



Airway evaluation in children with single ventricle cardiac physiology[☆]

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ABSTRACT

Objective: Children with single ventricle cardiac physiology (SVC) often require airway procedures as an adjunct to their care. Descriptive analysis with a focus on outcomes of airway procedures in SVC patients have not been fully described in the literature.

Methods: Retrospective, single-center cohort review of 270 patients born between Aug-2007 and Jan-2017. Patients were identified by cardiac database for single ventricle pathophysiology. A subset of these patients were identified to have been evaluated by otolaryngology with airway evaluations and/or interventions.

Results: 88/270 patients (32.6%) required investigation or intervention for airway pathology. The most frequent procedure was flexible fiberoptic laryngoscopy (58/88 patients); it was the only procedure performed in 40 patients. Seventeen patients required tracheostomies with an associated increased length of stay ($p < 0.001$). Patients with cardiac procedures involving dissection around the aortic arch were considered higher airway risk due to the threat of recurrent laryngeal nerve injury, and were more likely to have vocal cord paralysis (58%) compared to patients with lower risk procedures (21%; $p < 0.001$). However, on multivariate logistic regression, vocal cord paralysis did not statistically impact the odds for tracheostomy placement, although the presence of subglottic stenosis increased the odds ratio of tracheostomy by 14.7 ($p = 0.02$).

Conclusions: Children with SVC often require airway evaluation and intervention. Patients with high risk cardiac procedures had a higher risk of recurrent laryngeal nerve injury but the presence of subglottic stenosis was the best predictor for a tracheostomy. This study represents one of the largest series of SVC children evaluated for airway pathology.

1. Introduction

The incidence of children born with single ventricle physiology (SVC) in the USA has been reported to be approximately between 4 and 8 per 10,000 live births [1,2]. Children with single ventricle physiology (SVC) are at increased risk for adverse outcomes associated with anesthetics and tracheostomies [3]. Various studies demonstrate that requirement for tracheostomy in SVC children, particularly after cardiac surgery, is associated with high mortality [4–6]. Other studies show that mortality rates for tracheostomies in SVC children after hospital discharge are also high [7,8]. Often SVC children require airway procedures to facilitate ventilation or prevent airway compromise.

Currently, there is limited information in the literature regarding the types of airway procedures done in this high-risk patient population and long-term outcomes. This study aims to 1) describe the incidence and types of airway procedures performed on SVC patients after cardiac

surgery, 2) compare vocal cord paralysis in patients who underwent risk-stratified cardiac surgeries, 3) determine predictors for need for tracheostomies in this patient population, and 4) compare mortality of patients with and without tracheostomies.

2. Materials and methods

After institutional review board approval was obtained, a retrospective review of children (age < 18 years old) treated for single-ventricle palliation at the authors' institution between August 2007 and January 2017 was completed. Patients were identified for single ventricle physiology by the pediatric cardiothoracic database. A subset of these patients was identified to have been evaluated by otolaryngology with airway evaluations and/or interventions.

The cardiac procedures were risk-stratified based on the amount of dissection required around the aortic arch, risking injury to the

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Table 1
Demographics.

Gender	n	%
Male	55	63
Female	33	37
Ethnicity	n	%
African American	19	22
Caucasian	27	31
Other	38	43
Unknown	4	4

recurrent laryngeal nerve. Outcome measures included ICU length of stay, time variables related to the performance of airway procedures, indications and outcomes for these procedures were collected.

2.1. Statistical methods

Descriptive statistics were performed to summarize the clinical data based on procedure type, indications, and outcomes. Multivariate analysis with logistic regression was used to assess factors associated with tracheostomy and vocal fold paralysis. Survival analysis with Kaplan-Meier curve stratified by tracheostomy status was also conducted. Analysis was performed with STATA 14.2 (College Station, TX).

3. Results

The cohort patient population comprised of 270 patients (demographics in Table 1). 88/270 patients (32.6%) required investigation or intervention for airway pathology, the most frequent procedure being flexible fiberoptic laryngoscopy (FFL, 58/88 patients). FFL was the only procedure performed in 40 patients. Over the study period, 169 procedures were performed on the 88 patients, although 71 of these procedures were FFL. The types and proportions of the remaining procedures performed has been outlined in Fig. 1. Fifty-three patients had only one procedure performed; the rest received up to 11 procedures (median of two procedures). Patients with only one procedure had a mean intensive care unit length of stay (ICU LOS) that was less than those that had more than one procedure (44 vs 90 days, $p < 0.001$).

There was no statistically significant difference in ICU LOS between patients who were admitted at birth compared to patients admitted 30 days nor more after birth ($p = 0.903$, 95% confidence interval (CI) [-46.10, 9.52]). Mortality rate was 15.9% (14/88 patients). These patients had a longer mean ICU length of stay (111 days, range 0–218 days) compared to patients who survived (74 days). Mean age of death was 9.48 months (stand deviation 9.12, range 3.72–36.12). In contrast,

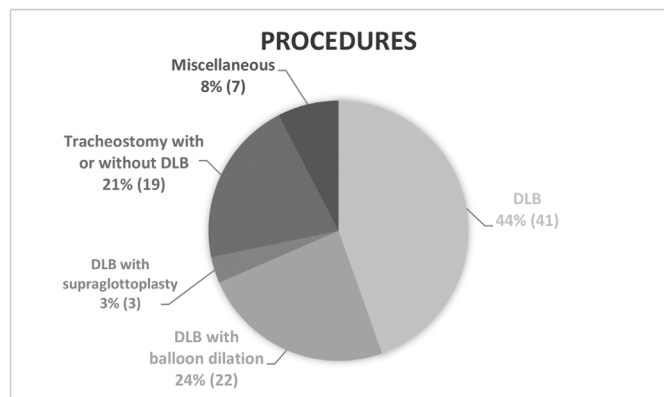


Fig. 1. Procedures performed in the Operating Room. DLB: Direct laryngoscopy and bronchoscopy, (n).

mortality rate for the 182 patients that did not require airway investigation or intervention was 23.6% (43/182), with a mean age of death of 6.48 months (stand deviation 9.36, range 0.12–45.12). The difference in the proportion of deaths between those patients that had airway intervention and those that did not was not statistically significant ($p = 0.15$).

A total of 18 tracheostomies were performed on 17 unique individuals. One patient had their tracheostomy tube removed to prevent a sternal wound infection after a Glenn procedure, but was not a candidate for decannulation, and was eventually brought back to the operating room to re-establish the tracheostomy. Logistic regression using tracheostomy as an outcome comparing various factors revealed an associated increased length of stay ($p < 0.001$, 95% CI [1.02, 1.06]), with an odds ratio (OR) of 1.04 for each increasing day a patient was in the ICU. The presence of subglottic stenosis increased the odds of tracheostomy (OR = 14.7; $p = 0.02$, 95% CI [1.68, 128.5]). Odds ratios for supraglottic edema and laryngotracheobronchomalacia were not statistically significant (OR = 0.07, $p = 0.09$, 95% CI [0.004, 1.05]; OR = 0.17, $p = 0.08$, 95% CI [0.02, 1.21], respectively). There was no statistically significant association between tracheostomy placement and age, gestational age at birth, gender, ethnicity, or insurance type. Kaplan-Meier survival analysis (Fig. 2) estimated an increased hazard ratio for death of 2.59 for patients with a tracheostomy ($p = 0.08$, 95% CI [0.9, 7.7]).

All primary cardiac procedures (Table 2) were risk-stratified based on the amount of dissection required around the aortic arch. Norwood procedures were the most common cardiac procedure performed. Overall, 37/88 (42%) of this patient population developed vocal cord paralysis. Patients with cardiac procedures involving dissection around the aortic arch were considered higher airway risk due to the threat of recurrent laryngeal nerve injury, and were more likely to have vocal cord paralysis (58%) compared to patients with lower risk procedures (21%; $p < 0.001$). However, on multivariate logistic regression, vocal cord paralysis did not statistically impact the odds ratio for tracheostomy placement. There was no statistically significant difference in hospital admission length of stay between high and low-risk patients (58 vs 60 days, $p = 0.211$). There was also no statistically significant difference between the proportion of ventilator-dependent patients as stratified by cardiac risk (low vs high) on discharge (53% vs 44%, $p = 0.32$). A total of 49 patients were ventilator-dependent on discharge.

The findings during airway diagnostic procedures are presented in Fig. 3. Left vocal cord paralysis was the most common finding, followed by malacia in the airway.

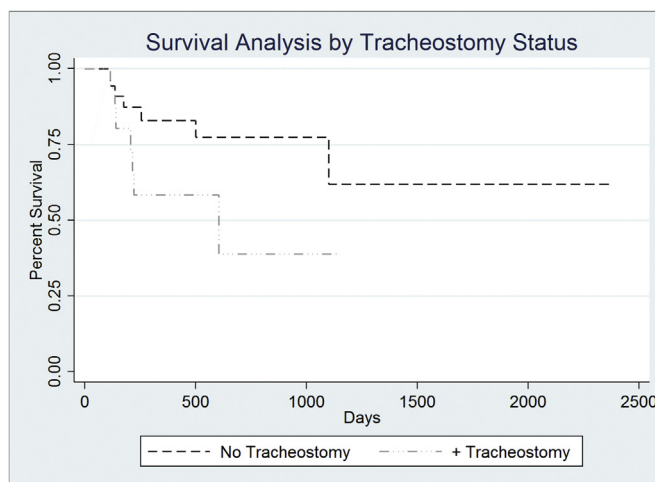


Fig. 2. Kaplan-Meier survival analysis by tracheostomy status. Hazard ratio of death = 2.586.

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