Original Investigation

Inpatient Observation for Elective Decannulation of Pediatric Patients With Tracheostomy

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IMPORTANCE The incidence and timing patterns of decannulation failure in children are unknown. There is substantial variability in the duration of inpatient hospitalization for patients undergoing decannulation, which represents an opportunity for improved resource use.

OBJECTIVE To determine the incidence and timing patterns of elective decannulation failure in the pediatric population and to determine an appropriate interval of inpatient observation following decannulation that optimizes both patient safety and resource use.

DESIGN, SETTING, AND PARTICIPANTS Retrospective review of medical records of consecutive patients 18 years or younger hospitalized for elective, inpatient decannulation between January 1, 2012, and October 31, 2013, at a quaternary care pediatric hospital.

MAIN OUTCOMES AND MEASURES Duration of decannulation hospitalization, failure of elective decannulation (decision not to decannulate or reinsertion of tracheostomy tube after decannulation), time interval from decannulation to failure.

RESULTS Forty-six patients completed 50 elective decannulation hospitalizations during the study period. The median duration of hospitalization for decannulation was 3.0 days. The hospitalization-specific failure rate was 16% (8 of 50), and the overall failure rate was 9% (4 of 46). Four patients were not able to tolerate capping of the tracheostomy tube and were discharged with their original tracheostomy tubes in place. Three of these patients were decannulated at a later hospitalization. In 4 patients, decannulation failed and they had to have their tracheostomy tubes replaced prior to discharge. Patients who did not tolerate decannulation were younger (mean [SD] age, 45.7 [17.0] months) than patients whose decannulation was successful (68.2 [48.0] months). All patients with unsuccessful decannulation attempts were symptomatic during capping. The longest interval from decannulation to tracheostomy reinsertion was 11 hours.

CONCLUSIONS AND RELEVANCE Elective decannulation failure occurred in 9% of this population and may be more common in younger patients and those with a diagnosis of vocal fold paralysis. Patients who are symptomatic during predecannulation capping are at high risk for decannulation failure. Inpatient observation for a 24-hour asymptomatic interval after decannulation may be sufficient because late failures were not observed in this sample.

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Mortality attributable to pediatric tracheostomy status ranges from 0.5% to 5%, with recent European and American reviews citing mortality rates of 3.2% and 3.6%, respectively.[1-3] Decannulation as soon as patients' underlying conditions permit is therefore advisable. Children with tracheostomy tubes may become candidates for decannulation through resolution of the underlying airway abnormality, natural expansion of the cross-sectional area of the airway with growth, or through surgical procedures designed to open narrowed airways. Because children may not be able to effectively communicate their respiratory status to caregivers, they are typically observed in the hospital for a period before and after planned decannulation. The incidence and timing patterns of decannulation failure (reinsertion of tracheostomy tube after planned removal) are unknown. Clinical predictors of successful decannulation also have not been defined. This leads to substantial variability in the duration of inpatient hospitalization for patients undergoing decannulation and represents an opportunity for improved use of resources.

The objectives of this study were to determine the incidence and timing patterns of elective decannulation failure in the pediatric population and to determine an appropriate interval of inpatient observation following decannulation that optimizes both patient safety and resource use.

Methods

Sample Selection

The institutional review board of the Children's Hospital of Philadelphia approved the study protocol and waived the requirement for informed consent due to the retrospective nature of the study. A retrospective review of consecutive patients undergoing elective decannulation was undertaken. The sample consisted of all patients 18 years or younger admitted to the Children's Hospital of Philadelphia for decannulation during the 2-year period encompassing 2012 through 2013. To ensure at least 2 months of follow-up, all hospitalizations were completed by October 31, 2013, and the last date of potential follow-up was December 31, 2013. Patients were identified from the records of the Center for Pediatric Airway Disorders, where a list of decannulation hospitalizations is maintained. This list was cross-checked with a database of intensive care hospitalizations under the primary *International Classification of Diseases, Ninth Revision, Clinical Modification* code "attention to tracheostomy" (V55.0). Age 18 years or younger, tracheostomy status, and hospitalization with intent for planned decannulation were the inclusion criteria. Exclusion criteria included age older than 18 years, patients decannulated during hospitalization for another primary diagnosis, decannulations during single-stage airway reconstruction, and patients whose records lacked appropriate documentation of the decannulation hospitalization.

All children at our institution must meet basic criteria prior to being scheduled for a decannulation hospitalization, including tolerating daytime capping of the tracheostomy tube, demonstrating ability to clear secretions, and lack of need for continuous ventilatory support. Patients undergo progressive daytime capping trials under parental supervision in the outpatient setting while under the management of our airway clinic. We do not allow capping during sleep in the outpatient setting. The tracheostomy tube may be downsized prior to initiating capping trials, or patients may simply be maintained with a smaller-than-age-appropriate tube (rather than upsized) if it appears that they are progressing toward decannulation.

Data Collection

Electronic medical records were reviewed for demographic information, medical history, details of the decannulation hospitalization, and details of long-term airway management. Date of birth, primary diagnosis leading to tracheostomy, tracheostomy placement date, and dates of admission and discharge surrounding decannulation were considered required data points. More than 1 primary diagnosis could be selected. In cases when the exact date of tracheostomy placement was unknown, the first day of the placement month was assigned. Intensive care nursing reports were reviewed to assess for use of respiratory support during the decannulation hospitalization.

For the purposes of the study, procedures categorized as "open airway surgery" included open laryngotracheal reconstruction, cricotracheal resection, tracheal resection, and slide tracheoplasty. The category "endoscopic airway surgery" included all airway interventions that were performed through the mouth or tracheostoma without a cervical skin incision. Procedures consisting of diagnostic laryngoscopy and/or bronchoscopy alone, in which no intervention was performed, were *not* categorized. Each patient had an operative airway evaluation (at minimum, diagnostic laryngoscopy and bronchoscopy) during the 30 days preceding admission for decannulation. Polysomnography (PSG) with the tracheostomy tube capped and predecannulation tonsillectomy and/or adenoidectomy were performed at the discretion of each patient's primary airway surgeon and were recorded.

The decannulation hospitalization included all consecutive hospital days (and associated procedures) surrounding attempted decannulation. Patients were admitted either directly from home, from the sleep laboratory after capped sleep study, or from the operating room after a minor procedure such as direct laryngoscopy and bronchoscopy with or without simple stoma revision (suture fixation of suprastomal area). The date of last follow-up was considered to be any patient contact prior to December 31, 2013 (office visit, telephone call, or telephone message), during which tracheostomy status could be determined.

Data Analysis

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at the Children's Hospital of Philadelphia.[4] Deidentified data were exported to Microsoft Excel (Microsoft) for analysis. The small number of decannulation failures did not support statistical analysis, and therefore descriptive statistics are presented. Mean and median values are presented for variables with outlying data points.

Table 1. Study Population and Demographic Characteristics

Characteristic	Decannulation Hospitalizations		
	All (N = 50)	Successful (n = 42)	Unsuccessful (n = 8)
Sex, No.			
Male	29	25	4
Female	21	17	4
Gestational age, wk			
Mean (SD)	33.2 (6.5)	33.0 (6.6)	28.6 (6.4)
Median (range)	36.0 (23-40)	36.0 (23-40)	36.5 (23-40)
Birth weight, kg			
Mean (SD)	1.75 (1.2)	1.77 (1.2)	1.66 (0.9)
Median (range)	1.41 (0.5-4.0)	1.22 (0.5-4.0)	1.75 (0.6-2.6)
Age at tracheostomy placement, median (range), mo	4.9 (0.4-199.2)	5.0 (0.4-199.2)	3.6 (1.6-24.5)
Diagnosis leading to tracheostomy, No. (%)			
Subglottic stenosis	12 (24)	11 (26)	1 (12)
Vocal fold paralysis[a]	10 (20)	5 (13)	5 (62)
Tracheomalacia[a]	12 (24)	8 (19)	4 (50)
Craniofacial	6 (12)	6 (14)	0
Lung disease and/or VDRF	27 (54)	23 (55)	4 (50)
Neuromuscular	2 (4)	1 (2)	1 (12)
Other	13 (26)	10 (24)	3 (38)
Comorbid conditions, No. (%)			
None	4 (8)	2 (4)	1 (12)
Cardiac[a]	16 (32)	12 (29)	4 (50)
Pulmonary	27 (54)	23 (55)	4 (50)
Gastrointestinal	30 (60)	24 (57)	6 (75)
Neurologic	10 (20)	9 (21)	1 (12)
Other	7 (14)	7 (17)	0
Age at decannulation, mo[a]			
Median (range)	58.8 (10.8-214.8)	60.2 (10.9-214.6)	46.2 (18.2-69.5)
Mean (SD)	65.6 (45.5)	68.2 (48.0)	45.7 (17.0)

Abbreviation: VDRF, ventilator-dependent respiratory failure.

[a] Indicates wide variability between groups.

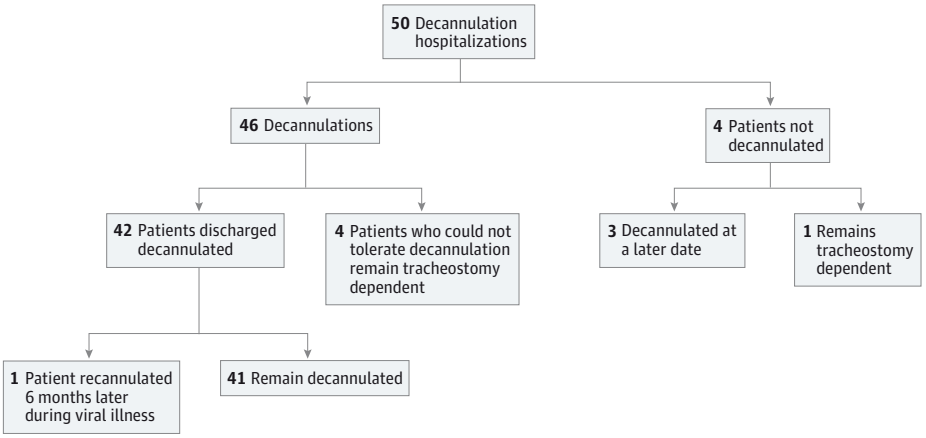
Results

Forty-six patients underwent 50 elective hospitalizations for decannulation during the study period. Demographic characteristics of the study sample, including primary and comorbid diagnoses, are presented in **Table 1**. A total of 8 decannulation hospitalizations were unsuccessful, yielding a hospitalization-specific failure rate of 16%. Four hospitalizations (8%) resulted in the patient being sent home with tracheostomy in situ due to difficulties during the overnight capping trial. Three of those patients returned for a later hospitalization during the study period and were successfully decannulated. Of the 46 patients who were decannulated, 42 (91%) remained successfully decannulated through hospital discharge. Results are summarized in **Figure 1**.

Four patients required reinsertion of their tracheostomy tubes, for a 9% decannulation failure rate. Symptoms precipitating decannulation failure included 1 patient with an immediate breath-holding spell, 2 patients with stridor and increased work of breathing in the first 2 hours after decannulation, and 1 patient with severe desaturation and hypoventilation approximately 11 hours after decannulation. No failures occurred during hours 12 through 48 of inpatient observation (**Figure 2**). Details on the 4 patients who did not tolerate decannulation can be found in **Table 2**. Need for adjunctive respiratory support after decannulation was uncommon: 6 patients required supplemental oxygen in the hospital, and 2 were discharged with home oxygen. Three patients were decannulated with immediate institution of planned nighttime continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) after consultation with the pulmonology service. No patient unexpectedly required CPAP or BiPAP after decannulation.

The majority of patients (n = 35 [70%]) underwent at least 1 endoscopic airway procedure, whereas only 26% of the study group (n = 13) underwent open airway reconstruction prior to decannulation. Open surgery was performed more frequently in the group that did not tolerate decannulation than in the group whose decannulation succeeded (62% vs 19%). A detailed description of the interventions performed prior to decannulation can be found in **Table 3**. Of the 4 patients for whom capping failed, 3 experienced failure as a result of capped PSG results (performed during the decannulation hospitalization). None of the 4 patients who had to be recannulated underwent a capped PSG prior to decannulation.

Figure 1. Flowchart of Decannulation Hospitalizations

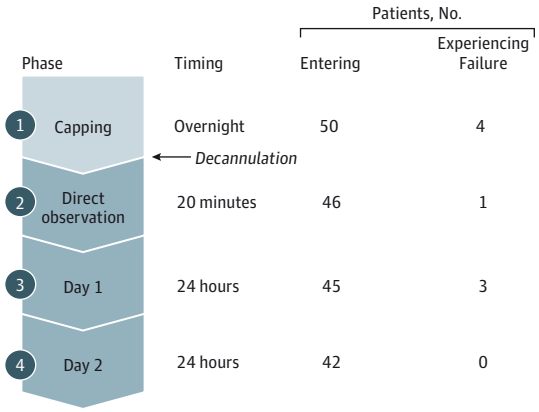


Flowchart showing final disposition of study patients. A total of 6 patients were still tracheostomy dependent at the conclusion of the study (4 who were unable to tolerate decannulation, 1 whose trial of capping of the tracheostomy tube failed, 1 who was recannulated during extended follow-up).

Mean and median follow-up duration were 24.6 and 15.36 weeks, respectively. Four patients did not have follow-up data available: 2 were international patients discharged back to their home countries, 1 had follow-up outside the study period, and 1 patient was lost to follow-up. One patient had a tracheostomy tube reinserted during the extended follow-up period, 6 months after decannulation, when he was hospitalized elsewhere for a respiratory infection.

The duration of hospitalization surrounding decannulation ranged from 1 to 8 days (mean, 2.78 days; median, 3.00 days). The single patient with an 8-day hospitalization underwent a sleep study after decannulation showing mild sleep apnea and returned to the operating room for adenoidectomy prior to discharge.

Figure 2. Study Protocol



Number of patients entering and experiencing failure of the study decannulation protocol at each stage.

Discussion

Reported decannulation failure rates in children range from 6.5% to 21.4% and are substantially higher than published failure rates in adults (1.9%-4.8%).[5-7] Overall, there were 8 unsuccessful hospitalizations for elective decannulation in our study, for a hospitalization-specific failure rate of 16% and overall failure rate of 9%, which are in accord with published data.

Although we were not able to identify statistically significant predictors of decannulation success or failure in this group, several interesting patterns did emerge. Patients who did not tolerate decannulation tended to be younger (median age, 46.2 vs 60.2 months) and had a different diagnosis profile than patients whose decannulation was successful (Table 1). Only 1 patient with an unsuccessful decannulation attempt had a primary diagnosis of subglottic stenosis, whereas the primary diagnosis of vocal fold paralysis was present in 5 of the 8 unsuccessful decannulation hospitalizations. Tracheomalacia was twice as common among patients who did not tolerate decannulation than among the general study population. Open surgery was performed more commonly in the group that did not tolerate decannulation, which is likely more indicative of underlying disease than any direct consequence of the surgical procedures. Of the 4 patients with unsuccessful decannulation attempts, 3 had a documented upper respiratory infection within 2 weeks of the decannulation hospitalization. Even though the patients had been "cleared" for decannulation with microlaryngoscopy and bronchoscopy, there may have been underlying airway reactivity or inflammation at play that contributed to failure.

It is often assumed that children can decannulate successfully despite not tolerating capping due to the relatively large obstruction caused by the capped tube in the airway. Whereas this may be true in selected patients, the recent clinical consensus statement on tracheostomy care published by the American Academy of Otolaryngology–Head and Neck Surgery Foundation recommends a capping trial for all patients older than 2 years.[7] Five patients in this sample were decannulated despite having symptoms (increased work of breathing, stridor, and/or coughing) with their tracheostomy tubes capped; 4 of those patients went on to experience a failed decannulation attempt and had their tracheostomy tubes reinserted. The single patient whose decannulation was successful despite symptomatic capping had a laryngoscopy and bronchoscopy with normal re-

Table 2. Patients Who Did Not Tolerate Decannulation

Patient No./ Sex/Age, y	Diagnoses	Symptoms	Likely Cause of Failure[a]
1/M/4	SGS, tracheomalacia, BPD, congenital heart disease, extreme premature birth (23 wk)	Increased work of breathing, coughing	Tested positive for rhinovirus during decannulation hospitalization
2/F/5	Tracheomalacia, BPD, extreme premature birth (25 wk)	Severe arterial oxygen desaturation 11 h after decannulation	Reduced vocal cord mobility seen on follow-up bronchoscopy, URI 2 wk prior to decannulation hospitalization
3/M/3	Mitochondrial disorder, hypotonia, seizures, vocal fold paralysis, premature birth (32 wk)	Stridor and increased work of breathing	URI 1 wk prior to decannulation hospitalization, failure of secretion management due to low tone and underlying neuromuscular disorder
4/F/5	Cyanotic congenital heart disease, vocal fold paralysis, reactive airway disease, premature birth (36 wk)	Immediate breath-holding with tachycardia and severe arterial oxygen desaturation	Poor cardiac reserve, breath-holding response to tracheostomy removal

Abbreviations: BPD, bronchopulmonary dysplasia; SGS, subglottic stenosis; URI, upper respiratory infection.

[a] Proposed causes are based on available information.

Table 3. Interventions Prior to Decannulation[a]

Intervention	Decannulation Hospitalizations, No. (%)		
	All (N = 50)	Successful (n = 42)	Unsuccessful (n = 8)
Open airway reconstruction	13 (26)	8 (19)	5 (62)
Anterior graft	1 (2)	1 (2)	0
Posterior graft	1 (2)	1 (2)	0
Anterior and posterior grafts	8 (16)	4 (10)	4 (50)
Resection	1 (2)	1 (2)	0
Cricotracheal resection	1 (2)	1 (2)	0
Multiple open procedures	4 (8)	3 (7)	1 (12)
Endoscopic surgery	35 (70)	27 (64)	8 (100)
Multiple endoscopic procedures	15 (30)	11 (26)	4 (50)
Tonsillectomy and adenoidectomy	22 (44)	19 (45)	3 (38)
Capped polysomnogram	21 (42)	18 (43)	3 (38)

[a] All patients tolerated continuous daytime capping of the tracheostomy tube prior to decannulation hospitalization. Other interventions are described.

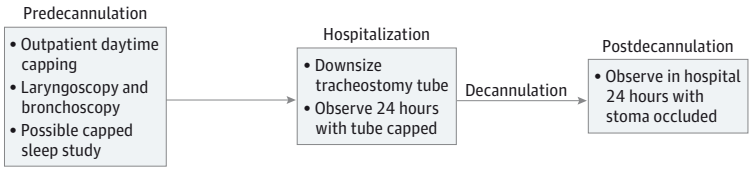
sults, as well as a capped sleep study with normal results during the decannulation hospitalization. Similar findings were noted by Waddell et al[8] in their 1997 review, in which decannulations were 2 to 4 times more likely to fail in children exhibiting restlessness, anxiety, or intercostal retractions than in those without symptoms. Our data support the use of capping trials and suggest the need for caution when decannulating patients who are symptomatic with their tracheostomy tubes capped.

Results of PSG with the tracheostomy tube capped provide a more objective data point for assessing patient readiness for decannulation. Forty-two percent of our study participants completed a capped PSG, and 6 of those 21 patients (29%) had a clear change in management on the basis of the results. In 3 patients, results allowed for institution of planned CPAP or BiPAP therapy (via a nasal or oronasal interface) prior to decannulation. Capping was deemed to have failed in 3 other patients on the basis of their PSG results, despite few or no overt symptoms. None of the 4 patients who did not tolerate decannulation had been evaluated with a capped PSG. Polysomnography is a low-morbidity but resource-intensive evaluation, so the utility of testing should be determined on a case-by-case basis, but the examination can provide valuable information about medically complex decannulation candidates.

All of the failures observed in this study group occurred during the first 12 hours of postdecannulation observation. No patient exhibited new signs or symptoms on the second day of observation, suggesting that extended observation may not be necessary. One patient had his tracheostomy tube reinserted 6 months later during a hospitalization for respiratory syncytial virus and metapneumovirus infection and is currently scheduled for decannulation. There were no other recannulations during the follow-up period.

Several protocols for elective decannulation hospitalizations are reported in the literature, and all involve downsizing the tracheostomy tube, a variable period of capping or occluding the lumen of the tube, decannulation, and a variable period of inpatient observation after decannulation. The duration of hospitalization with published protocols ranges from 3 to 10 days or more, depending on how patients progress.[7,9-11] Our protocol throughout the study period included inpatient, overnight capping; decannulation followed by a 20-minute period of direct observation; and inpatient observation for a 48-hour interval after decannulation. All patients admitted for elective decannulation are monitored in the pediatric intensive care unit (PICU), and the data presented here suggest that the observation interval can be shortened, thereby allowing valuable PICU space to be allocated to other, sicker patients. Our amended protocol is summarized in **Figure 3.**

Figure 3. Amended Protocol



Amended decannulation protocol based on presented data, showing shortened inpatient observation interval.

Our study is limited by its retrospective design and sample size. Because our data were collected retrospectively, we have limited information on decision-making parameters for the children who were not decannulated during their hospitalization. Patients who did not tolerate decannulation generally had detailed information about the peridecannulation period available in the medical record. The study interval was limited to a consecutive 2-year interval to ensure homogeneity in PICU care documentation and to ensure that our population was a truly comprehensive consecutive sample. A larger sample size might allow for better statistical characterization of the group of patients for whom decannulation fails because it is a relatively uncommon occurrence.

Conclusions

Failure of elective decannulation occurred in 9% of this population and may be more common in younger patients and patients with a diagnosis of vocal fold paralysis or tracheomalacia. Patients who are symptomatic during predecannulation capping are at elevated risk for decannulation failure, and the decision to proceed should be made with caution. Capped PSG should be considered prior to decannulation. Failure after decannulation occurs early; inpatient observation for a 24-hour asymptomatic interval after decannulation may be sufficient because late failures were not observed in this sample.

ARTICLE INFORMATION

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Author Contributions: Both authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Both authors.
Acquisition, analysis, or interpretation of data: Both authors.
Drafting of the manuscript: Prickett.
Critical revision of the manuscript for important intellectual content: Both authors.
Statistical analysis: Prickett.
Study supervision: Sobol.

Conflict of Interest Disclosures: None reported.

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Additional Contributions: Olivia Bernal, BA, Divison of Pediatric Otolaryngology, Children's Hospital of Philadelphia, provided assistance with data acquisition and management. She did not receive special compensation beyond her salary for her participation in this project.

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