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ORIGINAL RESEARCH

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Tracheal A-frame deformity and suprastomal collapse after pediatric tracheostomy

Rishi Suresh MD[1] | Helene Dabbous MD[2] | Swapnika Alahari BS[3] | Yann-Fuu Kou MD[1,4] | Romaine F. Johnson MD MPH[1,4] | Stephen R. Chorney MD MPH[1,4]

[1]Department of Otolaryngology – Head & Neck Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA

[2]Department of Otolaryngology-Head and Neck Surgery, West Virginia University, Morgantown, West Virginia, USA

[3]University of Texas Southwestern School of Medicine, Dallas, Texas, USA

[4]Children's Medical Center Dallas, Department of Pediatric Otolaryngology, Dallas, Texas, USA

Correspondence
Stephen R. Chorney, Department of Otolaryngology—Head and Neck Surgery, Division of Pediatric Otolaryngology, University of Texas Southwestern Medical Center, 2350 N. Stemmons Freeway, F6.221, Dallas, TX 75207, USA.
Email: stephen.chorney@utsouthwestern.edu

Abstract

Objectives: To determine the incidence of A-frame deformity and suprastomal collapse after pediatric tracheostomy.

Study design: Retrospective cohort.

Methods: All patients (<18 years) that had a tracheostomy placed at a tertiary institution between 2015 and 2020 were included. Children without a surveillance bronchoscopy at least 6 months after tracheostomy were excluded. Operative reports identified tracheal A-frame deformity or suprastomal collapse.

Results: A total of 175 children met inclusion with 18% ($N = 32$) developing A-frame deformity within a mean of 35.8 months (SD: 19.4) after tracheostomy. For 18 children (18/32, 56%), A-frame developed within a mean of 11.3 months (SD: 15.7) after decannulation. There were 96 children developing suprastomal collapse (55%) by a mean of 17.7 months (SD: 14.2) after tracheostomy. All suprastomal collapse was identified prior to decannulation. Older age at tracheostomy was associated with a lower likelihood of collapse (OR: 0.92, 95% CI: 0.86–0.99, $p = .03$). The estimated 5-year incidence of A-frame deformity after tracheostomy was 32.8% (95% CI: 23.0–45.3) and the 3-year incidence after decannulation was 36.1% (95% CI: 24.0–51.8). Highly complex children had an earlier time to A-frame development ($p = .04$). At 5 years after tracheostomy, the estimated rate of suprastomal collapse was 73.7% (95% CI: 63.8–82.8).

Conclusions: Tracheal A-frame deformity is estimated to occur in 36% of children within 3 years after tracheostomy decannulation. Suprastomal collapse, which approaches 74% at 5 years after tracheostomy, is more common when tracheostomy is placed at a younger age. Surgeons caring for tracheostomy-dependent children should recognize acquired airway obstruction and appropriately monitor these outcomes.

Level of evidence: 3.

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KEYWORDS
pediatric tracheostomy, suprastomal collapse, tracheal A-frame deformity

1 | INTRODUCTION

Tracheostomy carries significant morbidity and mortality in the pediatric population.[1] During the last several decades, there has been a shift towards tracheostomy for managing chronic respiratory issues.[2–4] As a result, long-term consequences of tracheostomy placement have become increasingly relevant in the pediatric population.

Structural abnormalities of the trachea following tracheostomy are particularly important as they may preclude decannulation or require surgical intervention. For example, fractured or weakened anterior tracheal cartilage can result in lateral collapse known as an "A-frame" deformity.[5] Additionally, some patients will develop suprastomal collapse where the anterior tracheal wall will collapse inward towards the posterior trachea.[6,7] Chronic inflammation associated with prolonged tracheostomy tube dependence can also result in the formation of granulomas that may also cause airway obstruction.[8]

To date, the incidence of structural abnormalities resulting from pediatric tracheostomy placement is understudied. Tracheal A-frame deformity and suprastomal collapse are causes of acquired airway stenosis that can limit successful tracheostomy decannulation. Therefore, recognizing the incidence, timing, and risk factors for these events are necessary when caring for children with a tracheostomy. The primary objective of this study is to characterize the incidence of A-frame deformity after pediatric tracheostomy in a large retrospective cohort. Secondary objectives include identifying the incidence of suprastomal collapse and factors associated with the development and timing of these obstructions. We hypothesized that both of these entities would be common in a pediatric cohort and that children requiring a tracheostomy for longer periods of time would be more susceptible to their development.

2 | MATERIALS AND METHODS

A retrospective cohort included patients who underwent tracheostomy at Children's Medical Center Dallas between January 1, 2015 and December 31, 2020. The Children's Health Airway Management Program (CHAMP) prospectively enrolls all pediatric tracheostomy patients in an electronic medical record registry (Epic Systems Corporation, Verona, WI) upon tracheostomy placement. Review and dissemination of this data at Children's Medical Center Dallas was approved by the University of Texas Southwestern Medical Center Institutional Review Board (IRB# 2019-1103). The database, maintained by CHAMP, has been capturing a full complement of clinical metrics since 2015. Only patients that had a tracheostomy placed at Children's Medical Center Dallas were included. Revision procedures or tracheostomies performed at outside institutions were excluded. Stoma maturation sutures at the time of tracheostomy are not routinely placed by the surgeons at this institution.

All included children needed at least one surveillance direct laryngoscopy with bronchoscopy (DLB) beyond 6 months after the tracheostomy placement. This allowed for an adequate duration of time to identify either A-frame deformities or suprastomal collapse. Children that did not receive an airway evaluation beyond 6 months were excluded. The surveillance DLB protocol at this institution includes an airway evaluation at the time of tracheostomy and then interval evaluations on an annual basis for the first 3 years. Subsequent assessments occur at longer intervals based on clinician recommendations. Frequency of assessments are ultimately based on patient clinical status and medical stability. A surveillance bronchoscopy after decannulation is always performed at the time of tracheocutaneous fistula (TCF) repair or when children have respiratory symptoms. This represents the majority of decannulated children. For the small subset of children with a TCF that closed spontaneously, a surveillance bronchoscopy would only be performed when presenting with respiratory symptoms.

The primary outcome was the incidence of tracheal A-frame deformity. Secondary outcomes included patient factors associated with the development of this process as well as its relationship with tracheal granuloma removal. The time to A-frame deformity was captured along with the relationship in achieving successful tracheostomy decannulation. In addition, the incidence of tracheal suprastomal collapse was also recorded.

Surgical operative reports were reviewed to determine incidence of A-frame deformity or suprastomal collapse. All otolaryngology airway operative notes at Children's Medical Center are standardized to identify these areas and are designed to reduce inconsistencies between surgeons. The definition of an A-frame deformity, as previously published, was the inward collapse of one or more tracheal rings resulting in an "A" shaped configuration of the lateral tracheal walls.[5] For suprastomal collapse, the currently accepted definition utilized was either anterior or anterolateral tracheal wall collapse above the stoma that causes a reduction in tracheal lumen dimensions.[7] Operative reports from airway evaluations are recorded in a consistent manner that ensures collection of the same set of variables every time a patient is taken to the operating room. Notes were also reviewed to determine whether tracheal granulomas were removed. Children may have had multiple bronchoscopies but the date at which the A-frame or suprastomal collapse was initially identified was recorded. Additionally, dates of successful tracheostomy decannulation were noted. All children were followed until their most recent airway evaluation with the latest follow-up on February 27, 2023.

Whether a patient developed suprastomal collapse or A-frame deformity was recorded. The size of tracheostomy tube at the time of suprastomal collapse identification was captured along with the outer

diameter. Tracheostomy tube size was determined by the child's age, weight, and the need for ventilatory support. No decisions on tube size were made based on the potential impact on airway structural integrity. Furthermore, if a patient required a minor airway intervention, such as granuloma removal, this was also recorded. Follow up time was defined by the time from tracheostomy to the time of the last direct laryngoscopy performed in the operating room. All patients who did not complete an airway evaluation in the operating room following their initial tracheostomy were excluded from the study (either due to mortality or lost to follow up).

Several patient characteristics and comorbidities captured by the CHAMP database including: sex (male/female); race (Black or African American, Other, White); ethnicity (Hispanic/non-Hispanic); gestational age (weeks); age at tracheostomy (years); indication for tracheostomy (respiratory failure, airway obstruction, secretion management, other); and ventilator requirement at index discharge (yes/no).

Key morbidity diagnoses were identified using *International Classification of Diseases, 9th Revision* (ICD-9) or *International Classification of Diseases, 10th Revision- Clinical Modification* (ICD-10-CM) terminology that were present or diagnosed during the index admission. These were based on ICD-9 or ICD-10-CM coding schemes: short gestation <37 weeks (765.21-28; P07); cardiac conditions (459.*, I00-I99); and chronic respiratory disease (518.83; P27, J96.1). Severe neurocognitive disability was also recorded (yes/no) and was defined as an inability to be educated in traditional classroom setting (e.g., global developmental delay). Patients with high complexity (yes/no) were defined as requiring total parental nutrition (TPN), having a history of sepsis, or requiring major cardiac surgery based on previous work at this institution.[9]

All statistics were performed with Stata (StataCorp., 2021; Stata Statistical Software: Release 17, College Station, TX: StataCorp LLC.). Continuous data are presented as means with standard deviations (SD) or medians with interquartile range (IQR), where appropriate. Categorical data are presented as counts with percentage. The univariate analysis used Student's *t*-testing for continuous variables and Fisher's exact test for categorical variables. Logistic regression models were utilized for the development of A-frame deformity and suprastomal collapse. Kaplan–Meier failure curves were created to estimate the rates of A-frame deformity and suprastomal collapse after tracheostomy placement and tracheostomy decannulation. Log-rank testing was performed to compare failure curves for significantly different time to event curves. Statistical significance was set at $p < .05$. This study adhered to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies.[10]

3 | RESULTS

A total of 175 children met inclusion with 32 children (18%) developing A-frame deformity. Table 1 compares demographic characteristics based on the development of A-frame deformity. The indication for tracheostomy placement was respiratory failure (63%, $N = 110$), airway obstruction (26%, $N = 46$), secretion management (4.6%, $N = 8$), and other (6.3%, $N = 11$). There was no difference in distribution of indications for children developing an A-frame deformity ($p = .18$) Longer length of follow up was associated with identification of A-frame deformity ($p < 0.001$). All other characteristics were similar between groups including history of tracheal granuloma excision which was not associated with the development of A-frame deformity ($p = 0.41$).

Among the 32 children that developed an A-frame deformity, identification occurred within a mean of 35.8 months (SD: 19.4) (median: 35.2 months, IQR: 15.4–45.3) after tracheostomy placement. There were 18 children (18/32, 56%) that developed the A-frame deformity within a mean of 11.3 months (SD: 15.7, median: 5.8, IQR: 4.0–10.1) after successful tracheostomy decannulation.

There were 96 children that developed suprastomal collapse (55%) after tracheostomy placement. Table 2 compares children who did and did not develop suprastomal collapse. Tracheostomy indication was no different ($p = .49$), but children developing suprastomal collapse were younger at tracheostomy placement (1.8 years (SD: 3.9) vs. 3.3 years (SD: 5.0), $p = .02$). The length of follow up was longer for those with suprastomal collapse (42.2 months vs. 27.8 months, $p < .001$). The outer diameter of tracheostomy tube in place at the time of suprastomal collapse was not different between children with mild, moderate, or severe collapse ($p = .44$). On logistic regression, older age at tracheostomy was associated with a lower likelihood of collapse (OR: 0.92, 95% CI: 0.86–0.99, $p = .03$). Identification occurred by a mean of 17.7 months (SD: 14.2) (median: 13.5, IQR: 7.0–26.4) after tracheostomy placement. However, the length of time until collapse was no different between children having a tracheostomy placed younger or older than 2 years (18.7 months (SD:14.8) vs. 11.8 months (SD: 7.7), $p = .09$). For these children, 31 (32%) were able to be successfully decannulated. All suprastomal collapse was identified prior to tracheostomy decannulation.

The cumulative incidence of A-frame deformity after tracheostomy is estimated in Figure 1. The cumulative rate of A-frame in the first year was 2.4% (95% CI: 0.9–6.2), by 3 years was 14.6% (95% CI: 9.2–22.7) and by 5 years was 32.8% (95% CI: 23.0–45.3). When looking at the estimated time to A-frame development after decannulation, Figure 2 estimated the incidence by 6 months as 18.4% (95% CI: 10.3–31.4), 12 months as 30.0% (95% CI: 19.6–44.3), and by 3 years as 36.1% (95% CI: 24.0–51.8). When compared to non-complex patients, complex patients had earlier time to A-frame development based on log-rank testing ($p = .04$; Figure 3).

In Figure 4, the cumulative incidence of suprastomal collapse after tracheostomy placement was estimated. By 1 year, the incidence was estimated at 24.2% (95% CI: 18.4–31.4), 2 years at 42.1% (95% CI: 34.7–50.4) and by 3 years at 61.9% (95% CI: 53.3–70.6). At 5 years after tracheostomy placement, the estimated incidence of suprastomal collapse was 73.7% (95% CI: 63.8–82.8). No patient factors were associated with time to development of suprastomal collapse after tracheostomy placement.

TABLE 1 Characteristics of pediatric tracheostomy patients by A-frame stenosis.

Characteristic	A-frame stenosis	No A-frame stenosis	Total	*p* value
Total, no. (%)	32 (18)	143 (82)	175 (100)	-
Males, no. (%)	15 (47)	79 (55)	94 (54)	.44
Gestational age week, mean (SD)	32.1 (6.7)	33.5 (5.9)	33.2 (6.0)	.25
Race, no. (%)				
White	16 (50)	73 (51)	89 (51)	.55
Black or African American	16 (50)	54 (38)	70 (40)	
Hispanic, no. (%)	8 (25)	43 (30)	51 (29)	.67
Age at tracheostomy, year, mean (SD)	2.5 (4.8)	2.5 (4.5)	2.5 (4.5)	.97
Tracheostomy indication, no. (%)				
Respiratory failure	21 (66)	89 (62)	110 (63)	.18
Airway obstruction	11 (34)	35 (24)	46 (26)	
Secretion management	0	8 (5.6)	8 (4.6)	
Other	0	11 (7.7)	11 (6.3)	
Short gestation, no. (%)	19 (59)	80 (56)	99 (57)	.84
Complex patient, no. (%)	21 (66)	68 (48)	89 (51)	.08
Congenital cardiac disease, no. (%)	16 (50)	62 (43)	78 (45)	.56
Ventilator at discharge, no. (%)	26 (81)	109 (77)	135 (78)	.65
Severe neurocognitive disability, no. (%)	18 (56)	54 (39)	72 (42)	.08
Granuloma excision, no. (%)	13 (41)	46 (32)	59 (34)	.41
Length of follow up month, mean (SD)	47.6 (21.3)	33.0 (19.9)	35.7 (20.9)	<.001

TABLE 2 Characteristics of pediatric tracheostomy patients by suprastomal collapse.

Characteristic	Stoma collapse	No stoma collapse	Total	*p* value
Total, no. (%)	96 (55)	79 (45)	175 (100)	-
Males, no. (%)	49 (51)	45 (57)	94 (54)	.45
Gestational age week, mean (SD)	33.0 (5.9)	33.6 (6.2)	33.2 (6.0)	.50
Race, no. (%)				
White	45 (52)	44 (61)	89 (56)	.26
Black or African American	42 (48)	28 (39)	70 (44)	
Hispanic, no. (%)	26 (27)	25 (32)	51 (29)	.51
Age at tracheostomy, year, mean (SD)	1.8 (3.9)	3.3 (5.0)	2.5 (4.5)	.02
Tracheostomy indication, no. (%)				
Respiratory failure	58 (60)	52 (66)	110 (63)	.49
Airway obstruction	29 (30)	17 (22)	46 (26)	
Secretion management	3 (3.1)	5 (6.3)	8 (4.6)	
Other	6 (6.3)	5 (6.3)	11 (6.3)	
Short gestation, no. (%)	58 (60))	41 (52)	99 (57)	.29
Complex patient, no. (%)	54 (56)	35 (45)	89 (51)	.17
Congenital cardiac disease, no. (%)	49 (51)	29 (37)	78 (45)	.07
Ventilator at discharge, no. (%)	75 (78)	60 (77)	135 (78)	.86
Severe neurocognitive disability, no. (%)	38 (40)	34 (44)	72 (42)	.76
Granuloma excision, no. (%)	35 (36)	24 (30)	59 (34)	.43
Length of follow up month, mean (SD)	42.2 (20.4)	27.8 (18.7)	35.7 (20.9)	<.001

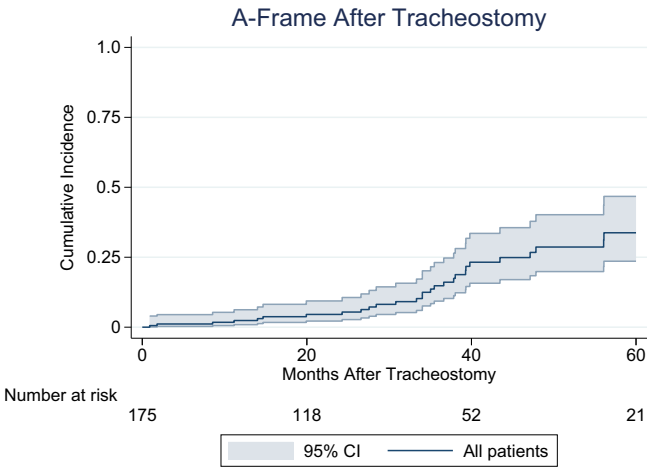

FIGURE 1 Estimated cumulative incidence of A-frame deformity after pediatric tracheostomy placement.

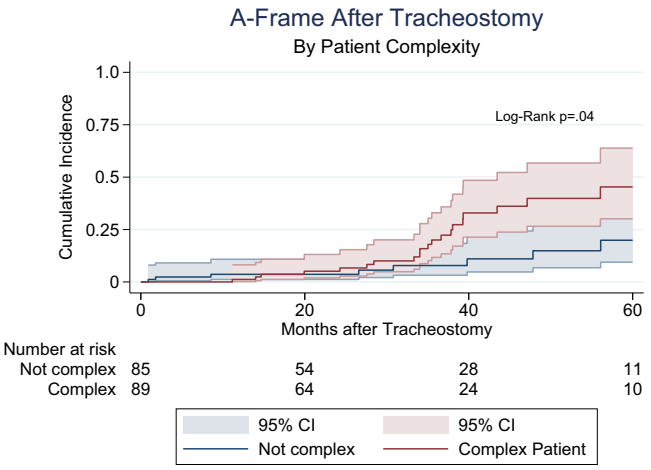

FIGURE 3 Estimated cumulative incidence of A-frame deformity after pediatric tracheostomy placement by patient complexity.

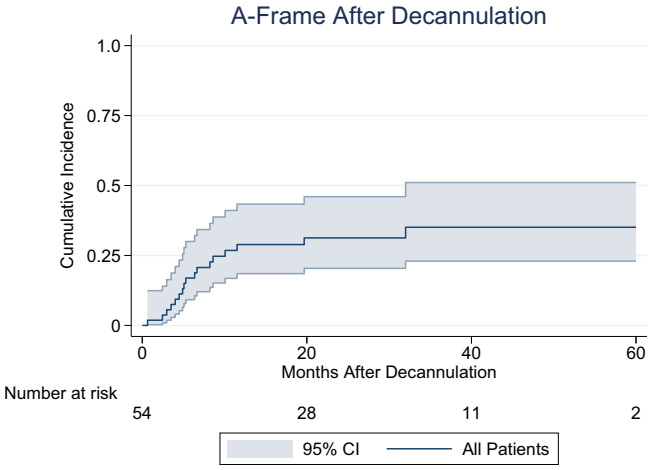

FIGURE 2 Estimated cumulative incidence of A-frame deformity after pediatric tracheostomy decannulation.

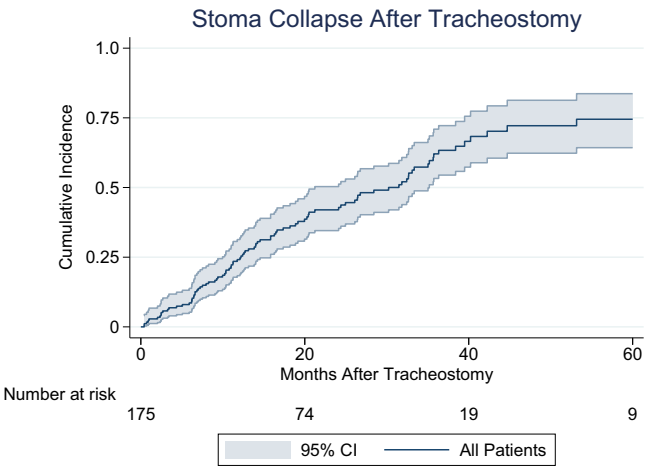

FIGURE 4 Estimated cumulative incidence of suprastomal collapse after tracheostomy placement.

4 | DISCUSSION

The rate of A-frame deformity after pediatric tracheostomy approaches 33% with an estimation of 36% at 3 years after successful decannulation. Suprastomal collapse is much more common and is estimated to develop in 74% of children by 5 years after tracheostomy placement. Of note, complex children had earlier times to A-frame deformity and younger children had higher rates of suprastomal collapse. This information can guide surveillance programs when surgeons care for children with a tracheostomy.

A-frame deformity and suprastomal collapse are airway findings that can preclude tracheostomy decannulation. This study emphasizes the importance of continued airway surveillance after pediatric decannulation as more than half of the A-frame deformities were identified after the tracheostomy had been removed. When these findings are mild, children can be observed, but moderate or severe cases can require open airway reconstruction in order to successfully decannulate patients or alleviate obstructive symptoms. This results in a long-term tracheostomy complication that can be often missed due to inconsistencies with monitoring.

The A-frame deformity is a variant of tracheal stenosis found in patients who have a history of tracheostomy tube placement. The incidence of tracheal stenosis after tracheostomy tube placement has been reported to occur between 0.6% and 21% of patients.[11] Kennedy et al. described A-frame deformity in children that underwent airway reconstruction and reported a rate of 34.5% with 78% of their population having a history of tracheostomy. They also noted patients developing an A-frame deformity were more likely to have had a history of tracheostomy placement.[5] Similarly, while we observed 18% of the study population had developed A-frame deformities, the cumulative estimated incidence at 5-years approached 33% after tracheostomy. The findings shown here are consistent with prior series and suggest one in every three pediatric tracheostomy patients may develop this acquired stenosis.

Interestingly, a relationship between patient complexity and the time to developing an A-frame was identified. This group includes children with cardiac comorbidities, a history of total parenteral nutrition, or having a history of sepsis. This group developed an A-frame deformity earlier than those without these risk factors. Other comorbidities associated with the presence of A-frame deformity have included a history of prematurity, as well as lung and gastrointestinal comorbidities.[5] Several theories have been described that contributes to the development of A-frame deformities, however strong data is lacking and there is no consensus on the etiology. A-frame deformity may result from weakness of the anterior tracheal cartilage or because of direct cartilage injury while the open tracheostomy is being performed. It has also been suggested that A-frame deformity can occur due to an absence of cartilage over the anterior wall of the trachea, subsequent necrosis from constant pressure and friction of the tracheostomy tube on the anterior tracheal wall.[12] Taken together, the development of this entity may be propagated by patient-related factors that may jeopardize the health and viability of tracheal cartilages. Additional studies are necessary to further explore the relationship between these factors and A-frame deformity in children.

A-frame deformity developed within a mean of 36 months after tracheostomy placement. The earlier detection of A-frame deformity in children who undergo airway reconstruction as compared to those that undergo tracheostomy tube placement could be due to the manipulation of cartilage over a larger surface area of the trachea, and thereby creating earlier manifestations of cartilage injury. Another theory is that patients who undergo airway reconstruction are likely to get more frequent surveillance bronchoscopy in the first few years postoperatively compared to patients who undergo tracheostomy tube placement. Kennedy et al. noted a median time of 24.8 months from airway reconstruction to the development of A-frame deformity.[5]

Suprastomal collapse is a common challenge after pediatric tracheostomy placement. More than half of the children in this study population developed suprastomal collapse after tracheostomy placement, which is comparable to the incidence reported by the International Pediatric Otolaryngology Group (IPOG).[7] Suprastomal collapse has been theorized to be a result of cartilage infection or inflammation, as well as a continuous displacement of the tracheal cartilage posteriorly by the curvature of the tracheostomy tube. Multiple factors have been suggested to contribute to the development of suprastomal collapse, but there currently is no consensus.[7] There has also been a wide range in the reported incidence of suprastomal collapse with some studies citing an incidence as low as 1.6%[13] and others reporting rates as high as 52%.[7] Given the consistency that our operative reports document airway findings and the data representing a retrospective cohort for nearly a decade, we are confident in the high estimated rate of this airway obstruction. It is also a challenge that will rarely present after tracheostomy decannulation. Therefore, surgeons should anticipate this acquired airway obstruction and include this as one of the sources of stenosis that might need to be addressed surgically for pediatric tracheostomy patients.

We found that children who developed suprastomal collapse were younger at the time of tracheostomy placement, with older age being associated with a lower likelihood of collapse. This suggests that the placement of a tracheostomy in patients younger than 2 years old may be more likely to lead to collapse. While the etiology is unclear, it may be a result of incising tracheal cartilage that is intrinsically weaker, more pliable, and thereby more likely to sustain long term sequelae from manipulation. Despite the difference in development of suprastomal collapse based on age at tracheostomy, we did not find a difference on the length of time from tracheostomy to observation of a collapse. This suggest that the time from cartilage injury to the observation of a collapse is independent of age. Further studies will be valuable to explore the relationship between age and suprastomal collapse. Nonetheless, this younger group of pediatric tracheostomy patients appear to be much more vulnerable to this obstruction.

Interestingly, we found that all suprastomal collapse was identified prior to patient decannulation, with the length of time until collapse identification at around 17.7 months after tracheostomy. Children with suprastomal collapse were followed for longer periods of time compared to patients with no observed airway findings (42.4 months vs. 27.8 months, $p > .001$) which is expected given those with suprastomal collapse might have been symptomatic. They may also have been followed longer to monitor progression of their obstruction and assess eligibility for decannulation. It is notable that in this series, almost one third of children with suprastomal collapse were successfully decannulated. However, airway surgery for A-frame deformity and suprastomal collapse are beyond the scope of this study.

Granulomas are often reported as the most common finding on diagnostic bronchoscopy in patients with tracheostomy tubes. Reported rates in the literature vary between 12% and 59% of tracheostomy patients.[4,13,14] Large granulomas may pose a risk if accidental decannulation were to occur and may prevent capping tolerance or decannulation. Granulomas are often resected when they are found to be obstructing and various methods for granuloma resection have been described. Based on the frequent presentation of tracheostomy patients with granulomas, many of which are resected on surveillance bronchoscopy, we would have thought that removal of tracheal granulomas would be associated with increased rates of A-frame deformity or suprastomal collapse. This is especially true since there may be some destabilization of the tracheal cartilages when granulomas are addressed. Our results showed that the rates of development of A-frame deformity were not significantly different based on whether a patient underwent granuloma excision at any point while the tracheostomy was in place. Similarly, the rates of development of suprastomal collapse were not found to be different based on whether patients underwent granuloma excision. Further work may be needed to ensure that these acquired airway stenosis are not exacerbated by removing tracheostomy granulomas.

There are a few key limitations to the findings from this study. First, the results shown here are based on a single center experience and are reflective of the practices of a team of pediatric otolaryngologists. The surgical technique for tracheostomy placement is uniform at this institution but variation in how the procedure was performed could impact outcomes. Second, this data is a retrospective cohort,

which can be subject to biases and documentation challenges. Patient charts and operative reports were reviewed to gather data and variables, and while our operative findings are reported in a consistent manner to ensure standardization, errors or missing information are possible. Third, there were periods of long gaps between some surveillance bronchoscopies with irregular timing of procedures due to variation in clinical status. This may have contributed to imprecision with measuring when airway findings developed. Finally, the indication for surveillance DLB procedures were not always standard and some children who did not obtain a DLB may have developed stenosis. As a result, the rates of the A-frame deformity and suprastomal collapse may be underestimated.

Despite these limitations, the results here have some generalizability. These findings imply that children with a tracheostomy should be closely followed with serial diagnostic laryngoscopy and bronchoscopy to identify the presence of airway deformities such as suprastomal collapse and A-frame deformity. Identification and perhaps addressing these processes can help reduce failed tracheostomy decannulation. Open airway reconstruction or other interventions prior to decannulation may be necessary. Lastly, it is essential to differentiate children with suprastomal collapse from those with A-frame deformities as the surgical interventions performed for each of these cases are different. Of note, we found that about 2% of patients with suprastomal collapse underwent airway surgery compared to 15% of patients with A-frame deformity. Taken together, pediatric tracheostomy patients should be periodically monitored with airway endoscopies in the months and years after tracheostomy placement. The lack of airway findings in the past do not always ensure the lack of these findings in the future as rates of A-frame and suprastomal collapse were estimated to increase in the first three to 5 years after tracheostomy placement.

5 | CONCLUSION

In this single-center, retrospective cohort study, the rate of A-frame deformity after pediatric tracheostomy approaches 33% at 5 years after placement and occurs earlier among complex patients. For an estimated 36% of children, an A-frame deformity can arise by 3 years after successful decannulation. While suprastomal collapse develops in an estimated 74% of children by 5 years after tracheostomy, it is much more common when tracheostomies placed in children younger than 2 years old. This information can help guide the approach and timing of airway surveillance as surgeons continue to care for children with a tracheostomy.

CONFLICT OF INTEREST STATEMENT

Romaine F. Johnson is editor-in-chief of *Laryngoscope Investigative Otolaryngology*. He was not involved in the editorial evaluation of or decision to accept this article for publication. All other authors have no disclosures.

ORCID

Helene Dabbous https://orcid.org/0000-0002-3971-9405
Yann-Fuu Kou https://orcid.org/0000-0001-6801-7544
Romaine F. Johnson https://orcid.org/0000-0002-2322-5347
Stephen R. Chorney https://orcid.org/0000-0003-1419-6019

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