiographic assessment of patients with known or suspected laryngotracheal injuries should be guided by the risk of concomitant injuries to nearby structures, in particular, the esophagus and cervical spine. As many as 50% of patients with laryngeal trauma have an associated cervical spine injury.[2,4] Initial investigations should include cervical spine X-rays, lateral soft tissue neck X-rays, and possibly an esophogram with water-soluble contrast if there is concern for esophageal injury.[12] A chest X-ray should also be obtained to assess for possible pneumothorax, pneumomediastinum, and subcutaneous emphysema, all of which are highly sensitive signs of laryngotracheal injury with an air leak.[2,7] A CT scan provides the most useful and detailed information regarding laryngeal cartilage fractures.[7]. Current recommendations suggest that this is necessary only when the results are likely to alter management.[2,7] Nonetheless, evidence suggests that in pediatric patients with known or suspected laryngotracheal injuries, CT scanning should be used as part of their evaluation.[4,8,9,12]

Management

Historically, patients with grade 1 or 2 laryngeal injuries have been treated conservatively with measures such as voice rest, humidification, prophylactic antibiotics, proton pump inhibitor therapy, and steroids, while injuries of grade 3 or greater have required surgical intervention.[2,10] Recent advances in endoscopic management of laryngeal blunt trauma have begun to reshape this approach, particularly regarding the management of grade 3 injuries limited to substantial mucosal trauma.[2] This approach can achieve similar results compared with open surgery while avoiding

Table 1. Schaefer-Fuhrman laryngeal injury classification

Grade	Description	Recommendations
1	Minor endolaryngeal hematoma or laceration, no detectable fracture	Conservative (humidified oxygen, observation)
2	Edema, hematoma, minor mucosal injury without exposed cartilage, non-displaced fracture on CT	Conservative treatment vs. tracheostomy, panendoscopy
3	Massive edema or hematoma, mucosal tears with exposed cartilage, vocal cord immobility, displaced fractures	Tracheostomy, panendoscopy, exploration, and repair
4	As with Grade 3, but with severe mucosal disruption, multiple fractures, disruption of anterior commissure, unstable laryngeal framework	Tracheostomy, panendoscopy, exploration, and repair with possible stent placement
5	Complete laryngotracheal separation	Emergent tracheostomy, exploration, and repair

much of the morbidity associated with surgical intervention, including the need for tracheostomy, provided the patient can be kept intubated for several days postoperatively.[9] Open surgical repair still has its place, however, and in cases with comminuted cartilage fractures, extensive mucosal or vocal cord avulsion, injuries requiring visualization of the paraglottic space, and injuries that cannot be optimally visualized or repaired with endoscopic strategies, open repair remains the standard of care.[9] Recent evidence also suggests that when open repair is deemed necessary, early intervention improves long-term outcome and decreases long-term sequelae such as persistent dysphonia, subglottic and rarely supraglottic stenosis, tracheostomy dependence, and the development of tracheoesophageal and tracheocutaneous fistulae.[6,7,9,10]

ECMO

ECMO is a relatively new tool in traumatic laryngotracheal injury management. The first case report describing successful ECMO for treating laryngotracheal trauma was published in 2012 by Ballouhey et al.[13] Since then, a small number of case reports and reviews of existing literature have shown that ECMO, in the right circumstances, can treat patients who only a few years ago would not have survived their injuries.[14–17] ECMO is far from a standard of care currently, but it can aid in the management of patients requiring surgical repair of injuries as well as those whose injuries will be managed medically.[15–17] ECMO can even allow patients with tracheal injuries with a known air leak to breathe spontaneously, thus decreasing the strain on patients undergoing conservative management or surgical anastomosis who have subsequently developed an air leak and for whom additional surgery is not desirable.[15,16]

Conclusions

Blunt laryngotracheal trauma is uncommon in pediatric patients, which is reflected in the paucity of literature on the subject. While many of these patients may present initially with no symptoms or minor ones, they can rapidly progress to respiratory distress; a high degree of vigilance is required to successfully manage these patients. When these patients have unstable airways, they require definitive airway management. While the manner of airway management remains controversial, it should unquestionably be performed by the most skilled and experienced personnel available, ideally in the operating room. Recent advances in the management of laryngotracheal injuries, including endoscopic techniques and ECMO, have decreased the morbidity and mortality associated with the injuries. Nonetheless, morbidity and mortality remain high in patients who have suffered high-grade laryngotracheal injuries.

Conflict of interest

The authors declare no conflicts of interest or sources of funding.

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