Bronchopulmonary Dysplasia and Ventilation-Associated Outcomes After Pediatric Tracheostomy

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Abstract

Objectives: To determine the time to ventilator liberation and decannulation after tracheostomy placement in children with bronchopulmonary dysplasia (BPD) and pulmonary hypertension. *Methods:* A prospective cohort study included all children (<18 years old) who underwent tracheostomy between 2015 and 2021 with or without a diagnosis of BPD. The primary outcome measures were times to mechanical ventilator liberation, tracheostomy decannulation, or death with tracheostomy in place. Patient demographics, associated comorbidities, and outcomes were compared between groups. *Results:* A total of 318 children met inclusion with a median (interquartile, IQR) age at tracheostomy of 6.9 (IQR: 4.1 – 49.2) months and 54% (N=170) were male. A diagnosis of BPD was made for 43% (N=136) and this group was younger at tracheostomy placement (5.2 vs. 24.5 months, $P<.001$) and more often had pulmonary hypertension (65% vs. 24%, $P<.001$) than children without BPD. Children with BPD spent a median of 2.92 years (IQR: 1.60 – 4.03) on mechanical ventilation compared to 1.84 years (IQR: 0.84 – 3.60) for children without BPD ($P=.003$). Unadjusted estimation of time to decannulation was longer for children with BPD (HR=0.92, 95% CI: 0.62 – 1.38). The adjusted survival analysis for time to mortality included pulmonary hypertension as a variable of significance (aHR= 2.5, 95% CI: 1.43 – 4.40). *Conclusion*: The presence of BPD is associated with an increased duration of mechanical ventilation and time to tracheostomy decannulation. Pulmonary hypertension is associated with an increased mortality risk among this vulnerable population of children.

Introduction

Bronchopulmonary dysplasia (BPD) is the most common chronic lung disease of prematurity with an estimated 10,000 to 15,000 infants diagnosed with BPD annually in the United States. Despite changes in diagnostic criteria, most studies suggest that both the incidence and prevalence have remained stable.[1,2] Patients diagnosed with BPD necessitate increased healthcare resources and often require long-term respiratory support. Additionally, comorbid medical conditions such as pulmonary hypertension and other sequelae of prematurity can influence their need for further care.[3-9]

Tracheostomy placement is often considered for children with BPD.[10,11] These patients require prolonged hospitalization and long-term intensive care given their medical complexity.[12-16] Research on tracheostomy outcomes for children with BPD has yielded varied findings on morbidity and mortality, perhaps due to the influence of comorbidities.[17-20] The relationship between patient characteristics, rates of tracheostomy, hospital readmissions, and mortality have been described for children with BPD.[21,22] The increasing use of tracheostomy in this population has resulted in single-instution series on duration of ventilator support and tracheostomy dependence.[17,18,20,23] However, there have been limited prospective studies looking at long-term ventilator and tracheostomy outcomes among children with BPD.

The Children's Health Airway Management Program (CHAMP) prospectively follows all children who had

tracheostomy placement at Children's Medical Center Dallas. Children are enrolled in a registry until decannulation, death, or reaching 21 years of age. This dataset has been used previously to publish work related to perioperative outcomes, socioeconomic and racial disparities, as well as tracheostomy caregiver quality of life.[24-27] CHAMP is therefore well-suited to explore longterm outcomes after tracheostomy surgery in children with BPD. The primary objective of this study is to examine the relationship between the presence of BPD and pulmonary hypertension with a patient's time to ventilator liberation as well as eventual decannulation. Based on prior data,[28] we hypothesized that children diagnosed with BPD and resultant secondary pulmonary hypertension would have an increased duration of mechanical ventilation and thus a prolonged time to tracheostomy decannulation.

Methods

A prospective cohort study included all children <18 years old who underwent tracheostomy placement between January 1, 2015 and December 31, 2021 at Children's Medical Center Dallas. This tertiary care children's hospital located in Dallas, Texas has a Level I pediatric trauma center and a Level IV neonatal intensive care unit (NICU). Patients who underwent tracheostomy at another facility or were older than 18 years at the time of tracheostomy were excluded. This study was approved by the UT Southwestern Medical Center Institutional Review Board (STU 2019-1103).

The CHAMP prospective tracheostomy registry was developed as a quality improvement initiative to track longitudinal outcomes of children after tracheostomy. CHAMP maintains the registry with monthly data cleaning performed to update each patient's current status. Children with tracheostomies are entered on the day of their tracheostomy and followed until reaching 21 years old, tracheostomy decannulation, or death. The registry is stored in the hospital electronic medical record system. All visits to the healthcare system are subsequently captured (e.g., outpatient clinic, inpatient admission, emergency department visits, etc.). For this study, data were collected and managed using REDCap electronic data capture tools hosted at UT Southwestern Medical Center.[29] Data entry personnel were blinded to the primary hypothesis of the study.

The cohort was divided into BPD and non-BPD patients. The diagnostic definition of BPD continues to lack uniformity. However, children classified as having BPD were generally premature infants who required respiratory support for more than 28 days after birth. The primary outcome measures were times to mechanical ventilator liberation, tracheostomy decannulation, or death with tracheostomy still in place. Censoring occured if the patient was lost-to-follow or aged out of the system at 21 years old.

The following demographic variables were collected: age at tracheostomy placement (months), sex (male or female), race (Native American or Pacific Islander, Asian, African American or Black [hereto referred to as Black]), ethnicity (Hispanic or non-Hispanic), primary payer (Medicaid, private, other), and the caregiver's preferred language (English, Spanish, other). Both race and preferred language are self-selected by the caregiver.

Comorbidities recorded, which were based on the *International Classification of Diseases, 9th Revision* (ICD-9) and*International Classification of Diseases, 10th Revision- Clinical Modification* (ICD-10-CM) codes included: BPD, preterm birth (< 37 weeks gestatational age), congenital malformations, newborn complications, maternal complications, bacterial sepsis of newborn, birth hypoxia, respiratory distress syndrome, sepsis, cardiac conditions, chronic respiratory failure, trauma, pulmonary hypertension, and tracheobronchomalacia.

The Social Capital Atlas and Opportunity Atlas (https://opportunityinsights.org/) datasets were used to measure the cohort's socioeconomic status (SES). The specific measures from the Social Capital Atlas were economic connectedness (EC) and support ratio, while the fraction of single parents and median household income were obtained from the Opportunity Atlas. EC measures low-SES individuals' connection to high-SES individuals within their ZIP code. It is calculated by taking the average share of high-SES friends among low-SES individuals in each ZIP code. The support ratio measures the density of social networks within a ZIP code. It is calculated by taking the proportion of within-ZIP code friendships where the pair share a third mutual friend within the same ZIP code. The fraction of single parents by county is defined as the

percentage of households with children under 18 that a single parent heads. The median household income was also determined at the county level. These measures can help glean insights into the risk of economic hardship or challenges to caring for a child with a tracheostomy.[30-32]

The child's last known status was recorded as of their latest follow up date. This included: alive with a tracheostomy, decannulated, died with a tracheotomy in place, or lost to follow-up. Lost to follow-up was defined as not being seen by any provider in the system in 24 months. Further, the neurocognitive ability of the child (average, mild/moderate impairment, and severe impairment) was documented. Severe impairment refers to children with global developmental delay.

All statistics were performed with Stata Statistical Software (StataCorp. 2023. *Stata Statistical Software: Release 18* . College Station, TX: StataCorp LLC.) The distribution of continuous data was determined with quantile plots and the Shapiro-Wilk test for normality. Due to the skewness of the data, continuous variables are presented as median with interquartile ranges (IQR) (25th - 75th percentile). Categorical data are presented as counts with percentages. Kruskal-Wallis's test for continuous variables was used and the Pearson chi-square test for categorical variables to determine differences between the two groups. A parametric regression survival analysis with Weibull distribution was created to model the hazard ratios of the three outcomes and adjust for confounding. In addition to BPD, the model included variables with a P <.25 in the univariate analysis. Variables where the P >.05 were sequentially dropped until the final model was formed. Survival analysis results are presented as hazard ratios (HR) with 95% confidence intervals (CIs). The model was checked for fit using visual inspection of goodness of fit plots.

A power analysis was performed using a two-sample log-rank test to determine the required sample size for our study. Based on previous research, an anticipated hazard ratio of 1.7 was considered, which indicates a 70% higher risk of decannulation at any given time in the BPD group compared to the non-BPD group. The significance level (alpha) was set to 0.05, and the power at 0.8. This resulted in a total required sample size of 184 participants, distributed evenly into two groups of 92 each. To correct for multiple comparisons, the Bonferroni method was used, and the statistical significance was set to$P$ <.0167 to account for our three primary outcomes. Of note, secondary findings of significance are to be interpreted with caution. Missing data were handled by listwise deletion.

Results

There were 318 patients who met inclusion. The mean time for follow-up was 2.3 years (range = 0.1 to 7.8 years). The final status at the end of the follow-up period was N=140 (44%) alive with a tracheostomy in place, N=96 (30%) decannulated, N=61 (19%) died with a tracheostomy in place, and N=21 (6.6%) lost to follow up.

Tracheostomies were placed at a median age of 6.9 months (IQR: 4.1 – 49.2 months). The population was N=170 (53%) male and N=148 (47%) female. There were N=175 (55%) White, N=105 (33%) Black, N=15 (4.7%) Asian, and N=23 (2.7%) other. There were N=96 (30%) who identified as Hispanic. The preferred language was predominately English (N= 270, 86%) followed by Spanish (N=39, 12%). For further details, please refer to **Table 1** .

Socioeconomic findings for the population were based on zip-code and county level measurements obtained from the Opportunity Insights' databases on Social Capital and Opportunity Indices. The median (IQR) range for the economic connectiveness ratio was 0.73 (0.58-0.92); the support ratio was 0.85 (0.81-0.94); the fraction of single parents was 0.37 (0.28 – 0.38), and median household income was $53,442 ($49,529 – $62,463).

Table 2 shows associated conditions for the patient population. Notable findings include 41% (N=121) short gestation; N=72 (23%) having a history of respiratory distress syndrome; and N=133 (42%) being diagnosed with pulmonary hypertension. Other associated conditions included cardiac conditions (42%), birth hypoxia (11%), and tracheobronchomalacia (7.5%).

The median length of stay for the index stay when the tracheostomy was placed was 101 days (IQR: 52-166

days). The total number of patients discharged on a ventilator was N=272 (86%). The median time to ventilator liberation and eventual decannulation was 2.3 and 1.9 years, respectively. The median time to death for patient who expired with a tracheostomy in place was 0.70 years. The level of neurocognitive disability was considered severe in N=170 (59%) of children.

The number of children with BPD was N=136 (43%). Almost all were discharged on a ventilator. There were several statistically significant differences between children with tracheostomies with and without BPD. Children with BPD tended to be younger at the time of tracheostomy placement (5.2 months vs. 24.5 months, P <.001), have shorter gestational ages (28 weeks vs. 38 weeks,P <.001), and weighed less at tracheostomy placement (1.1 vs. 2.9 kg, P <.001). A higher proportion were Black (44% vs. 25%, P =.004). The level of social support by neighborhood level was slightly decreased among children with BPD (0.83 vs. 0.86, P =.021). Severe disabilities such as non-ambulant cerebral palsy or profound sensorineural hearing loss were also more common among those with BPD (63% vs. 57%, P =.003). See Table 3 for additional details.

Unadjusted estimates of time to mechanical ventilator liberation for children with BPD, compared to non-BPD children, showed a hazard ratio of 0.81 (95%, CI 0.63 – 1.04, P =.10). A confounder-adjusted estimation also did not find any variable associated with time to ventilator liberation. Additional analysis showed children with BPD spent a median of 2.92 years (IQR 1.60 – 4.03, P =.003) on mechanical ventilation compared to 1.84 years (IQR 0.84 – 3.60,P =.003) for children without BPD. See **Table 4** for further details.

Unadjusted estimation of time to decannulation for children with BPD yielded HR=0.92 (95% CI, 0.62 – 1.38). The adjusted model found the time on a ventilator interacted with BPD (see **Table 5**). The model suggests that children with BPD on a ventilator are more likely to take longer to decannulate than a child on a ventilator who does not have BPD. Using the 25^{th}, 50^{th}, and 75^{th} percentiles for time to decannulation, the median times to decannulation would be 2.6, 3.2, and 4.5 years for BPD and 1.8, 3.1, and 5.8 years for non-BPD children. The model's goodness-of-fit is presented in **Figure 1** . In addition, statistical significance held when using jackknife regression variance components estimation for model validation suggesting that outliers did not have a substantial impact on regression coefficients.

The unadjusted survival analysis for time to mortality found that the HR for BPD was 0.58 (95% CI, 0.34 – 0.98). The adjusted model includes pulmonary hypertension as a variable of significance (aHR = 2.5, 95% CI: 1.43 – 4.40) while reducing the confidence interval of the effects of BPD on mortality (aHR = 0.38, 95% CI: 0.22 – 0.69). The model did not reveal a statistical interaction between the two variables suggestive of an additive effect (**Table 6)** . Goodness-of-fit plots (**Figure 2**) and jackknife regression of the model suggested a good fit. Additional subgroup or sensitivity analyses were not performed.

Discussion

This prospective study of children with a tracheostomy found that the diagnosis of BPD had a statistically significant impact on time to ventilator liberation as well as decannulation. Children with BPD obtaining a tracheostomy required increased duration of ventilation and took longer to achieve decannulation compared to non-BPD children. Additionally, BPD was associated with a lower hazard of mortality, although this effect was influenced by the presence of pulmonary hypertension. This data can further guide clinicians as they care for this critical population of tracheostomy patients.

The presence of BPD was associated with an increased time to ventilator liberation. Prior studies have similarly demonstrated that successful liberation from the ventilator is likely within the first few years of life across patients with different classes of BPD severity.[17,20] While these findings are encouraging, it remains important to note that increased durations of mechanical ventilation are likely to be required by children with BPD. This increased duration of mechanical ventilation can have a significant impact on not only the quality of life of the patient, but also their caregivers. These impacts manifest as patients and their families navigate challenges associated with medical equipment, physician visits, financial responsibilities, and potential complications such as infections that may necessitate readmission.[4,13,25] In order to improve care for this vulnerable population, physicians should recognize how social determinants of health can impact

outcomes. Further studies examining these factors will be beneficial when managing BPD patients with a tracheostomy.

Children with BPD on mechanical ventilation had increased times to tracheostomy decannulation. Patients who undergo tracheostomy are more likely to be medicaly complex and thus more likely to experience higher rates of complications due to the presence of comorbid conditions.[33,34] Moreover, children with a tracheostomy for respiratory support in the setting of BPD have higher rates of hospitalization and morbidity.[14] These findings suggest that BPD is associated with an increased duration that a tracheostomy remains in place. This may be due to higher rates of complications in pediatric tracheostomy patients such as respiratory infections and subsequent readmissions that have been examined in prior studies.[25] Of note, the median time to ventilator liberation and eventual decannulation for our study population was 2.3 and 1.9 years, respectively. This result is likely the consequence of children who did not require mechanical ventilation undergoing decannulation earlier than their peers who did require advanced respiratory support which adds to the overall time that the tracheostomy is in place.[35] At present there are no studies that have directly examined the relationship between the presence of BPD, pulmonary hypertension, and time to decannulation. However, existing literature does suggest that decannulation within the first few years of life is likely across a spectrum of BPD severity with excellent survival rates.[17, 28] The addition of BPD to a complex patient profile may also contribute to the development of other exacerbating pathologies such as pulmonary hypertension that worsen overall clinical status.[5,16,18] It is likely that the added complexity of BPD and its sequelae contributed to the increased time to decannulation amongst BPD patients when compared to non-BPD patients within this study. Further studies directed at intervention strategies to reduce complications associated with BPD may provide further insight into these findings and allow for better care of this vulnerable patient population.

While the presence of BPD was associated with a decreased mortality hazard ratio, the additional diagnosis of pulmonary hypertension was associated with an increased mortality hazard ratio. Prior studies have found an increased risk of mortality amongst patients with moderate to severe BPD and comorbid pulmonary hypertension.[36,37]This increase in mortality has previously been hypothesized as being related to prolonged hypoxemic events that are associated with BPD-associated pulmonary hypertension.[38] These recurrent episodes of hypoxemia may also offer insight into the increased prevalence of disability identified amongst patients within the present sample. While adequate oxygenation and pulmonary function is of well-understood importance in premature newborns, it may play an even more significant role in long term outcomes than previously anticipated in those with BPD and pulmonary hypertension. Thus, the increased prevalence of disability identified by this study as well as others[8,39] suggests that neurodevelopmental follow up to evaluate for additional care needs may be warranted to optimize outcomes for this vulnerable patient population, even after eventual ventilator liberation and decannulation.

There are multiple limitations to this study. First, this study was conducted using data with unidentified factors influencing the outcomes of this study not controlled for during analysis. Additionally, given the variance of criteria for diagnosis of BPD across institutions, these findings may not be generalizable to all populations based on non-homogenous standards of diagnosis as previously discussed. To minimize misclassification bias, multiple authors of this study verified diagnoses and other key datapoints collected from patient charts. The risk of misclassification is also mitigated by the fact that this data is from a single institution and is thus not as susceptible to variations in diagnostic criteria. Finally, children who have undergone tracheostomy are more likely to present with multiple medical comorbidities that may complicate the respiratory-related outcomes examined within this sample. Though variables of interest like BPD and pulmonary hypertension were directly examined, it is possible that there are other unidentified factors that influenced the outcomes of this study. Despite these limitations, this study allows for the exploration of the relationship between BPD and comorbidities like pulmonary hypertension and their associations with key respiratory outcome measures. This study was also conducted utilizing data from patients who were cared for at a tertiary care children's hospital with a Level I pediatric trauma center and Level IV neonatal intensive care unit (NICU). As a result, this study was able to capture important data on a high number of clinically complex patients, thus offering further information on a particularly vulnerable population with a

stable incidence across the United States.

Overall, this information can generalize and inform individuals caring for pediatric tracheostomy patients with BPD and pulmonary hypertension. The presence of these two comorbid diseases did impact respiratory-related outcomes, particularly time to decannulation, as anticipated. Thus, this data may inform teams caring for this vulnerable patient population as they seek to provide high-quality long-term care for these children with regards to ventilator liberation and decannulation. Regarding future research opportunities, comorbidities like subglottic stenosis or reasons for delays in decannulation such as a failed sleep study thus requiring adenotonsillectomy could be further explored. These efforts could further guide care efforts for this patient population and eventually lead to optimization of existing protocols for these individuals.

Conclusion

This prospective study of children with a tracheostomy found that the diagnosis of BPD was associated with an increased time to decannulation as well as an increased duration of mechanical ventilation. While bronchopulmonary dysplasia alone was associated with a decreased hazard ratio for mortality, the added presence of pulmonary hypertension was associated with an increased hazard ratio for mortality. Further investigation using multinstituonal data to explore and corroborate these findings would be valuable.

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Figure 1: Goodness-of-fit Plot for Decannulation Model

Figure 2. Goodness-of-fit Plot for Mortality Model

Table 1. Demographics of Children with a Tracheostomy by Presence of Bronchopulmonary Dysplasia

Variable	BPD Absent	BPD Present	Total	*P* value
Total, n (%)	182 (57)	136 (43)	318 (100)	-
Age at tracheostomy, mo. (IQR)	24.5 (4.2-127.6)	5.2 (3.9-7.1)	6.9 (4.1-49.2)	<.001
Gestational Age, mo. (IQR)	38.0 (36.0-40.0)	28.0 (25.0-37.0)	36.0 (28.0-39.0)	<.001
Birth Weight, kilograms, IQR	2.9 (2.4-3.4)	1.1 (0.76-2.4)	2.4 (1.1-3.1)	<.001
Weight at tracheostomy, kg. (IQR)	10.3 (5.4-28.0)	5.1 (4.1-6.4)	6.2 (4.5-14.5)	<.001
Corrected age, mo. (IQR)	7.9 (-4.8-99.3)	-0.89 (-3.0-0.53)	-0.20 (-3.9-28.5)	
Sex, n (%)				
Female	91 (50)	57 (42)	148 (47)	.15
Male	91 (50)	79 (58)	170 (54)	
Race, n (%)				
American Indian/Alaska Native	0 (0)	1 (0.7)	1 (0.3)	.004
Asian	7 (3.8)	8 (5.9)	15 (4.7)	
Black or African American	45 (25)	60 (44)	105 (33)	
White	116 (64)	59 (43)	175 (55)	
More Than One Race	4 (2.2)	2 (1.5)	6 (1.9)	
Unknown / Not Reported	10 (5.5)	6 (4.4)	16 (5.0)	
Ethnicity, n (%)				
Hispanic	59 (32)	37 (27)	96 (30)	.32
Not Hispanic	123 (68)	98 (72)	221 (70)	
Unknown / Not Reported	0 (0)	1 (0.7)	1 (0.3)	
Primary Language, n (%)				
English	153 (85)	117 (87)	270 (86)	.24
Spanish	26 (14)	13 (9.7)	39 (12)	
Other	2 (1.1)	4 (3.0)	6 (1.9)	
Primary Payer, n (%)				
Medicaid	134 (74)	107 (79)	241 (76)	.57
Private	44 (24)	27 (20)	71 (22)	
Other	4 (2.2)	2 (1.5)	6 (1.9)	
Economic connectiveness, (IQR)	0.76 (0.58-0.94)	0.72 (0.55-0.90)	0.73 (0.58-0.92)	.17
Support ratio, (IQR)	0.86 (0.81-0.96)	0.83 (0.79-0.90)	0.85 (0.81-0.94)	.02
Fraction single parents, (IQR)	0.36 (0.26-0.38)	0.38 (0.28-0.38)	0.37 (0.28-0.38)	.27
Median Household Income, USD (IQR)	53442 (48901-62463)	53442 (53442-62178)	53442 (49530-62463)	.89

Continuous variable P values based on Kruskal–Wallis equality-of-populations rank test

Categorical variable P values based on Pearson's $\chi 2$ test

Table 2. Associated Conditions of Children with Tracheostomies by Presence of Bronchopulmonary Dysplasia

Variable	BPD Absent	BPD Present	Total	*P* value
Total, n (%)	182 (57)	136 (43)	318 (100)	-

Variable	BPD Absent	BPD Present	Total	*P* value
Short gestation	41 (23)	90 (66)	131 (41)	<.001
Congenital Malformations	72 (40)	57 (42)	129 (41)	.67
Newborn complications	62 (34)	83 (61)	145 (46)	<.001
Maternal complications	37 (20)	58 (43)	95 (30)	<.001
Bacterial sepsis of newborn	1 (0.5)	2 (1.5)	3 (0.9)	.40
Respiratory Distress Syndrome	41 (23)	31 (23)	72 (23)	.96
Birth Hypoxia	19 (10)	15 (11)	34 (11)	.87
Sepsis	12 (6.6)	9 (6.6)	21 (6.6)	.99
Cardiac conditions	67 (37)	66 (49)	133 (42)	.04
Chronic respiratory	95 (52)	94 (69)	189 (59)	.002
Trauma	19 (10)	2 (1.5)	21 (6.6)	.001
Pulmonary HTN	44 (24)	89 (65)	133 (42)	<.001
Tracheobronchomalacia	9 (4.9)	15 (11)	24 (7.5)	.04

Categorical variable P values based on Pearson's χ 2 test

Table 3. Outcomes of Children with a Tracheostomy by Presence of Bronchopulmonary Dysplasia

Variable	BPD Absent	BPD Present	Total	*P* value
Total, n (%)	182 (57.2%)	136 (42.8%)	318 (100.0%)	
Time on ventilator, y. (IQR)	1.84 (0.84-3.60)	2.92 (1.60-4.03)	2.34 (1.16-3.82)	.003
Time with tracheostomy, y. (IQR)	1.21 (0.40-2.64)	2.73 (1.60-3.89)	1.88 (0.68-3.60)	<.001
Current Status, n (%)				
Alive with tracheostomy	81 (45)	59 (43)	140 (44)	.03
Decannulated	46 (25)	50 (37)	96 (30)	
Died	38 (21)	23 (17)	61 (19)	
Lost to Follow Up	17 (9.3)	4 (2.9)	21 (6.6)	
Neurocognitive Disability, n (%)				
Normal	28 (17)	5 (4.1)	33 (12)	.003
Mild/moderate	43 (26)	41 (33)	84 (29)	
Severe	93 (57)	77 (63)	170 (59)	

Continuous variable P values based on Kruskal–Wallis equality-of-populations rank test

Categorical variable P values based on Pearson's χ 2 test

Table 4. Parametric Survival Analysis of Time to Ventilator Liberation Among Children with a Tracheostomy

Variable	Hazard Ratio	Standard error	z-score	*P* value	95% CI
No BPD	0.25	0.03	-10.34	<.001	0.19-0.33
BPD	0.84	0.10	-1.63	.10	0.63-1.04

Abbreviations: BPD= Bronchopulmonary dysplasia

Table 5. Parametric Survival Analysis of Time to Decannulation Among Children with a Tracheostomy

Variable	Hazard Ratio	Standard error	z-score	*P* value	95% CI
BPD	0.12	0.09	-2.94	.003	0.03-0.49
Time on ventilator	0.19	0.05	-6.51	<.001	0.11-0.31
BPD*Time on ventilator	2.23	0.61	3.09	.002	1.35-3.84

Abbreviations: BPD= Bronchopulmonary dysplasia

Table 6. Parametric Survival Analysis Among Children with a Tracheostomy

Variable	Hazard Ratio	Standard Error	z-score	*P* value	95% CI
BPD	0.39	0.11	-3.25	.001	0.22-0.69
pHTN	2.52	0.72	3.24	.001	1.44-4.40

Abbreviations: BPD= Bronchopulmonary dysplasia; pHTN= pulmonary hypertension