Importance

Pediatric tracheotomy is a complex procedure with significant postoperative complications. Wound-related complications are increasingly reported and can have considerable impact on clinical course and health care costs to tracheotomy-dependent children.

Objective

The primary objective of this study was to identify the type and rate of complications arising from pediatric tracheotomy.

Design, Setting, and Participants

A retrospective review of medical records of 302 children who underwent tracheotomy between December 1, 2000, and February 28, 2014, at a tertiary care pediatric referral center. Records were reviewed for preoperative diagnoses, gestational age, age at tracheotomy, tracheotomy technique, and incidence of complication.

Main Outcomes and Measures

Main outcome measures included incidence, type, and timing of complications. Secondary measures included medical diagnoses and surgical technique.

Results

Of the 302 children who underwent tracheotomy, the median (SD) age at time of tracheotomy was 5 months (64 months) and the range was birth to 21 years. The most frequent diagnosis associated with performance of a tracheotomy was ventilator-associated respiratory failure (61.9%), followed by airway anomaly or underdevelopment (25.2%), such as subglottic or tracheal stenosis, laryngotracheomalacia, or bronchopulmonary dysplasia. The remaining indications for tracheotomy included airway obstruction (11.6% [35 of 302]) and vocal fold dysfunction (1.3% [4 of 302]). No statistical significance was found associated with diagnosis and incidence of complications. Sixty children (19.9%) had a tracheotomy-related complication. Major complications, such as accidental decannulation (1.0% [3 of 302]). There were no deaths associated with tracheotomy. Minor complications, such as peristomal wound breakdown or granuloma (12.9% [39 of 302]) and bleeding from stoma (1.7% [5 of 302]), were more common. Of all complications, 70% (42 of 60) occurred early (<7 days postoperatively) and 20% (12 of 60) were late (>7 days postoperatively).

Conclusions and Relevance

Pediatric tracheotomy at our institution is associated with an overall 19.9% incidence of complications. Although the rate of major complications such as accidental decannulation or death is low, rates of peristomal skin breakdown and development of granuloma are more frequently reported and can occur at any point following tracheotomy. Further work is necessary to understand and mitigate wound care issues in post-tracheotomy care.
Tracheotomy has been performed for centuries, with the earliest reported surgical airway done in 100 BC by Asclepiades. Not until the 20th century, however, with the onslaught of a devastating diphtheria epidemic, did the practice expand to the pediatric population. Until the past 40 years, the primary indication for pediatric tracheotomy was upper airway obstruction secondary to acute infections. With the introduction of vaccines against microorganisms responsible for these infections—such as Haemophilus influenzae, Streptococcus pneumoniae, and Corynebacterium diphtheria—and increased use of endotracheal intubation, rates of upper airway obstruction requiring surgical management have decreased. Today, indications for pediatric tracheotomy primarily include chronic respiratory failure with ventilator dependence, neurologic impairment, congenital airway anomalies, craniofacial anomalies, trauma, and vocal fold dysfunction. Up to 80% of children undergoing tracheotomy have chronic comorbidities that can make placement of a tracheotomy and postoperative care challenging. These children frequently require their tracheotomy for months to years, and demand high-complexity tertiary care as well as labor-intensive home care. For tracheotomy-dependent children with comorbidities, the cost of hospitalization is significantly higher when compared to comorbidity-matched children without tracheotomy.

Postoperative complications following tracheotomy can occur early (within the first 7 days of surgery) or late (8 days or later). Complications of tracheotomy can be defined as major, including accidental decannulation, bleeding, tracheotomy tube occlusion, and death, or as minor, encompassing wound breakdown and formation of granulation tissue.

Our study aims to examine all complications of tracheotomy in the inpatient population at Nemours/Alfred I. duPont Hospital for Children (N/AIDHC) and to discuss causes and implications of tracheostomal wound breakdown.

Methods

Study Design and Setting
This is a retrospective review of the N/AIDHC medical records for all children between December 1, 2000, and February 28, 2014, with diagnoses and procedures related to initial placement of a tracheotomy tube as defined by Current Procedural Terminology codes 31600, 31601, 31603, and 31610. This study was approved by the Nemours Institutional Review Board. No consents were required and all data was deidentified.

Study Participants
Participants were patients who underwent primary tracheotomy between December 1, 2000, and February 28, 2014, at N/AIDHC. Patients with a preexisting tracheotomy were excluded. A total of 333 tracheotomy surgeries were identified; 18 had insufficient data, while 13 were secondary surgeries. These 31 patients were excluded from further analysis. A total of 302 individual patients were identified and further examined for age at tracheotomy, medical diagnosis, use of stay and/or maturing sutures, incidence of complication, and timing of complication.

Main Outcomes and Measures
Main outcome measures included incidence, timing, and type of complication noted in post-tracheotomy patients. Secondary measures included medical diagnoses and surgical technique.

Surgical Technique
After appropriate patient positioning and operative site preparation, a skin incision is carried out either vertically or horizontally per surgeon discretion. Careful dissection down to the trachea is undertaken. When in the surgical field, the thyroid isthmus is usually divided in the midline with electrocautery, or suture ligated and divided. In many cases, maturing sutures, from the deep dermal anterior skin to the pre-tracheal tissues, are placed inferiorly. A vertical incision of the trachea is made through the third and fourth tracheal rings, and nylon stay sutures are placed on either side of the vertical tracheal incision. Stay sutures are kept long and, at the conclusion of the procedure, are taped to the chest skin and clearly labeled with side, enabling quick identification and airway access in the event of accidental decannulation. An appropriately sized tracheotomy tube is inserted, and placement is checked by ventilator parameters, in some cases by flexible bronchoscopy through the tracheotomy tube and/or chest radiography. Tracheotomy ties are snugly fit around the neck.

Results
The medical records of 302 children who underwent tracheotomy at N/AIDHC were reviewed for any tracheotomy-specific complication occurring within 7 days of tracheotomy or more than 7 days following surgical procedure (Table). Of the 302 children who underwent tracheotomy, most were younger than 3 years; the median (SD) age at tracheotomy was 5 months (64 months), although the range was wide (birth–21 years) (Figure 1). There was no statistically significant difference between the median age at the time of tracheotomy between children who developed early (5 months), late (4 months), or no complications (6 months) using the Wilcoxon rank sum test (P = .37). The most frequent diagnosis associated with performance of a tracheotomy was ventilator-associated respiratory failure (61.9%), followed by airway anomaly or underdevelopment (25.2%), such as subglottic or tracheal stenosis, laryngotracheomalacia, or bronchopulmonary dysplasia. The remaining indications for tracheotomy included airway obstruction (11.6% [35 of 302]) and vocal fold dysfunction (1.3% [4 of 302]). No statistical significance was found associated with diagnosis and incidence of complications (Table).

Of all children undergoing tracheotomy during the study period, 19.9% (60 of 302) had a complication noted. The vast majority of these were wound-care–related (12.9% of total [39 of 302], or 65% of all complications [39 of 60]), including...
wound breakdown and granulation tissue formation. Wound-related complications were generally noted by nursing staff or respiratory therapist, followed by notification of the Pediatric Otolaryngology service for wound assessment and management. Other complications included bleeding from the tracheostoma (1.7% [5 of 302]) and accidental decannulation (0.99% [3 of 302]). Notably, there were no tracheotomy-related deaths recorded during the study period. A total of 70% of complications (42 of 60) were seen early (presenting up to 7 days after tracheotomy) and 20% (12 of 60) presented late (more than 7 days after tracheotomy). Timing could not be determined in the remaining 10%.

We also examined surgical technique. In 59.6% (180 of 302) of tracheotomies, both maturing and stay sutures were used. In 29.1% (88 of 302), stay sutures alone were used, and maturing sutures were used alone in only 7.3% (22 of 302). A Bjork flap was used in 2.3% (7 of 302) of all patients and in 100% of children over age 12. Surgical technique could not be determined in 1.7% (5 of 302). Differences in technique used for performance of tracheotomy were owing to attending surgeon preference. Of the 3 cases of accidental decannulation, both maturing and stay sutures were used for 2, and rapid recannulation was noted. In 1 case, stay sutures alone were used, and maturing sutures were placed after the decannulation event. No mortality was associated with decannulation or the tracheotomy procedure during this study period. The χ² test was used to examine the association of surgical technique with incidence of complications. No statistically significant difference was found between techniques (Table).

### Discussion

More than 4800 pediatric tracheotomies are performed each year in the United States. Improved survival at specialized children's hospitals and in hospitals with high case volumes
of pediatric tracheotomy has been reported.5 Pediatric tracheotomy-associated hospitalization accounts for a substantial portion of health care cost to these children and their families, and the variability in the surveillance and management of these patients may contribute to increased hospitalization rates.4 Overall mortality associated with tracheotomy has decreased,1 with no deaths recorded during the study period. However, our study does show a significant incidence of complications: the institutional data reflect that almost 20% of all children undergoing the procedure had a tracheotomy-related complication. Although major complications, such as death and accidental decannulation, are well-known risks of tracheotomy, their incidence has substantially decreased over the past 3 decades and they were minimal in our study (0% and <1%, respectively). This has been attributed to routine use of stay and/or maturing sutures as well as use of the Bjork flap in older pediatric patients.6

Complication rates associated with pediatric tracheotomy have varied widely in the literature (11%-51%).5,7-12; in our study, the overall complication rate was 19.9% (Figure 2). To our knowledge, our series of 302 patients is the largest series of pediatric tracheotomies performed at a single institution to be examined for overall complications. With improved surgical techniques, there has been a decrease in mortality and serious morbidity associated with pediatric tracheotomy. Now, wound-related problems are the most frequently reported complication associated with pediatric tracheotomy.7,8 In our study, the overall wound-specific complication rate was 12.9%, accounting for 65% of all complications. No single patient characteristic was found to have a statistically significant association with increased incidence of complications.

Tracheotomy tubes are typically secured snugly, such that a finger may be placed between the skin and tie, to balance the need for a secure tie while reducing pressure on the neck skin. At our institution, we use Dale Tracheostomy Tube Holders (Dale Medical Products, Inc) and soft foam ties. Snug tracheotomy ties, the moist nature of the wound itself, location in the short pediatric neck, and proximity to oral secretions all contribute to chronic inflammation of the skin surrounding the tracheotomy tube. Early wound breakdown is recognized as skin erythema and/or blanching, which may progress to frank ulceration.

Tracheotomy care in the postoperative period is generally undertaken by intensive care unit nurses and unit respiratory therapists. Wound care is greatly dependent on these supporting health care providers' comfort level in managing the surgical airway. Fear of accidental decannulation may lead to hesitation to manipulate the tracheotomy tube and inadequate skin examination and wound care.9 To our knowledge, there is no current standardized classification system for tracheotomy wounds, further complicating communication between various teams caring for tracheotomy patients, although 1 has been proposed by Jaryszak et al.8

Pressure ulcers have been categorized as targeted never events by the Centers for Medicare & Medicaid Services, stimulated by state and federal initiatives that require mandatory reporting of pressure ulcers.10 Reimbursement rates from Medicaid as well as from private insurers have been linked to never events. Tracheotomy wounds may be classified as pressure ulcers and, less often, as surgical site infections, and thus have recently undergone more scrutiny. The potential for financial repercussions for health care institutions related to tracheotomy complications must be appreciated in addition to the clinical impact to the patients who develop skin breakdown and ulceration.

Limitations of this study include its retrospective nature, which may underestimate the number of complications, particularly when wound-care–related, as these may have been managed by a critical care team and not recorded in our database. Further, as a tertiary referral center, long-term complications outside of the initial tracheotomy admission may have been treated elsewhere and thus not captured in the N/AIDHC database.

Development of a standardized, widely applied tracheotomy wound care classification system to facilitate consistent description of the wound and promote accurate recording of wound progression is essential. Although our aim is to minimize post-tracheotomy wound complications, it is unlikely to eliminate this complication completely. Rather, by early and prompt identification, we propose that these wounds may be classified quickly and appropriately treated so that healing can be promoted as early as possible. At our institution, this process will involve the application or development of a concise and reliable wound classification system, standardized recognition of wound status on admission, and guideline-driven evidence based management regimens. This process will be subject to the Plan, Do, Study, Act methodology13 and will include routine photodocumentation of wound status. Further studies of a prospective nature focused on the development of wound-care protocols are needed for targeted improvement in the care of tracheotomy-dependent children. Future goals include development of a standardized, multidisciplinary approach to address wound concerns in the postoperative pediatric tracheotomy patient.

Conclusions

Pediatric tracheotomy at our institution is associated with an overall 19.9% incidence of complications, over half of which
are wound-care–related. Tracheotomy-associated major morbidity and mortality are rare; however, wound care complications in the post-tracheotomy child have increased. Peristomal skin breakdown and development of granuloma may occur at any time point post-tracheotomy. With increasing scrutiny of hospital-acquired wound complications or ulcers, it is essential to focus attention on this broad topic. Further work to understand and mitigate this problem should be undertaken.

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Study concept and design: Levi, Shah.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: All authors.
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REFERENCES