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Risk Factors and In-Hospital Outcomes Following Tracheostomy in Infants

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Abstract

Objective—To describe the epidemiology, risk factors, and in-hospital outcomes of tracheostomy in infants in the neonatal intensive care unit (NICU).

Study design—We analyzed an electronic medical record from 348 NICUs from 1997–2012, and evaluated the associations between infant demographics, diagnoses, and pre-tracheostomy cardio-pulmonary support with in-hospital mortality. We also determined the trends in use of infant tracheostomy over time.

Results—We identified 885/887,910 (0.1%) infants who received a tracheostomy at a median postnatal and postmenstrual age of 72 days (25^{th}, 75^{th} percentile 27, 119) and 42 weeks (39, 46) respectively. The most common diagnoses associated with tracheostomy were bronchopulmonary dysplasia [396/885 (45%)], other upper airway anomalies [202/885 (23%)], and laryngeal anomalies [115/885 (13%)]. In-hospital mortality after tracheostomy was 125/885 (14%). On adjusted analysis, gestational age (GA) near term, small for gestational age (SGA) status, pulmonary diagnoses, number of days of F_iO_2>0.4, and inotropic support before tracheostomy were associated with increased in-hospital mortality. The proportion of infants requiring tracheostomy increased from 0.01% in 1997 to 0.1% in 2005 (P<0.001), but has remained stable since.

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The other authors declare no conflicts of interest.

Conclusions—Tracheostomy is uncommonly performed in hospitalized infants, but the associated mortality is high. Risk factors for increased in-hospital mortality after tracheostomy include GA near term, SGA, and pulmonary diagnoses.

Keywords

database; infants; mechanical ventilation; mortality; neonates; tracheostomy

Tracheostomy may be required in infants with lung disease, airway anomalies, or neurologic, cardiac, or other diseases. With improved survival of extremely preterm infants, the number of infant tracheostomies is expected to increase, although this trend has not yet been demonstrated in the literature.[1,2]

Epidemiologic data on infant tracheostomy are mostly limited to single-center studies,[3,4] which focus on premature infants, with particular emphasis on those with bronchopulmonary dysplasia (BPD).[4-6] Data regarding tracheostomy and outcomes in other infant populations are limited, as are data on risk factors associated with outcomes following tracheostomy. The few existing studies evaluating risk factors include predominantly older children, focus on the postnatal age at tracheostomy, and report different clinical outcomes. One study found that tracheostomy performed later in life was associated with need for home ventilation and gastrostomy tube placement, and a second observed an increased association between death and neurodevelopmental outcomes.[7,8] Risk factors associated with poor outcomes specifically in infants have not been completely reported.

The objectives of this retrospective multicenter study are to describe the epidemiology of tracheostomy in infants admitted to neonatal intensive care units (NICUs) and to identify risk factors associated with in-hospital mortality following tracheostomy.

Methods

We used an electronic medical record from a clinical data warehouse that prospectively captures information on infants cared for by the Pediatrix Medical Group in 348 NICUs in North America. Data on multiple aspects of care are entered into a shared electronic record to generate admission and daily progress notes, and discharge summaries. Information regarding maternal history, demographics, medications, laboratory results, diagnoses, and procedures is then transferred to the data warehouse for quality improvement and research purposes.[9]

We included all infants who underwent tracheostomy during their initial hospitalization at one of 348 NICUs managed by the Pediatrix Medical Group between 1997 and 2012. Infants with missing information on postnatal age at tracheostomy and those with unknown discharge status were excluded. We extracted data on all days of hospitalization in the NICU. This study was approved by the Duke University Institutional Review Board without the need for written informed consent because the data were collected without identifiers.

Definitions

We reviewed all infant diagnoses associated with tracheostomy to identify possible indications for tracheostomy. We grouped diagnoses of interest into airway, pulmonary, neuromuscular, and central nervous system (CNS) categories. Airway diagnoses included vocal cord paralysis, laryngeal anomalies (atresia, webs, stenosis, or malacia), subglottic stenosis, tracheobronchomalacia, or other upper airway anomalies (macro- or micrognathia, macroglossia, choanal stenosis or atresia, nasal atresia, or other upper airway obstruction). Pulmonary diagnoses included pulmonary hypoplasia, BPD, chronic aspiration, congenital diaphragmatic hernia, tracheoesophageal fistula, or other pulmonary anomalies. Given the association between BPD and several of the diagnoses considered as possible tracheostomy indications, BPD was considered to be a possible indication for tracheostomy only if another possible indication for tracheostomy was not present. In those cases where there was another possible indication, BPD was only considered a comorbidity and not listed as a possible indication. We classified infants <32 weeks gestational age (GA) as having BPD if they received supplemental oxygen or respiratory support (nasal cannula, continuous positive airway pressure, or mechanical ventilation) continuously from a postmenstrual age of 36 0/7-36 6/7 weeks. We classified infants ≥32 weeks GA as having BPD if they received supplemental oxygen or respiratory support (nasal canula, continuous positive airway pressure, or mechanical ventilation) continuously from a postnatal age of 28-34 days.[10] Neuromuscular diagnoses included spinal muscular atrophy type 1, congenital muscular dystrophy, myasthenia gravis (including congenital), or other musculoskeletal anomalies. CNS diagnoses included hypoxic ischemic encephalopathy (HIE) and congenital CNS malformations. Because the database does not include a primary indication for tracheostomy, each indication variable listed above was coded as a binary (yes/no) variable, so an infant could have more than one possible diagnosis associated with tracheostomy. We defined congenital heart disease (CHD) as any cardiac malformation except patent ductus arteriosus and biscupid aortic valve (Table I; available at www.jpeds.com). Genetic syndromes were defined as any of the following diagnoses: trisomies (eg, trisomy 21, 18, 13), genetic associations (eg, CHARGE, VACTERL), deletion syndromes (eg, 13q-, 5p-), and clinically relevant syndromes (e.g., DiGeorge syndrome, Treacher-Collins). We defined retinopathy of prematurity (ROP) as stage III or IV ROP, intraventricular hemorrhage (IVH) as grade III or IV IVH, supplemental oxygen as the need for fraction of inspired oxygen (F_iO_2) > 0.4, and mechanical ventilation as the need for conventional or high-frequency ventilation (HFV).

Our primary outcome of interest was in-hospital mortality. Secondary outcomes included duration of mechanical ventilation, time to wean to $F_iO_2 < 0.4$ and supplemental $F_iO_2>0.21$ after tracheostomy, defined as time from tracheostomy to the first day off mechanical ventilation and the first day with an $F_iO_2=0.21$, respectively.

Statistical Analyses

We summarized continuous and categorical variables as medians with 25th and 75th percentiles and counts with proportions, respectively. We used Wilcoxon rank sum, Kruskal-Wallis, chi-square, and Fisher exact tests to compare the study variables across groups, as appropriate. We evaluated trends in proportion of tracheostomies over time using the

Cochran-Armitage test for trend. For the risk factor analysis, we performed univariable logistic regression analysis for GA, birth weight, small for gestational age (SGA), male sex, ethnicity, presence of genetic syndromes, presence of CHD, BPD diagnosis, categories of possible indications for tracheostomy, postmenstrual age, postnatal age, and number of days on mechanical ventilation, HFV, inotropic support, and F_iO_2>0.4 prior to tracheostomy as predictors of in-hospital mortality. We classified GA into 5 *a priori* defined categories: ≤25; 26-28; 29-32; 33-36 and ≥37 weeks and BW into 3 *a priori* defined categories: <1000; 1000-1500; and >1500g. All variables significant in univariable analysis (P<0.05) were considered candidates for inclusion in the full model, and we used forward addition (P=0.15) and backward elimination (p=0.2) techniques to identify a reduced model. This reduced model was then inspected, and clinically relevant covariates that had been removed in the reduction steps were added back into the model. Following standard model assumption diagnostics including assessment of collinearity using variance inflating factors, the following variables remained in the final model: GA, SGA, male sex, postnatal age at tracheostomy, number of days requiring F_iO_2>0.4, and number of days requiring inotropic support prior to tracheostomy, airway indication for tracheostomy, pulmonary indication for tracheostomy, and quintiles of discharge year. Given concerns about the correlation between unobserved NICU-specific effects and the variables included in our models, we used mixed models with fixed effects for NICU to estimate the final model parameters. This approach allowed us to control for the effect of each individual NICU in the final model. We conducted an *a priori* defined sensitivity analysis of our final model limited to inborn infants. This was done to evaluate the potential for referral bias induced by including infants transferred from another NICU and for whom the entire hospital course before tracheostomy was not known.

We analyzed the data using STATA 13.1 (College Station, TX), and considered a P-value of <0.05 statistically significant.

Results

We identified 885/887,910 infants (0.1%) requiring tracheostomy, of whom 760/885 (86%) survived to NICU discharge (Table II). The proportion of infants requiring a tracheostomy initially increased over the course of our study from 0.01% in 1997 to 0.1% in 2005 (p<0.001). This proportion remained relatively unchanged from 2005 to 2012, with 0.1% of infants receiving a tracheostomy in 2012. The median birth weight and GA were 1547 g (25^{th}, 75^{th} percentile: 749, 2765), and 31 weeks (26, 37), respectively. Median birth weight and GA were higher in survivors compared with non-survivors (1771 g [770, 2850] vs. 905 g [610, 1680], P<0.001, and 33 weeks [26, 28] vs. 28 weeks [25, 34], P<0.001, respectively). The majority of infants (754/885 [85%]) suffered from at least one comorbidity. BPD was the most common comorbidity (680/885 [77%]) followed by CHD (175/885 [20%]) and ROP (113/885 [13%]).The most common diagnoses associated with tracheostomy were BPD (396/885 [45%]), upper airway anomalies (202/885 [23%]), and laryngeal anomalies (115/885 [13%]) (Table III). Among the 803/885 (91%) infants with known BPD status, concomitant upper airway anomalies were less common in those with BPD (44%) compared with those without BPD (65%), p<0.001.

The median duration of any mechanical ventilation (conventional or HFV) prior to tracheostomy was 37 days (8, 84) (Table IV). Infants who survived after tracheostomy had shorter duration of mechanical ventilation prior to tracheostomy (32 days [6, 77] vs. 70 days [36, 114], $P<0.01$). Median duration of mechanical ventilation prior to tracheostomy was longer in infants with pulmonary diagnoses compared with those with airway, neuromuscular, or CNS diagnoses (64 days [29, 98] vs. 18 days [4, 61], 24 days [10, 47], and 24 days [9, 47], $P<0.001$, respectively). HFV was provided in 370/885 (41.8%) of infants, but was less frequently provided in those who survived compared with those who died (284/760 [37.4%] vs. 86/125 [68.8%], $P<0.01$). HFV was more frequently provided in infants with pulmonary diagnoses compared with those with airway, neuromuscular or CNS diagnoses (262/433 [61%] vs. 122/425 [29%], 7/26 [27%], and 16/76 [21%], $P<0.001$).

Median weight, postnatal age, and postmenstrual age on day of tracheostomy were 3206 g (2630, 3890), 72 days (27, 119), and 42 weeks (39, 46), respectively. There was no difference in median weight on day of tracheostomy between infants who survived compared with those who died (3205 g [2650, 3875] vs. 3290 g [2486, 3943], $P=0.84$). However, the median postnatal and postmenstrual ages on the day of tracheostomy were lower in survivors compared with non-survivors (64 days [24, 111] vs. 114 days [81, 142], $P<0.001$, and 41 weeks [38, 45] vs. 44 weeks [42, 49], $P<0.001$, respectively). The median F_iO_2 requirement on day of tracheostomy was 0.3 (0.21, 0.41) and was lower in survivors compared with non-survivors (0.28% [0.21, 0.4] vs. 0.4 [0.3, 0.55], $P<0.001$).

A total of 125/885 infants (14%) died at a median of 114 days (81, 142) after tracheostomy. Median postnatal and postmenstrual ages on the day of death were 161 days (125, 207) and 52 weeks (47, 57). Non-survivors died at a median of 45 days (18, 82) after tracheostomy. The survival rates in four diagnostic categories for tracheostomy were: airway (392/425 [92.2%]), pulmonary (351/433 [81.1%]), neuromuscular (24/26 [92.3%]), and CNS (64/76 [84.2%]). Survivors were discharged at a median of 40 days (22, 65) after tracheostomy. Median postnatal and postmenstrual ages on the day of discharge for survivors were 109 days (61, 172) and 48 weeks (44, 54) respectively. The median total length of stay was shorter in survivors compared with non-survivors (98 [56, 167] vs. 152 [105, 200] days, $P<0.001$). After tracheostomy, 289/885 infants (32.7%) were never weaned off mechanical ventilation prior to discharge. This includes 93/289 infants (32%) who died on mechanical ventilation and 196/289 infants (68%) discharged on a home ventilator. Eighty-four of 769 survivors (11%) were discharged on $F_iO_2>0.4$. For those infants who were weaned off mechanical ventilation for at least 1 day after tracheostomy, the median duration to freedom from mechanical ventilation was 6 days (3, 11). Weaning off oxygen to a $F_iO_2=0.21$ for at least 1 day after tracheostomy was successfully accomplished in 633/885 infants (72%). Median duration to wean to $F_iO_2 < 0.4$ was 2 days (2, 3). Median duration to wean off oxygen after tracheostomy was 3 days (2, 10). Survivors had a shorter median duration to wean off oxygen compared with non-survivors (3 days [2, 9] vs. 6 days [3, 17], $P=0.002$).

On adjusted analysis, GA 29-36 weeks (as opposed to those younger or older), SGA, pulmonary diagnoses, days of $F_iO_2>0.4$, and inotropic support before tracheostomy were independent risk factors for in-hospital mortality (Table V). Results were similar in a sensitivity analysis limited to inborn infants: with the exception of pulmonary diagnoses,

which was no longer associated with increased mortality, all other risk factors and their association with mortality following tracheostomy remained unchanged.

Discussion

We studied a large cohort of infants receiving tracheostomy and found that, overall, tracheostomy was rarely performed (0.1% of all NICU infants), but mortality in those requiring tracheostomy was high (14%) compared with mortality in all hospitalized infants in the Pediatrix database over the study period (2.5%). Pulmonary indications, moderate prematurity, SGA status, and surrogates for severity of illness prior to tracheostomy were associated with increased mortality.

The overall rate of tracheostomy in our study (0.1%) is lower than the 0.6–2.7% reported in previous studies.[3,11] This is likely because we included all infants admitted to the NICU, and previous studies focused on low birth weight infants (<2500 g) or those with BPD.[5,6,11,12] In a single-center study including all infants regardless of diagnosis or GA, tracheostomy rate was still higher than our cohort at 1.8%.[3] The Pediatrix Clinical Data Warehouse, the data source for our study, represents a broad mix of NICUs of different acuity levels including academic medical centers and community hospitals, and may be a more accurate representation of the NICU population across the United States.[9] We observed an increase in the proportion of infants requiring tracheostomy over the early years of our study, but no significant increase since 2005. The Neonatal Research Network report on very low birth weight infant survival from 2003 to 2007 showed that survival without morbidity, including survival without intubation, improved over this time period, and survival with BPD decreased.[1] Further, use of prenatal steroids increased over the same time period. These findings may suggest that as interventions to prevent significant lung disease and BPD are implemented, the number of infants requiring tracheostomy may decrease.

The most common diagnoses associated with receipt of tracheostomy in our cohort were pulmonary diagnoses (48.9%). This is in contrast with findings from previous studies that reported upper airway anomaly was the most common indication for tracheostomy in infants and children.[8,13] BPD was the most common diagnosis within the pulmonary diagnostic category that was associated with tracheostomy in our cohort (44%). This is consistent with a single-center study of 165 infants requiring tracheostomy in which BPD was the indication for tracheostomy in 58% of infants.[3] In, 20% of infants requiring tracheostomy in our cohort had a diagnosis of CHD. These significant comorbidities may explain the high in-hospital mortality rate (14%) observed in our cohort. This finding is again consistent with previous studies, which have reported overall mortality rates ranging from 16% to 25%.[3,8,12,14]

We found that pulmonary diagnoses were associated with higher mortality, but airway diagnoses were not associated with mortality. Both the Pediatric Health Information Systems study and a review of the Kids Inpatient Database reported similar findings in children.[13,15] There are conflicting data regarding the association between GA and mortality after tracheostomy in infants. In a single-center study of 127 infants at 23–42 weeks GA with an overall mortality of 21%, higher GA was associated with higher mortality even after controlling for respiratory severity score (the product of mean airway pressure and F_iO_2) and

postnatal age at tracheostomy.[8] However, in the review of the Kids Inpatient Database of >18,000 hospitalizations of children requiring tracheostomy, prematurity, defined as a GA < 36 weeks, was associated with increased mortality.[15] In our cohort, only moderate and late —not severe—prematurity was associated with increased risk of mortality when compared with full-term infants. We postulate that selection bias with overall lower survival of infants ≤28 weeks GA to tracheostomy partly explains why mortality was not highest in this subgroup. Indeed, selection bias may explain the similar findings of another study involving 793 infants with severe BPD that demonstrated increased risk of mortality in infants 28-32 weeks GA compared with those <28 weeks GA.[16] Regardless of this potential survival bias, it is worth noting that infants ≤28 weeks GA who survive to tracheostomy are not at significantly higher risk of mortality than full-term infants. In addition, we postulate that despite the high overall mortality rate reported in our study, tracheostomy may actually protect against mortality in an extremely high-risk population. It is imperative that future studies examine the impact of hospital course on long-term neurodevelopmental outcomes and identify steps to mitigate this risk.

The strengths of our study include its sample size and inclusion of a diverse group of NICUs. Our study is less likely to suffer from referral bias than previous single-center studies. The daily data collected in the Pediatrix Clinical Data Warehouse allowed to us provide a detailed description of infants requiring tracheostomy and to evaluate the association between diagnoses and other risk factors associated with receipt of tracheostomy and mortality. We did not, however, attempt to compare risk factors for mortality between infants with tracheostomy and those without tracheostomy. Our study is primarily limited by the fact that our data come from a shared electronic medical record and has not undergone the development and scrutiny of a prospective study database. We were, for example, not able to identify cause of death, which may or may not have been related to respiratory illness and tracheostomy itself. We also did not have any information on potential complications after tracheostomy, which may add significant morbidity for these medically complex infants. We attempted to control for severity of illness by including surrogate covariates in the multivariable model, but did not have data to more precisely identify the degree of respiratory compromise such as ventilator settings (positive end expiratory pressure) or mean airway pressure. Finally, we can comment only on diagnoses associated with tracheostomy, as the actual indication for the surgical procedure was not captured in the database.

In conclusion, we found that tracheostomy was rarely performed in infants but was associated with significant mortality. We identified several risk factors for mortality after tracheostomy in adjusted analysis, including moderate prematurity, SGA status, and pulmonary diagnoses. We did not identify a significant association between postnatal age at tracheostomy and mortality. Our study supports the notion that tracheostomy is associated with high mortality in infants, primarily in those with severe pulmonary disease. Future studies are needed to identify additional strategies that can mitigate the risk associated with tracheostomy, including infant selection for and timing of the procedure.

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Abbreviations

BPD	bronchopulmonary dysplasia
GA	gestational age
NICU	neonatal intensive care unit
SGA	small for gestational age

Table I
Congenital heart disease diagnoses in our cohort of infants

Cardiac Diagnosis	Number of infants (%)
Atrial septal defect	87 (41.1)
Ventricular septal defect	81 (38.2)
Pulmonary valve stenosis	20 (9.4)
Double outlet right ventricle	4 (1.9)
Aoritc valve stenosis	2 (0.9)
Transposition of great vessels	2 (0.9)
Atrioventricular septal defect	2 (0.9)
Pulmonary artery atresia	1 (0.5)
Total anomalous pulmonary venous return	1 (0.5)
Ebstein anomaly	1 (0.5)
Others/Unclassified	11 (5.2)
Total	**212 (100)**

More than 1 defect was recorded for some infants.

Table II

Subject demographics

	All	Survived	Died	
	N=885, n (%)	N = 760, n (%)	N = 125, n (%)	P[a]
Gestational age (weeks)				<0.001
≤25	215 (24.2)	176 (23.2)	39 (31.2)	
26–28	149 (16.8)	119 (15.7)	30 (24.0)	
29–32	101 (11.4)	80 (10.5)	21 (16.8)	
33–36	148 (16.7)	130 (17.1)	18 (14.4)	
≥37	272 (30.7)	255 (33.6)	17 (13.6)	
Birth weight (g)				<0.001
<1000	339 (38.3)	272 (35.8)	67 (53.6)	
1000–1500	98 (11.1)	80 (10.5)	18 (14.4)	
>1500	448 (50.6)	408 (53.7)	40 (32.0)	
Male	508 (57.6)	424 (55.9)	84 (67.7)	0.01
Race/ethnicity				0.002
White	374 (43.5)	332 (45.1)	42 (34.4)	
Black	232 (27.0)	182 (24.7)	50 (40.1)	
Hispanic	219 (25.5)	192 (26.1)	27 (22.1)	
Others	34 (4.0)	31 (4.2)	3 (2.5)	
Inborn	508 (59.0)	433 (58.8)	75 (60.5)	0.72
Comorbidities				
CHD	175 (19.7)	144 (18.9)	31 (24.8)	0.24
ROP	113 (37.0)	88 (11.6)	25 (20.0)	0.002
BPD[b]	680 (76.9)	579 (76.1)	101 (80.8)	0.03
Genetic anomaly	100 (11.3)	87 (11.5)	13 (10.4)	0.73
IVH	55 (6.2)	44 (5.8)	11 (8.8)	0.20

CHD: congenital heart disease; BPD: bronchopulmonary dysplasia; IVH: intraventricular hemorrhage grade III or IV.

[a] P-values are from chi-square tests of association comparing the distribution of each variable between infants who survived and those who died.

[b] BPD was considered a comorbid condition regardless of the presence of other diagnoses.

Table III

Diagnoses associated with tracheostomy

	All	Survived	Died	
	N = 885, n (%)	N = 760, n (%)	N = 125, n (%)	P[a]
Airway	425 (48.0)	392 (51.6)	33 (26.4)	<0.001
Laryngeal anomaly	115 (13.0)	109 (14.3)	6 (4.8)	
Other upper airway anomaly	202 (22.8)	192 (25.3)	10 (8.0)	
Subglottic stenosis	29 (3.3)	28 (3.7)	1 (0.8)	
Tracheobronchomalacia	108 (12.2)	89 (11.7)	19 (15.2)	
Vocal cord paralysis	66 (7.5)	65 (8.6)	1 (0.8)	
Pulmonary	433 (48.9)	351 (46.2)	82 (65.6)	<0.001
Aspiration	54 (6.1)	47 (6.2)	7 (5.6)	
CDH	17 (1.9)	12 (1.6)	5 (4.0)	
BPD[b]	396 (44.7)	320 (42.1)	76 (60.8)	
Pulmonary hypoplasia	40 (4.5)	29 (3.8)	11 (8.8)	
Other pulmonary anomaly	52 (5.9)	37 (4.9)	15 (12.0)	
TEF	28 (3.2)	25 (3.3)	3 (2.4)	
Neuromuscular	26 (2.9)	24 (3.2)	2 (1.6)	0.34
Muscular dystrophy	6 (0.7)	5 (0.7)	1 (0.8)	
Other musculoskeletal anomaly	19 (2.2)	18 (2.4)	1 (0.8)	
Werdnig-Hoffmann syndrome	1 (0.1)	1 (0.1)	0 (0)	
CNS	76 (8.6)	64 (8.4)	12 (9.6)	0.66
Congenital malformation	53 (6.0)	45 (5.9)	8 (6.4)	
HIE	23 (2.6)	19 (2.5)	4 (3.2)	

CDH: congenital diaphragmatic hernia, BPD: bronchopulmonary dysplasia; TEF: tracheaesophageal fistula; CNS: central nervous system; HIE: hypoxic ischemic encephalopathy.

[a] P-values are from chi-square tests of association separately comparing the distribution of each indication category between infants who survived and those who died.

[b] BPD was considered an indication for tracheostomy only if other indications were absent.

Table IV

Median (25th percentile, 75th percentile) duration of respiratory support before and after tracheostomy

	Survived	Died	
	N = 760	N = 125	P[a]
Before tracheostomy			
Days of F_iO_2>40%	3 (0, 23)	26 (3, 79)	<0.001
Days of MV	32 (6, 77)	70 (36, 114)	<0.001
Days of HFV	13 (6, 27)	16 (6, 32)	0.45
After tracheostomy			
Days of F_iO_2>40%	1 (0, 7)	15 (4, 41)	<0.001
Days of MV	11 (4, 44)	39 (17, 68)	<0.001
Days of HFV	0 (0, 0)	2 (0, 10)	<0.001

F_iO_2: fraction of inspired oxygen; MV: mechanical ventilation; HFV: high-frequency ventilation.

[a]P-values are from Wilcoxon rank-sum tests comparing the distribution of each variable between infants who survived and those who died.

Table V

Adjusted odds ratios (95% confidence interval) for mortality after neonatal tracheostomy

	Odds Ratio (95% CI)
Gestational age, weeks	
≤25	1.82 (0.62, 5.37)
26–28	2.18 (0.76, 6.26)
29–32	**4.24 (1.48, 12.14)**
33–36	**4.06 (1.59, 10.41)**
≥37	Reference
Small for gestational age	**1.90 (1.11, 3.29)**
Male	1.37 (0.77, 2.26)
Postnatal age at tracheostomy	1.01 (0.99–1.01)1.01 (1.00, 1.01)
Days of inotrope prior to tracheostomy	**1.05 (1.01, 1.10)**
F_iO_2 > 40% before tracheostomy	**1.01 (1.01, 1.02)**
Airway diagnosis	0.70 (0.38, 1.30)
Pulmonary diagnosis	**1.97 (1.06, 3.68)**

MV: mechanical ventilation; F_iO_2: fraction of inspired oxygen.