Tracheotomy Tube Placement in Children Following Cardiothoracic Surgery: Indications and Outcomes

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Purpose: To review the indications for and outcomes of children requiring tracheotomy tube placement following cardiothoracic surgery, charts were reviewed retrospectively at a tertiary care center for fifteen children who had undergone tracheotomy tube placement following cardiothoracic surgery between 1994 and 2000.
Outcomes Measure: Morbidity and/or mortality associated with tracheotomy tube placement in this patient population, duration of tracheotomy tube, and rate of decannulation.
Results: Fifteen out of approximately 3000 children undergoing cardiothoracic surgery required tracheotomy tube placement over a 6-year period. Indications included diaphragmatic paresis (DP) (7 patients), vocal cord paresis (VP) alone (3 patients), DP and VP (2 patients), subglottic stenosis (SS) and DP (1 patient), VP and SS (2 patients), and cerebrovascular infarct (1 patient). The mean age at the time of tracheotomy tube placement was 36.5 months (range, 0.75-108 months). The mean duration of intubation between cardiothoracic procedure and tracheotomy was 31.6 days (range, 0-72 days). Six patients were successfully decannulated following a mean of 7.4 months of tracheotomy tube dependence. All 6 decannulated patients had DP necessitating tracheotomy and ventilatory support. Eight patients continue to be tracheotomy tube–dependent, and one patient died of unrelated causes. There was no short-term or long-term morbidity or mortality associated with tracheotomy tube placement.
Conclusion: Tracheotomy tube placement is rarely indicated following cardiothoracic surgery in children. The most common indication is DP, which is usually transient. Most children will eventually be candidates for decannulation.

With the advent of earlier diagnosis of anomalies in children, more complex cardiac anomalies are managed at a younger age. Cardiothoracic procedures carried out on infants and young children may result in postoperative complications, such as failure to wean from the ventilator or airway trauma in this high-risk population. Children undergoing cardiothoracic surgery may experience several complications following prolonged postoperative intubation, including subglottic stenosis, diaphragmatic paresis, and vocal cord paresis.[1]

The most common pediatric congenital cardiac defects are tetralogy of Fallot, ventricular/atrial septal defects, pulmonary atresia, tricuspid atresia, and transposition of the great arteries. Several surgical procedures are used to correct the defects. The Blalock-Taussig shunt is used in the repair of tetralogy of Fallot and pulmonary atresia with ventricular septal defect. In tricuspid atresia, the Blalock-Taussig procedure may be used along with a Rashkind balloon atrial septostomy or a surgical septectomy. The bidirectional Glenn shunt, and the modified Fontan and/or cavopulmonary isolation procedures are other options for repair of tricuspid atresia. The Rastelli and the Mustard procedures are commonly carried out in the repair of transposition of the great arteries with ventricular septal defect and pulmonary stenosis.[2]

At our institution we conducted a 6-year review of children undergoing cardiothoracic

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surgery to identify indications and outcomes of children requiring tracheotomy tube placement following cadiothoracic surgery.

MATERIALS AND METHODS

A 6-year retrospective chart review of all patients who had undergone pediatric cardiothoracic surgery requiring tracheotomy tube placement was carried out. Fifteen out of 3000 pediatric patients had undergone tracheotomy tube placement following cardiothoracic surgery for congenital cardiac defects. Each patient had been brought to the operating room for a diagnostic direct laryngoscopy and bronchoscopy followed by tracheotomy tube placement. Thirteen of the 15 patients had a controlled airway by endotracheal tube placement before tracheotomy.

Factors considered in this study included indications for tracheotomy tube placement, morbidity and mortality following tracheotomy, duration of the tracheotomy tube placement, and the rate of decannulation. All patients had their cardiothoracic procedure and tracheotomy carried out at the authors' institution.

RESULTS

The mean age of the patients at the time of tracheotomy was 36.5 months (range, 3 weeks to 108 months). Ten patients were boys, and 5 were girls. Seven patients had diaphragmatic paresis, and 3 had vocal cord paresis as the sole condition necessitating tracheotomy placement. One patient had both diaphragmatic and vocal cord paresis, 1 had subglottic stenosis and diaphragmatic paresis, and 2 had vocal cord paresis and subglottic stenosis. One child had a cerebrovascular infarct. Mean intubation time, defined as the time from intubation for cardiothoracic surgery to time of tracheotomy placement, was 31.6 days. Six patients have been decannulated successfully with no long-term sequelae. The mean time to decannulation was 7.4 months. The 6 decannulated patients each sustained diaphragmatic paresis following their initial cardiothoracic procedure and required long-term ventilatory care. Eight patients continue to be dependent on a tracheotomy tube and 1 patient has died as a result of the cerebrovascular infarct incurred following cardiothoracic surgery. Evaluation of short-term and long-term morbidity and mortality demonstrated no complications or deaths as a result of tracheotomy tube placement (Table 1).

COMMENT

Indications for tracheotomy tube placement in the pediatric population may include acute or chronic upper airway obstruction or a requirement for long-term ventilatory support.[3] In this study we reviewed indications and outcomes for tracheotomy tube placement over a 6-year period in children who had undergone cardiothoracic surgery. Fifteen of 3000 children (0.5%) required tracheotomy tube placement, and all patients but 1 required tracheotomy tube placement secondary to impairment of laryngeal or respiratory muscle function. Most of these injuries appeared to be transient. No patient had early or delayed complications related to tracheotomy tube placement.

Respiratory insuffiency after pediatric cardiothoracic surgery is often due to diaphragmatic paralysis.[4] According to Tonz et al, 25 (1.5%) of 1,656 pediatric cardiac surgical procedures over a 10-year period resulted in diaphragmatic paralysis.[5] In our study, this was most commonly seen after the Blalock-Taussig procedure, which includes a lateral thoracotomy. The lateral thoracotomy approach exposes the phrenic nerve, which can potentially lead to stretch injury, contusion, or laceration, resulting in diaphragm paresis.[2] Five of 15 patients in our study underwent this type of repair and 4 of these 5 patients experienced diaphragmatic paresis due to phrenic nerve contusion or laceration; however, 5 patients undergoing other types of cardiothoracic surgeries suffered from diaphragmatic paresis as well. Fourteen of our 15 patients underwent a period of ventilatory support longer than 2 weeks, with at least 1 failed attempt at extubation. The treatment course for each child resulted in a tracheotomy tube placement that followed a thorough pulmonary and airway evaluation. Diaphragm muscle function was evaluated by a chest radiograph, ultrasound, and, in some cases, electromyography. Airway evaluation included assessment of vocal cord function, assessment of the subglottic and tracheal airway anatomy, and diagnosis and management of obstructing lesions such as granulomas. The benefits of tracheotomy tube placement include reduced risk of endotracheal tube obstruction, a simplified and often facilitated

TABLE 1. Fifteen Pediatric Patients With Tracheotomy Tube Placement Following Cardiothoracic Surgery Between 1994 and 2000

Patient	Indicators	Cardiac Disease	Cardiac Procedure	Length of Intubation	Duration of Tracheotomy	Decannulation	Age at Tracheotomy
LB	Diaphragmatic weakness	Pulmonary atresia, ventricular septal defect, aortic pulmonary collaterals	Blalock-Taussig shunt	72 d	8/13/99-5/19/00	Yes	36 mo
LF	Diaphragmatic weakness, left true vocal cord paresis	Double outlet right ventricle, ventricular septal defect, atrial septal defect, coarctation	Coarctation repair, closure of patent ductus arteriosus	50 d	8/29/97-7/10/98	Yes	66 mo
JL	Bilateral true vocal cord paresis	Coarctation of aorta, hypoplasia of left ventricle, mitral valve stenosis, patent ductal arteriosus	Repair of coarctation	28 d	3/99-	No	3 wk
NL	Diaphragmatic weakness	Pulmonary atresia, ventricular septal defect	Right unifocalization/shunt to right pulmonary artery	20 d	8/5/98-	No	66 mo
KM	Diaphragmatic weakness	Multiple ventricular septal defects, atrial septal defect	Closure of ventricular septal defect/aortic septal defect	Unable to obtain	5/26/00-	No	9 mo
CP	Neurocerebral infarct, midbrain	Asplenia, heterotaxy, dextrocardia, situs inversus, pulmonary atresia	Fontan procedure, Glenn shunt	21 d	7/9/99-	Deceased	108 mo
AT	Diaphragmatic weakness	Tetralogy of Fallot, pentalogy of Cantrell	Blalock-Taussig shunt		8/11/98	No	54 mo
EV	Right true vocal cord paresis, subglottic stenosis	Transposition of great vessels, ventricular septal-defect, small patent foramen ovale	Right Blalock-Taussig shunt	Not intubated	4/23/99	No	42 mo
AG	Subglottic stenosis, bilateral true vocal cord paresis	Mitral valve regurgitation	Mitral valve repair		3/98	No	30 mo
AF	Subglottic stenosis, left diaphragmatic weakness	Type II truncus arteriosus	Bilateral pulmonary artery banding, Blalock-Taussig shunt		9/10/00-	Yes	30 mo
VM	Left true vocal cord paresis	Coarctation of the aorta, mitral valve regurgitation	Repair of coarctation	11 d	7/99	No	4 mo
NN	Bilateral true vocal cord paresis	Aortic stenosis, patent ductus arteriosus, patent foramen ovale	Repair of valves	Not intubated	9/1/94-3/1/96; 10/25/96	Yes/no	36 mo
IA	Diaphragmatic weakness	Congenital myopathy	Orthotopic heart transplant	9 d	2/14/97-	No	13 mo
KT	Diaphragmatic weakness	Dextrocardia, double outlet single ventricle	Fontan, Glenn, Davis-Kage-Stansel procedure			Yes	24 mo
JD	Diaphragmatic weakness	Left transposition of great arteries	Left Blalock-Taussig shunt	42 d	7/31/92	Yes	54 mo

weaning process from the ventilator, earlier oral intake, and preservation of glottic and subglottic anatomy.[3] Of the 9 patients with diaphragmatic paresis, 5 were successfully decannulated within 6 months of tracheotomy tube placement with no short-term or long-term complications.

Recurrent laryngeal nerve injury may also be a complication of pediatric cardiothoracic surgical procedures. Vocal cord paralysis is defined as immobility of the vocal cords due to mechanical fixation in a neurologically intact patient and/or paralysis of the intrinsic laryngeal musculature. The natural resting state of the vocal cords after paralysis is the paramedian or median position. These positions can cause obstruction of the airway at the level of the glottis and result in dyspnea, stridor, and aspiration risk for the pediatric patient.

Surgical trauma is a common source of vocal cord paralysis. Vocal cord paralysis may occur in up to 25% of patients undergoing head and neck surgery and in 17% of those patients undergoing lung or mediastinal procedures for malignancies.[6] Intubation trauma or prolonged intubation may result in vocal cord fixation, which may have a similar clinical presentation to that of vocal cord paralysis.

Vocal cord paralysis can be diagnosed by several methods. An extubated patient can be evaluated for stridor and voice changes, the use of accessory respiratory muscles, and respiratory distress. These symptoms may all be consistent with bilateral vocal cord paralysis. Unilateral vocal cord paralysis may present as hoarseness, a weak cry or cough, or aspiration.[6] Other diagnostic tools include pulmonary function testing, imaging studies (computed tomography and magnetic resonance imaging), laryngeal electromyography, and fiberoptic or direct laryngoscopy. In our study 6 patients had vocal cord paralysis, and each of these patients had undergone an operative evaluation under sedation with spontaneous ventilation to diagnose the vocal cord paralysis. Two of these patients were not intubated and were symptomatic at the time they were brought to the operating room for evaluation.

There are several surgical options to consider if vocal cord paralysis is permanent. Partial posterior laser cordotomy may provide static enlargement of the glottic airway, facilitating eventual decannulation.[6] In our study the only patient with vocal cord paralysis who was successfully decannulated experienced a combined diaphragmatic paresis along with a vocal cord paresis. Both of these pareses resolved spontaneously. The other 5 patients with vocal cord paralysis have not yet been decannulated.

Subglottic stenosis is another potential complication from prolonged intubation following pediatric cardiothoracic surgery.[7] Prolonged intubation may result in granulation tissue or circumferential scarring, leading to a fixed subglottic narrowing.[8,9] In our study, 3 of 15 patients developed subglottic stenosis. Each patient was taken to the operating room for diagnostic evalution of the stenosis using a rigid pediatric bronchoscope. Tracheotomy was carried out to bypass the stenosis and expedite weaning from the ventilator.[1] One patient was successfully decannulated 12 months after placement of the tracheotomy.

In patients with complex congenital cardiac disease, contusion or disruption of the recurrent laryngeal nerve or the phrenic nerve during cardiothoracic surgery is oftentimes unavoidable. Recognition of these events intraoperatively or in the early postoperative period may allow for earlier extubation with even temporary tracheotomy tube placement. This, in turn, may minimize the incidence of laryngotracheal stenosis acquired from prolonged intubation.

CONCLUSION

Tracheotomy tube placement is rarely indicated following cardiothoracic surgery in children. The most common indication is diaphragmatic paresis, which is usually transient. Most children will eventually be candidates for decannulation.

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