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Factors associated with 30-day all-cause hospital readmission after tracheotomy in pediatric patients

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Abstract

Objective—To determine factors associated with post-tracheotomy hospital readmission within 30 days of discharge.

Methods—Children 18 years and younger who underwent tracheotomy at Children's Hospital Los Angeles (CHLA) between 1/1/2005 and 12/31/2013 with at least 30 days of follow-up at CHLA were identified through ICD-9 procedure codes. Patient characteristics and covariates were obtained by linking manual chart review and administrative data. We used multivariate logistic regression to identify the independent association between risk factors and the primary outcome of 30-day all-cause same-hospital readmission.

Results—Of the 273 patients included, the median age at admission was 6 months [interquartile range (IQR): 1–51 months]. Among this primarily male (60.8%) and Hispanic (66.3%) cohort with a high proportion of discharge on positive pressure ventilation (47.1%), the 30-day readmission rate was 22% (n=60). Of the readmissions, 92% (n=55) were unplanned and 64% (n=35) were associated with acute respiratory illnesses. Multivariate regression analysis demonstrated that, among patients < 12 months, discharge on positive pressure ventilation [adjusted odds ratio (aOR)=2.88, 95% confidence interval (CI)=1.19–6.97] was associated with increased odds of readmission, while gastrostomy tube placement during the tracheotomy hospitalization (aOR=0.42, 95% CI=0.19–0.96) and prematurity (aOR=0.35, 95% CI=0.15–0.83) were associated with decreased odds of readmission. In patients > 1 year of age, increased length of hospitalization (aOR=1.01 per hospital day, 95% CI=1–1.02) and presence of comorbid malignancy (aOR=6.03, 95% CI=1.25–29.16) were associated with increased odds of readmission.

Conclusions—Over one-fifth of children undergoing tracheotomy had an unplanned hospital readmission within 30 days after discharge. Because the majority of readmissions were unplanned and due to acute respiratory illnesses, future research should investigate how discharge procedures

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and improved care coordination may lower readmission rates in high-risk patients (e.g., patients discharged on positive pressure ventilation).

Keywords

Pediatric; Tracheotomy; Readmissions; Respiratory infections

1. Introduction

Pediatric patients with tracheostomy are medically complex and high utilizers of health care resources who require the care of multidisciplinary tracheostomy teams during their hospitalizations. These teams include the consultant services of otorhinolaryngologists, critical care specialists, neonatologists, pulmonologists, and general pediatricians, as well as the expertise of nurses, therapists, and equipment specialists.¹ On average, while hospitalized, these patients have 9.3 physician-led services and 4.3 non-physician-led services involved in their care.¹ Given their medical complexity, patients with tracheostomy are at increased risk for morbidity, including hospital readmissions. According to 2013 data from the Healthcare Cost and Utilization Project on tracheostomy placement in 7856 adults, nearly 23% of patients were readmitted within 30 days.² In studies of pediatric patients, readmission rates were 26.8–45% at 30 days,^{3–5} 50% at 3 months,⁶ 63% at 6 months,⁶ 50–76% at 1 year,^{7,8} and 56% at 2 years.⁹ In previous investigations of readmissions among pediatric patients with tracheostomies, respiratory complications and infections were the most common reasons for readmission, contributing to 41–75.3% of readmissions.^{3,7–9}

Given the current data available on tracheostomy readmissions, there is a paucity of research on risk factors, comorbidities, or patient characteristics associated with readmission following tracheostomy placement in a general pediatric population. Overall, patients who undergo tracheotomy face the risk of developing procedure-related complications and present an opportunity for planned intervention to decrease negative outcomes and readmissions.¹⁰ Thus, the objectives of this study were to determine rates of readmissions among pediatric patients and identify characteristics and potentially modifiable or preventable risk factors associated with 30-day all-cause hospital readmissions among pediatric patients undergoing tracheotomy at our institution.

2. Materials and Methods

2.1 Setting and participants

This is a retrospective cohort analysis of 273 pediatric patients who underwent tracheostomy placement at Children's Hospital Los Angeles (CHLA), an urban academic pediatric hospital, between January 1, 2005 and June 30, 2013. We included all patients 18 years old and younger discharged with an *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* procedure code consistent with tracheotomy (ICD-9: 31.1, 31.2, 31.21, 31.29) who were discharged from the hospital and who had at least 30 days of follow-up at CHLA. Patients who were over 18 years old, died, or were decannulated during index hospitalization were excluded from the study. Additionally, we

excluded one patient who had a 606-day length of stay, given that this patient's stay was an extreme outlier value.

2.2 Main outcome variable

Through manual chart review, we defined the main outcome, 30-day all-cause hospital readmission, as any hospital admission within 30 days following discharge after tracheotomy. Two investigators (H.Y. and C.R.) independently identified readmission diagnoses and classified readmissions as planned or unplanned.

2.3 Patient characteristics and covariates

We obtained information on covariates through a combination of manual chart review of the electronic medical record's admission and operative notes by using medical record numbers and, through the patient's medical record number, linked CHLA discharge diagnosis data from the Pediatric Health Information System (PHIS) database.¹¹ The PHIS database contains inpatient data from over 45 freestanding children's hospitals across the United States and provides up to 41 discharge ICD-9 codes. Data abstracted through manual chart review included patient demographics, such as admission age at hospitalization where tracheostomy placement occurred (in months/years), sex, race/ethnicity (defined as Hispanic, non-Hispanic White, non-Hispanic Black, or other), insurance status (private or public), and prematurity (defined as < 37 weeks gestation). Additional data gathered included length of hospital stay during which initial tracheostomy placement occurred (in days) and discharge on chronic positive pressure ventilation.

To identify medical comorbidities associated with tracheotomy indications, we used ICD-9 codes obtained from CHLA-specific PHIS database contribution previously used in prior studies examining pediatric tracheotomy^{12–18} as well as the malignancy complex chronic condition flag, as defined by Feudtner et al.¹⁹ Specific medical comorbidities categories include upper airway obstruction/vascular anomaly (e.g., hemangioma, anomalies of aortic arch, subglottic stenosis, vocal cord paralysis), chronic lung disease (e.g., cystic fibrosis, bronchopulmonary dysplasia, chronic respiratory failure), neuromuscular disease (e.g., anoxic brain injury, hydrocephalus, demyelinating disorders, congenital brain or nervous system anomalies, encephalopathy, muscular dystrophies) and trauma (e.g., intracranial hemorrhage following injury, quadriplegia)

2.4 Statistical methodology

Descriptive statistics were used to assess the relationship between patient characteristics and readmissions within 30 days of discharge. Bivariate logistic regression analyses were used to estimate the relationship between the predictor and outcome variables through unadjusted odds ratios (uOR) with 95% confidence intervals (CI). Because of the distribution and effects of prematurity for participants less than 12 months and because of differential care locations for each age group (NICU versus PICU), we developed two models, one for patients < 12 months and a second for those ≥ 12 months. Our multivariate logistic regression analysis retained variables at the $p < .15$ level in bivariate analyses; this allowed for the identification of variables that, while not autonomously associated with the outcome variable, may be a confounder in the relationship between other predictor variables and the

primary outcome. In addition to these variables, any demographic and/or covariates with medical reasons for being included in the final model were also retained. For the multivariate model, we collapsed the Race/Ethnicity data into Hispanic versus non-Hispanic. Adjusted odds ratios (aOR; 95% CI) were reported, with p-values <0.05 considered statistically significant. All analyses were produced using SPSS Statistics for Windows, version 23. The study was approved by the Children's Hospital Los Angeles Institutional Review Board.

3. Results

Of the 273 patients meeting inclusion criteria, the median age of admission where tracheotomy occurred was 6 months (IQR=1–51 months) and the median length of hospitalization was 74 days (IQR=43–122 days). In our cohort, 61% (n=166) of patients were male, 66% (n=181) were Hispanic or Latino, and 88% (n=241) had public insurance (i.e., Medicaid). With respect to medical comorbidities associated with indication for tracheostomy placement, over one-half of patients had underlying chronic lung disease (56.8%; n=155), neuromuscular disease (54.2%; n=148). Upon discharge, nearly half were discharged on positive pressure ventilation (47.1%; n=128). Additional information for the entire cohort are presented in Table 1.

With respect to the primary outcome, in this cohort of 273 patients, 22% (n=60) of patients had a hospital readmission within 30 days post-discharge following tracheostomy placement. Of these patients, 92% (n=55) of readmissions were unplanned. Nearly 64% (n=35) were due to respiratory infections, 20% (n=11) had gastrointestinal diagnoses, 5.5% (n=3) had tracheostomy complications, and 9% (n=5) had non-respiratory infectious diagnoses.

3.1 Patients 12 months old

There were 166 patients 12 months old included in the cohort, 21.7% (n=36) of whom were readmitted within 30 days following discharge after tracheotomy. Upon bivariate analysis, patient characteristics meeting *a priori* p-values for inclusion in the multivariate model included prematurity (uOR=0.50, 95% CI=0.23–1.08, p=0.08), upper airway obstruction (uOR=0.48; 95% CI=0.23–1.04; p=0.06), placement of a gastrostomy tube during the hospitalization where they underwent tracheotomy (uOR=0.56, 95% CI=0.27–1.18, p=0.13), and discharge on mechanical ventilation (uOR=1.83, 95% CI=0.86–3.90, p=0.12). Length of hospitalization (uOR=1.00, 95% CI=1.00–1.01, p=0.26) and patient age (uOR=1.01, CI=0.90–1.13, p=0.88) were not associated with increased odds of readmission.

In the multivariate logistic regression model shown in Table 2, demographic factors associated with increased odds of readmission included discharge on home positive pressure ventilation (aOR=2.88, 95% CI=1.19–6.97, p=0.02). Patients who had a history of prematurity has decreased odds of readmission (aOR=0.35, 95% CI=0.15–0.83, p=0.02), as well as patients with gastrostomy tube placement during the index hospitalization (aOR=0.42, 95% CI=0.19–0.96, p=0.04). Patient age and associated upper airway obstruction were not independently associated with increased odds of 30-day readmission.

3.2 Patients above one year of age

There were 107 patients over one year of age included in the cohort, 22.4% (n=24) of whom were readmitted within 30 days following discharge after tracheotomy. Bivariate analysis of patient characteristics showed that having a comorbid malignancy was associated with significantly increased odds of readmission (uOR=9.88, 95% CI=2.65–26.78, p=0.001). Additional variables that met the *a priori* p-value threshold for inclusion in the multivariate model included public insurance (uOR=0.25; 95% CI=0.06–1.1; p=0.07), length of stay (uOR=1.01 per day, 95% CI=1.00–1.02, p=0.06), chronic lung disease (uOR=0.49; 95% CI=.19–1.26; p=0.14), and neuromuscular disease (uOR=0.47; 95% CI=0.18–1.23; p=0.12). Patient age (uOR=1.05, 95% CI=0.97–1.14, p=0.25), discharge on positive pressure ventilation (uOR=0.75, 95% CI=0.29–1.90, p=0.54), and gastrostomy tube placement (uOR=0.66, 95% CI=0.25–1.76, p=0.40) were not associated with increased odds of readmission.

In the multivariate logistic regression model shown in Table 3, demographic factors associated with increased odds of readmission included malignancy (aOR=6.03, 95% CI=1.25–29.16, p=0.03) and increased length of stay (aOR=1.01 per day, 95% CI=1.00–1.02, p=0.04). Admission age approached significance for increased odds of readmission (aOR=1.10, 95% CI=1.00–1.22, p=0.06). Neither public insurance status, chronic lung disease, nor neuromuscular disease was independently associated with increased odds of 30-day readmission.

4. Discussion

In our retrospective study of a cohort of 273 patients undergoing tracheotomy at an urban tertiary care institution, we found that over one-fifth of patients had a hospital readmission within 30 days of discharge. Over 90% of readmissions were unplanned, and respiratory infections were the most common readmission diagnoses. The readmission rate in the entire CHLA cohort is comparable to the national 30-day readmission rate for adults with tracheostomy² but lower than that of previous pediatric studies.^{3–5} Different factors were associated with readmission in the two age groups. Among the younger cohort, prematurity and new gastrostomy tube placement were associated with decreased odds of 30-day all-cause hospital readmission while discharge on positive pressure ventilation was associated with increased odds of readmission. Among the older cohort, we found that length of hospitalization and having a comorbid malignancy were associated with increased odds of all-cause readmission.

In the study cohort less than one year of age, after controlling for length of stay, prematurity was independently associated with decreased odds of hospital readmission. Though tracheostomy placement in premature infants is complex due to the nature of the procedure, possible complications, and patient size, previous studies of tracheostomy in premature infants have established the safety and utility of tracheostomy for prolonged ventilator support in anatomic obstruction^{20,21} and severe pulmonary disease.²² Improved outcomes in this population may be attributed to several factors, including closer post-discharge follow-up or administration of palivizumab as prophylaxis against respiratory syncytial virus for preterm infants with chronic lung disease.²³ Viral bronchiolitis, often caused by the

respiratory syncytial virus, is the most common cause of hospitalization in infants less than a year old in the US.²⁴ Given that two-thirds of readmitted patients were diagnosed with respiratory illnesses, the protective effect of palivizumab prophylaxis is a possible explanation for lower readmission odds.

Among the cohort less than 1 year of age, there were different associations between technology dependence and independent odds of readmission. Our finding that discharge on positive pressure ventilation were associated with increased odds of readmission complements other studies that demonstrate high readmission rates among pediatric patients with tracheostomy requiring mechanical ventilator support.^{6,25} These higher readmission rates may be due to the complex home care or medical comorbidities associated with ventilator dependency. Interestingly, new gastrostomy tube placement was associated with decreased odds of readmission. Gastrostomy tube placement in infants with tracheostomy dependency may decrease oropharyngeal aspiration events that lead to respiratory infections. Further, gastrostomy tube placement may allow parents to maintain hydration and feeding in patients with underlying respiratory illness that may influence oral feedings.

For children older than one year of age, we found that longer length of stay and concurrent malignancy were associated with increased odds of readmission. Older patients likely have more longstanding and advanced comorbid conditions because of progression of underlying illnesses, which could contribute to their increased length of hospitalization. Consequently, hospital readmissions should be anticipated in this group. Similarly, patients with coexisting malignancy experienced significantly increased odds of readmission; these readmissions were likely due to a combination of planned readmissions for chemotherapy and for unplanned, but not unexpected, complications of chemotherapy (e.g., fever with neutropenia). Prior studies have also demonstrated high readmission rates among pediatric patients with cancer. In this population, 30-day readmission rates are as high as 41% following hematopoietic stem cell transplantation²⁶ and 84% following chemotherapy.²⁷

Our study was not without several limitations. Because the cohort was from a single freestanding children's hospital with a predominately Hispanic and Medicaid population, our results may reflect center-specific practices in managing patients with tracheostomy, preparation for discharge, and follow-up care and, therefore, may not be generalizable to pediatric patients undergoing tracheotomy at other hospitals. Additionally, patients undergoing tracheotomy at CHLA that required readmission may have been admitted to other hospitals; this cannot be determined through review of our institution's medical records, leading to a lower estimated readmission rate. Furthermore, due to the retrospective nature of the study, missing data may have contributed to errors in data collection. In our study, while prematurity was protective against readmissions in the short term, poor neurodevelopmental outcomes reflect a long-term comorbidity not captured by our outcome. Because both the neonatal and pediatric intensive care units at CHLA are quaternary referral centers for children requiring complex surgery, there may be referral bias; thus, the patients included in our study may not be reflective of all pediatric patients undergoing tracheotomy in the United States.

Despite these limitations, we have identified risk factors that may inform future interventions to decrease readmissions and improve the quality of care provided to pediatric patients undergoing tracheotomy, as well as reasons for readmission among our cohort. Hospital revisits in pediatric patients with general surgical conditions have been shown to poorly correlate with the reason for index admission.²⁸ Thus, in pediatric patients with tracheostomy, any planned interventions should focus on specific reasons for readmission, the majority of which were associated with acute respiratory infections in our study population. Potential interventions to reduce readmissions include development of a structured discharge process,²⁹ improving access to home health services and evaluating interventions to improve airway clearance techniques to decrease airway infections. Through an initial investigation of the discharge process of pediatric patients with ventilators and tracheostomies in the Pulmonary Habilitation Program, Sobotka and colleagues have shown that approval of public funding and staffing of home nursing present two major barriers to the discharge process.³⁰ Collaboration among state agencies, nursing agencies, and hospital teams and the use of transitional care facilities may present opportunities for streamlining the discharge process and ultimately reducing readmissions. Creating comprehensive medical homes for medically complex children as well as integrated outpatient programs for children with tracheostomy may provide access to care outside of the hospital and reduce readmissions by providing regular follow-up care.³⁰ Future studies should investigate discharge procedures and follow-up care received by patients to investigate variations in patient and parent education on topics that could contribute to increased readmissions due to infections. Finally, our data may be used to risk stratify patients that may benefit from targeted intervention or improved care coordination to minimize readmission risk.

5. Conclusions

In our cohort of 273 pediatric patients undergoing tracheotomy, for patients < 12 months, prematurity and placement of gastrostomy tube was associated with decreased odds of 30-day hospital readmission, while discharge on home mechanical ventilation was associated with increased odds of readmission. In the cohort > 1 year, increased length of hospitalization and comorbid malignancy increased odds of readmission. The majority of readmissions were unplanned and due to acute respiratory illnesses, suggesting that future research should investigate how discharge procedures and improved care coordination may lower readmission rates in specific populations.

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Table 1
 Characteristics of pediatric patients undergoing tracheotomy, stratified by 30-day all-cause hospital readmission

	Hospital readmission within 30 days of discharge			
	Total	No	Percent	Yes
Demographics				
<i>Admission age</i>	273 (100%)	213	78.0	60
0 months	50 (18.3%)	42	19.7	8
1 – 12 months	116 (42.5%)	88	41.3	28
1 – 4 years	48 (17.6%)	39	18.3	9
5 – 12 years	32 (11.7%)	26	12.2	6
13 – 18 years	27 (9.9%)	18	8.5	9
<i>Gender</i>				
Male	166 (60.8%)	128	60.4	38
Female	107 (39.2%)	85	39.6	22
<i>Race/Ethnicity</i>				
Hispanic	181 (66.3%)	141	66.2	40
Non-Hispanic White	24 (8.8%)	18	8.5	7
Non-Hispanic Black	29 (10.6%)	23	10.8	6
Other/Missing	39 (14.3%)	31	14.6	7
<i>Public Insurance</i>	241 (88.3%)	192	90.1	49
Hospitalization Details				
<i>Length of Stay in Days [Median (IQR)]</i>	74 (42.5, 121.5)	72 (41, 120)		88.5 (50.5, 133)
<i>Comorbidities Associated with Indication for Tracheotomy</i>				
Prematurity	97/270 (35.5%)	81	38.0	16
Upper airway obstruction	94 (34.4%)	80	37.6	14
Chronic lung disease	155 (56.8%)	123	57.7	32
Neuromuscular disease	148 (54.2%)	120	56.3	28
Trauma	12 (4.4%)	9	4.2	3
<i>Other Comorbidities</i>				
Malignancy	26 (9.5%)	14	6.6	12
Discharge on home positive-pressure ventilation	128 (47.1%)	97	45.8	31

Hospital readmission within 30 days of discharge					
	Total	No	Percent	Yes	Percent
<i>Surgical Comorbidities</i>					
Heart surgery	27 (9.9%)	24	11.3	3	5.0
Gastrostomy tube placement	136 (49.8%)	112	52.6	24	40.0

Table 2

Multivariate logistic regression of factors associated with post-tracheotomy readmission in patients 12 months old.

Variables	Adjusted Odds Ratio (95% CI)	p-value
<i>Hospitalization Details</i>		
Admission age, in months	.98 (.86 to 1.11)	.70
<i>Comorbidities associated with Indication for Tracheostomy</i>		
Premature	.35 (.15 to .83)	.02
Upper Airway Obstruction	.50 (.22 to 1.13)	.10
<i>Medical Comorbidities</i>		
Discharge on home PPV	2.88 (1.19 to 6.97)	.02
<i>Surgical comorbidities</i>		
Gastrostomy tube placement	.42 (.19 to .96)	.04

Table 3

Multivariate logistic regression of factors associated with post-tracheotomy readmission in patients > 1 year old.

Variables	Adjusted Odds Ratio (95% CI)	p-value
<i>Demographics</i>		
Public insurance	.46 (.08 to 2.80)	.40
<i>Hospitalization Details</i>		
Admission age, in years	1.10 (1.00 to 1.22)	.06
Length of stay (per additional day)	1.01 (1.00 to 1.02)	.04
<i>Comorbidities associated with Indication for Tracheostomy</i>		
Chronic lung disease	.91 (.30 to 2.74)	.86
Neuromuscular disease	.46 (.14 to 1.56)	.21
<i>Medical Comorbidities</i>		
Malignancy	6.03 (1.25 to 29.16)	.03