

# Pediatric Tracheotomy Wound Complications

## Incidence and Significance

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**Objectives:** To determine the incidence and to describe wound complications and associated risk factors of pediatric tracheotomy.

**Design:** Retrospective case series.

**Setting:** Freestanding tertiary care academic pediatric hospital.

**Patients:** Sixty-five consecutive children undergoing tracheotomy over 15 months.

**Main Outcome Measures:** Postoperative wound complications objectively and independently documented by an advanced practice nurse specializing in tracheotomy care. Secondary outcome measures included comorbidities, mortality rates, and wound status after subsequent examinations and management.

**Results:** The mean (SEM) patient age at tracheotomy was 45 (8.7) months (median age, 9.1 months). The most common indication for tracheotomy was pulmonary disease (36.9%), followed by neurologic impairment and la-

ryngeal abnormalities. There were 19 patients (29%) with and 46 patients (71%) without wound complications. There were no significant differences between the 2 groups in age ( $P = .68$ ) or weight ( $P = .55$ ); however, infants younger than 12 months had an increased complication rate (39% vs 17%,  $P = .04$ ). The type of tracheotomy tube was predictive of postoperative wound complications ( $P = .02$ ). All patients with wounds received aggressive local wound care. Five of 13 patients had complete resolution of stomal wounds, whereas 8 patients had persistent wound issues. There were 5 non-wound-related mortalities.

**Conclusions:** With attempts to classify tracheotomy wound breakdowns as reportable events, including never events, increasing emphasis is being placed on posttracheotomy care. This study demonstrates that wound breakdown in pediatric tracheotomy patients is common. These complications can be mitigated, although not prevented completely, with aggressive wound surveillance and specialized wound care.

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**H**ISTORICALLY, MOST ATTENTION has been given to the tragic complications of tracheotomy in children, with little emphasis on wound complications. As medicine has advanced and the management of tracheotomies has evolved, there has been a huge decrease in such severe complications. As such, attention has been focused on optimizing the quality of life of these patients, including ensuring the integrity of their tracheostoma. Kremer et al<sup>1</sup> reviewed 20 published studies in addition to their own data regarding complications of pediatric tracheotomy. Wound complications were one area of analysis, and the reported rates of wound complications ranged from 0% to 12%. In an additional 6 studies evaluating premature infants and neonates, the rate was as high as 15%. Granuloma, which was a frequent early complication in their review, had rates as high as 40%. Thirteen of these 27 studies reported a rate of 0% or did not record wound complications.

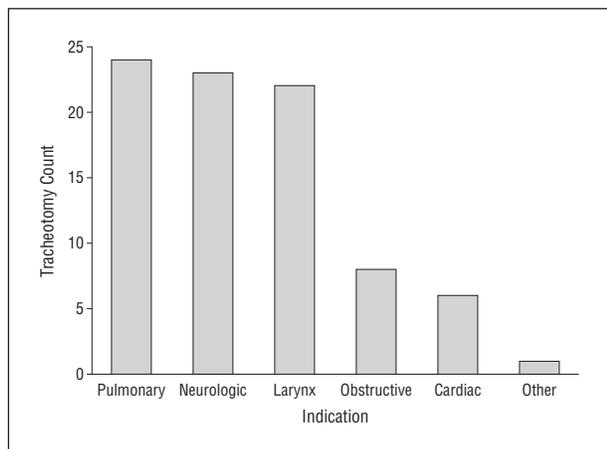
One potential reason for the lack of reporting of tracheotomy wound complications is the lack of a standardized staging system. Wounds in other locations are assessed based on criteria from the National Pressure Ulcer Advisory Panel (**Table**).<sup>2</sup> Although this staging system has not been universally applied to tracheotomy wounds, it is the logical next step, and the system is being used at Children's National Medical Center, Washington, DC. Furthermore, because tracheotomy wounds are associated with a device, they are reportable to the Department of Health as a *never event*. A never event is a distinctly identifiable patient safety event that poses the potential for serious harm to patients and it is considered entirely preventable.<sup>3</sup> Due to pressure from reimbursement organizations, the need to clearly describe and categorize wound complications has become imperative. It is prudent for otolaryngologists to provide such data on wound breakdown in their own surgical procedures rather than to leave this to others to speculate regarding the incidence and significance of such.

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**Table. Pressure Ulcer Staging System<sup>a</sup>**

Stage	Description
I	Intact skin with nonblanchable redness of a localized area usually over a bony prominence.
II	Partial-thickness loss of dermis presenting as a shallow open ulcer with a red-pink wound bed without slough. May also present as an intact or open/ruptured serum-filled blister.
III	Full-thickness tissue loss. Subcutaneous fat may be visible, but bone, tendon, and muscle are not exposed.
IV	Full-thickness tissue loss with exposed bone, tendon, or muscle.

<sup>a</sup>Adapted from the National Pressure Ulcer Advisory Panel.<sup>2</sup>



**Figure 1.** Distribution of indications for pediatric tracheotomy (N=65).

This has significant implications due to the changing trends in pediatric tracheotomy.<sup>4</sup> Tracheotomy for acute airway compromise has decreased, and patients with prematurity, congenital malformations, and neuromuscular diseases are surviving and constituting a set of sicker, younger patients requiring tracheotomy for long-term maintenance of their airway. These patients are expected to have higher wound complication rates,<sup>1</sup> underscoring the importance of obtaining data about expected wound complication rates in this population of patients and of establishing potential “normative” data for us to benchmark ourselves and our progress as tracheotomy wound care evolves.

## METHODS

Children’s National Medical Center Institutional Review Board approval was obtained. Patients were identified from the Children’s National Medical Center database on the bases of *Current Procedural Terminology* codes for tracheotomy (codes 31600, 31601, and 31603) over 15 months (May 1, 2008, through July 31, 2009). This period was chosen because these data were entirely based on an electronic documenting system in May 2008 allowing for more complete and systematic review of the medical record. The subjectivity of assessing paper medical records and the dependence of this study on records being completely scanned into the medical record system were, thus, excluded from this analysis.

Sixty-five consecutive patients were identified from this database. There were no exclusion criteria. Patient demographic, history, and tracheotomy-specific data were accumu-

lated, and a database was created. The patients were separated into 2 groups based on the presence (n=19) or absence (n=46) of a wound complication. Postoperative wound complications were objectively and independently documented by an advanced practice nurse specializing in tracheotomy care using the National Pressure Ulcer Advisory Panel guidelines (Table). Secondary outcome measures included comorbidities, mortality rates, and wound status after subsequent examinations and management. Data were analyzed using a commercial software package (SPSS Statistics 18; SPSS, Inc, Chicago, Illinois).  $P < .05$  was considered statistically significant.

## RESULTS

### AGE

The mean (SEM) patient age at tracheotomy was 45 (8.7) months (median age, 9.1 months). No significant difference was noted in age between the groups with vs without postoperative wound complications (39.3 vs 47.4 months,  $P = .68$ , 2-tailed  $t$  test assuming unequal variances). When considering patients younger than 1 year, however, 14 of 36 patients (39%) had a wound complication, whereas 5 of 29 patients (17%) older than 1 year had a wound complication ( $P = .04$ , Fisher exact test). The indications for tracheotomy are outlined in **Figure 1**.

### CULTURE

Culture data were obtained from 2 weeks before until 2 weeks after tracheotomy. Thirty-two patients had preoperative cultures and 37 had postoperative cultures. Overall, 49 of 65 patients had some culture data in this time frame. A positive culture result (preoperative, postoperative, or both) did not predict postoperative wound complications ( $P = .19$ , Fisher exact test). When considered independently, positive preoperative ( $P = .06$ , Fisher exact test) and postoperative ( $P = .28$ , Fisher exact test) culture results did not predict wound complications.

### DURATION OF VENTILATION

Patients who were using mechanical ventilatory assistance beyond the first tracheotomy tube change were considered to have extended ventilation. Eleven of 41 patients (27%) with extended mechanical ventilatory assistance had wound complications, whereas 8 of 24 patients (33%) without extended mechanical ventilatory assistance had wound complications (likelihood ratio, 0.31;  $P = .58$ ).

### TYPE OF TRACHEOTOMY TUBE

The type of tracheotomy tube used was associated with postoperative wound complications ( $P = .02$ ). The complication rates for Shiley (Covidien-Nellcor, Boulder, Colorado), standard Bivona (Smiths Medical, Dublin, Ohio), and Bivona FlexTend (Smiths Medical) tracheotomy tubes are shown in **Figure 2**. The choice of the Bivona FlexTend tracheotomy tube predicted postoperative wound complications compared with other tracheotomy tubes (likelihood ratio, 4.9;  $P = .03$ , Fisher exact test).

## OTHER

No significant differences were noted between the 2 patient populations for weight (11.1 vs 13.3 kg,  $P = .55$ ) or surgeon ( $P = .42$ ). One surgeon used maturation sutures to create a matured stoma at the time of tracheotomy. This surgeon performed 20 of the tracheotomies in this series. There was no significant difference in the rate of wound complications based on maturation of the stoma at the time of surgery (25% vs 33%,  $P = .14$ , Fisher exact test). No additional hospitalization days or separate admissions were solely attributable to posttracheotomy wound complications.

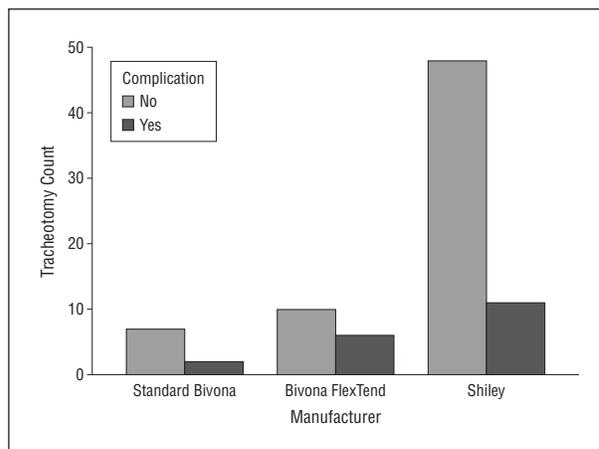
## COMMENT

Wound complications associated with pediatric tracheotomy are seldom reviewed or discussed in the literature.<sup>1</sup> When considered, peristomal granulation receives the most attention.<sup>5,6</sup> As such, the goal of this study was to perform an introspective review of a series of tracheotomy wound issues to ascertain a baseline level of such and to possibly identify predictors of wound breakdown. Furthermore, because there is a national push toward withholding reimbursement in cases of pressure ulcers and other wound issues, it is imperative that otolaryngologists provide normative data on one of our more frequent surgical procedures.

This is the largest series specifically devoted to wound complications of pediatric tracheotomy. Not only were peristomal wounds considered, but pressure wounds from the tracheotomy tube or ventilation circuit and ulcerations from the tracheotomy ties were also evaluated. The results of this retrospective review suggest that wound complications are common. This is not surprising considering the comorbid conditions and young age (median age, 9.1 months) associated with these patients. Although there was no significant difference between the 2 groups for age, when considering infants younger than 12 months, we found a significantly higher complication rate (39% vs 17%). This is consistent with the literature presented previously.<sup>1</sup>

Frequently, there was more than 1 indication for tracheotomy tube placement, highlighting the severity of these patients' medical conditions (Figure 1). In addition, nutritional status is frequently poor in this subset of patients. As a measure of nutritional status, we attempted to analyze albumin levels; however, they were infrequently obtained (only 28 of 65 patients in this series had albumin levels measured). Furthermore, when multiple albumin levels were obtained, the specific implications for wound breakdown were difficult, if not impossible, to determine.

The type of tracheotomy tube used predicted wound complications after pediatric tracheotomy. At Children's National Medical Center, the Bivona FlexTend tracheotomy tube is selected when both the attending surgeon and the advanced practice nurse determine that the patient's anatomy requires this specialized tube. The most common reason for selecting this tube is a short neck or excessive submental soft tissue, which will occlude the lumen



**Figure 2.** Tracheotomy tube-specific data on wound complications. The Bivona FlexTend (Smiths Medical, Dublin, Ohio) tracheotomy tube had an increased rate of wound complications ( $P = .02$ ).

of the other tubes or cause excessive pressure on the flanges or hub of the tracheotomy tube. Although in this series it is impossible to state that those receiving a Bivona FlexTend tracheotomy tube had a statistically significant difference in chin-to-chest distance, which was not measured as part of this retrospective study, or in a quantitative measure of submental soft tissue, the selection of the Bivona FlexTend tracheotomy tube for these reasons may result in selection bias entering into an assessment of wound complications because these patients may be more predisposed than others to complications. One potential concern of the Bivona FlexTend tracheotomy tube was a V-shaped flange where the base of the mechanical ventilator attachment overrode the flange and pressed against the skin above and below the stoma. We were investigating whether changes made in the flange shape and mechanical ventilator attachment would make a significant difference in the wound complication rate.

Literature does suggest that the surgical technique may affect peristomal wound complications. Prescott<sup>6</sup> and Park et al<sup>7</sup> suggested that the creation of a formal tracheostoma may reduce peristomal granulation, with the added benefit of reducing morbidity associated with accidental decannulation. One surgeon at Children's National Medical Center performed maturation sutures in a similar manner as that presented by Park et al.<sup>7</sup> This technique has the theoretical advantage of essentially closing the incision to prevent the impairment of healing that the tracheotomy tube can cause. When considering this surgeon's procedures, this technique did not predict a statistically significantly different rate of wound complications.

When a procedure goes from being classified as clean contaminated (class II) to contaminated (class III), the wound infection rate increases from less than 10% to 20%, respectively.<sup>8,9</sup> The definition of contaminated includes the presence of nonpurulent inflammation. One hypothesis is that an incision into an infected trachea may be related to the development of wound complications as a result of infection. We found that the presence of positive preoperative or postoperative respiratory culture findings did not predict posttracheotomy wound complications in the present patients. However, no standardized perioperative antibiotic drug regimen was used for these



**Figure 3.** View of a stage IV posttracheotomy wound.

tracheotomy patients during the study. Although the presence of a positive preoperative respiratory culture result did not meet statistical significance, with increased numbers, this may become significant. Prolonged endotracheal intubation and mechanical ventilatory assistance are sources of positive preoperative respiratory culture results and may be a source of the contamination responsible for the increased wound complication rate. Biofilms may play an important role in these patients intubated preoperatively for an extended time.<sup>10</sup>

In addition to being vigilant about controlling infection, we have instituted systemwide practices to help reduce tracheotomy wound complications: (1) the use of a specialty-trained tracheotomy nurse with a background in wound care, (2) the use of barrier protection between the flanges of the tracheotomy tube and the skin, and (3) aggressive wound care when potential wound issues are recognized to prevent progression to stage III or IV wounds (**Figure 3**). Despite their prevalence, wound complications after pediatric tracheotomy have a low morbidity rate that may decrease over time with the addition of the steps outlined previously herein. In no case was a wound complication solely responsible for additional days spent in the hospital, and neither was there any readmission solely for wound care. With aggressive local wound care, 5 of 13 patients with documented follow-up had clean tracheotomy wounds, and the other 8 wounds were healing well (5 were granulating, 2 had erythema, and 1 had superficial excoriation from the tube ties).

As indicated previously, a *never event* is a patient safety event that should be considered preventable<sup>3</sup> and be accurately tracked so that an organization has the capacity through quality improvement efforts to reduce the incidence of these events. Some researchers have attempted to classify tracheotomy wound breakdown as a never event; this series clearly demonstrates that a significant proportion of patients will experience wound breakdown during the immediate postoperative course for a tracheotomy and that these events are not entirely preventable. By using the information in this study and by developing a classification scheme for posttracheotomy

wounds, our specialty could develop best care practices for the maintenance of posttracheotomy patients to optimize outcomes and facilitate improvement in patient quality of life.

In conclusion, with attempts to classify tracheotomy wound breakdowns as never events, increasing emphasis is being placed on posttracheotomy care. This study demonstrates that wound breakdown in pediatric tracheotomy patients is common. Despite the somewhat high prevalence of wound breakdown, minimal morbidity is associated with it. These complications can be mitigated, although not prevented completely, with aggressive wound surveillance and specialized wound care.

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**Author Contributions:** All authors had full access to all 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:* Jaryszak, Shah, and Peña. *Acquisition of data:* Jaryszak and Amling. *Analysis and interpretation of data:* Jaryszak, Shah, Amling, and Peña. *Drafting of the manuscript:* Jaryszak, Shah, and Peña. *Critical revision of the manuscript for important intellectual content:* Jaryszak, Shah, Amling, and Peña. *Statistical analysis:* Jaryszak. *Administrative, technical, and material support:* Shah and Peña. *Study supervision:* Shah and Peña.

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