Pediatric Tracheostomy Decannulation: 11-Year Experience

Kristen L. Seligman, MD¹, Bryan J. Liming, MD², and Richard J. H. Smith, MD¹

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Abstract

Objective. To determine the successful decannulation rate with a published pediatric tracheostomy decannulation protocol.

Study Design. Case series with chart review.

Setting. A single tertiary care institution.

Subjects and Methods. A chart review was performed for patients aged ≤5 years who underwent tracheostomy. Extracted data included demographic data, indication for tracheostomy, age at tracheostomy and decannulation, comorbidities, and surgical complications. Records were searched for documentation of early decannulation failure (within 1 month of decannulation) or late failure (within 1 year).

Results. Forty patients with a tracheostomy aged ≤5 years underwent attempted decannulation during the 11-year study period. Seventeen patients were excluded from the study for documentation of nonprotocol decannulation. The final study population of 23 patients underwent a total of 27 decannulations, 26 of which were performed by protocol. Of the 26 protocol decannulations, 22 were successful, for a failure rate of 15%.

Conclusion. Twenty-six protocol decannulations were attempted among 23 patients, 4 of which were unsuccessful for an overall failure rate of 15%. This result is consistent with rates reported in other published decannulation protocols. We believe that our protocol minimizes resource utilization in its use of pulse oximetry over polysomnography, while maximizing patient safety and success through the use of capping trials for very young and very small pediatric patients.

Keywords

pediatric tracheostomy, tracheostomy decannulation, decannulation protocol

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Tracheostomy remains an effective method of bypassing an obstructed upper airway and/or providing ventilatory support for pediatric patients. Attendant risks include granuloma formation, infection, cannula obstruction, accidental decannulation, postdecannulation tracheocutaneous fistula (TCF), and death.¹ Mortality typically reflects the underlying comorbidities necessitating tracheostomy, although tracheostomy-associated mortality is not inconsequential. In a recent literature review on tracheostomy-related complications, Dal’astra et al¹ found that the overall mortality rate of pediatric tracheostomy ranged from 2.2% to 59%, with a tracheostomy-specific mortality of 0% to 5.9%.

Most pediatric patients are decannulated during childhood. Decannulation as early as feasible reduces tracheostomy-related complications, negative impacts on patient and family quality of life, and the socioeconomic burden of a tracheostomy on patients and the health care system.²⁻⁴ The initial hospitalization costs for tracheostomy placement alone average >$100,000, and the ongoing financial burden for medical appointments and home tracheostomy care is substantial.² Caregivers of patients with a tracheostomy report a negative impact on nearly all aspects of life, including sleep, social life, relationships, and ability to maintain employment.³ One study found that the emotional and financial stress of caring for a child with a tracheostomy had a significant detrimental effect on caregiver mental health.⁴

While a consensus statement on assessing the readiness for decannulation was published,⁵ a consensus protocol for tracheostomy decannulation is lacking. According to the consensus statement, most agree that operative airway assessment should be performed prior to decannulation of pediatric patients and that capping is generally recommended for patients aged ≥2 years. There is a concern that capping may occlude the airway completely of infants aged

¹Department of Otolaryngology–Head and Neck Surgery, University of Iowa, Iowa City, Iowa, USA
²Department of Otolaryngology–Head and Neck Surgery, Tripler Army Medical Center, Honolulu, Hawaii, USA

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Corresponding Author:
Richard J. H. Smith, MD, Department of Otolaryngology–Head and Neck Surgery, University of Iowa, 200 Hawkins Dr, Iowa City, IA 52242, USA.
Email: richard-smith@uiowa.edu
<2 years given that the tracheostomy tube may occupy the entire lumen in a small caliber airway. In the absence of a standardized protocol, current decannulation methods vary considerably in cost and invasiveness, and include capped polysomnography, downsizing tubes, long-term capping trials, inpatient capping with short-term observation, and inpatient observation after decannulation without capping.

In 1997, the senior author published a case series illustrating a reliable method to predict decannulation success of very young and very small pediatric patients. This method consists of a 2-step process: (1) endoscopically guided tracheostomal resection of suprastomal granulation tissue and (2) placement of a fenestrated tracheostomy tube, followed by a 12- to 24-hour capped observation trial. Prospectively, the method was shown to be effective at predicting the preparedness for decannulation of 9 of 10 patients. Additionally, this method allows for a capping trial of very small patients with small-caliber airways. Although other methods of decannulation were assessed over the past few years, the effectiveness of this method has not been reviewed since the publication of this protocol. The objectives of this study were therefore (1) to reassess the efficacy of this protocol for predicting successful decannulation of pediatric patients aged ≤5 years and (2) to examine the secondary outcomes of mortality, postdecannulation complications, and rate of recannulation.

Methods

Patient Population

This study was approved by the Institutional Review Board at the University of Iowa. The study included patients with a tracheostomy aged 0 to 5 years for whom decannulation was attempted between 2005 and 2016.

Protocol

For the past 2 decades, the Division of Pediatric Otolaryngology at the University of Iowa has followed the same decannulation protocol. Briefly, eligibility for decannulation is determined by a multidisciplinary team involving otolaryngology, speech pathology, and pulmonology. When a pediatric patient with a tracheostomy is determined to be ready for decannulation, the first step is rigid endoscopy under general anesthesia to assess airway patency and peri-stomal granulation tissue. All granulation tissue is removed transtomally with Kerrison rongeurs under endoscopic guidance. The existing tracheostomy tube is removed, and a fenestrated tube is fashioned from a new tracheostomy tube (Shiley Tracheostomy; Covidien-Medtronic, Minneapolis, Minnesota). Visual confirmation is used to correctly place the fenestration on the outer curvature so that when the tracheostomy tube is appropriately secured, the fenestration lies in the center of the child’s airway.

The preexisting unfenestrated tracheostomy tube is replaced, and the child is allowed to recover fully from anesthesia. The tracheostomy tube is changed at bedside, with the unfenestrated tube replaced with the newly fashioned, fenestrated one. The fenestrated tube is capped, and the child is monitored in the hospital for the next 12 to 24 hours on continuous pulse oximetry. This period always includes the remainder of the day after the procedure as well as the following night. If the child maintains adequate oxygenation (>90%) throughout the observation period and does not show signs of obstruction (stridor, cyanosis, retractions, tachypnea, etc), the decannulation trial is considered a success, and the capped fenestrated tracheostomy tube is removed, typically on the morning after the procedure. A bandage is placed over the tracheostomy site, and the child is observed for an additional half-day with continuous pulse oximetry. If the child remains stable according to the aforementioned criteria, discharge with outpatient follow-up 3 to 4 weeks later is arranged.

Database Search and Analysis

A search of the electronic medical record (EMR) from 2005 to 2016 was completed by procedure codes for “tracheostomy placement” or “tracheostomy revision” (Current Procedural Terminology 31600, 31601, and 31603) and by refining the search to include charts with documentation of tracheostomy decannulation. Exclusion criteria included the following: nonprotocol decannulation (ie, patients who were capped without placement of a fenestrated tube), decannulations performed by services other than otolaryngology, decannulations performed following airway reconstruction, and decannulation at other institutions. Extracted data included demographic data, indication for tracheostomy, age at tracheostomy, age at decannulation, comorbidities, and surgical complications. The EMR was also searched for documentation of early decannulation failure, defined as recannulation within 1 month of decannulation, or late decannulation failure, defined as recannulation within 1 year of decannulation. These time frames were chosen per our clinical experience with tracheostomy failures. Descriptive statistics were calculated for study population characteristics and decannulation failure rate.

Results

Forty patients with a tracheostomy aged ≤5 years underwent attempted decannulation during the 11-year period from 2005 to 2016. Seventeen patients were excluded from the study for documentation of nonprotocol decannulation, which included decannulation immediately following airway reconstruction (8 patients), decannulation at an outside hospital/institution (5 patients), decannulation after capping trial without creation of fenestrated tube (3 patients), and decannulation by another service (1 patient). Although the fenestrated tracheostomy protocol is employed for all patients aged 0 to 5 years at our institution, 3 children underwent decannulation after capping trials without creation of a fenestrated tube for the following reasons: 1 child was decannulated by parents without physician approval after a successful daytime capping trial, and 2 patients were tolerating capping 24 hours a day, including at night. Nighttime capping without supervision is never recommended, but these instructions are not always followed. The final study
population included 23 pediatric patients who had at least 1 documented decannulation trial according to the fenestrated tracheostomy protocol.

Twenty-three study patients underwent a total of 27 decannulations, 26 of which were performed by the protocol. Of the 26 protocol decannulations, 22 were successful, for a failure rate of 15% (Figure 1). Of these failures, 3 (12%) occurred in the early postdecannulation period, and 1 (3%) occurred in the late postdecannulation period. Median age at tracheostomy placement was 4 months (range, 10 days–21 months); median age at decannulation attempt was 24 months (range, 7 months–4 years).

Fifty-two percent of patients were female, and the majority (60%) were of non-Hispanic white ethnicity. The most common indication for tracheostomy was upper airway obstruction (52%), followed by pulmonary disease (32%). The majority of patients had ≥1 major comorbidities, with 57% carrying the diagnosis of a known genetic syndrome. Prematurity was documented in 43% and congenital heart disease in 47%. Population characteristics are summarized in Table 1.

Of the 23 study patients, 20 underwent a single decannulation attempt, each of which was successful with no documented failures to date. Three patients underwent >1 decannulation attempt due to decannulation failure. These 3 patients underwent a total of 7 decannulation attempts between the ages of 0 and 5 years, 6 of which were performed according to protocol. Protocol decannulation failures are summarized in Table 2.

Patient 1 underwent tracheostomy at 10 days for Goldenhar’s syndrome and micrognathia, and the first decannulation attempt was performed according to protocol at 6 months. Failure was not immediate but at 4 months postdecannulation, and tracheostomy was replaced due to failure to thrive and obstructive sleep apnea (OSA). A second decannulation attempt was made at 2 years, this time following a nonprotocol home capping trial. An exception was made to the protocol since the patient had been tolerating home capping 24 hours a day for weeks. This decannulation also failed, and the patient was recannulated a week later. The patient was successfully decannulated at 8 years after mandibular distraction osteogenesis and adenotonsillectomy.

Patient 2 underwent tracheostomy at 4 months due to prolonged intubation for congenital heart disease. The first decannulation attempt was made at 11 months and failed due to development of respiratory distress in the setting of acute viral illness. She required intubation 12 days postdecannulation, and a tracheostomy was placed a day later. She was successfully decannulated according to protocol a year later at 22 months.

Patient 3 underwent tracheostomy at 3 months for prolonged intubation secondary to multiple congenital anomalies, including micrognathia and tracheomalacia. A protocol...
decannulation was first attempted at 16 months and failed within 24 hours due to respiratory distress. A second protocol decannulation attempt was made at 24 months and resulted in another early decannulation failure 2 days later because of nocturnal obstruction. The patient was successfully decannulated according to protocol at age 4 years, a few months after undergoing laryngotracheoplasty.

There were no deaths in our study population due to tracheostomy- or decannulation-related issues, although there was 1 patient death related to progression of underlying disease. An expected postdecannulation outcome was persistence of TCF requiring surgical closure. TCF was documented in 11 of 23 patients (48%), with a median time of 5 months to surgical repair.

Discussion
Tracheostomy decannulation of pediatric patients should be guided by objective data with a goal of optimizing outcomes. Decannulation failure is stressful for the patient and caregiver, with the potential for associated morbidity and even death. Accurately assessing a child’s readiness for decannulation is of utmost importance. However, because many children with tracheostomies have multiple comorbidities and other factors that contribute to tracheostomy dependence, predicting success can be challenging.

Failure after decannulation has ranged in the literature from 0% to 32%. A comparison among the various decannulation protocols is summarized in Table 3, with failure rates calculated according to the metrics of this article. In our study, we had 26 protocoled decannulations among 23 patients, 4 of which were unsuccessful for an overall failure rate of 15%. The early failure rate was 12%, while 1 patient (3%) was recannulated 4 months after decannulation due to failure to thrive in the setting of micrognathia and OSA.

Wirtz et al. reported on 35 patients ranging in age from 5 months to 17 years (median, 1-3 years) who underwent a decannulation protocol consisting of bronchoscopy with removal of obstructing granulation tissue, followed by decannulation in the immediate postoperative period. Similar to our protocol, theirs does not rely on polysomnography to assess candidacy; however, their protocol differs

<table>
<thead>
<tr>
<th>Table 2. Characteristics of Patients with Failed Decannulation Attempts.</th>
</tr>
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<tbody>
<tr>
<td><strong>Indication for Decannulation Attempt, mo</strong></td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Patient 1: Goldenhar’s syndrome with severe micrognathia, 6 mo</td>
</tr>
<tr>
<td>Patient 2: Prolonged ventilation requirements secondary to congenital heart disease requiring heart transplantation, 11 mo</td>
</tr>
<tr>
<td>Patient 3: Prolonged intubation, micrognathia, and tracheomalacia</td>
</tr>
<tr>
<td>16 mo</td>
</tr>
</tbody>
</table>

Abbreviations: DLB, direct laryngoscopy and bronchoscopy; SGS, subglottic stenosis.
from ours in that they do not place a fenestrated tube and do not perform capping trials prior to decannulation. In the event of an emergency, our protocol has the advantage of maintaining airway access with a capped tube in the immediate predecannulation period, allowing for the simple and rapid solution of uncapping in the event that a child fails the protocol and requires ongoing tracheostomy use. A protocol that relies on complete tube removal requires that the child be recannulated in the event of decannulation failure, which may be difficult in an emergent situation.

Other protocols rely on polysomnography as an integral part of the predecannulation workup or postdecannulation monitoring. At our institution, polysomnography is a limited resource that can be difficult to schedule and costs approximately $600 to $1700. While it is unclear what defines an acceptable polysomnogram for a patient with a tracheostomy, the general consensus as applied to decannulation protocols is that the parameters of apnea/hypopnea index and desaturation events are the greatest predictors of decannulation success. Since continuous pulse oximetry also detects both desaturation events and, by extension, apneic/hypopneic episodes, we consider it a more cost-effective method of detecting crucial desaturation and apneic events, in agreement with multiple studies showing that nocturnal oximetry is a cost-effective alternative to polysomnography for detecting obstructive events.

Although some physicians may argue that creating a fenestrated tube solely for the purpose of assessing readiness for decannulation is excessive resource utilization, it is important to note that this protocol targets children ≤5 years old; it is unnecessary to create a fenestrated tube as part of the decannulation procedure for older children with larger caliber airways. We believe that the placement of a fenestrated tracheostomy tube is valuable for very young

**Table 3. Literature Review of Decannulation Protocols.**

<table>
<thead>
<tr>
<th>Study</th>
<th>Decannulation Protocola</th>
<th>Population Size, n</th>
<th>Mean Age at Decannulation, mo</th>
<th>Decannulation Attempts, n</th>
<th>Early, &lt;1 mo</th>
<th>Late, 1 mo--1 y</th>
<th>Overall Failure Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>Creation of fenestrated tracheostomy, followed by inpatient capping trial with fenestrated tube in place</td>
<td>23</td>
<td>23.8</td>
<td>26</td>
<td>3 (12)</td>
<td>1 (3)</td>
<td>15</td>
</tr>
<tr>
<td>Cristea (2016)</td>
<td>Decannulation with placement of occlusive dressing, followed by 24-h observation with PSG</td>
<td>189</td>
<td>35</td>
<td>210</td>
<td>43 (20)b</td>
<td>4 (2)</td>
<td>22</td>
</tr>
<tr>
<td>Lee (2016)</td>
<td>Capped PSG</td>
<td>30</td>
<td>84</td>
<td>30</td>
<td>4 (13)</td>
<td>NA</td>
<td>13</td>
</tr>
<tr>
<td>Merritt (1997)</td>
<td>Creation of fenestrated tracheostomy, followed by inpatient capping trial with fenestrated tube in place</td>
<td>10</td>
<td>56.2</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Prickett (2015)</td>
<td>Outpatient capping trials, sometimes (42%) with PSG, followed by inpatient admission for downsizing and capping trial</td>
<td>46</td>
<td>65</td>
<td>46</td>
<td>4 (9)</td>
<td>1 (2)</td>
<td>11</td>
</tr>
<tr>
<td>Robison (2015)</td>
<td>Capped PSG</td>
<td>28</td>
<td>58</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tunkel (1996)</td>
<td>Capped PSG</td>
<td>16</td>
<td>37</td>
<td>14</td>
<td>1 (7)</td>
<td>NA</td>
<td>7</td>
</tr>
<tr>
<td>Waddell (1997)</td>
<td>Inpatient observation with gradual downsizing and eventual capping over a 9-d period</td>
<td>84</td>
<td>66</td>
<td>101</td>
<td>32 (32)</td>
<td>NA</td>
<td>32</td>
</tr>
<tr>
<td>Wirtz (2016)</td>
<td>Decannulation and observation without capping, downsizing, or PSG</td>
<td>35</td>
<td>NAe</td>
<td>35</td>
<td>0</td>
<td>2 (6)</td>
<td>6</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not available; PSG, polysomnography.
aAll protocols report use of operative laryngoscopy and bronchoscopy prior to decannulation.
bAll failures in this study occurred within 24 hours after decannulation while still under observation in the hospital as part of the protocol.
cOur senior author’s original publication on the protocol discussed in this paper.
dOne patient was recannulated after 15 months, outside of the one year late decannulation failure metric used in this study.
eMedian age, 12 to 36 months.
and very small children, as the tube typically occupies a larger percentage of the total airway, potentially making it difficult to breathe around even a downsized capped tube. By using a fenestrated tube, it is easier to assess the likelihood of success among children with very small airways. We believe that the additional cost of a tracheostomy tube (which we fenestrate) is worthwhile. It is worth noting that a Shiley tracheostomy tube costs on average $100, which is a fraction of the cost of polysomnography.

Another concern with the creation of custom fenestrated tracheostomy tubes is that modification of an Food and Drug Administration–approved device may expose the surgeon to liability in the event of device malfunction or complication. According to the administration’s guidelines, modification of approved devices requires a 510(k) premarket approval only if it significantly alters the safety and efficacy of the device.19 Use of a custom fenestrated tube provides a better assessment of readiness for decannulation, with minimal impact on the safety and effectiveness of the tube. Other minor modifications to tracheostomy tubes have been described.20-22 Although encountered less frequently in otolaryngology, medical device modification is common practice in other branches of medicine, such as interventional radiology. In his review of the legal implications of device modification in interventional radiology, Smith23 notes that while modification does expose the physician to liability for negligent use of a modified product, a similar legal exposure for negligence exists in nearly all aspects of patient care.

The clinical assessment of tracheostomy decannulation candidacy was discussed in the consensus statement published in 2013.5 We include awake airway endoscopy, absence of ventilator assistance, and absence of aspiration in our clinical assessment. We rely heavily on our multidisciplinary team of pediatric pulmonologists and speech pathologists when proceeding with a decannulation trial. Note that our protocol differs from the consensus statement in that we do not perform a prolonged outpatient daytime capping trial. Consideration of other medical comorbidities, need for future surgical procedures, and the patient’s social situation must be included. In addition, we consider autumn and winter to be relative contraindications to tracheostomy decannulation due to the high incidence of viral illness during this time of year. Of the 26 decannulations in our series, only 4 occurred outside the months from April to September. We recently added end-tidal CO2 monitoring to assess hypventilation during the tracheostomy occlusion phase. Anecdotally, it helps to inform the decision to decannulate and assess the safety of decannulation; however, the value of end-tidal CO2 monitoring is not specifically addressed in this study.

In reviewing the decannulation failures in our series, we noted several observations and opportunities for improvement. Patient 1 had a history of Goldenhar’s syndrome and micrognathia and, prior to completing treatment of the micrognathia, was decannulated twice—once following a home capping trial and once according to protocol. Failures were not immediate (at 1 week and 4 months, respectively) and were due to failure to thrive and OSA. It is noteworthy that this patient’s micrognathia was so severe that the airway could be assessed only with a Hollinger-Tucker laryngoscope and then with difficulty. Successful decannulation was possible at age 8 years after mandibular distraction osteogenesis and adenotonsillectomy. In retrospect, this patient’s upper airway obstruction should have been addressed more extensively prior to consideration of decannulation.

Patient 2 acquired respiratory syncytial virus 12 days after decannulation and was admitted to and intubated at an outside institution for ventilatory support. After discussion with the parents, the decision was made to replace the tracheostomy given the need for intubation in the setting of a severe viral illness. It is possible that the child may have recovered from the respiratory syncytial virus and not needed subsequent tracheostomy replacement. She was successfully decannulated according to protocol the following summer.

Patient 3 was decannulated twice despite multilevel airway pathology, which included grade I subglottic stenosis and tracheomalacia with suprastomal collapse. Of note, the patient did have an episode of stridor during her capped observation trial, which resolved with repositioning. This event may have been an early sign of impending decannulation failure and perhaps should have prompted an extended capped observation period; however, since the episode of stridor was brief, the decision was made to proceed with decannulation. After a second failed decannulation attempt, the patient underwent laryngotraceoectomy and was successfully decannulated.

The limitations to our study include those inherent to a study from a single-institution review. Case details are extracted from the EMR, and at times, key details were missing from the record. Because we had a relatively small number of patients, multivariate analysis was precluded, and we were not able to identify significant predictors of decannulation failure. One noteworthy point, however, is the high rate of persistent TCF (48%), which we do not consider a “complication” but rather an expected sequela of a long-term tracheostomy. While our rate of persistent TCF is higher than the 3% to 37% reported in other studies, we were not able to determine the reason.24-29 Our practice at the time of decannulation is to remove the tracheostomy tube and place a dressing over the tracheostomy tract, allowing the tract to heal by secondary intention. Practices vary among providers regarding whether an occlusive or nonocclusive dressing is used; however, details of the type of dressing could not be derived from the EMR. TCF is higher in the pediatric population due to children’s inability to self-occlude with phonation and coughing. Some authors have shown that primary closure achieves high rates of successful closure.30-33 However, concerns with primary closure include life-threatening complications, such as subcutaneous emphysema, pneumomediastinum, and difficulty replacing the tracheostomy in the event of an early
decannulation failure. Other factors associated with persistent TCF include age at cannulation and total duration of tracheostomy placement.

In summary, we have presented a series of patients who underwent decannulation following a published protocol. Our overall rate of decannulation failure was 15%, which is consistent with rates reported in other studies. We believe that our protocol minimizes resource utilization in its use of pulse oximetry over polysomnography. We also think that our protocol maximizes patient safety and success by allowing for capping trials in very young and small pediatric patients aged ≤5 years. It is clear from published reports that decannulation protocols can be tailored to the practices and needs of different institutions with comparable rates of successful decannulation.

Author Contributions


Disclosures

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