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RESEARCH ARTICLE

Role of Tracheostomy in Pediatric Patients Who Underwent Heart Surgery: A Single-Center Experience

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ABSTRACT

Objectives: This study aimed to review the characteristics and outcomes of children with congenital heart disease requiring tracheostomy after cardiac surgery.

Methods: Medical records of 65 out of 2814 consecutive patients who required tracheostomy after congenital heart surgery between March 2018 and March 2023 were retrospectively reviewed. Outcomes such as hospital survival, long-term survival, and weaning from positive pressure ventilation were elucidated.

Results: During the 5-year period, a total of 65 of 2814 (2.3%) patients required tracheostomy in the pediatric intensive care unit after surgery. The median patient age was 5 (range, 0.6–24) months and the median weight was 4.3 kg (range, 3.3–11). A total of 23 (35.5%) patients demonstrated a single-ventricle physiology while 42 (64.5%) patients manifested with biventricle physiology. A total of 11 (16.9%) patients were syndromic, including Down syndrome in 6 patients, Di George syndrome in 3 patients, and Williams syndrome in 2 patients. In the whole cohort (65 patients), the mean time to tracheostomy from cardiac surgery was 30±16 days. In-hospital mortality was noted in 20 of the patients (30.8%) who underwent tracheostomy. Twenty-six patients (40%) were decannulated and discharged without a tracheostomy, and 14 patients (22%) were discharged with a tracheostomy cannula and home-type mechanical ventilator (HMV).

Conclusion: Tracheostomy is a viable option for pediatric patients with prolonged mechanical ventilation after heart surgery for congenital heart disease. It creates an opportunity to discharge patients on HMV, if repeated attempts of extubation and decannulation fail, albeit with potential risks.

Keywords: Mechanical ventilation, pediatric intensive care unit, tracheostomy

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Introduction

Congenital heart disease (CHD) may manifest as part of a genetic syndrome, which affects multiple organ systems; however, it can also present as an isolated defect that can potentially affect other organ systems as a result of pathophysiology or due to complications during the treatment course. Pediatric patients with congenital heart defects are already at risk of respiratory problems, as most of these patients are born with immature lungs and have syndromes with facial and airway deformities (such as 22q11 deletion syndrome; trisomy 21; and coloboma, heart defect, choanal atresia, retarded growth and development, and ear deformity; and vertebral defects, anal atresia, cardiac defects, tracheo-esophageal fistula, renal anomalies, and limb abnormalities), which can predispose affected children to airway problems, pulmonary artery or vein anomalies, aortopulmonary collaterals or pulmonary hypertension, immune deficiencies, and recurrence of pulmonary infections. Patients undergoing heart surgery are prone to respiratory complications preoperatively, perioperatively, and postoperatively not only because of the predisposing factors, but also due to possible postoperative complications such as low cardiac output syndrome, prolonged mechanical circulatory support, pulmonary edema, neurological disorders, hospital-acquired infections, and di-

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aphragm or vocal cord paralysis, which may increase the risk of prolonged mechanical ventilatory support.

Prolonged mechanical ventilation after surgery for CHD is common and approximately 10% of children remained intubated after 7 days.[1,2] Most of these children will be eventually extubated; however, a small subset will require further intervention such as tracheostomy to facilitate long-term mechanical ventilation and possibly home ventilation.[3] After cardiac surgery, children are at an even higher risk of morbidity, with one study finding showing that children undergoing cardiac surgery have a fivefold risk of dying after tracheostomy than those without surgery.[4]

The indication for tracheostomy is multi-factorial even with or without the presence of a residual cardiac defect; however, prolonged mechanical ventilation and repeated failed extubation are the main indications documented in the patient charts. Additionally, the timing of tracheostomy is highly variable among studies.

This study aimed to determine the evolution of the decision-making process for our institution in terms of indications, timing, and management outcomes for the pediatric heart surgery patients who require long-term mechanical ventilatory support and who are candidates for tracheostomy.

Methods

A retrospective review of the medical records of 65 consecutive patients who required tracheostomy after congenital heart surgery between March 2018 and March 2023 was conducted. Data were retrospectively collected from the patient's previous hospital records. The medical records of the demographic characteristics, cardiac diagnosis, operative procedures, presence of genetic syndromes, and comorbidities were documented. The institutional ethics committee approved the study on 11/29/2022 (E-28001928-604.01.01) and was conducted in accordance with the principles of the Declaration of Helsinki. Since the trachea and airway of children with CHD are small, immature, and sometimes present with anomalies due to genetic disorders, tracheostomy cannulas are surgically inserted in all patients. The exclusion criteria included patients who underwent intervention secondary to congenital heart anomaly without undergoing surgery.

Patients were accepted as candidates for tracheostomy after failure of three elective extubation attempts, and the indications for tracheostomy included prolonged intubation, tracheobronchomalacia, tracheal and bronchial stenosis, vocal cord paralysis, hemodynamic instability, and diaphragmatic paralysis.

Surgical Technique

A horizontal skin incision is made 1–1.5 cm below the carotid cartilage in the anterior midline of the neck. After extending the incision into the platysma muscle, the sternohyoid and sternothyroid muscles are laterally retracted. The second and third tracheal rings are then determined. After the incision between the second and third ring, the tracheostomy tube is then placed. Thereafter, the tube is connected to the anesthesia circuit and confirmed using end-tidal CO_2.

Statistical Analysis

Continuous variables were reported as the mean±standard deviation for normally distributed variables and as the median (range) for non-normally distributed variables. Categorical variables were reported as n (%). For all statistical analyses, the IBM SPSS Statistics Software 21 (SPSS Inc., Chicago, IL, USA) was used.

Results

During the 5-year period, a total of 65 out of 2814 (2.3%) patients required tracheostomy in the pediatric intensive care unit (ICU) after a pediatric cardiac operation, and the male/female ratio was 32 out of 33. The median age of the patients was 5 (range, 0.6–24) months and the median weight of the patients was 4.3 (range, 3.3–11) kg. Twenty-three (35.5%) patients had a single-ventricle physiology while 42 (64.5%) patients presented with biventricle physiology. A total of 11 (16.9 %) patients were syndromic, including Down syndrome in 6 patients, Di-George syndrome in 3 patients, and Williams syndrome in 2 patients. A total of 23 patients (35%) required preoperative mechanical ventilation and 26 patients (40%) had a history of prior hospitalization. The median cardiopulmonary bypass and aortic cross-clamp times were 83 min (range, 59–106) and 144 min (range, 103–194), respectively. Antegrade cerebral perfusion was used for a median of 20 min (range, 16–28) in 17 patients (Table 1).

Sternal closure was delayed in 42 patients (64.6%) with a mean of 4.3±2.9 days. Owing to mediastinitis or delayed sternal closure in six patients (9.2%), vacuum-assisted closure therapy was performed. Sudden cardiac arrest occurred in nine patients (9.2%). Of all patients, 22 out of 65 (34%) required postoperative extracorporeal membrane oxygenation (ECMO) support due to cardiopulmonary resuscitation or low cardiac output. In the early postoperative period, left diaphragm plication was conducted in 15 patients and bilateral diaphragmatic plication was performed in three patients due to diaphragmatic paralysis. Renal replacement therapy with peritoneal dialysis was performed in 38 (58.4%) patients. Chylothorax developed in 21 patients (32.3%), and thoracic duct ligation was performed in five patients. Pneumonia and sepsis (confirmed through microbiological cultures) were observed in 51 (78.4%) and 16 (24.6%) patients, respectively, and the medical therapy was administered according to the antibiograms (Table 1).

Table 1. Patient characteristics

Variables (%, mean±SD, median (range))	All patients (n=65)	
	n	%
Gender		
Male	32	49.2
Female	33	50.8
Age (months)	5 (0.6–24)	
Weight (kg)	4.3 (3.3–11)	
Syndrome	11	16.9
Down	6	9.2
Di-George	3	4.6
Williams	2	3.1
Cardiac physiology		
Univentricular heart	23	35.3
Biventricular heart	42	64.7
Preoperative status		
Hospitalization	26	40
Need of MV	23	35
Type of surgery		
Palliative	31	47.7
Corrective	34	52.3
CC time (min)	83 (59–106)	
CPB time (min)	144 (103–194)	
ASP time (min)	20 (16–28)	
Vasoactive inotrope score	21.4±9.8	
Complications		
Delayed sternal closure	42	64.6
Sternal closure time (day)	4.3±3.9	
VAC therapy	6	9.2
Sudden cardiac arrest	9	13.8
ECMO support	22	33.8
Diaphragmatic paralysis	18	27.5
Peritoneal dialysis	38	58.4
Chylothorax	21	32.3
Neurological event	9	13.8
Pneumonia	51	78.4
Sepsis	16	24.6

SD: Standard deviation; MV: Mechanical ventilation; CC: Cross clamp; CPB: Cardiopulmonary bypass; ASP: Antegrade cerebral perfusion; VAC: Vacuum assisted closure; ECMO: Extra Corporeal Membrane Oxygenator

Table 2. Summary of underlying congenital heart defects

Variables (%)	All patients (n=65)	
	n	%
Univentricular heart	23	35.3
Complex univentricular defects	9	13.8
Borderline LV	3	4.6
HLHS	7	10.8
Tricuspid atresia	2	3.1
IVS-PA	3	4.6
Biventricular Heart	42	64.7
TOF-CAVSD	1	1.5
VSD-PA	7	10.8
DORV	1	1.5
Vascular ring	2	3.1
Aortic stenosis	1	1.5
Arcus hypoplasia	5	7.7
Transposition of great arteries	7	10.8
Aortopulmonary window	2	3.1
CAVSD	3	4.6
Tetralogy of fallot	2	3.1
LVOTO	1	1.5
TOF-absent pulmonary valve	2	3.1
VSD	2	3.1
Pulmonary insufficiency	1	1.5
TAPVR	2	3.1
Shone's complex	2	3.1
Other	1	1.5

LV: Left ventricle; HLHS: Hypoplastic left heart syndrome; IVS: Intact ventricular septum; PA: Pulmonary atresia; DORV: Double outlet right ventricle; CAVSD: Complete atrioventricular septal defect; LVOTO: Left ventricular outflow tract obstruction; TOF: Tetralogy of fallot; VSD: Ventricular septal defect; TAPVR: Total anomalous pulmonary venous return

In the entire cohort (65 patients), the mean time to tracheostomy from cardiac surgery was 30±16 days. The median time for ICU stay after tracheostomy was 38 (21–108) days, while the mean time for ICU stay was 104±87 days. Furthermore, the mean time for hospital stay was 126±97 days. In-hospital mortality was noted in 20 of the patients (30.8%) who underwent tracheostomy. The mortality rate was 28.6% (12/42) in the biventricular heart subgroup and 34.7% (8/23) in the univentricular heart subgroup (Table 2). According to the surgery type, mortality rate was found in 7 out of 34 (20.5%) in the total correction subgroup and 13 out of 31 (41%) in the palliative surgery subgroup. The outcomes are presented in Table 3.

Five patients (7%) transferred to another institution under pediatric ICU for further noncardiopulmonary disease treatment. Three of these patients were decannulated and discharged after treatment completion with good recovery; however, two of them died during the follow-up at the last transferred center. Forty patients (62%) were discharged from our center and 26 (40%) were decannulated, discharged, and recovered, while 4 out of 26 died because of unknown reasons during follow-up. Twenty-two of these patients survived without any tracheostomy-related disability. A total of 14 patients (22%) were discharged with a tracheostomy cannula and home-type mechanical ventilator (HMV). In patients who could be discharged with an HMV; the mean follow-up time with

Table 3. Outcomes

Variables (%, mean±SD, median (range)	All patients (n=65)	
	n	%
Time to tracheostomy (day)	30±16	
PCICU stay with tracheostomy (day)	38 (21–108)	
Total PCICU stay (day)	104±87	
Total hospital stay (day)	126±97	
Follow-up duration with HMV (day)	254±101	
In hospital mortality	20	30.8
In hospital mortality (palliative operations)	13	41.9
In hospital mortality (total corrections)	7	20.5

SD: Standard deviation; PCICU: Pediatric cardiac intensive care unit; HMV: Home type mechanical ventilator

HMV was 254±101 days. Five of them (36%) were decannulated, and five of them (36%) survived with the help of HMV. Three of them (21%) died while on HMV and one of them was lost to follow-up (Fig. 1).

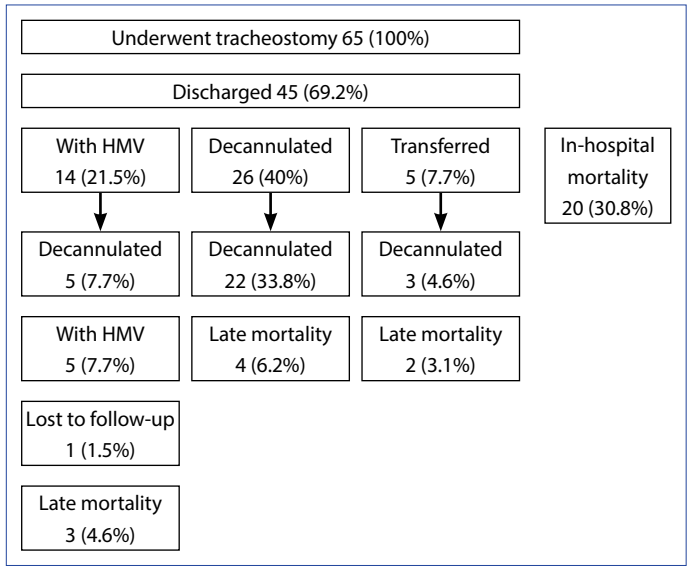

Figure 1. Follow-up chart of the patients.
HMV: Home-type mechanical ventilator.

Discussion

This study retrospectively reviewed the results of CHD and tracheostomy patients in the last 5 years at our hospital. A total of 2814 patients underwent surgery for CHD and 65 of these patients required tracheostomy throughout the course (2.3%). Published reports of patients requiring tracheostomy ranged from 0.2% to 2.7%.[5]

It is an established fact that pediatric cardiac patients who require a tracheostomy during the treatment course are at risk of a significantly higher mortality and morbidity rates compared to the normal population and other CHD patients who were treated without the need for tracheostomy. In the literature, the hospital survival following CHD surgery and tracheostomy is reported at approximately 60.5% to 80%[1,4,6,7] which is close to our series, where 40 out of 65 (62%) survived until discharge. Although pediatric patients with tracheostomy and CHD have a higher risk of mortality than other patients, precise comparisons remain unclear.[5]

Almost 20 years ago, an earlier report from our center retrospectively reviewed patients between 2002 and 2005, with a similar cohort entitled "Indications and results of tracheostomy in pediatric postoperative intensive care unit."[8] The patient population was similar; however, patients in our series are more complicated both for anatomical classification of the defects and surgical techniques that were used for repair. Additionally, experience and technological advancements already evolved that allowed optimal management of many sick children that had poor recovery in the earlier series, such as the use of ECMO that became routine practice after 2015.

Also, we had the opportunity to evaluate and compare two different time zones to assess how our clinic has evolved since then. In our series, the time on ventilator from the heart surgery to tracheostomy is longer (25.1±11 days vs. 30±16 days), the mean time for ICU stay was 55.8±17.3 days vs. 104±87 days, and the mean hospitalization time was 71.6±34.6 days vs. 126±97 days, respectively. The total mortality is 48% vs. 30.8%. In the days from the operation to tracheostomy, the length of ICU stay and the length of hospitalization were longer for our recent series, and the mortality rates remained better than before. Moreover, advancements in medicine were demonstrated in the cohort containing complex patients with hemodynamic instability, high inotrope scores, and a significant need for ECMO application, and technology allowed the pediatric cardiac team to be more equipped in pushing for survival in these patients. Technological advancements in the field of non-invasive ventilation treatment have also allowed the ICU team to afford more aggressive therapy for mechanical ventilator-dependent patients with CHD; thus, tracheostomy as an option is maintained as the last resort, if clinically warranted.

The distribution of the tracheostomy patients according to the univentricular versus biventricular pathways was also analyzed. There were 42 out of 65 patients in the biventricular group and 23 out of 65 in the univentricular group. In the biventricular patients, 34 patients underwent corrective procedures, where the mortality was 7 out of 34 and eight of them had palliative procedures and a mortality of 5 out of 8, with a total mortality of 12 out of 42. In the uni-

ventricular group, where the patients were managed with palliative surgical strategies, the mortality was 8 out of 23. When the cohort is stratified between corrective and palliative procedures, the mortality tends to be better for patients going through corrective procedures, with 7 out of 34 versus 13 out of 31. The reduced survival in single-ventricle patients may be attributed to the complex cardiopulmonary interactions, underlying pulmonary disease, and the requirement for low pulmonary vascular resistance to maintain a single-ventricle physiology.[5] Furthermore, the corrective pathway provides better hemodynamics, creating less complications through less residual defects.[6]

Tracheostomy is an essential procedure which facilitates patient care, ambulation, oral feeding, rehabilitation, and ventilator weaning and has been increasingly performed in children requiring prolonged mechanical ventilation; however, in children, a consensus is lacking regarding the indications and right timing.[9–11] In some patients with a tracheostomy, they could be discharged home with the HMV. In our series, 26 out of 65 patients (40%) were decannulated and discharged home with good recovery, and 14 patients (22%) were discharged with a tracheostomy cannula and HMV. Advantages of HMV include decreased hospital-acquired infections, increased mobility, improved nutrition, and decreased healthcare costs.[12] However, the safety profile of HMV especially out of the hospital is still questioned by both doctors and parents.

The study limitations include its retrospective design and the limited number of patients. As is typical for single-center studies, these results may not be applicable to all centers performing pediatric cardiac surgery.

Conclusion

Tracheostomy for children with CHD after pediatric heart surgery is rare and is associated with high risks; however, sometimes, it can be a life saver for patients that require prolonged mechanical ventilation and provides the patient, physician, and family an opportunity to decrease the hospitalization period, thus preventing infections, improving nutrition, increasing mobility, and lowering hospital costs.

Disclosures

Ethics Committee Approval: The study was approved by The Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee (Date: 29/11/2022, No: E-28001928-604.01.01).

Informed Consent: Written informed consent was obtained from all patients.

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