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Evaluation of tracheostomy patients in a pediatric cardiac intensive care unit: our five-year single-center experiences

Pediyatrik kardiyak yoğun bakım ünitesindeki trakeostomili hastaların değerlendirilmesi: Beş yıllık tek merkezli deneyimimiz

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ABSTRACT

Background: In this study, we analyzed the data related to pediatric cardiac intensive care unit patients undergoing tracheostomy.

Methods: A total of 18 patients (10 girls, 8 boys; mean age 9.4±10.5 months; range 2 to 42 months) who were hospitalized in the pediatric cardiac intensive care unit at a single center between January 2010 and January 2015 and who underwent tracheostomy during the hospitalization period were retrospectively analyzed.

Results: At baseline, genetic disorders were identified in three patients. Among 1,450 patients who underwent cardiac surgery, 10 received total correction and eight received palliation. The mean intubation time without tracheostomy was 41.0±12.9 days and the number of extubation attempts was 4.2±0.8. Two patients had neurological damage. No patients developed pneumomediastinum, pneumothorax, wound site infection or mediastinitis following tracheostomy. One patient underwent revision of the tracheostomy site due to bleeding. None of the patients had late tracheostomy complications such as tracheal stenosis during the follow-up period. Six of 18 tracheostomy patients died in the pediatric cardiac intensive care unit and one died at home following discharge (mortality 38.8%). Eight of 12 tracheostomy patients who were discharged underwent decannulation. Three patients are currently under follow-up at home using a home-type ventilator.

Conclusion: Tracheostomy procedures may be performed in patients with prolonged intubation time following cardiac surgery with a low complication rate. However, the morbidity and mortality rates in this patient population still remain high due to several factors implicated in this complicated process.

Keywords: Cardiac surgery; child; pediatric cardiac intensive care unit; prolonged intubation, tracheostomy.

ÖZ

Amaç: Bu çalışmada trakeostomi uygulanan pediyatrik kardiyak yoğun bakım ünitesindeki hastalara ilişkin veriler analiz edildi.

Çalışma planı: Ocak 2010 - Ocak 2015 tarihleri arasında tek bir merkezde pediyatrik kardiyak yoğun bakım ünitesinde yatan ve hastanede yatış döneminde trakeostomi uygulanan toplam 18 hasta (10 kız, 8 erkek; ort. yaş 9.4±10.5 ay; dağılım 2-42 ay) retrospektif olarak incelendi.

Bulgular: Başlangıçta üç hastada genetik bozukluk saptandı. Kardiyak cerrahi uygulanan 1450 hastanın 10'una total düzeltme ve sekizine palyasyon yapıldı. Trakeostomi uygulanmadan geçen ortalama entübasyon süresi 41.0±12.9 gün ve ekstübasyon girişimi sayısı 4.2±0.8 idi. İki hastada nörolojik hasar vardı. Trakeostomi sonrası hastaların hiçbirinde pnömomediastinum, pnömotoraks, yara yeri enfeksiyonu ya da mediastinit gelişmedi. Bir hastada kanama nedeniyle trakeostomi revizyonu yapıldı. Hastaların hiçbirinde takip döneminde trakeal darlık gibi geç dönem trakeostomi komplikasyonları gözlenmedi. On sekiz trakeostomi hastasının altısı pediyatrik kardiyak yoğun bakım ünitesinde ve biri ise taburculuk sonrasında evde kaybedildi (mortalite %38.8). Taburcu edilen 12 trakeostomi hastasının sekizine dekanülasyon yapıldı. Üç hasta halen ev tipi ventilatör ile evde takip edilmektedir.

Sonuç: Trakeostomi işlemleri kardiyak cerrahi sonrası entübasyon süresi uzamış olan hastalarda düşük komplikasyon oranı ile uygulanabilir. Ancak, bu karmaşık süreçte rol oynayan çeşitli faktörler nedeniyle, morbidite ve mortalite oranı bu hasta popülasyonunda halen yüksek seyretmektedir.

Anahtar sözcükler: Kardiyak cerrahi; çocuk, pediyatrik kardiyak yoğun bakım ünitesi; uzamış entübasyon; trakeostomi.

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In recent years, early and rapid extubation following pediatric cardiac surgery has become widely adopted.[1] The form of the cardiac pathology, the complexity of the operation, surgical complications, the presence of residual defects, myocardial dysfunction, presence of pulmonary parenchyma, and comorbid problems may complicate extubation, thereby, increasing the length of stay on the mechanical ventilator.[2-4]

Prolonged endotracheal intubation complicates postoperative procedures, leading to increased mortality and morbidity rates.[5] Tracheostomy emerges as an alternative method for the prevention of such problems.[5] Tracheostomy has been associated with shorter durations of sedation used, decreased respiratory workload, lower infection risk, more comfortable mobilization, and easier oral feeding, which is particularly important for infants.[6,7] However, no consensus on tracheostomy procedures, indications, and outcomes in patients treated in the pediatric cardiac intensive care unit (PCICU) has been reached yet. Therefore, in this study, we aimed to analyze the data related to PCICU patients undergoing tracheostomy at a single center.

PATIENTS AND METHODS

A total of 18 patients (10 girls; 8 boys; mean age 9.4±10.5 months; range 2 to 42 months) who were hospitalized in the PCICU at a single center between January 2010 and January 2015 and who underwent tracheostomy during the hospitalization period were retrospectively analyzed. A study form was designed to gather data of each patient included in the study, including demographics, cardiac diagnoses, presence of genetic abnormalities, comorbidities, surgical procedures, and length of stay on the mechanical ventilator in the postoperative period. The duration and number of extubations, reason for tracheostomy, decannulation time, the presence of postoperative residual cardiac defects, and emerging complications were thoroughly analyzed. Each tracheostomy procedure was performed in the pediatric cardiovascular surgery clinic. For this procedure, a reverse flap incision in the shape of the letter "U" was performed. The mobilized flap was fixed under the skin.

The study only included patients who underwent tracheostomy following the performance of surgical or transcatheter intervention in the PCICU. Patients who did not undergo any interventions or who were over the age of 18 were excluded from the study. The study protocol was approved by the Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee. A written informed consent was obtained from each parent. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Statistical analysis was performed using PASW version 17.0 (SPSS Inc., Chicago, IL, USA) software. Descriptive data were expressed in standard deviation, median and range. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 1,450 patients underwent cardiac surgery and hospitalized in the PCICU. Cardiac surgical/transcatheter intervention was performed on 18 patients and the rate of tracheostomy was 1.2%. Ten patients (56%) undergoing tracheostomy were females and eight (44%) were males. The mean body weight was 5.8±2.9 kg (range, 3.8 to 14 kg). At baseline, genetic disorders were identified in three patients (n=2, Down syndrome; n=1, DiGeorge syndrome). For the diagnosis of genetic diseases, chromosome analysis was performed in two patients with Down syndrome and fluorescent in situ hybridization was used in the patient with DiGeorge syndrome. Among the patients who underwent cardiac surgery, 10 received total correction and eight received palliation (n=6, pulmonary banding; n=1, central shunt; n=1, patent ductus arteriosus stenting). Four patients had single-ventricle morphology. The mean intubation time without tracheostomy was 41.0±12.9 days (range, 20 to 77), while the number of extubation attempts was 4.2±0.8 (range, 2 to 6). Two patients had neurological damage; one of them who had mental retardation and muscular hypotonicity also had a neurological disorder at baseline, while the other with cerebral hypoxic damage developed a neurological disorder during the perioperative period. The main cardiac pathologies, operation types, duration of tracheostomy, risk factors for tracheostomy, and current overall condition of the patients are summarized in Table 1.

The risk factors associated with tracheostomy were sepsis (n=14, 78%), chromosomal abnormality (n=3, 17%), neurological impairment (n=2, 11%), pleural effusion (n=3, 17%), diaphragmatic paralysis (n=3, 17%), chylothorax (n=2, 11%), ventilator-associated pneumonia (n=2, 11%), and tracheomalacia (n=1, 5.5%). Ventilator-associated pneumonia was defined as the presence of infiltration on chest X-ray, increased acute phase reactants, worsening overall condition, and positive cultures from lower respiratory tract secretions. Such patients were observed to have proliferations of *Staphylococcus aureus*, *Pseudomonas*

Table 1. Main cardiac pathologies, operation types, duration of tracheostomy, risk factors for tracheostomy, and current overall condition of the patients undergoing tracheostomy

Patient number	Sex/age (months)	Body weight (kg)	Cardiac pathology	Surgery or intervention	Duration of intubation before tracheostomy (days)	Trial of extubation	Risk factors for tracheostomy	Follow-up	Cause of death
1	F/3	4	TGA	ASO	39	3	Postoperative systolic dysfunction, pleural effusion, sepsis	Death	Intractable heart failure, sepsis
2	M/6	4.5	Complete AVSD-arcus hypoplasia	Pulmonary banding-arcus reconstruction	47	4	Chromosomal anomaly, chylothorax, sepsis	Death	Sepsis, multiorgan dysfunction
3	F/4	4	PA, aortic outlet RV, systolic dysfunction	PDA stenting	66	5	Hypoxia, perioperative systolic dysfunction	Death	Intractable heart failure
4	F/2	3.8	TGA	ASO	44	4	Tracheomalacia, VAP	Home-type ventilator support	–
5	M/3	4.2	DORV-VSD, hypoplastic ventricle	Pulmonary left banding-atrial septectomi	36	5	Sepsis, pleural effusion	Death	Sepsis, multiorgan dysfunction
6	F/3	4.1	Supracardiac TAPVR	TAPVR correction	32	4	Diaphragmatic paralysis, sepsis	Home-type ventilator support	–
7	F/3	4	VSD-AC	Pulmonary banding-correction of coarctation	42	4	Sepsis	Death	Sepsis
8	M/14	7	Intermediate AVSD	Total correction	42	4	GERD, sepsis	Decannulated	–
9	F/6	6	VSD-ASD	Pulmonary banding	37	4	VAP, pleural effusion	Decannulated	–
10	F/3	4.8	DORV-VSD, hypoplastic left ventricle	Pulmonary banding	41	4	Chromosomal anomaly, sepsis	Decannulated	–
11	M/26	10	RAI-DORV-VSD-PH	Pulmonary banding	30	4	Diaphragmatic paralysis, sepsis	Decannulated	–
12	M/6	5	Complete AVSD	Total correction	77	6	Neurological impairment, sepsis	Death	Sepsis
13	M/19	11	VSD-PS	Total correction	32	3	Diaphragmatic paralysis, sepsis	Decannulated	–
14	M/2	3.9	Arcus hypoplasia	Arcus reconstruction	35	4	Sepsis	Decannulated	–
15	F/14	5.5	Truncus arteriozus type 2	Total correction with conduit	46	6	Chylothorax, sepsis	Home-type ventilator support	–
16	M/4	5	Supracardiac TAPVR	TAPVR correction	20	4	Neurological, impairment pulmonary hypertensive crisis	Decannulated	–
17	F/9	4.1	VSD-PS	Total correction	38	4	Chromosomal anomaly, sepsis	Decannulated	–
18	F/42	14	VSD-PA	Central shunt	34	4	Hypoxia, sepsis	Death	Sepsis, multiorgan dysfunction

TGA: Transposition of great arteries; ASO: Arterial switch operation; AVSD: Complete atrioventricular septal defect; PA: Pulmonary atresia; RV: Right ventricle; PDA: Patent ductus arteriosus; DORV: Double outlet right ventricle; VSD: ventricular septal defect; PH: Pulmonary hypertension; TAPVR: Total abnormal pulmonary venous return; AC: Aortic coarctation; GERD: Gastroesophageal reflux disease; ASD: Atrial septal defect; VAP: Ventilatory associated pneumonia; RAI: Right atrial isomerism; PS: Pulmonary stenosis.

aeruginosa, and *Acinetobacter* in their tracheal secretion cultures, respectively. The diaphragmatic paralysis was diagnosed in the catheterization laboratory under fluoroscopy. Diaphragm plication was performed in two patients and clinical follow-up was performed for one. The patients who received diaphragm plication were

unable to be weaned from the mechanical ventilation. In one of the two patients who underwent plication, successful decannulation following tracheostomy was performed. The other patient in whom plication failed was followed with a home-type ventilator. For both patients with chylothorax, this complication was associated with ductus thoracicus injury. For the treatment, drainage with a thoracic tube (12 days in one patient and five days in the other patient), total parenteral nutrition support and a diet containing medium-chain fatty acids were applied. For the first patient, intravenous octreotide was also included in the treatment. No surgical ligations were required due to chylothorax. One patient underwent total revision of the tracheostomy site due to bleeding. No patients developed pneumomediastinum or pneumothorax following tracheostomy. Povidone iodine was used for dressings and no wound infections or mediastinitis were observed in any patients. Of 18 patients, six died in the PCICU, while one died at home following discharge (mortality 38.8%). Eight of 12 patients who were discharged (at 1 month, 3 months, 4 months, 4 months, 5 months, 6 months, 6 months, and 8 months after tracheostomy, respectively) underwent decannulation. Three patients are currently under follow-up at home using a home-type ventilator. The follow-up periods of these patients were two, three, and five months. The overall post-tracheostomy conditions of the patients are summarized in Figure 1. Late tracheostomy complications such as tracheal stenosis were not observed in any patients during the follow-up period.

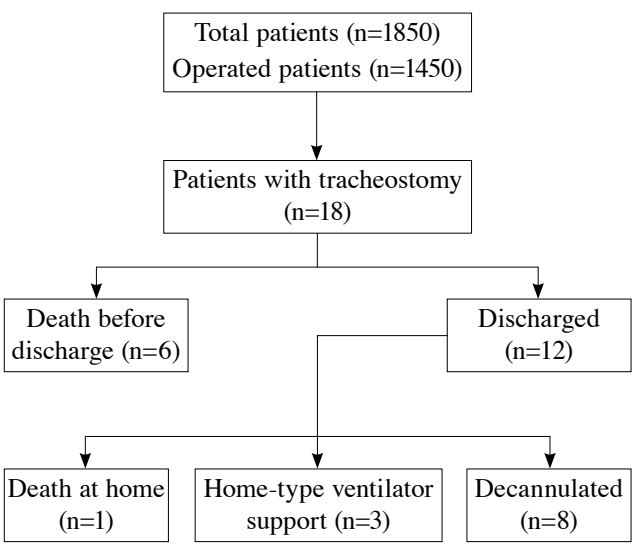

Figure 1. The overall post-tracheostomy conditions of the patients undergoing tracheostomy.

DISCUSSION

Prolonged intubation may jeopardize comfort, nutrition, or mobility in children. Therefore, at several centers, tracheostomy has been performing at an increasing frequency in children with prolonged intubation. Tracheostomy has several potential advantages compared to the nasotracheal or orotracheal intubation procedures. Initially, it reduces the workload during respiration, improves pulmonary drainage, controls airway safety, enables patient mobilization, and facilitates weaning from mechanical ventilation.[3,8] Furthermore, in an adult study, tracheostomy following cardiac surgery was associated with reduced morbidity, shorter total length of stays in the hospital and intensive care unit, and reduced in-hospital mortality without increased mediastinitis.[5] Another important advantage of tracheostomy is that it enables oropharyngeal coordination in breastfed infants and young children. Despite all these advantages, long-term mechanical ventilation support (>7 days) has remained limited to a small number of cases.[5] As a result, no sufficient clinical data are available on the procedures or results of tracheostomy following cardiac surgery in infants and children. The medical indications for tracheostomy include a prolonged need for mechanical ventilation, preservation of the airway, a need for airway access to externalize secretions, avoidance of translaryngeal intubation complications, improved patient comfort, provision of improved in-patient care outside the ICU, and enhanced patient safety.[9,10]

With the developments in prenatal diagnosis, neonatal resuscitation, intraoperative techniques, and perioperative intensive care, complicated congenital cardiac surgeries have been performing in the pediatric population at an increasing frequency.[5] On the other hand, despite these developments, a small proportion of patients may still require prolonged respiratory support following surgical intervention. The major risk factors for prolonged mechanical ventilation support include high-risk surgical procedures which involve poor cardiac function, a tendency toward residual lesions following surgical repair, and underlying complicated congenital heart diseases.[11] Since complicated congenital heart diseases are currently correctible and positive efforts have increased to overcome postoperative complications, prolonged mechanical ventilation support has been used more frequently in this patient population. In a study of 37 infants and children with tracheostomy following cardiothoracic surgery, 24 underwent surgery for congenital heart disease; 15 of these received biventricular repair, while nine underwent palliative surgical procedures.[2]

In terms of palliative procedures, two children received total cavopulmonary connection, three underwent staging procedures before corrective intervention, and four received single-ventricle palpation. In our study, nine patients (50%) with tracheostomy had a complicated congenital heart disease and four of these had a single-ventricle morphology. Among the patients who received interventions (surgical or interventional), eight underwent palliation and 10 had total correction.

For the additional malformations associated with other systems accompanied by congenital heart diseases, acute perioperative process and long-term treatment are critical in the management of these conditions. Neurological disorders and abnormalities are among the major factors for tracheostomy. Kabbani et al.[12] reported neurological factors to be the foremost reason for tracheostomy, occurring in 68% of the patients in his study. In our study, neurological disorders were observed in two patients undergoing tracheostomy in the PCICU. While the neurological condition was present in one of these patients at baseline, it developed during the perioperative period in the other. Furthermore, three patients (42%) who underwent tracheostomy also had genetic abnormalities in addition to congenital heart disease in our study.

On the other hand, the optimal timing of tracheostomy is still controversial, which should be individualized by taking into account patient-specific medical concerns and considerations regarding the patient and his or her family. In the 1980s, early tracheostomy was performed before day 21 of translaryngeal intubation.[9] Devarajan et al.[5] examined the effects of early tracheostomy in patients requiring prolonged mechanical ventilation following cardiac surgery and revealed that tracheostomy within 2 to 10 days postoperatively shortened the length of hospital stay and reduced morbidity and mortality. On the other hand, some authors suggest that tracheostomy should be performed, if the intubation time is to be longer than to three weeks.[2,11-15] The overall approach of our clinic, in the presence of underlying complicated cardiac disease or additional genetic or neurological abnormalities, in particular, is that patients should not remain intubated for more than three weeks, if there have been repeated attempts at extubation; it would be more appropriate to monitor these patients by performing tracheostomy. In our study, the mean duration of tracheostomy was 41.0±12.9 days (range, 2 to 77). The reasons behind this prolonged time were that the majority of our patients were in the infant age group, our tendency to observe the recovery possibilities without the need for an artificial airway, the high complexity-percentage of the underlying heart disease, the complexity of the surgical procedures performed, and the failure of the families of some patients to provide a written informed consent for tracheostomy within given time. Furthermore, particularly in pediatric patients with complicated congenital cardiac diseases and labile conditions, the patient's hemodynamic or clinical condition (i.e. acute kidney/liver failure, bleeding diathesis secondary to coagulation disorder, sepsis) may not be appropriate for tracheostomy, even if that procedure is planned and this situation may result in delayed tracheostomy.

Furthermore, respiration and airway complications are particularly common after cardiac surgery.[3] Other surgery-related complications include diaphragmatic dysfunction secondary to phrenic nerve injury and vocal cord paralysis secondary to laryngeal nerve injury.[14,15] Additional well-defined complications in these patients, which may lead to prolonged mechanical ventilation following cardiac surgery and may deteriorate respiratory function, are chronic pleural effusion and chylothorax.[15,16] In consistent with the literature data, we also observed three patients (16.6%) with diaphragmatic paralysis, three (16.6%) with pleural effusion, two (11%) with chylothorax, and one (5.5%) with tracheomalacia.

In the present study, the mortality rate in the patient group who underwent tracheostomy following cardiac surgery remained high. In the study of Hoskote et al.,[2] 15 patients (41%) were in the neonatal period and 12 (32%) had accompanying chromosomal abnormalities. In addition, 15 patients (41%) died on admission: nine patients died due to sepsis and multi-organ failure, five had persistent myocardial dysfunction, and three had major chromosomal abnormalities. In our study, six of 18 patients died in the PCICU, while one died at home following discharge (total mortality 38.8%). Six patients died due to sepsis and multi-organ failure and two died due to persistent myocardial dysfunction (one of these patients also had sepsis).

In conclusion, tracheostomy may be more frequently indicated in patients with underlying complicated congenital heart disease or additional genetic or neurological disorders compared to patients undergoing cardiac surgery due to congenital heart disease. The number of infant cases with complicated congenital heart disease who undergo palliative surgery is a significant proportion of this patient population. Based on our study results, tracheostomy procedures may be performed in patients with prolonged intubation time following cardiac surgery

with a low complication rate. However, the morbidity and mortality rates in this patient population still remain high due to several factors implicated in this complicated process.

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REFERENCES

1. Harris KC, Holowachuk S, Pitfield S, Sanatani S, Froese N, Potts JE, et al. Should early extubation be the goal for children after congenital cardiac surgery? J Thorac Cardiovasc Surg 2014;148:2642-7.
2. Hoskote A, Cohen G, Goldman A, Shekerdemian L. Tracheostomy in infants and children after cardiothoracic surgery: indications, associated risk factors, and timing. J Thorac Cardiovasc Surg 2005;130:1086-93.
3. Alibrahim IJ, Kabbani MS, Abu-Sulaiman R, Al-Akhfash A, Mazrou KA. Outcome of tracheostomy after pediatric cardiac surgery. J Saudi Heart Assoc 2012;24:163-8.
4. Heffner JE. Timing of tracheotomy in mechanically ventilated patients.Am Rev Respir Dis 1993;147:768-71.
5. Devarajan J, Vydyanathan A, Xu M, Murthy SM, McCurry KR, Sessler DI, et al. Early tracheostomy is associated with improved outcomes in patients who require prolonged mechanical ventilation after cardiac surgery. J Am Coll Surg 2012;214:1008-16.
6. Enç Y, Aydemir N, Biçer Y, Yurtseven N, Orhan G, Özay B, et al. Indications and results of tracheostomy in pediatric postoperative intensive care unit. Turk Gogus Kalp Dama 2008;16:24-8.
7. Challapudi G, Natarajan G, Aggarwal S. Single-center experience of outcomes of tracheostomy in children with congenital heart disease. Congenit Heart Dis 2013;8:556-60.
8. Mohr AM, Rutherford EJ, Cairns BA, Boysen PG. The role of dead space ventilation in predicting outcome of successful weaning from mechanical ventilation. J Trauma 2001;51:843-8.
9. Durbin CG Jr. Indications for and timing of tracheostomy. Respir Care 2005;50:483-7.
10. Dursun O, Ozel D. Early and long-term outcome after tracheostomy in children. Pediatr Int 2011;53:202-6.
11. Trachsel D, Hammer J. Indications for tracheostomy in children. Paediatr Respir Rev 2006;7:162-8.
12. Kabbani MS, Al-Eathan A, Azzam M, Al Alem H, Abu-Taleb A, Hijazi O. Tracheostomy in pediatric intensive care. Analysis of 5-year-experience and review of literature. Saudi Med J 2004;25:1282-4.
13. Amin RS, Fitton CM. Tracheostomy and home ventilation in children. Semin Neonatol 2003;8:127-35.
14. Wynne DM, Kong K, Berkowitz RG. Unplanned tracheostomy following pediatric cardiac surgery. Otolaryngol Head Neck Surg 2009;140:933-5.
15. Bandla HP, Hopkins RL, Beckerman RC, Gozal D. Pulmonary risk factors compromising postoperative recovery after surgical repair for congenital heart disease. Chest 1999;116:740-7.
16. Yıldız O, Öztürk E, Altın HF, Ayyıldız P, Kasar T, İrdem A, et al. Chylothorax following pediatric cardiac surgery. Turk Gogus Kalp Dama 2015;23:434-40.