ORIGINAL ARTICLE

Outcome of tracheostomy after pediatric cardiac surgery

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Objective: **To investigate the incidence, timing indications and outcome of tracheotomy in children who underwent cardiac surgeries.**

Methods: **All pediatric cardiac patients (under 14 years of age) who underwent cardiac surgeries and required tracheotomy from November 2000 to November 2010 were reviewed. The data were collected and reviewed retrospectively.**

Results: **Sixteen children underwent tracheotomy after cardiac surgery. Fifteen of these cases had surgery for congenital heart disease, and one had surgery for an acquired rheumatic mitral valve disease. The mean ± SEMs of the durations of ventilation before and after tracheotomy were 60.4 ± 9.8 and 14.5 ± 4.79 days respectively (*P* value 0.0002). The means ± SEM of the lengths of ICU stay before and after tracheotomy were 63.31 ± 10.15 and 22 ± 5.4 days respectively (*P* value 0.0012). After the tracheotomy 12/16 patients (75%) were weaned from their ventilators and 10/16 were discharged from the PCICU. Six patients were discharged from the hospital and 3 were successfully decannulated. The overall survival rate was 9/16 (56%).**

Conclusion: **Tracheostomy shortens the duration of mechanical ventilation and facilitates discharge from the ICU. The mortality of tracheotomy patients is still significant but is mainly related to the primary cardiac disease.**

Keywords: Tracheostomy, Pediatric cardiac surgery, ICU stay, Ventilator associated pneumonia

Introduction

Extubation after pediatric cardiac surgery is feasible in the majority of patients; however, in a substantial minority of patients, extubation may not be achievable [1]. Failure to achieve extubation and the need for prolonged mechanical ventilation can influence early recovery after pediatric cardiac surgery and ultimately affect the outcome. Prolonged endotracheal tube (ET) intubation leads to many complications, including local trauma, accidental tube displacement, nosocomial infections, and aspiration around the ET, tracheal mucosal dysfunction and emotional and psychiatric problems [2].

Transforming the chronic artificial airway from a trans-laryngeal to a tracheostomy airway has many advantages. Tracheostomy placement provides a stable airway with a reduced risk for pulmonary infection and allows for a more rapid liberation from the ventilator. Furthermore, tracheostomy allows less

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sedation, easier nursing care and an improved chance of moving to chronic home ventilation rather than remaining in a critical care unit [1].

Tracheostomy in infants and children has been widely reported in patients with congenital and acquired airway abnormalities, but it has rarely been investigated in infants and children after cardiac surgery [1]. Children, particularly in cases after complex cardiac surgery, are prone to many respiratory complications, such as tracheal-bronchial malacia, vocal cord paralysis, external airway compression, and diaphragmatic paralysis. The development of such complications may hinder weaning and extubation and can lead to artificial airway dependence and chronic ventilation [3]. In pediatric patients, there is no clear and specific time indicated for moving the patient from an artificial trans-laryngeal airway to tracheostomy. Furthermore, there is a paucity of data concerning tracheostomy in pediatric cardiac patients. In this study, we aimed to review our experience with tracheostomy in pediatric cardiac patients. We investigated the need for this procedure after pediatric cardiac surgery, the indications, timing of the tracheostomy and its outcome.

Materials and methods

A retrospective study at King Abdulaziz Cardiac Center, King Abdulaziz Medical City, National Guard Health Affairs was carried out. All pediatric patients under the age of 14 years who underwent tracheostomy after cardiac surgery during the period from November 2000 to November 2010 were included. Patients included in the study were followed longitudinally. The demographic data, cardiac diagnosis, history of other non-cardiac diseases, number of extubation trials, tracheostomy timing, duration of mechanical ventilation before and after the tracheostomy, and length of the pediatric cardiac intensive care unit (PICU) stay before and after the tracheostomy were recorded. Data regarding the patient's respiratory, cardiac and neurological conditions prior to tracheostomy were also collected. The indications for tracheostomy were based on the physician's clinical judgment and diagnosis. If performed, the bronchoscopy findings were reported. The in-hospital mortality as well as the cause of death in the tracheostomy patients were recorded. The data in this study were represented as the mean ± standard errors of the mean (SEM) or percentage, as indicated. The study was approved by our institutional research committee. Data were analyzed using SPSS-16 for windows.

Results

During the 10-year study period, 16 patients met our inclusion criteria and underwent tracheostomy. During the same period 3344 cardiac surgeries were done in our center, the percentage of tracheostomies to cardiac surgeries was about 0.5%. Twelve of the 16 patients (75%) were females. The mean age and weight at the time of the tracheostomy were 20.6 ± 9.0 months and 7.7 ± 2.7 kg respectively. Eleven patients (69%) were less than 8 months of age, and nine patients (56%) weighed less than 4 kg.

The details of the cardiac diagnosis upon admission and the cardiac surgery performed are summarized in Table 1. Fifteen patients had surgery for congenital heart diseases (CHD), and one had surgery for acquired heart disease (severe rheumatic mitral valve regurgitation). Of the 15 patients with CHD, 12 underwent biventricular correction, and 3 underwent palliative surgical procedures (Glenn and pulmonary artery banding).

After cardiac surgery, six patients could not be sufficiently weaned from ventilation to allow an extubation trial, while extubation attempts failed on two or more occasions in 10 patients. The mean duration of ventilation before and after tracheostomy were 60.4 ± 9.8 and 14.5 ± 4.8 days, respectively (*P* value: 0.0002). The mean lengths of stay in the PICU before and after tracheostomy were 63.3 ± 10.2 and 22 ± 5.4 days, respectively (*P* value: 0.0012) (Table 1).

Before their tracheotomies, all patients had some degree of hypoxia, as assessed by the hypoxia index [PaO_2/FiO_2] of less than 400. The mean PaO_2/FiO_2 was 213 ± 27. Ten patients (62.5%) had associated neurological impairment or significant developmental delay at the time of their tracheotomies. Nine patients (56%) had 15 episodes of sepsis before tracheostomy whereas six patients had 9 episodes of sepsis after tracheostomy. The main septicemia etiologies were gram-negative (Gm –ve) organisms, mainly *Pseudomonas* and *Klebsiella*. Eight patients (50%) had 15 episodes of ventilator-associated pneumonia (VAP) prior to their tracheotomies, and none experienced it afterwards. The main VAP etiologies were Gm –ve organisms as well, mainly *Pseudomonas* and *Klebsiella*. Eight patients (50%) had gastro-esophageal reflux disease (GERD), and all of these patients required gastrostomy tube and fundoplication. Six patients (37.5%) had upper-airway abnormalities that were confirmed by bronchoscopy. These abnormalities consisted of vocal cord paralysis in four patients and subglottic stenosis in two patients. Five patients (31.3%) had lower-airway diseases, such as bron-

Table 1. The cardiac diagnosis upon admission and the primary cardiac operation performed for each patient as well as the timing and indications for the tracheostomy in all patients.

Case No.	Cardiac diagnosis at admission	Primary surgery	Duration of intubation before tracheostomy (days)	Number of extubation trials	Risk factors & indications of tracheostomy
1	Criss–cross heart, DORV, COA, PDA, VSD, ASD, post COA repair & PAB	Glenn	55	6	Hypoxia, GERD, upper airway obstruction, lower airway disease, diaphragmatic paralysis
2	Right atrial isomerism, single ventricle, asplenia, TAPVD	TAPVD repair & Glenn	42	3	Hypoxia, GERD, diaphragmatic paralysis, neurological impairment, sepsis
3	Pulmonary atresia, hypoplastic TV, multiple small VSDs, PDA	BT shunt & PDA ligation	43	Failure of weaning	Hypoxia, sepsis, VAP
4	IAA type B, VSD, ASD, PDA	IAA repair, VSD closure, ASD closure, PDA ligation	94	Failure of weaning	Hypoxia, GERD, upper airway obstruction sepsis, VAP, Chromosomal anomaly
5	VSD, TR, AR	VSD closure, TV repair & AV repair	29	3	Hypoxia, upper airway obstruction
6	PDA, pulmonary hypertension	PDA ligation	14	5	Hypoxia, GERD, upper airway obstruction, neurological impairment, CHARGE association
7	Balanced AVSD	AVSD repair	28	Failure of weaning	Hypoxia, neurological impairment, Chromosomal anomaly
8	PA,VSD, MAPCAS	Right-sided unifocalization of the MAPCAS & construction of the central shunt	83	10	Hypoxia, GERD, upper airway obstruction, VAP
9	COA and VSD S/P COA repair, VSD closure and balloon ortoplasty, cardiogenic shock due to sever LVOT obstruction	Modified kono	35	Failure of weaning	Hypoxia, GERD, VAP, upper airway obstruction, lower airway disease, neurological impairment
10	Rheumatic heart disease with sever MR	MV repair	35	2	Hypoxia, neurological impairment, musculoskeletal disease
11	Trucus arteriosus type II and VSD	VSD enlargement, LV-aorta tunnel, take-down of the MPA from aorta, RV-PA conduit	125	Failure of weaning	Hypoxia, GERD, sepsis, VAP lower airway disease, chylothorax, neurological impairment
12	TOF (PA and multiple VSD) S/P BT shunt	Take-down of the BT shunt, VSD closure & RV-PA conduit	154	5	Hypoxia, diaphragmatic paralysis, neurological impairment, sepsis, VAP
13	IAA type B, DORV, VSD	IAA repair by direct anastomosis, PAB	54	Failure of weaning	Hypoxia, lower airway disease, neurological impairment, sepsis
14	DORV, PA, S/P bilateral BT shunt	Take-down of both BT shunts, LV-aorta tunnel, RV-PA conduit, PDA ligation	67	4	Hypoxia, lower air way disease, diaphragmatic paralysis, Musculoskeletal disease, VACTRL association
15	D-TGA, IVS, PDA, ASD	ASO	85	6	Hypoxia, GERD, neurological impairment, sepsis, VAP, chylothorax
16	VSD & ASD	VSD patch closure & VSD patch closure	23	4	Hypoxia, neurological impairment, sepsis, VAP, chromosomal anomaly

ASD: atrial-septal defect. AR: aortic regurgitation. AVSD: atrial-ventricular septal defect. BT: Blalock-Taussig. COA: coarctation of the aorta. DORV: double-outlet right ventricle. D-TGA: dextro-transposition of the great arteries. IAA: interrupted aortic arch. LVOT: left ventricular outflow tract. LV: left ventricle. MAPCAS: major aortopulmonary artery collaterals. MR: mitral regurgitation. PA: pulmonary atresia. PAB: pulmonary artery banding. PDA: patent ductus arteriosus. RV: right ventricle. TAPVD: total anomalous pulmonary venous drainage. TOF: tetralogy of Fallot. TR: tricuspid regurgitation. VSD: ventricular septal defect.

chomalacia, chronic lung disease and bronchial asthma. Four patients (25%) had depressed left ventricular function before their tracheostomies. Four patients (25%) had diaphragmatic paralysis, which was unilateral in 2 cases and bilateral in the other 2 cases. All of the diaphragmatic paralysis patients needed diaphragmatic plication before tracheostomy tube insertion. Three patients (18.8%) had confirmed chromosomal anomalies, which consisted of trisomy 21 in two patients and a 22q11 micro-deletion in one. Two patients (12.5%) were syndromic; one had CHARGE association, and the other had VACTERL association. Two patients (12.5%) had musculoskeletal diseases, (severe kyphoscoliosis in one and peripheral neuro-myopathy in the other). Two patients (12.5%) had a post-operative chylothorax and both required thoracic duct ligation before their tracheotomies.

All patients survived the first 4 weeks after tracheostomy. Twelve patients (75%) were successfully extubated, and 10 (62.5%) were subsequently discharged from the ICU. Six patients were discharged to their homes. Three of these patients were successfully decannulated, and the other three were discharged with a tracheostomy tube in place (Fig. 1).

During the follow-up period, nine patients (56%) survived, and seven died (44% mortality rate). Six of the deceased patients died during hospitalization, and one died at home. In five cases, mortality was due to the primary cardiac condition and/or other associated risk factors like sepsis. However, in two cases, mortality was due to complications directly related to the tracheostomy and consisted of massive bleeding from a tracheo-innominate fistula in one and mechanical obstruction with severe hypoxic insult in the other. The overall survival during the follow-up period was 56% (Table 2).

Discussion

Tracheostomy in children has become an increasingly common procedure in major pediatric hospitals over the past three decades. The indications for tracheostomy in children are mainly due to upper-airway obstruction secondary to anatomical abnormalities, the anticipated need for prolonged ventilation and the need for effective pulmonary toileting [4].

Complex CHD which requires complex and high-risk surgeries with a tendency toward residual lesions and poor cardiac function after the

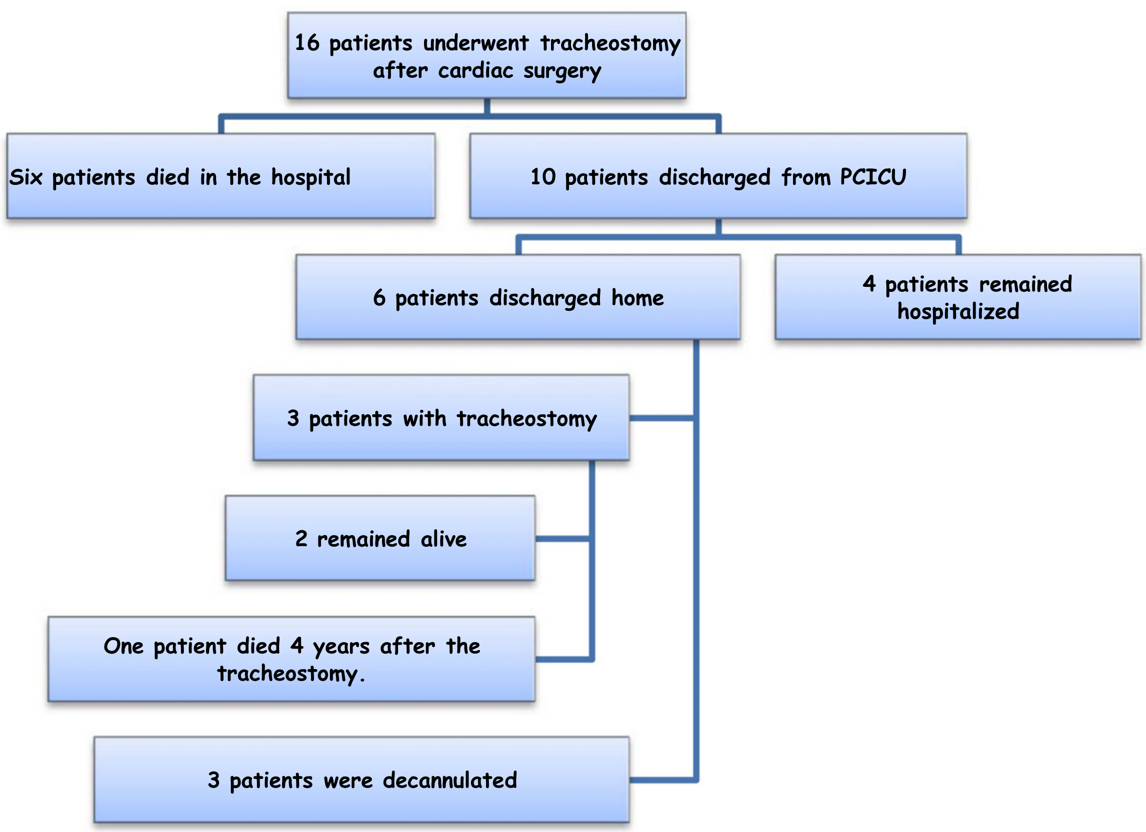

Figure 1. The outcome of the 16 tracheostomiesed patients during their follow-up.

Table 2. Post-tracheostomy mortality and its related causes.

Cardiac diagnosis	Primary cardiac surgery	Cause of death	Detail of cause
IAA type B, DORV, VSD	IAA repair by direct anastomosis, PAB	Cardiac	Heart failure and refractory arrhythmia
TOF (PA and multiple VSD) S/P BT shunt	Take-down of the BT shunt, VSD closure & RV-PA conduit	Cardiac	Chronic heart failure
VSD & ASD	VSD patch closure & VSD patch closure	Sepsis	Septicemia with multi-organic failure
D-TGA, IVS, PDA, ASD	ASO	Sepsis	Septicemia with prolonged Chylothorax
PDA, pulmonary hypertension	PDA ligation	Complication of tracheostomy	Prolonged hypoxic insult probably due to a mechanical obstruction in the tracheostomy tube 4 years after the tracheostomy
DORV, PA, S/P bilateral BT shunt	Take-down of both BT shunts, LV-aorta tunnel, RV-PA conduit, PDA ligation	Complication of tracheostomy	Massive bleeding from the tracheostomy tube during suction
Trucus arteriosus type II and VSD	VSD enlargement, LV-aorta tunnel, take-down of the MPA from aorta, RV-PA conduit	Other	Acute respiratory distress syndrome with multi-organic failure

repair, is an important risk factor for long-term ventilator support [3].

After cardiac surgery, respiratory and airway complications are common. Examples of these complications include vocal cord palsy due to recurrent laryngeal nerve injury and diaphragmatic dysfunction due to phrenic nerve injury [5,6]. In our study, vocal cord paralysis was diagnosed in four patients who required tracheostomy (25%). Diaphragmatic paralysis was also observed in four patients (25%) who required tracheostomy. Chronic pleural effusion and chylothorax are also well-known complications that can compromise respiratory function and contribute to prolonged mechanical ventilation after cardiac surgery [6]. Chylothorax was observed in two of our cases (12.5%).

The vast majority of our patients had some degree of hypoxia before their tracheotomies, which was reflected by an abnormal hypoxia index (a PaO_2/FiO_2 ratio of less than 400). The hypoxia was probably attributable to chronic lung disease or residual cardiac lesions that affected the lung and caused a ventilation/perfusion mismatch with subsequent hypoxia.

One of the important associated risk factors was GERD which was observed in 50% of our cases. Several reports have suggested that chronic reflux may be associated with the development and progression of subglottic stenosis [7]. GERD is a common finding in ventilator-dependent children. They often require gastrostomy and sometimes Nissen fundoplication [8].

Neurological impairment or abnormality is one of the important factors for tracheostomy (observed in 10 of our patients (62.5%)). In one study, neurological factors were the leading reason for tracheostomy and were present in 68% of cases [2].

Nosocomial infections are an important cause of morbidity and mortality in the ICU. It may contribute to the requirement for prolonged intubation. The incidence of ventilator-associated pneumonia (VAP) in the literature is widely variable, ranging from 10% to 71% [9]. This variability is mainly due to the variable diagnostic criteria and different patient population included in those studies. In our study, we diagnosed 15 episodes of VAP in eight patients. It is recognized that the risk of VAP increases with an increasing duration of mechanical ventilation [10]. Furthermore, the incidence of VAP significantly decreases after a tracheostomy. Septicemia was noted in 56% of our patients. Nine patients (56%) developed 15 episodes of septicemia before their tracheotomies. After tracheostomy, six patients developed 9 episodes of septicemia. There was a 37.5% reduction in the incidence of septicemia after tracheostomy. It is possible that the reduction in the incidence of septicemia after tracheostomy was due to the reduced need for central lines and sedation or analgesia after the tracheostomy.

It was reported that the morbidity and mortality associated with pediatric tracheostomy are higher than those in adults; the younger the patient, the higher the complication rate, and the greater the morbidity associated with the tracheostomy [1,11,12].

In our study, we found that tracheostomy placement significantly shortened the ventilation duration and the length of the ICU stay. This finding is consistent with those of other studies [2].

The timing of tracheostomy in children remains controversial. Some authors have suggested that a tracheostomy may be performed if intubation is expected to last beyond 2–3 weeks [1–6]. In our study, the mean time for tracheostomy placement was almost 2 months after cardiac surgery. This is due to the fact that many patients are young infants who are expected to improve and recover in time without the need for artificial airways. Another concern for the delayed tracheostomy is the risk of infection transmission from the tracheostomy orifice to the fresh mediastinal wound after surgery.

Conclusion

Despite the high mortality, mostly due to the complexity of the underlying cardiac disease and cardiac surgery; tracheostomy shortened the duration of mechanical ventilation and the length of ICU stay. Tracheostomy significantly reduced ventilator-associated pneumonia and the incidence of sepsis. After tracheostomy, many of our patients were extubated and discharged from the hospital. The mortality associated with tracheostomy is mainly related to heart disease and the complexity of the surgery.

Conflict of interest statement

The authors have no conflict of interest to declare.

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