Tracheostomy after pediatric cardiac surgery: Frequency, indications, and outcomes

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Objectives: This study was designed to review baseline characteristics and outcomes of children requiring tracheostomy after cardiac surgery.

Methods: A retrospective review of children under age 2 requiring tracheostomy after cardiac surgery between January 1999 and December 2005 was performed. Indications for tracheostomy, survival, and completion of staged palliation were documented.

Results: After cardiac surgery, 59 (1.3%) of 4503 patients with a median age at surgery of 15 days and weight of 3.5 kg required tracheostomy. Median duration from surgery to tracheostomy was 36 days (range 10–145 days). Genetic syndromes or major noncardiac comorbidities were present in 40% of patients. Biventricular repair was performed in 34 patients and univentricular repair in 25. Tetralogy of Fallot variants (29%) and coarctation ± ventricular septal defect (21%) constituted the majority of biventricular lesions associated with tracheostomy, whereas unbalanced atrioventricular septal defect and hypoplastic left heart syndrome with highly restrictive atrial septal defect accounted for 52% of the single ventricle group. Indications for tracheostomy included the following: multifactorial (37%), tracheobronchomalacia, (24%), cardiac (12%), bilateral vocal cord paralysis (10%), bilateral diaphragm paralysis (2%), and other airway issues (15%). Hospital survival was 75% with intermediate-term (median, 25.5 months; range, 1–122 months) survival of 53%. Of 25 single ventricle patients, 6 (24%) had successful completion of the Fontan procedure. Of 12 patients with single ventricle who were ventilator-dependent after initial repair, 10 died, 1 remains at hemi-Fontan, and 1 has undergone completion of the Fontan procedure.

Conclusions: Requirement for tracheostomy in pediatric patients after cardiac surgery was associated with significant mortality. Patients with single ventricle have the highest late death rate and those with chronic ventilator dependency were unlikely to undergo successful Fontan completion. (J Thorac Cardiovasc Surg 2011;141:413-8)

Although the vast majority of children undergoing cardiovascular surgery tolerate early extubation, some require prolonged ventilatory support and are unable to be weaned from mechanical ventilation. Such patients often require tracheostomy to facilitate long-term mechanical ventilation. Other patients may have congenital airway anomalies, or postoperative airway complications may develop, which necessitate tracheostomy for airway maintenance. Additionally, many children undergoing surgery for congenital heart disease have genetic syndromes such as 22q11 deletion syndrome, which can be associated with airway and facial abnormalities. Previous studies have shown that airway issues prolong mechanical ventilation and increase length of stay in the intensive care unit (ICU) in infants after cardiac surgery.[1-3] Additionally, infants and children undergoing cardiac surgery, particularly patients with single ventricle undergoing multiple repairs, are at risk for surgical complications that increase the risk for respiratory compromise. These include hemidiaphragm paralysis and vocal cord paralysis for those patients undergoing complex aortic arch repairs.

Early reports did not demonstrate increased mortality with prolonged mechanical ventilation, although more recent reports have demonstrated increased mortality and prolonged ICU stay in neonates undergoing cardiac surgery.[4,5] Early tracheostomy is common in adults after cardiac surgery, with data demonstrating higher mortality and ICU length of stay in patients undergoing delayed tracheostomy.[6] There are no established criteria or routine practices in the pediatric population. Data from the pediatric population are limited to small, single-center reviews, with results highly dependent on the patient population and practice patterns of the particular study center.[7-9] There are no studies specifically examining outcomes of patients with single ventricle, including Fontan completion rates. Inasmuch as tracheostomy is likely a surrogate for poor hemodynamic or pulmonary status, it is likely to predict patient outcomes including the ability to proceed successfully through the Fontan procedure. The

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Abbreviations and Acronyms

HLHS = hypoplastic left heart syndrome
ICU = intensive care unit
VACTERL = vertebral abnormalities, anal atresia, cardiac abnormalities, tracheoesophageal fistula and/or esophageal atresia, renal agenesis and dysplasia, and limb defects

aims of this study were to describe the indications for tracheostomy in infants and children undergoing cardiac surgery, as well as the outcomes of these patients, particularly those with single ventricle physiology.

METHODS

A retrospective review was performed at a single center. Patient admissions to the congenital heart center service were identified using ICD-9 tracheostomy codes. All children less than 2 years old with congenital heart disease undergoing tracheostomy between January 1999 and December 2005 were studied. The vast majority of patients underwent diagnostic bronchoscopic examination before or at the time of tracheostomy. Institutional Review Board approval from the University of Michigan was obtained with waiver of informed consent.

Baseline Data

Baseline data including demographics, cardiac diagnosis, and surgical procedure performed were documented. If multiple cardiac anomalies were present, the most hemodynamically significant lesion was used. Presence of genetic syndromes and other noncardiac comorbidities were also recorded. Comorbidities were included if they required intervention in the neonatal period or infancy (ie, tracheoesophageal fistula or congenital diaphragmatic hernia).

Indications for Tracheostomy

Potential indications for tracheostomy included tracheobronchomalacia, tracheal and subglottic stenosis, vocal cord paralysis, other upper airway issues, suboptimal hemodynamics, and diaphragm paralysis. The indication for tracheostomy was determined by a panel of reviewers consisting of 2 pediatric cardiac intensivists (T.C. and R.G.) and an attending pediatric otolaryngologist (M.T.). For patients in whom one precise etiology could not be determined or agreed on, the indication was deemed multifactorial and the likely factors were explicitly stated. Suboptimal hemodynamic status was defined as moderate or worse systemic ventricular function, moderate or greater atrioventricular valve insufficiency, significant hypoxemia, or other significant residual disease. These indications were labeled ''cardiac'' for the purposes of this analysis.

Outcome Measures

Short-term survival (ie, survival to hospital discharge) was recorded. Intermediate-term survival was defined as survival to most-recent follow-up. The need for mechanical ventilation at the time of hospital discharge was also documented. The records for patients undergoing staged palliation were examined to determine whether patients successfully completed their palliative series, including successful completion of the Fontan procedure. Finally, records were reviewed to determine whether patients had been successfully decannulated and, if so, to document the time from the date of tracheostomy to decannulation.

Statistical Analysis

Statistical analysis was performed using GraphPad InStat version 3.06 (GraphPad Software, San Diego, Calif). Medians (ranges) or means (standard deviations) were used to express descriptive data. Categorical data were assessed using contingency tables and χ^2 or Fisher's exact test as appropriate.

RESULTS

Baseline Characteristics

A total of 4503 cardiac procedures were performed in children less than 2 years of age during the 7-year study period. A total of 59 (1.3%) patients required tracheostomy after cardiac surgery. Of these, 25 (11 girls) patients had single ventricle anatomy, and 34 (16 girls) had biventricular anatomy. The median age at surgery was 15 days (range, 1–581 days), with a median weight of 3.5 kg (range, 1.9–11.1 kg). The median duration from the date of surgery to tracheostomy was 36 days (range, 10–145 days) and the median length of hospital stay was 62 days (range, 6–345 days). Median duration of follow-up for survivors to hospital discharge was 47 months (range, 1–122 months). One patient was lost to follow-up after transfer to an outside hospital. A total of 24 (40%) patients had a genetic syndrome or major noncardiac comorbidity. Common genetic syndromes included Down syndrome in 5 patients, DiGeorge syndrome in 4 patients, and VACTERL (vertebral abnormalities, anal atresia, cardiac abnormalities, tracheoesophageal fistula and/or esophageal atresia, renal agenesis and dysplasia, and limb defects) in 4 patients. Other chromosomal abnormalities of unclear significance (unbalanced translocation of chromosomes 4 and 8, as well as a partial duplication of chromosome 9) were also seen. In terms of noncardiac issues, Pierre Robin sequence was present in 4 patients, omphalocele in 2 patients, and Dandy–Walker malformation, large encephalocele, and congenital rubella syndrome in 1 patient each. Of the 25 patients with single ventricle, 4 (16%) had a genetic syndrome or major comorbidity compared with 20 of 34 (59%) patients undergoing biventricular repairs ($P = .0012$).

The underlying cardiac diagnoses for patients requiring tracheostomy are shown in Table 1. A large proportion of patients (35%) had conoventricular lesions including tetralogy of Fallot with or without associated lesions including absent pulmonary valve, pulmonary atresia, and interrupted aortic arch. Coarctation of the aorta with or without ventricular septal defect accounted for 21% of patients, and vascular rings and slings accounted for an additional 12% of patients requiring tracheostomy. High-risk single ventricle anatomy comprised a disproportionate degree of patients with single ventricle who required tracheostomy. Of 25 patients with single ventricle, 7 had complete atrioventricular septal defect, 6 hypoplastic left heart syndrome (HLHS) with highly restrictive or intact atrial septa, 1 HLHS with moderate–severe tricuspid regurgitation, 1 with tricuspid