Tracheostomy Complications in Institutionalized Children with Long-term Tracheostomy and Ventilator Dependence

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Abstract

Objectives. (1) To identify tracheostomy complications in institutionalized children with chronic tracheostomy. (2) To determine factors that predispose to development of tracheostomy complications in institutionalized children with chronic tracheostomy.

Study Design. Case series with chart review over 10 years.

Setting. Tertiary children’s hospital.

Subjects and Methods. Children were included if they underwent tracheostomy before 21 years of age and resided at a pediatric nursing facility. Most children were ventilator dependent and had severe comorbid medical conditions, including developmental delay and cerebral palsy. The number of tracheostomy complications and unplanned hospital admissions were recorded. Interventions for tracheostomy complications were also reviewed.

Results. Thirty-two institutionalized children with chronic tracheostomy were included. The mean age at time of tracheostomy was 5.4 years, with a mean duration of institutionalization of 9.1 years. Twenty-seven children (84%) experienced tracheostomy complications. The total number of complications was 79. The most common tracheostomy complications identified were peristomal granulation (n = 13) and suprastomal granulation (n = 12). Age at time of tracheostomy, duration of institutionalization, and ventilator dependence did not predict the likelihood of developing a complication. Of 32 patients, 20 were evaluated in the emergency room during the study, and there were 48 unplanned admissions for tracheostomy-related complications during the study. Forty-five urgent direct laryngoscopy and bronchoscopy procedures were performed in a total of 20 children with tracheostomy complications.

Conclusions. Tracheostomy complications are common in institutionalized children with chronic tracheostomy and are challenging to manage. Further research is necessary to determine novel ways to reduce tracheostomy complications in this population.

Keywords
pediatric, tracheostomy, airway, complications, prevention, management, quality improvement

Received September 18, 2015; revised December 23, 2015; accepted January 4, 2016.

As compared with adult tracheostomy, pediatric tracheostomy is associated with significantly increased morbidity and mortality.1,2 Complication rates of pediatric tracheostomies as high as 77% have been reported.8 Pediatric tracheostomy complications are often divided into early and late complications. Early complications are those that occur within the first 7 days after the procedure. Examples include accidental decannulation, mucus plugging, pneumothorax/pneumomediastinum, and subcutaneous emphysema. Late complications of pediatric tracheostomy include peristomal/suprastomal granulation, tracheal stenosis, tracheomalacia, infection, stomal breakdown, tracheocutaneous fistula, and death. Mortality rates in children with tracheostomies have been reported as high as 42%.2 However, the majority of these deaths were likely related to comorbid medical conditions, such as congenital heart disease. Recent literature that has focused on tracheostomy-specific deaths describes a much lower mortality rate of 0.05% to 3.6%.2,6,9-11 The most commonly identified causes of tracheostomy-related death are accidental decannulation and obstruction of the tracheostomy tube.2,6 Young age, low birth weight, and a history of heart disease or central nervous system disease increase the likelihood of mortality in children with tracheostomy.2

The majority of literature regarding pediatric tracheostomy has focused on indications and complications. There is a paucity of literature regarding the evaluation and management of
children with long-term tracheostomy. Furthermore, studies have failed to address strategies to prevent late complications in these patients. A consensus statement from the American Thoracic Society (ATS) on the care of children with chronic tracheostomies recommends airway evaluation with either rigid or flexible bronchoscopy every 6 to 12 months. Such evaluation allows for the identification of airway pathology and complications, ensures the appropriate tracheostomy tube size and position, and determines readiness for decannulation. However, a recent survey of members of the American Society of Pediatric Otolaryngologists found that only 59% of respondents routinely perform annual surveillance endoscopy in chronic tracheostomy patients. Forty-one percent of providers reported that they performed airway endoscopy only prior to decannulation or if the patient is experiencing difficulties related to the tracheostomy. Thus, there is great variability in how children with chronic tracheostomy are managed.

Many children with tracheostomy have significant comorbid medical conditions, such as neurologic impairment and cerebral palsy, which make their management challenging. These children are often poor candidates for decannulation and thus are at risk for prolonged tracheostomy and ventilator dependence. We sought to describe our experience in the care of institutionalized children with long-term tracheostomy dependence and severe comorbid medical conditions. The primary objective of this study was to identify tracheostomy-related complications in institutionalized patients with chronic tracheostomy. We also sought to describe interventions commonly employed to treat tracheostomy-related complications. With advances in medical care, severely disabled children with tracheostomy are surviving longer. We propose strategies to minimize complications and optimize airway management in these children.

Methods

This study was approved by the Institutional Review Board of Eastern Virginia Medical School and the Hospital Research Coordination Committee of the Children’s Hospital of The King’s Daughters. A retrospective chart review was conducted at this tertiary children’s hospital between December 2004 and December 2014. Children were eligible for inclusion in the study if they underwent tracheostomy before 21 years of age and resided at a pediatric skilled nursing facility. There are currently 2 institutions in our geographic area that provide residential care for tracheostomy- and ventilator-dependent children. Children were excluded if they were tracheostomy and ventilator dependent but living at home with caregivers.

Subjects were identified by searching patient lists from the institutions. Paper and electronic records from both the institutions and the children’s hospital were reviewed for tracheostomy-related emergency room visits, procedures, and admissions. Tracheostomy-related findings or events were considered complications if they required a medical or surgical intervention. For analysis, tracheostomy-related complications were classified as follows: accidental decannulation, trachea or stoma bleeding, tracheitis, stoma migration, peristomal granulation, suprastomal granulation, distal trachea granulation, or “other.” Examples of tracheal complications that were classified as “other” included stoma dehiscence, tracheostoma false passage, and stoma cellulitis. Unplanned admissions were defined as admissions from the emergency room or directly from the nursing facility for acute tracheostomy-related complications. Planned admissions, such as those following surveillance endoscopy, were not included. Patient demographic data were also recorded, including the presence of comorbid medical conditions and the duration of tracheostomy dependence and institutionalization. Direct laryngoscopy and bronchoscopy (DLB) indications and findings were reviewed. DLBs were considered urgent if they were performed for an indication other than airway surveillance.

Descriptive statistics were reported for all studied variables. Proportions were calculated for categorical variables, whereas mean and standard deviation were calculated for continuous variables. Logistic regression was performed to assess for factors associated with the risk of a child having a complication. Statistical significance was set a priori at an alpha of 0.05 (2-tailed). All analyses were performed in SAS 9.4 (SAS Institute, Cary, North Carolina).

Results

A total of 32 institutionalized tracheostomy-dependent children were identified and included in the analysis. There were 17 boys (53.1%) and 15 girls (46.9%) with a mean age of 16.3 years (range, 6-27 years; SD, 6.1 years) at the time of analysis. Eight children were deceased at the time of data collection. The mean age at time of tracheostomy was 5.4 years (range, 2 months to 20 years; SD, 5.9 years) with a mean duration of institutionalization of 9.1 years (range, 1-27 years; SD, 5.4 years). The most common indication for tracheostomy placement was respiratory failure with ventilator dependence. Twenty-four children (75%) were ventilator dependent, and all of the children were gastrostomy tube dependent. All of the children included in the study had severe comorbid medical conditions, including significant developmental delay. Cerebral palsy and seizure disorder were also common.

The majority of children (84%) experienced at least 1 tracheostomy-related complication during the study period. There were only 5 children identified that did not have any tracheostomy complications. The majority of children experienced multiple different tracheostomy-related complications. Of the 32 patients, the total number of complications was 79.

The most common tracheostomy complications identified were peristomal granulation (n = 13) and suprastomal granulation (n = 12). Other common complications were distal tracheal granulation, tracheitis, and accidental decannulation. A summary of tracheostomy complications is shown in Table 1. Less common complications (as denoted by “other” in Table 1) include stoma dehiscence, stomal false passage, and peristomal cellulitis. Age at the time of...
1.54, P = .39), age at the time of tracheostomy (OR = 0.94, 95% CI: 0.65-1.54, P = .76), duration of institutionalization (OR = 1.01, 95% CI: 0.65-1.54, P = .98), and ventilator dependence (OR = 4.99, 95% CI: 0.20-124, P = .33) did not affect the likelihood of developing a complication. The presence of peristomal granulation (OR = 1.24, 95% CI: 0.26-5.92, P = .78) or suprastomal granulation (OR = 2.86, 95% CI: 0.59-13.96, P = .19) was not associated with the development of distal granulation tissue.

There were a total of 62 visits to the emergency room for tracheostomy-related problems during the study. Of the 32 patients, 20 (62%) were evaluated in the emergency room during the study period. A common indication for emergency room visit was accidental decannulation with difficulty replacing tracheostomy tube. There were 48 unplanned admissions for tracheostomy-related complications during the study. Eighteen subjects (56%) were admitted as part of routine surveillance endoscopy. Twelve children (38%) required intervention during a surveillance bronchoscopy. Surveillance DLB findings that required further intervention included suprastomal granuloma (n = 6), subglottic stenosis (n = 2), peristomal granulation (n = 2), and tracheomalacia (n = 2). Balloon dilation was performed to address subglottic stenosis in one patient being considered for decannulation and for another patient to ensure a patent airway should accidental tracheostomy tube dislodgement or plugging occur. Longer tracheostomy tubes were utilized to bypass significant tracheomalacia in 2 patients to determine if positive pressure ventilation might be weaned.

A total of 110 DLBs were performed during the study period. The most common indication for DLB was surveillance; 65 DLBs (59%) were performed as part of routine surveillance endoscopy. Twelve children (38%) required intervention during a surveillance bronchoscopy. Surveillance DLB findings that required further intervention included suprastomal granuloma (n = 6), subglottic stenosis (n = 2), peristomal granulation (n = 2), and tracheomalacia (n = 2). Balloon dilation was performed to address subglottic stenosis in one patient being considered for decannulation and for another patient to ensure a patent airway should accidental tracheostomy tube dislodgement or plugging occur. Longer tracheostomy tubes were utilized to bypass significant tracheomalacia in 2 patients to determine if positive pressure ventilation might be weaned. Forty-five urgent DLBs were performed in a total of 20 children. The most common indications for urgent DLB were difficulty replacing/changing the tracheostomy tube (n = 8), difficulty with ventilation (n = 8), and granulation tissue (n = 8). Examples of interventions performed during urgent DLBs included excision of distal tracheal granulation tissue with either cold instrumentation or laser, stoma revisions, or utilization of custom-length tracheostomy tubes to bypass tracheal granulation.

Children with tracheal complications frequently required surgical intervention with urgent DLB. Suprastomal and distal granulation were most frequently treated surgically, while peristomal granulation, tracheitis, and stomal migration were managed medically. Suprastomal granulomas were typically excised with either a rongeur or microdebrider through the stoma or by foreign body forceps introduced through a rigid bronchoscope. Distal granulation tissue was treated with the use of the OmniGuide CO2 laser through the rigid bronchoscope. Topical and systemic steroids and custom-length tracheostomy tubes were also used to manage these patients. The majority of cases of peristomal granulation were successfully treated with meticulous stoma care with neomycin/polymyxinB/dexamethasone ophthalmic ointment and hydrocolloid wound dressing (DuoDERM). Stomal migration was managed with ventilator rotation and utilization of abdominal binders to secure ventilator tubing in the midline. In rare cases of medical management failure, stomoplasty was performed for peristomal granulation or stomal migration. Tracheitis was treated with culture-directed antibiotic therapy.

As mentioned above, 8 patients died during the study period for an overall mortality rate of 25%. Two of these deaths were related to chronic tracheostomy, making the tracheostomy-related mortality 6.25%. One child had significant distal tracheal granulation tissue that persisted despite multiple airway procedures. His family elected to withdraw care. The second child died after providers were unable to ventilate her following an accidental decannulation. Three patients (9.38%) were successfully decannulated during the study period, with 1 having had a successful laryngotracheal reconstruction allowing for decannulation. The other 2 children who were decannulated had improvement in their respiratory status that allowed them to be weaned from the ventilator.

**Discussion**

In recent years, the indications for pediatric tracheostomy have changed from infectious and inflammatory processes to prematurity, subglottic stenosis, and neuromuscular disease. Recent series have also demonstrated an increase in the duration of tracheostomy and a decreased decannulation rate. Thus, providers are now frequently being challenged to care for children with long-term tracheostomy dependence. Protocols detailing the management of such patients are lacking. In fact, the ATS noted that there has been “disappointingly little research” in children with chronic tracheostomy.

Early tracheostomy complications have been extensively described, while less literature exists regarding long-term complications of tracheostomy in children. Kremer et al reviewed complications from a series of 25 children <6 years of age who underwent tracheostomy for the indication of prematurity. They reported a late complication rate of 56%, with the majority of complications identified as

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<th>Complication</th>
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<td>Accidental decannulation</td>
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<td>Bleeding</td>
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<td>Tracheitis</td>
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<td>Stomal migration</td>
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<td>Other complication</td>
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granulomas. Tracheal stenosis was the second-most common complication, occurring in 12% cases. Tracheomalacia and tracheal polyps were rare but reported.\textsuperscript{2} The authors did not, however, discuss how the identified complications were managed.

A recent study aimed to identify common indications for hospitalization in children with tracheostomy. The majority of subjects in this analysis had multiple chronic medical conditions, similar to our subject population. There was no mention of how many of these children were cared for at home versus skilled nursing facilities. Ambulatory care–sensitive conditions (including pneumonia and dehydration) and tracheotomy-related complications (including bleeding and tracheoesophageal fistula) were the most common reasons for hospitalization. Costs for hospitalization among children with tracheostomy totaled $360 million. The authors concluded that future research is needed to investigate how to optimize the long-term care of children with tracheostomy.\textsuperscript{17}

For prevention of early complications associated with skin breakdown following tracheostomy, Lippert and colleagues developed a protocol of using foam tracheostomy collars and drain sponges and performing the first tracheostomy change on postoperative day 3.\textsuperscript{18} Thus, early complication rates can likely be reduced by meticulous postoperative care. However, the majority of studies have failed to address the management of late complications in children with chronic tracheostomy. Such complications can be very challenging to treat.

The ATS recently published a consensus statement for the care of the child with chronic tracheostomy. This was a multidisciplinary effort, but the authors noted that the majority of recommendations were made in the absence of scientific data due to the lack of research in this area. The consensus statement discusses the importance of selecting an appropriate-size tracheostomy tube and utilizing the pre-measure suction technique.\textsuperscript{12} However, the authors did not offer definitive recommendations regarding management of complications. Similarly, the clinical consensus statement published by the American Academy of Otolaryngology—Head and Neck Surgery Foundation noted that the majority of literature regarding management of tracheostomy was of low quality and limited to small case series and expert opinions. The authors did identify 13 key action statements, many of which focused on patient and caregiver education, regarding tracheostomy management in adults and children. However, they were unable to reach a consensus on topics such as frequency of tracheostomy tube change and surveillance DLB. Specific recommendations for complication prevention and management in children with chronic tracheostomy were not detailed.\textsuperscript{19}

In our study, we noted that late tracheostomy complications were common in a group of institutionalized children with chronic tracheostomy dependence. Peristomal granulation and suprastomal granulomas were the most common complications noted. Granulomas are believed to evolve from granulation tissue. Friction from the tracheostomy tube at the stoma site and at the distal portion of trachea likely contributes to the formation of airway granulation tissue. Foreign body reaction to the tracheostomy tube may also contribute. Suction trauma and infection may lead to airway mucosal injury and necrosis with subsequent granulation tissue formation. Various surgical and medical interventions were utilized during the study to treat airway granulation. The majority of cases of peristomal granulation were successfully treated with meticulous stoma care with neomycin/polymyxinB/dexamethasone ophthalmic ointment and hydrocolloid wound dressing (DuoDERM), cautery, and/or stomal revision. Suprastomal granuloma was managed with excision via cold instrumentation (eg, rongeur or micro-debrider) through the stoma or by foreign body forceps introduced through a rigid bronchoscope. Distal airway granulation tissue was one of the most challenging complications to treat in this population. Medical management with topical and systemic steroids and custom-length tracheostomy tubes and surgical management with utilization of the OmniGuide CO\textsubscript{2} laser through the rigid bronchoscope allowed for successful treatment in the majority of patients. However, recurrence was common.

The complication rate in our study was higher than rates previously reported in other series of patients with chronic tracheostomy. It is surprising that institutionalized children with access to skilled nursing care 24 hours a day had such a high complication rate. A possible explanation for this finding is the severe associated comorbid medical conditions that were common in our subjects. Most patients in this study were ventilator dependent and confined to a bed or gurney. Many of these children were also tracheostomy dependent for a prolonged period. Similarly, Giancoli et al described a direct relationship between length of tracheostomy and airway complications. The complication rate rose from 11% in children who had a tracheostomy for <100 days to >80% in those that had a tracheostomy >500 days.\textsuperscript{20}

Tom et al published a prospective study of 32 children who underwent surveillance airway endoscopy every 6 months for at least 18 months following tracheostomy. The rate of children that developed airway lesions such as granulomas was high (>44%), prompting the authors to recommend surveillance endoscopy every 6 months in children with chronic tracheostomy.\textsuperscript{21} Similarly, 38% of children undergoing surveillance DLBs in our study had an airway finding that necessitated intervention. In another recent study of children with chronic tracheostomy undergoing surveillance DLB, over half (58%) of procedures resulted in further airway interventions. Such interventions included debridement of granulation tissue, tracheostomy tube exchange, and subglottic dilation. Interestingly, the presence of airway symptomatology preoperatively did not predict the need for intervention in this study. The authors concluded that surveillance DLB in pediatric tracheostomy patients is warranted. They also highlighted the need for the development of clinical practice guidelines to aid in the management of such patients.\textsuperscript{22} Controversy exists
regarding the optimal timing of surveillance endoscopy. Future studies need to assess factors such as comorbid medical conditions, anesthetic risk, and economic impact when making this determination.

After reviewing this series of severely disabled children with chronic tracheostomy dependence, we propose the following management strategies to address airway complications commonly identified in this population. Consider performing surveillance endoscopy every 1 to 2 years to rule out the development of airway pathology and to ensure adequate tracheostomy tube size. Children with ventilator dependence may benefit from having the ventilator side alternated every 2 to 4 weeks to prevent stomal breakdown. Other suggested techniques for preventing tracheal stoma breakdown included the placement of DuoDERM or a similar type of dressing at the stoma site and the use of abdominal binder to stabilize ventilator tubing. Granulation tissue at the stoma site and in the distal trachea can be managed operatively with the microdebrider and carbon dioxide laser, respectively. Custom-length tracheostomy tubes are also useful in the management of distal tracheal granulation.

After identifying the frequency of tracheostomy complications, we—in conjunction with respiratory therapists and nurses at the institutions—implemented a standardized tracheostomy management protocol. Our goal was to improve the quality of care and decrease complication rates in this population of institutionalized children. The protocol, which is detailed below, included frequent clinical assessment with fiberoptic tracheoscopy as well as surveillance DLB and ventilator rotation. All children are evaluated by a pediatric otolaryngologist at the institution every 3 to 6 months. The lead respiratory therapist or nurse attends all the evaluations to relay any problems with ventilation, tracheostomy tube changes, or other issues. A flexible tracheoscopy through the tracheal stoma is performed at each evaluation. All children undergo surveillance DLB every 1 to 2 years. Ventilator rotation from the right to the left side of the bed occurs every 2 to 3 weeks. Tracheostomy tube changes are performed at least monthly, and DuoDERM is placed around the tracheostomy stoma and replaced as needed. Future research is needed to determine whether such standardized tracheostomy management protocols improve outcomes in children with chronic tracheostomy dependence.

To our knowledge, this is the first work to describe the complications and interventions related to chronic tracheostomy in a group of severely disabled institutionalized children. Limitations of our review include its retrospective nature and the small sample size. In addition, we did not collect data regarding the type of tracheostomy performed. Prior research has suggested that the type of tracheal incision made during initial tracheostomy tube placement may influence the tracheostomy complication rate. Suprastomal collapse and tracheal stenosis were more common in children who had a tracheal H-shaped incision or a tracheal cartilage (Bjork) flap, as compared with those who had a vertical tracheal incision. This factor should be addressed in future reviews. Ideally, multi-institutional prospective trials focused on the management of children with chronic tracheostomy dependence will allow for the development of new evidence-based treatment protocols.

**Conclusion**

Tracheostomy complications are common in institutionalized children with chronic tracheostomy. Tracheostomy complications in this population of children frequently require surgical intervention and are challenging to treat. Further research is necessary to determine novel ways to reduce tracheostomy complications in this population of children.

**Author Contributions**

Lyndy J. Wilcox, study conception and design, literature review, data interpretation, drafting and revision of manuscript, presentation of study; Brittany C. Weber, data acquisition, data interpretation, drafting of manuscript; Tina D. Cunningham, data analysis, data interpretation, drafting and revision of manuscript; Cristina M. Baldassari, study conception and design, literature review, data interpretation, drafting and revision of manuscript.

**Disclosures**

**Competing interests:** None.

**Funding interests:** None.

**Sponsorships:** None.

**Funding source:** None.

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