Tracheostomy in children with congenital heart disease: a national analysis of the Kids' Inpatient Database.

Background: While single-institution studies reported the indications and outcomes of tracheostomy in children with congenital heart disease (CHD), no national analyses have been performed. We sought to examine the indications, performance, outcomes, and resource utilization of tracheostomy in children with CHD using a nationally representative database.

Methods: We identified all children undergoing tracheostomy in the Kids' Inpatient Database 1997 through 2009, and we compared children with CHD to children without CHD. Within the CHD group, we compared children whose tracheostomy occurred in the same hospital admissions as a cardiac operation to those whose tracheostomy occurred without a cardiac operation in the same admission.

Results: Tracheostomy was performed in n=2,495 children with CHD, which represents 9.6% of all tracheostomies performed in children (n=25,928), and 3.5% of all admissions for children with CHD (n=355,460). Over the study period, there was an increasing trend in the proportion of all tracheostomies that were done in children with CHD (p<0.0001) and an increasing trend in the proportion of admissions for children with CHD that involved a tracheostomy (p<0.0001). The population of children with CHD undergoing tracheostomy differed markedly in baseline characteristics, outcomes, and resource utilization. Similarly, the subgroup of children whose tracheostomy was performed in the same admission as a cardiac operation differed significantly from those whose tracheostomy was not.

Conclusions: Tracheostomy is an increasingly common procedure in children with CHD despite being associated with significantly greater resource utilization and in-hospital mortality. The population of children with CHD who undergo tracheostomy differs markedly from that of children without CHD who undergo tracheostomy, and important differences are observed between children who undergo tracheostomy in the same admission as a cardiac surgical procedure and those who undergo tracheostomy in a nonsurgical admission, as well as between children with single-ventricle physiology and children with two-ventricle physiology.

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6   **Introduction**

7   Congenital heart disease (CHD) has become more prevalent worldwide.(van der Linde et

8   al., 2011) Surgical techniques to treat even the most complex structural lesions, along with

9   improved intensive care unit (ICU) capabilities, have improved survival for children with CHD.

10 (Nieminen, Jokinen & Sairanen, 2001) But with greater long-term survival of children with

11 complex CHD and other significant comorbid conditions, a fraction of children with CHD require

12 tracheostomy for airway protection and/or ventilator dependence. Many children experience a

13 prolonged and difficult recovery after cardiac operations, and even after the initial recovery,

14 children with CHD have greater vulnerability to subsequent critical illness.(Székely et al., 2006)

15 For instance, even routine respiratory infections can be life-threatening and require ventilator

16 support in children with complex, palliated CHD.

17   Single-institution studies(Challapudi, Natarajan & Aggarwal; LoTempio & Shapiro;

18 Hoskote et al., 2005; Rossi et al., 2009; Cotts et al., 2011; Costello et al., 2014) have reported

19 indications and outcomes of tracheostomy in this population, but these studies have been small

20 (sample size range: 4-59) and lack external validity because of substantial heterogeneity in

21 institutional practices surrounding postoperative ventilator management and decision-making

22 about tracheostomy. These studies report different patterns of how commonly tracheostomy is

23 used in this population and the timing of its performance. No national analyses have been

24 performed. We used an established, nationally representative administrative database to examine

25 the indications, performance, outcomes, and resource utilization of tracheostomy in children with

26 CHD nationwide. This database provides a novel opportunity to explore broad patterns of

27 tracheostomy in the pediatric CHD population across geography, different practice environments,

28 and different institutional preferences.

29   **Methods**

30   This study was exempt from institutional review board review because it uses publicly

31   available, deidentified data. Administrative records were extracted from discharge datasets for

32   the years 1997 to 2009 from the Kids' Inpatient Database (KID), part of the Healthcare Cost and

33   Utilization Project (HCUP) of the Agency for Healthcare Research and Quality. KID is the

34   largest publicly available, all-payer database of inpatient pediatric care in the United States. Each

35   dataset, released every third year, includes records on a sample of discharges from all community,

36   non-federal, non-rehabilitation hospitals in states that participate in HCUP. Hospitals are

37   identified in KID by type according to classifications established by the National Association of

38   Children's Hospitals and Related Institutions (NACHRI): children's general hospitals, children's

39   specialty hospitals, children's units in a general hospital, or not identified as a children's hospital.

40   KID contains discharge sample weights to facilitate nationally representative estimates

41   based on the sampling design; these weights adjust for growth in participation from 1997, when

42   2,521 hospitals in 22 participating states submitted records reflective of 6.7 million national

43   discharges, to 2009, when 4,121 hospitals in 44 states submitted records reflective of 7.4 million

44   national discharges. While KID contains limited data on each inpatient encounter, its size and

45   sampling frame facilitate the analysis of comparatively rare clinical events at a national level.

46   Diagnostic, comorbidity, and procedural information was based on HCUP-supplied

47   international classification of diseases, ninth revision, clinical modification (ICD-9-CM) codes:

48   tracheostomy (Volume 3 procedure codes 31.1-2), congenital heart disease (745.x, 746.x, and

49   747.1-4), single-ventricle anatomy (747.7, 745.3, and procedure code 39.21), pulmonary

50   hypertension (416.x), genetic syndromes (758.0-5), vocal cord paralysis/paresis (478.30-34),

51   tracheal or bronchial pathology (519.1, 519.19, 748.3) and respiratory failure (518.5x, 518.8x,

52   770.84, 799.1, and V46.1-2). Cardiac surgical procedure codes were used to define whether the

53   tracheostomy was performed during an admission that included a cardiac operation or an

54 admission that did not. A composite comorbidity point score was calculated based on the van

55 Walraven modification of the Elixhauser comorbidity measure.(Elixhauser et al., 1998)

56   We compared children with CHD who underwent tracheostomy ("CHD group") to

57 children without CHD who underwent tracheostomy ("non-CHD group"). Within the CHD

58 group, we compared admissions of children whose tracheostomy occurred in the same hospital

59 admissions as a cardiac operation ("cardiac surgical group") to those whose tracheostomy

60 occurred without a cardiac operation in the same admission ("nonsurgical group"). Because

61 patients with single-ventricle physiology are a subgroup of particular interest, we also compared

62 children with single-ventricle physiology to those with two-ventricle physiology.

63   Discharge weights were used to create national estimates within the KID sampling frame.

64 Primary outcome measures included inpatient length of stay (variable LOS), timing of the

65 performance of tracheostomy relative to admission and cardiac surgery (calculated from variables

66 PRDAYx), total inpatient hospital charges (variable TOTCHG), and in-hospital mortality

67 (variable DIED). Hospital charges were indexed to inflation by adjusting all values to 2009

68 dollars using the Bureau of Labor Statistics Consumer Price Index subindex specific to inpatient

69 hospital services with a baseline of December 1996 taken as 100.(Bureau of Labor Statistics)

70   *Statistical analysis*

71   Because the sampling frame of the KID requires the use of advanced techniques

72 (facilitated by PROC SURVEYMEANS in SAS) to estimate variance, continuous variables are

73 presented as mean ± standard error. Discrete variables are presented as number (percentage).

74 Inter-group comparisons were carried out using the Mann-Whitney-Wilcoxon test for continuous

75 variables and Fisher's exact test or Pearson's chi-squared test for categorical variables, as

76 appropriate. Trends over time were examined by month of hospital admission using a seasonal

77 Mann-Kendall test for trend (a nonparametric test to determine the presence and direction of a

78   trend over time(Hirsch, Slack & Smith, 1982) and accounts for seasonal variability, since

79   inpatient pediatric care might involve seasonal fluctuations due to, for instance, patterns of winter

80   illness, surgical scheduling in relation to school calendars, etc). For trend analyses only, records

81   with missing data for the month of admission (8.6% of all KID records) were excluded; these

82   records were included for all non-trend analyses and descriptive data. A predetermined alpha of

83   0.05 was used as the threshold of statistical significance. Trend analyses were performed using R

84   (R 3.0.3, The R Foundation for Statistical Computing, Vienna, Austria). All other analyses were

85   performed using SAS (SAS 9.3, SAS Institute, Cary, NC, USA).

86   **Results**

87   Tracheostomy was performed in n=2,495 children with CHD, which represents 9.6% of

88   all tracheostomies performed in children (n=25,928), and 3.5% of all admissions for children

89   with CHD (n=355,460).

90   The performance of tracheostomy demonstrated a significantly increasing trend over time

91   among children with and without CHD (p<0.0001 for both, Figure 1). Over the study period,

92   children with CHD accounted for a significantly increasing proportion of all tracheostomies

93   (p<0.0001; Figure 2), and tracheostomy admissions accounted for an increasing proportion of

94   admissions among children with CHD (p<0.0001, Figure 3).

95   Table 1 shows baseline characteristics for the CHD and non-CHD groups. . The CHD

96   group was predominantly (86%) neonates or infants, whereas the majority (63%) of the non-CHD

97   group was older than age 10. The CHD group had a roughly even balance of boys and girls,

98   whereas the non-CHD group was 64% male. A greater fraction of the CHD group received

99   Medicaid, received care in urban teaching hospitals, and received care in a recognized children's

100 hospital or unit. Table 2 shows outcomes of tracheostomy admissions in the CHD and non-CHD

101 groups. The CHD group underwent tracheostomy significantly later in their hospitalization, was

102 less likely to be discharged to a skilled nursing or long-term care facility, and had a longer length

103 of stay, greater total hospital charges, and greater in-hospital mortality.

104   Table 3 shows baseline characteristics for the CHD group, divided into cardiac surgical

105 and nonsurgical subgroups. Children in the cardiac surgical group had were less likely to have

106 tracheal or bronchial pathology and more likely to have respiratory failure as an indication for

107 tracheostomy. Table 4 shows outcomes of tracheostomy admissions in the cardiac surgical and

108 nonsurgical groups. The majority (86%) of CHD patients in the cardiac surgical group underwent

109 tracheostomy after their cardiac operation, an average of 49.6 ± 3.1 days after the cardiac

110 operation and 72.3 ± 4.5 days after initial hospital admission.

111   Table 5 shows outcomes of tracheostomy admissions in children with single-ventricle

112   physiology (n=169, 6.8% of all CHD tracheostomy admissions) compared to children with two-

113   ventricle physiology. Compared to two-ventricle CHD patients, single-ventricle patients had a

114   higher average age (1.9 ±0.4 vs 1.1 ± 0.1 years), underwent tracheostomy later in their admission

115   (60.0 ± 5.0 vs 46.2 ± 1.9 days), had greater total hospital charges ($754,764 ± 47,887 vs

116    $593,437 ± $17,028), and much greater in-hospital mortality (35.5% vs 14.9%).

Discussion

117

118   The principal finding of this study is that tracheostomy is an increasingly common

119   procedure in children with CHD despite being associated with significantly greater resource

120   utilization and in-hospital mortality.

121   In both the CHD and non-CHD groups, we observed an increasing trend in the proportion

122   of admissions involving tracheostomy. This may reflect a shift in practice towards the belief that

123   earlier tracheostomy improves outcomes for critically ill patients, which has been well-

124   established in adults(Gomes Silva et al., 2012) and has begun to gain acceptance in other

125   pediatric populations, including trauma(Holscher et al., 2014) and burns(Palmieri, Jackson &

126   Greenhalgh, 2002). However, even beyond this broader overall increase in tracheostomy, we

127   found that children with CHD accounted for an increasing proportion of all tracheostomy

128   admissions. This may reflect increasing acceptance of tracheostomy by congenital heart surgeons

129   as a bridge to recovery in critically ill patients, increasing complexity of cases (with a greater

130   attendant risk of prolonged ICU recovery), or expansion of surgical programs to include children

131   with other comorbid conditions (e.g. pulmonary hypertension) that might previously have been

132   viewed as contraindications to surgical candidacy and that complicate their recovery from

133   congenital heart surgery.

134   The population of children with CHD who undergo tracheostomy differs markedly from

135   that of children without CHD who undergo tracheostomy. The CHD group mostly was composed

136   of a gender-balanced population of neonates and infants at urban, tertiary, children's hospitals,

137   whereas the non-CHD group was comprised mostly of pre-teen and teenage boys. These

138   observations suggest a bimodal pattern of pediatric critical illness, in which CHD is a major

139   contributor in the neonatal and infant period, but a comparatively less common contributor in the

140   school-age and adolescent age group .

141   Within the population of children with CHD undergoing tracheostomy, we observed

142 important differences between those whose tracheostomy occurred in the same hospital

143 admissions as a cardiac operation and those whose tracheostomy did not. The cardiac surgical

144 group had higher baseline comorbidity scores, were more likely to have care in urban teaching

145 hospitals and in an identified children's hospital or unit. The cardiac surgical group was also less

146 likely to have tracheal or bronchial pathology and more likely to have respiratory failure as an

147 indication for tracheostomy.

148   The cardiac surgical group underwent tracheostomy later in their hospitalization, had a

149 longer length of stay, greater total hospital charges, and greater in-hospital mortality. Within the

150 group that had both a tracheostomy and a cardiac surgical procedure in the same admission, the

151 timing of the two procedures was notable. Most children (86.4%) had cardiac surgery prior to

152 their tracheostomy; a minority (10.5%) had a tracheostomy prior to cardiac surgery. Performance

153 of tracheostomy on the same day as a cardiac operation was rare (3.1%).

154   Children with single-ventricle physiology undergoing tracheostomy were older than those

155 with two-ventricle CHD; the mean age of 1.9 years in the single-ventricle group suggests a

156 predominance of tracheostomies occurring remote from initial palliation, though longitudinal

157 information on sequential surgical procedures is not available. The single-ventricle group was

158 more likely to reflect a tracheostomy performed in a surgical admission, and the longer interval to

159 tracheostomy suggests a prolonged ICU course in an attempt to avoid tracheostomy. This group

160 demonstrated high mortality, with more than 1 in 3 children in the single-ventricle group dying in

161 the same admission in which tracheostomy is performed. We suspect that in this context,

162 tracheostomy is a marker for complex critical illness, but it is also important to note that a causal

163 role may exist, as prolonged positive pressure ventilation may have significant pathophysiologic

164 effects on the single-ventricle circulation.(Shekerdemian et al., 1997) Further investigations

165 would be needed to determine the benefits and risks of early compared to late tracheostomy in

166 single-ventricle patients with respiratory failure.

167   Our results are consistent with the prior single-institution analyses that have demonstrated

168 significant mortality and long length of stays in pediatric CHD patients who require

169 tracheostomy. Our analysis provides a comprehensive, national depiction of the timing of

170 tracheostomy in cardiac surgical and nonsurgical admissions; prior analyses have provided

171 widely varying information about timing. Our analysis also adds important information about

172 trends over time and across the entire nation, information on resource utilization associated with

173 tracheostomy admissions, and a benchmark to which future in-depth, single-institution studies

174 can compare their practices.

175   We believe it is important to note that KID is a database of admissions, so this analysis

176 does not provide longitudinal data on patients with a tracheostomy through multiple hospital

177 admissions or outpatient events. Any individual child who has multiple hospitalizations may

178 appear in KID multiple times; no mechanism allows for connecting the records from separate

179 admissions, and one must interpret this analysis in light of this feature. For instance, we cannot

180 determine the timing or frequency of readmissions in patients with tracheostomy after the initial

181 admission when the tracheostomy was performed. Administrative data also lack clinical details,

182 including ventilator dependence, tracheostomy decannulation, and tracheostomy-associated

183 surgical complications, so this analysis cannot add information about those dimensions of

184 tracheostomy performance in children with CHD.

185   Several limitations to this study exist as a result of structural features of the KID

186 database. First, all administrative analyses are limited by classification error. However, such

187 error is less likely to occur with respect to procedural codes that are important to reimbursement;

188 hospitals have an incentive to ensure that all performed procedures are coded properly. Similarly,

189 important comorbidity information (e.g. CHD) is more likely to be reliably coded than minor

190   coexisting conditions of less significance to the primary problem treated in the admission. These

191   features are likely to mitigate the effects of classification error in our analysis of a major,

192   conspicuous procedure in a population with a major cardiac condition.

193   Classification error is likely to be a particular concern in our analysis of single-ventricle

194   patients, as the diagnosis codes we used to identify single-ventricle physiology are incomplete.

195   Some diagnoses (for instance, atrioventricular canal) include a heterogeneous range of defects

196   that may involve either single-ventricle or two-ventricle physiology, depending on severity. ICD-

197   9 codes cannot differentiate the single-ventricle subset of these patients. However, it is most

198   likely that classification error underestimates the single-ventricle population, suggesting that the

199   differences we observed might be even more pronounced if we were able to identify all single-

200   ventricle patients.

201   Second, resource utilization information is available only for the entire hospital

202   admission, which precludes knowledge of the distribution of individual contributors to resource

203   utilization (e.g. medication costs, supplies, procedures). This analysis offers information on

204   resource utilization in admissions of patients undergoing tracheostomy, but it cannot elucidate the

205   resources specifically devoted to tracheostomy itself as compared to other care provided in the

206   same admission.

207   Third, total hospital charges as reported in the NIS represent hospital billing, not actual

208   expenditures or reimbursement. The complex, nonlinear relationships between hospital charges,

209   hospital costs, insurance reimbursement, and patient co-payments complicate the extrapolation of

210   these results to an estimation of the true societal cost of inpatient care in children with a

211   tracheostomy. However, to the degree that the relationship between charges, costs, and other

212   parameters does not change drastically over short periods of time, hospital charges at minimum

213   are useful for analysis of resource utilization trends, allow for aggregation of data at the national

214   level, and give some sense of the magnitude of resource utilization devoted to this population.

215   Fourth, KID provides data only triennially, and its sampling frame does change slightly

216   from year to year. Discharge weights adjust to produce national estimates for each year, and we

217   also attempted to address this by ensuring that the ICD9 codes used to identify tracheostomy have

218   not changed during the study period.(National Center for Health Statistics and the Centers for

219   Medicare & & Services, 2013)

220   Fifth, the trend analyses were limited by a small amount of missing data (8.6% of all

221   records did not include the month of admission, only the year). We believe the benefit of greater

222   data granularity outweighed the downsides of this limitation, as use of year only would

223   significantly limit the power of trend analyses and would prohibit any adjustment for seasonal

224   fluctuations.

225   Despite these limitations, this analysis is useful in demonstrating the relative trends in

226   performance of tracheostomy and its resource utilization implications. It captures national

227   practice patterns and outcomes to demonstrate that tracheostomy is an increasingly common

228   intervention in children with CHD, and in children undergoing heart surgery during the same

229   admission, is usually performed significantly later (on average, 49 days) in the admission. It

230   outlines important demographic and clinical differences between children with CHD who

231   undergo tracheostomy and children without CHD who undergo tracheostomy. Future studies must

232   build on these results to further investigate the benefits of early vs late tracheostomy, to

233   determine if the significant resource utilization associated with tracheostomy improves overall

234   resource utilization, recovery, or long-term outcomes. Our subgroup analysis of single-ventricle

235   patients suggests that in particular, focused studies analyzing the benefits of tracheostomy in this

236   subpopulation will be revealing.

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Figure 1

National estimates of total admissions including the performance of tracheostomy by month

Children with CHD (blue bars; increasing trend, p<0.0001); children without CHD (red bars; increasing trend, p<0.0001).

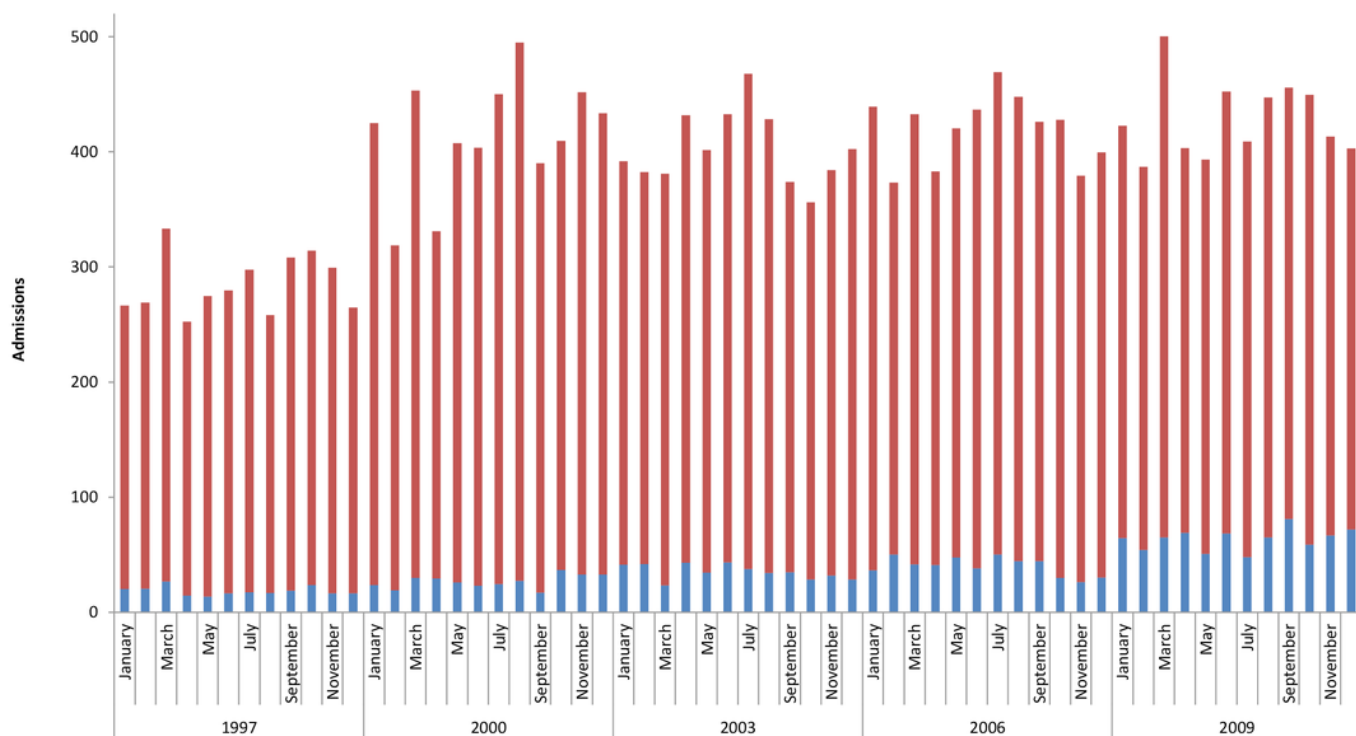



Figure 2

Proportion of all pediatric admissions with performance of a tracheostomy accounted for by children with CHD, by month.

Increasing trend, p<0.0001.

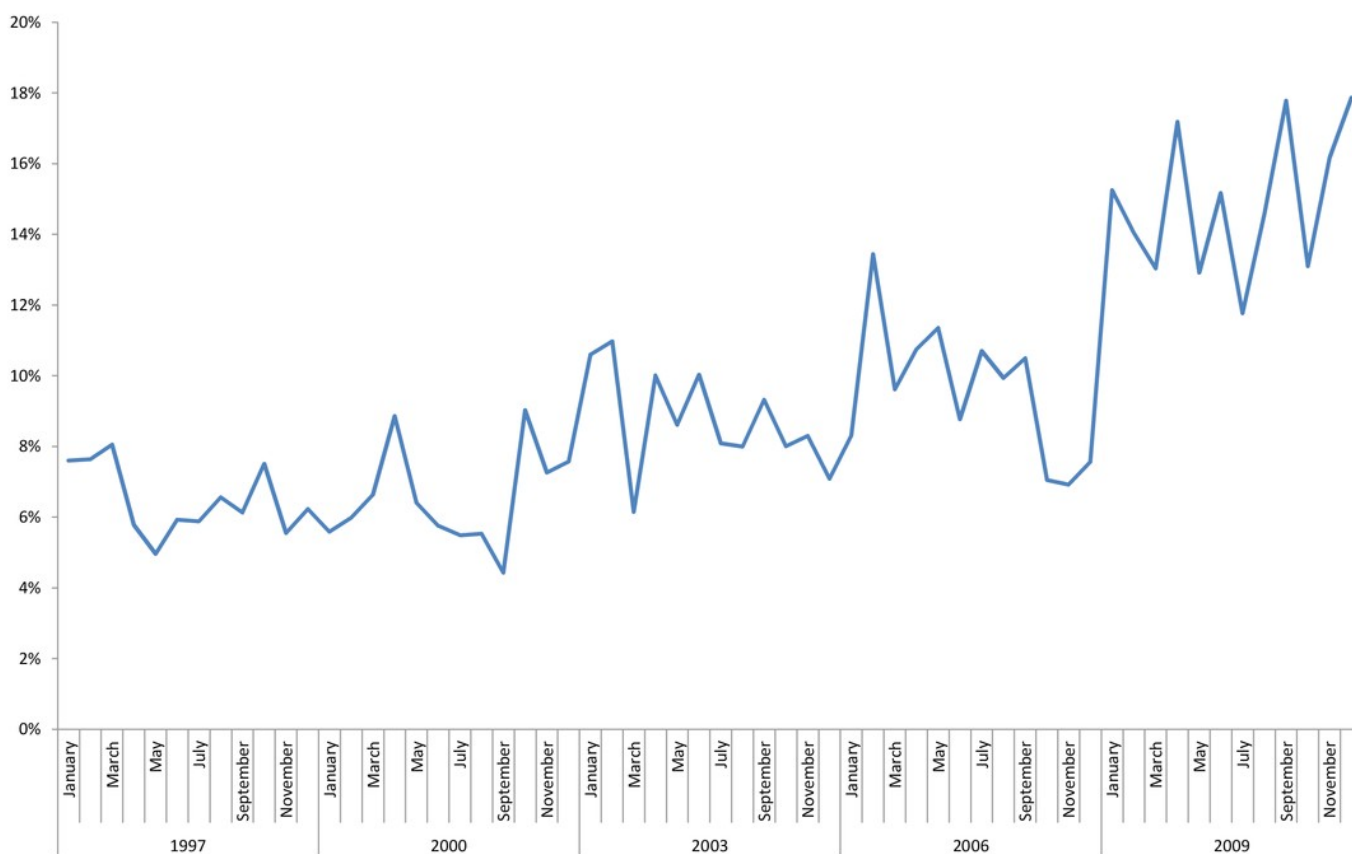



Figure 3

Percentage of all admissions of children with CHD that involve performance of a tracheostomy.

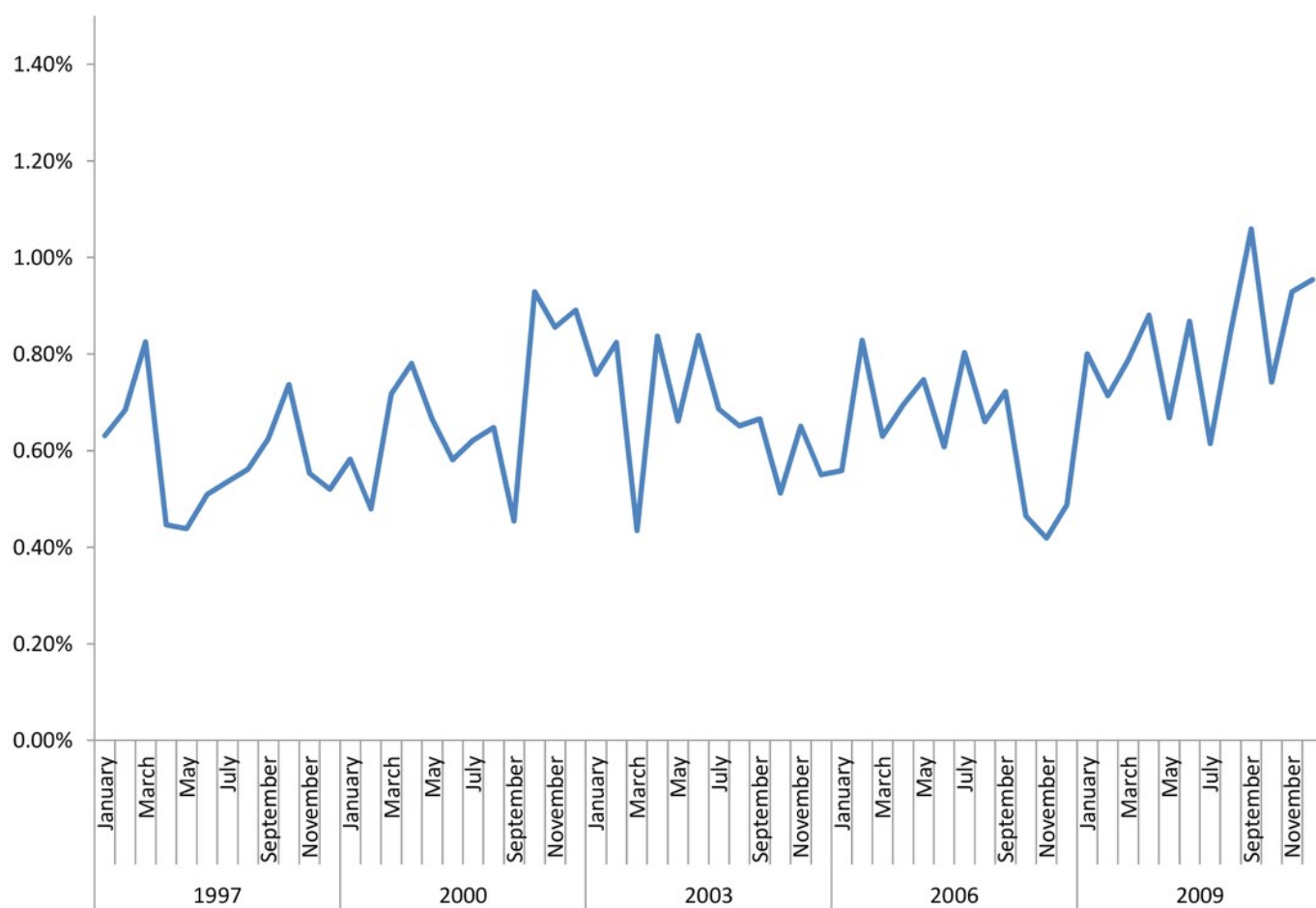
Increasing trend, p<0.0001.

Characteristics of children with and without congenital heart disease undergoing tracheostomy.

Table 1: Characteristics of children with and without congenital heart disease undergoing tracheostomy.

	CHD n=2495		No CHD n=23433		p
	n	%	n	%	
Age (years)	1.2	± 0.1	11.2	± 0.2	<0.0001
Age category					<0.0001
Birth admission	513	(20.6%)	1453	(6.2%)	
<1yr, readmission since birth	1631	(65.4%)	4462	(19.0%)	
age 1-4	190	(7.6%)	1771	(7.6%)	
age 5-9	42	(1.7%)	940	(4.0%)	
age >=10	119	(4.8%)	14807	(63.2%)	
Sex					<0.0001
Male	1284	(51.5%)	15083	(64.4%)	
Female	1211	(48.5%)	8350	(35.6%)	
Race					<0.0001
White	913	(36.6%)	9682	(41.3%)	
Black	391	(15.7%)	3803	(16.2%)	
Hispanic	465	(18.6%)	3311	(14.1%)	
Asian	51	(2.0%)	475	(2.0%)	
Other/Missing	675	(27.0%)	6162	(26.3%)	
van Walraven score	4.0	± 0.2	4.1	± 0.1	0.2958
Genetic syndrome	254	(10.2%)	353	(1.5%)	<0.00
Pulmonary hypertension	241	(9.7%)	405	(1.7%)	<0.00
Vocal cord paralysis/paresis	150	(6.0%)	864	(3.7%)	<0.00
Tracheal/bronchial pathology	706	(28.3%)	2428	(10.4%)	<0.00
Respiratory failure	1383	(55.4%)	1374	(58.6%)	0.008
Payer					<0.0001
Medicare	**	**	84	(0.4%)	
Medicaid	1390	(55.7%)	9936	(42.4%)	
Private insurance	947	(38.0%)	10859	(46.3%)	
Self-pay/other	154	(6.2%)	2554	(10.9%)	
Hospital Setting					<0.0001
Rural	16	(0.7%)	415	(1.8%)	
Urban, nonteaching	250	(10.0%)	3501	(14.9%)	
Urban, teaching	2229	(89.3%)	19517	(83.3%)	
Hospital Type*					<0.0001

Children's general hospital	759	(30.4%)	3393	(14.5%)
Children's specialty hospital	**	**	42	(0.2%)
Children's unit in a general hospital	1103	(44.2%)	9085	(38.8%)
Not identified as a children's hospital	633	(25.4%)	10913	(46.6%)

**number not reported in keeping with KID privacy rules for cells with n<10. True values used to calculate p values.

Values are number (percentage) or mean ± standard error, as appropriate.

Outcomes of tracheostomy in children with and without congenital heart disease.

Table 2: Outcomes of tracheostomy in children with and without congenital heart disease.

	CHD n=2495		No CHD n=23433		p
	n	%	n	%	
Days from admission to tracheostomy	47.0	± 1.8	18.4	± 0.5	<0.0001
Length of stay (days)	98.6	± 2.5	47.4	± 0.9	<0.0001
Total hospital charges	$603,651	± $16,479	$368,956	± $7,344	<0.0001
Discharge disposition (of alive discharges)					<0.0001
Home, routine	862	(41.3%)	7673	(35.1%)	
Home with home health	581	(27.8%)	3571	(16.3%)	
Nursing facility/subacute/long-term care	645	(30.9%)	10636	(48.6%)	
Mortality	407	(16.3%)	1553	(6.6%)	<0.0001

Values are number (percentage) or mean ± standard error, as appropriate.

Characteristics of children with congenital heart disease undergoing tracheostomy in admissions involving cardiac surgery or nonsurgical admissions.

Table 3:   Characteristics of children with congenital heart disease undergoing tracheostomy in admissions involving cardiac surgery or nonsurgical admissions.

	Cardiac surgery n=590		No cardiac surgery n=1905		p
	n	%	n	%	
Age (years)	1.3	± 0.2	1.1	± 0.1	0.11
Age category					<0.0001
Birth admission	64	(10.9%)	448	(23.5%)	
<1yr, readmission since birth	431	(73.0%)	1200	(63.0%)	
age 1-4	56	(9.5%)	134	(7.0%)	
age 5-9	**	**	36	(1.9%)	
age >=10	32	(5.5%)	87	(4.6%)	
Sex					0.76
Male	300	(50.9%)	984	(51.7%)	
Female	290	(49.1%)	921	(48.3%)	
Race					0.0011
White	221	(37.5%)	692	(36.3%)	
Black	53	(8.9%)	338	(17.8%)	
Hispanic	122	(20.8%)	343	(18.0%)	
Asian	**	**	43	(2.2%)	
Other/Missing	185	(31.4%)	489	(25.7%)	
van Walraven score	5.2	± 0.3	3.7	± 0.2	<0.0001
Genetic syndrome	51	(8.6%)	212	(11.1%)	0.20
Pulmonary hypertension	68	(11.5%)	174	(9.1%)	0.18
Vocal cord paralysis/paresis	54	(9.1%)	96	(5.1%)	0.016
Tracheal/bronchial pathology	112	(18.9%)	488	(25.6%)	0.007
Respiratory failure	400	(67.8%)	983	(51.6%)	<0.0001

Payer					0.59
Medicare	**	**	**	**	
Medicaid	327	(55.5%)	1063	(55.8%)	
Private insurance	219	(37.1%)	729	(38.3%)	
Self-pay/other	44	(7.5%)	110	(5.8%)	
Hospital Setting					0.031
Rural	**	**	13	(0.7%)	
Urban, nonteaching	36	(6.2%)	213	(11.2%)	
Urban, teaching	550	(93.2%)	1679	(88.1%)	
Hospital Type*					<0.0001
Children's general hospital	242	(41.1%)	516	(27.1%)	
Children's specialty hospital	**	**	**	**	
Children's unit in a general hospital	261	(44.3%)	842	(44.2%)	
Not identified as a children's hospital	87	(14.7%)	547	(28.7%)	

**number not reported in keeping with KID privacy rules for cells with n<10. True values used to calculate p values.

Values are number (percentage) or mean ± standard error, as appropriate.

Outcomes of tracheostomy in children with congenital heart disease during cardiac surgical or nonsurgical admissions.

Table 4: Outcomes of tracheostomy in children with congenital heart disease during cardiac surgical or nonsurgical admissions.

	Cardiac surgery n=590		No cardiac surgery n=1905		p
	n	%	n	%	
Days from admission to cardiac surgery	28.5	± 4.0			
Days from admission to tracheostomy	64.8	± 3.7	42.2	± 1.9	<0.0001
Timing of tracheostomy relative to cardiac surgery					
Same day	18	(3.1%)			
Tracheostomy before cardiac surgery	62	(10.5%)			
Days from admission to tracheostomy	44.3	± 4.1			
Days from tracheostomy to cardiac surgery	46.6	± 9.5			
Days from admission to cardiac surgery	74.1	± 14.5			
Tracheostomy after cardiac surgery	510	(86.4%)			
Days from admission to cardiac surgery	22.7	± 4.1			
Days from cardiac surgery to tracheostomy	49.6	± 3.1			
Days from admission to tracheostomy	72.3	± 4.5			
Length of stay (days)	119.2	± 5.2	92.3	± 2.5	<0.0001
Total hospital charges	$844,914	± $32,124	$548,515	± $17,660	<0.0001
Discharge disposition (of alive discharges)					0.20
Home, routine	255	(43.2%)	776	(40.8%)	
Home with home health	139	(23.5%)	553	(29.1%)	
Nursing facility/subacute/long-term care	196	(33.2%)	576	(30.3%)	
Mortality	133	(22.5%)	274	(14.4%)	<0.0001

Values are number (percentage) or mean ± standard error, as appropriate.

Outcomes of tracheostomy in children with congenital heart disease and single-ventricle physiology compared to children with congenital heart disease and two-ventricle physiology.

Table 5: Outcomes of tracheostomy in children with congenital heart disease and single-ventricle physiology compared to children with congenital heart disease and two-ventricle physiology.

	Single-ventricle n=169		Two-ventricle n=2326		p
	n	%	n	%	
Age (years)	1.9	± 0.4	1.1	± 0.1	0.003
Days from admission to tracheostomy	60.0	± 5.0	46.2	± 1.9	0.0005
Cardiac surgical admission	110	(65.1%)	480	(20.6%)	<0.0001
Days from admission to cardiac surgery	21.6	± 9.2	29.8	± 4.4	0.22
Timing of tracheostomy relative to cardiac surgery					0.11
Same day	**	**	13	(2.7%)	
Tracheostomy before cardiac surgery	**	**	56	(11.7%)	
Tracheostomy after cardiac surgery	99	(90.0%)	411	(85.6%)	
Length of stay (days)	104.2	± 7.4	98.2	± 2.6	0.029
Total hospital charges	$754,764	± $47,887	$593,437	± $17,028	<0.0001
Discharge disposition (of alive discharges)					0.36
Home, routine	74	(43.8%)	957	(41.1%)	
Home with home health	34	(20.1%)	656	(28.2%)	
Nursing facility/subacute/long-term care	61	(36.1%)	713	(30.7%)	
Mortality	60	(35.5%)	347	(14.9%)	<0.0001

**number not reported in keeping with KID privacy rules for cells with n<10. True values used to calculate p values.

Values are number (percentage) or mean ± standard error, as appropriate.