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Pediatric Tracheotomy: Indications and Outcomes

Pediatrik Trakeotomi: Endikasyonlar ve Sonuçlarımız

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ABSTRACT Objective: To investigate the indications and outcomes of our pediatric tracheotomy patients. **Material and Methods:** In this retropective study, we reviewed 47 pediatric patients who were performed tracheotomy by Otorinolaryngology Department between 2013 and 2018. Age, gender, indications of tracheotomy, presence of syndromic condition, duration of intubation, decannulation outcomes and mortality rates were collected. **Results:** The present study included 47 pediatric cases that underwent a tracheotomy, of which 48.9% (n=23) were female and 51.1% (n=24) were male. The mean age of the patients at the time of the tracheotomy was 4.20±5.94 years and the age range was 29 days to 17.99 years. The mean intubation time was 39.23±32.09 days (range 6–154 days). The indication for tracheotomy was neurological deficit in 46.8% (n=22), cardiopulmonary disease in 29.8% (n=14), trauma in 17.0% (n=8), craniofacial anomaly in 4.3% (n=2) and airway obstruction in 2.1% (n=1) of the patients. Age was significantly higher in the trauma patients than in the patients who underwent a tracheotomy with indications of neurological deficit and cardiopulmonary disease (p=0.049; p=0.001). The intubation time was significantly higher in patients with cardiopulmonary disease than in patients with neurological deficit and trauma (p=0.048; p=0.001). A syndrome was detected in 19.1 (n=9) of the patients. Of the patients, 46.8% (n=22) were survivors, 42.6% (n=20) were non-survivors, and 10.6% (n=5) could not be reached. Death due to tracheotomy was not observed in any patient. Decannulation rate was 40.9% (n=9) in survivors. **Conclusion:** Indications and results may vary in studies examining pediatric tracheotomy patients. For this reason, it is important to follow up-to-date data on this issue and to reveal the differences. In this study, children with neurological deficits and cardiopulmonary disease constitute the majority of pediatric cases undergoing a tracheotomy, with trauma ranking third among the etiologies. A limited number of tracheotomies were performed with indications of craniofacial anomalies and airway obstructions. Intubation time was high in the group with cardiopulmonary disease and tracheotomy age was high in patients with trauma.

Keywords: Pediatric; tracheotomy; heart diseases; nervous system diseases; cumulative trauma disorder

ÖZET Amaç: Bu çalışmanın amacı pediatrik trakeotomi hastalarımızın endikasyon ve sonuçlarını araştırmaktır. **Gereç ve Yöntemler:** Bu retrospektif çalışmada 2013-2018 yılları arasında Kulak Burun Boğaz Bölümü tarafından trakeotomi uygulanan 47 pediatrik hasta gözden geçirildi. Hastaların yaş, cinsiyet, trakeotomi endikasyonları, sendromik durum varlığı, entübasyon süresi, dekanülasyon sonuçları ve mortalite oranları incelendi. **Bulgular:** Bu çalışmaya trakeotomi uygulanan 47 çocuk olgu dahil edildi; bunların %48,9'u (n=23) kız ve%51,1'i (n=24) erkekti. Trakeotomi sırasında hastaların ortalama yaşı 4,20 ± 5,94 yıl ve yaş aralığı 29 gün ila 17,99 yıl arasındaydı. Ortalama entübasyon süresi 39,23±32,09 gün (6-154 gün) idi. Trakeotomi endikasyonları %46,8 (n=22) nörolojik defisit, %29,8 (n=14) kardiyopulmoner hastalık, %17,0 (n=8) travma, %4,3 (n=2) kraniyofasiyal anomali ve %2,1 (n=1) hava yolu obstrüksiyonu idi. Travma hastalarında yaş, nörolojik defisit ve kardiyopulmoner hastalığı olan hastalardan anlamlı olarak daha yüksekti (p=0,049; p=0,001). Entübasyon süresi kardiyopulmoner hastalığı olan hastalarda nörolojik defisit ve travması olanlara göre anlamlı derecede yüksekti (p=0,048; p=0,001). Hastaların %19,1'inde (n=9) bir sendrom saptandı. Hastaların %46,8'i (n=22) yaşamakta, %42,6'sı (n=20) ex olmuş ve %10,6'sına (n=5) ulaşılamamıştır. Trakeotomiye bağlı ölüm hiçbir hastada gözlenmemiştir. Dekanülasyon oranı sağ olanların %40,9'unda (n=9) gözlenmiştir. **Sonuç:** Pediatrik trakeotomi hastalarının incelendiği çalışmalarda endikasyonlar ve sonuçlar değişiklikler gösterebilmektedir. Bu nedenle bu konu ile ilgili güncel verilerin izlenmesi, farklılıkların ortaya konulması önem taşımaktadır. Bu çalışmada, pediatrik trakeotomi için en sık endikasyon nörolojik defisit, ardından ikinci sırada kardiyopulmoner hastalık ve üçüncü sırada travma gelmektedir. Kraniyofasiyal anomali ve hava yolu tıkanıklığı belirtileriyle sınırlı sayıda hastaya trakeotomi yapılmıştır. Entübasyon süresi kardiopulmoner hastalığı olan grupta, trakeotomi yaşı ise travmalı hastalarda yüksek saptanmıştır.

Anahtar Kelimeler: Pediatrik; trakeotomi; kalp hastalıkları; sinir sistemi hastalıkları; kümülatif travma hastalıkları

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Pediatric tracheotomy is a life-saving surgical procedure that was first performed in the early 1600s to a child who aspirated a bone.[1] Main indications of tracheotomy includes upper airway obstructions, accessing the lower airway for long-term ventilation and pulmoner toilet.[2,3] Over the years, there have been changes in indications.[3-5] During 1970s and 1980s, the most important reason for tracheotomy was acute upper respiratory tract obstruction due to infections with *Haemophilus influenzae* and *Corynebacterium diphtheriae*, however this has changed with the onset of vaccination against these microorganisms.[3,4] Over the 30 years, although emergency tracheotomy indications decreased, it was shown that pediatric tracheotomy has performed more frequently.[5,6] This condition is thought to be associated with increasing survival rates of preterm infants and the patients with neurological and cardiopulmonary diseases by the improvement of non-invasive mechanical ventilation systems and intensive care.[3,5]

It is important to keep up to date literature information about pediatric tracheotomy for accurate patient management. Thus, in this study, we aimed to present the indications and outcomes of our pediatric tracheotomy patients.

MATERIAL AND METHODS

The study was approved by Clinical Research Ethics Committee, University of Health Ministry, Union General Secretariat of Public Hospitals (Approval Number: 2019.02.23). Pediatric patients were performed tracheotomy by Otorinolaryngology Department between 2013 and 2018 were included in the study. Patients, older than 18 years of age at the time of tracheotomy procedure were excluded from the study.

The parameters studied were as follows: age, gender, indications of tracheotomy, presence of syndromic condition, duration of intubation, decannulation outcomes, current life information. Decanulation and life information of patients were completed by file scanning and calling families. All cases consisted of patients who underwent elective tracheotomy. Due to missing records, complications of the patients were not mentioned in the study.

We defined the primary indication for tracheotomy into 5 categories including cardiopulmonary disease, neurological impairment, traumatic injury craniofacial anomalies, and airway obstruction.

TRACHEOTOMY PROCEDURE

Support was placed under the shoulder for head extension. The head was taped to hold it in the midline. Important structures such as thyroid and cricoid cartilage and suprasternal notch were palpated and marked. The surgical site is cleaned with povidone-iodine and sterile covers were covered. In the planned incision, site 1% lidocaine solution with 1:100,000 adrenaline was injected and local anesthesia was provided. Skin incision was made midline transverse between cricoid cartilage and suprasternal notch. Subcutaneous tissues and plasticis muscle were passed. Strep muscles were split into midline. Thyroid tissue was eliminated towards the superior or inferior or, if necessary, the isthmus was discontinued. Cricoid cartilage was defined on the trachea. Tissues on the 2nd and 3rd tracheal rings were cleared and the rings were clearly exposed. Traction sutures (4-0 or 5-0 nonabsorbable monoflament sutures) were placed on both sides of the vertical incision line. A vertical incision was made in the 2nd and 3rd tracheal rings. Intubation tube was pulled and tracheotomy cannula was placed and cannula cuff was inflated. Traction sutures were pasted on both sides by writing left and right. Laces of the cannula were tied at the side of the neck. All postoperative patients were admitted to the pediatric intensive care unit.

STATISTICAL ANALYSIS

The statistical analysis was carried out using NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) software. Descriptive statistics (mean, standard deviation, median, frequency, percentage, minimum, maximum) were used for the evaluation of the study data. Shapiro-Wilk test was applied and the graphs were examined to test for the normal distribution of the quantitative variables. Kruskal Wallis test with post hoc Dunn test was used to compare quantitative variables without normal distribution between three groups, and Mann-Whitney U-test was used to compare two groups. Pearson's Chi-square test, Fisher-Freeman-Halton test and

Fisher's Exact test were used for the comparison of qualitative variables. A *p* value <0.05 was considered statistically significant.

RESULTS

A total of 47 children who underwent tracheotomies were evaluated in the study, of which 48.9% (n=23) were female and 51.1% (n=24) were male. The mean age of the patients at the time of the tracheotomy was 4.20±5.94 years and the age range was 29 days to 17.99 years. Of the total, 34 patients (72.2%) were younger than 2 years. All cases underwent a planned tracheotomy procedure.

The mean intubation time was 39.23±32.09 days (range 6–154 days) (Table 1). The indication for tracheotomy was neurological deficit in 46.8% (n=22), cardiopulmonary disease in 29.8% (n=14), trauma in 17.0% (n=8), craniofacial anomaly in 4.3% (n=2) and airway obstruction in 2.1% (n=1) of the patients (Table 1) (Figure 1).

A statistically significant difference was observed in the age at the time of the tracheotomy according to the indications (p=0.001; p<0.01). Age was significantly higher in the patients with neurological deficits than in patients with cardiopulmonary disease (p=0.030; p<0.05), whereas the children with trauma were significantly older than those undergoing the procedure with indications of neurological deficit and cardiopulmonary disease (p=0.049; p=0.001) (Table 2).

A statistically significant difference was observed in the intubation times according to the indications (p=0.005; p<0.01). The intubation time was significantly higher in patients with cardiopulmonary disease than in patients with neurological deficit and trauma (p=0.048; p=0.001) (Table 2).

A syndrome was detected in 19.1 (n=9) of the patients, with four patients with Down syndrome, 1 with Leigh syndrome, 1 with Treacher Collins syndrome, 1 with trisomy 13 syndrome, 1 with Werdnig-

TABLE 1: Distributions of descriptive properties.

		n (%)
Sex	Female	23 (48.9)
	Male	24 (51.1)
Tracheotomy ages (years)	Min-Max (Median)	1 month-17.99 years (0.85)
	Mean±SD	4.20±5.94
Syndrome	No	38 (80.9)
	Yes	9 (19.1)
	Down syndrome	4 (44.5)
	Leigh syndrome	1 (11.1)
	Syndromic baby (not typed)	1 (11.1)
	Trichers colli syndrome	1 (11.1)
	Trizomi 13 syndrome	1 (11.1)
	Wedding Hoffman syndrome	1 (11.1)
Intubation time (days)	Min-Max (Median)	6-154 (30)
	Mean±SD	39.23±32.09
Indications	Neurological	22 (46.8)
	Cardiopulmonary disease	14 (29.8)
	Trauma	8 (17.0)
	Craniofacial anomalies	2 (4.3)
	Airway obstruction	1 (2.1)
Life situation	Alive	22 (46.8)
	Ex	20 (42.6)
	Unreachable	5 (10.6)
Decanulation status (n=22)	No	13 (59.1)
	Yes	9 (40.9)

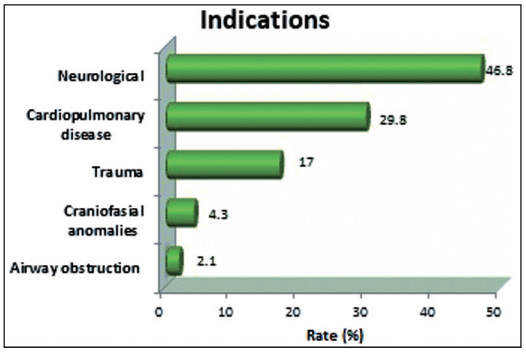

FIGURE 1: Distribution of indications.

Hoffmann syndrome and 1 with a syndromic condition that could not be clearly diagnosed (Table 1).

Of the patients, 46.8% (n=22) were survivors, 42.6% (n=20) were non-survivors and 10.6% (n=5) could not be reached by calling, thus life and decanulation information of the patients were not available. All deaths were related to the disease. No tracheotomy-related deaths were noted. A statistically significant difference was found between the survivors and non-survivors in terms of age, with age at the time of the tracheotomy being significantly lower in the non-survivors (p=0.001; p<0.01) (Table 2). A statistically significant difference was found in intubation times between the survivors and non-survivors, with intubation time being longer in the

TABLE 2: Outcomes according to indications.

		Indications				
		[1]Neurological	[2]Cardiopulmonary disease	[3]Trauma	p	Post Hoc
Tracheotomy ages (years)	Min-Max (Median)	0.22-17.99 (1.05)	0.08-10.95 (0.44)	1.66-17.99 (13.84)	[b]0.001**	1>2; p:0.030*
	Mean±SD	3.86±5.88	1.20±2.82	11.18±5.85		3>1p:0.049*
						3>2p:0.001**
Intubation time (days)	Min-Max (Median)	9-154 (29.5)	12-110 (52)	6-35 (9.43)	[b]0.005**	2>1p:0.048*
	Mean±SD	39.14±36.27	54.21±28.00	18.13±9.43		2>3p:0.001**
Decanulation status (n=20)	No	8 (88.9)	1 (33.3)	2 (25.0)	0.013*	2>1
	Yes	1 (11.1)	2 (66.7)	6 (75.0)		3>1

Kruskal Wallis test&Post hoc Dunn test. [d]Fisher Freeman Halton Test.*p<0.05; **p<0.01.

SD: Standard deviation; Min: Minimum; Max: Maximum.

TABLE 3: Assessment of living status by descriptive characteristics.

		Life situation		
		Alive (n=22)	Ex (n=20)	p
Sex; n (%)	Female	7 (36.8)	12 (63.2)	[a]0.067
	Male	15 (65.2)	8 (34.8)	
Tracheotomy ages (years)	Min-Max (Median)	0.22-17.99 (4.97)	0.08-1.55 (0.59)	[b]0.001**
	Mean±SD	7.60±6.99	0.66±0.40	
Syndrome; n (%)	No	19 (55.9)	15 (44.1)	[c]0.445
	Yes	3 (37.5)	5 (62.5)	
Intubation time (days)	Min-Max (Median)	6-154 (16.5)	12-111 (42)	[b]0.004**
	Mean±SD	31.95±37.66	49.10±25.95	
Indications; n (%)	Neurological	9 (47.4)	10 (52.6)	[d]0.005**
	Cardiopulmonary disease	3 (25.0)	9 (75.0)	
	Trauma	8 (100)	0 (0)	
	Craniofasial anomalies	1 (50.0)	1 (50.0)	
	Airway obstruction	1 (100)	0 (0)	

Evaluations was performed by exclusion of 5 cases that were not reached in terms of life status.

[a]Pearson Chi-Square Test; [b]Mann Whitney U Test; [c]Fisher's Exact Test; [d]Fisher Freeman Halton Test; **p<0,01.

SD: Standard deviation; Min: Minimum; Max: Maximum.

non-survivors than in the survivors (p=0.004; p<0.01) (Table 3).

Survival was significantly affected by the indications (p=0.005; p<0.01) (Table 3). The rate of mortality was higher in those undergoing the procedure with indications of neurological deficits, cardiopulmonary disease and craniofacial anomalies than in those with trauma and airway obstruction. Survival was not significantly affected by the presence of a syndrome (p>0.05) (Table 3).

Nine (40.9%) of the surviving cases were decannulated whereas 59.1% (n=13) of the surviving cases were not decannulated (Table 1). Of the patients that underwent decannulation, the indication for tracheotomy was trauma in 6, cardiopulmonary disease in 2 and neurological deficit in 1 patient. A statistically significant difference was noted in decannulation status according to the indications (p=0.013; p<0.05), with the rate of decannulation being significantly higher in the patients with cardiopulmonary disease and trauma (p<0.05).

DISCUSSION

The most common indication for tracheotomy in our hospital was neurological deficit, with a rate of 46.8%, followed by cardiopulmonary disease and trauma with rates of 29.8% and 17%, respectively. Airway obstruction and craniofacial anomalies were less common indications for tracheotomy. In previous studies involving large series in literature, airway obstruction was found to be the most common reason for pediatric tracheotomy, reported to be 72% in the study by Özmen et al., and 70% in the study by Mahadevan et al.[3,7] Gergin et al. reported that the most common indications for tracheotomy were cardiopulmonary disease (32%) and neurological deficit (31%).[5] Lin et al. reported neurological deficit as the most common indication for tracheotomy (40.8%), followed by upper airway obstruction (28.9%); while Funamura et al. reported neurological anomalies (38.9%) and cardiopulmonary diseases (21.2%) as the most common indications.[8,9] In Roberts et al. study, the most common indications was long term ventilation (66%) including diseases such as tracheobronchomalacia, chronic neurodevelopmental disorder, congenital diaphragmatic hernia, congenital muscular dystrophy, congenital hypoventilation syndrome, esophageal atresia, and tracheaesophageal fistula. Weaning in cardiac patients were the second indication (38%).[10] Cia et al. reported that the airway obstruction was the first frequent indication (46.5%) and the neurologic reasons were the second indication (28.7%).[11] Our results seemed to be in line with the results of Gergin et al. and Funamura et al. Due to the fact that our country has an important pediatric cardiac surgery reference center at a very close distance to our hospital and there is no pediatric intensive care unit in this center, patients with cardiac disease are followed up in our hospital and cardiopulmonary disease take second place in tracheotomy indications.

Although previous studies have recommended tracheotomy in pediatric cases requiring ventilation for more than 8 days, subsequent studies have suggested that this decision be based on the individual characteristics of the patient between days 2 and 134.[12,13] Studies in literature report different intubation times according to indications.[8] The intubation time in the patients in the present study was minimum 6 days and maximum 154 days, with a mean duration of 39 days. Our patient, who was intubated for the longest period, is a hypotonic patient with epilepsy. The factor in extending the intubation period was that the family did not approve the tracheotomy for a while. Intubation times differ significantly according to the indications, with significantly longer times reported in patients with cardiopulmonary disease than in patients with neurological deficit and trauma (p=0.048; p=0.001). Although tracheotomy decision could be made faster in patients with neurological disease and trauma etiology, in patients with cardiopulmonary disease, entubation times could be extended with the idea that patients could tolerate extubation by lowering pulmonary pressure heights after surgery or medical treatment. Similarly to the present study, the mean intubation time in the study by Özmen et al. was 32 days.[3] The mean intubation time in the study by Lin et al. was 61.8 days, the range being between 0 and 334 days. In the study of Lin et al., the mean intubation time was the longest among individuals with craniofacial anomalies (108.8 days) and the shortest (17.9 days) following post-

traumatic sequel. Their study suggested that an early tracheotomy reduces the need for mechanical ventilation and the length of hospital stay following the tracheotomy opening.[8]

The mean age at tracheotomy was 4.2 years in the present study and 72.3% (34/47) of our patients were children under 2 years of age. Of the remaining 13 patients, 6 (12.7%) underwent a tracheotomy with the indication of trauma. Studies have found the age to be higher among pediatric patients that underwent tracheotomy with indications of trauma, and in these studies, the age was higher in the children who underwent tracheotomy opening due to neurological deficits than in the other groups.[5,9] In accordance with these studies, in our study, age was significantly higher in the patients that underwent the procedure with neurological indications than those with cardiopulmonary disease ($p=0.030$; $p<0.05$), whereas age was significantly higher in trauma patients than in patients with neurological deficits and cardiopulmonary disease ($p=0.049$; $p=0.001$). We think that the fact that cardiopulmonary and neurological diseases were diagnosed early in life caused the tracheotomy age to be lower in these patients.

Pediatric tracheotomy is associated with a high mortality rate that ranges between 13 and 19% in different studies, although this is associated with the tracheotomy procedure in less than 3% of the patients.[3,4,9,14,15] Survival was evaluated in only 42 children, as 5 patients could not be reached and 42.6% of the patients had died. All deaths were related to the disease. No tracheotomy-related death was noted. The mortality rate in the present study is higher than in those reported in literature.[3,5,10,14,16] The mortality rate in the study of Ozmen et al. was 19% and 1% of the patients died from tracheotomy-related complications.[3] In the study of Gergin et al., tracheotomy-related and unrelated mortality rates were 0.4% and 14%, respectively.[5] In the study of Roberts et al., the mortality rate was 22.1% and 1.2% of the patients died due to the tracheotomy-related complications.[10] In a recent review study, the tracheotomy-related mortality rate was reported to be 0-5.9% and the overall mortality rate was 2.2-59%.[16] The overall mortality rate in the study by Funamura et al. was 16.6%, and the presence of cardiopulmonary disease and older age were found to be associated with high mortality.[14] In the present study, the majority of non-survivors had neurological or cardiopulmonary disease. Furthermore, age at the time of tracheotomy was significantly lower ($p<0.01$) and intubation time was significantly higher ($p<0.01$) among the non-survivors than the survivors. The rate of mortality was found to be significantly higher in patients with neurological and cardiopulmonary disease. No significant relationship was found between the presence of a syndrome and survival rates. We thought that the high number of cases with chronic diseases in our study increased our mortality rates.

When 22 survivors (46.8%) were evaluated in terms of decannulation status, 9 (40.9%) had undergone decannulation. In decannulation rates in the study of Roberst et al. and Chia et al. were 44.4% and 39%, respectively.[10,11] Chia et al. mentioned that chronic conditions leading to malnutrition and developmental delay may be a limited potential for decannulation.[11] In our study, patients who underwent a tracheotomy due to trauma (6/9) comprised the majority of these patients. This finding suggests that decannulation can be possible in individuals without a chronic disease, and so such patients must be evaluated in the shortest time possible and be returned to normal life.

CONCLUSION

The most common indication for pediatric tracheotomy in the present study was neurological deficit, followed by cardiopulmonary disease and trauma. A limited number of tracheotomies were performed with indications of craniofacial anomalies and airway obstructions. Intubation times have been prolonged and the need for pediatric tracheotomy has increased in relation to the advanced intensive care unit support. It is important to present new data into the literature in order to maintain consensus regarding the management of such cases.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company

that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Selin Üstün Bezgin, Taliye Çakabay;* ***Design:*** *Selin Üstün Bezgin, Taliye Çakabay;* ***Control/Supervision:*** *Selin Üstün Bezgin, Taliye Çakabay;* ***Data Collection and/or Processing:*** *Selin Üstün Bezgin, Murat Koçyiğit, Havva Duru İpek, Safiye Giran Örtekin, Hakan Gemici;* ***Analysis and/or Interpretation:*** *Selin Üstün Bezgin, Taliye Çakabay;* ***Literature Review:*** *Selin Üstün Bezgin, Taliye Çakabay;* ***Writing the Article:*** *Selin Üstün Bezgin;* ***Critical Review:*** *Taliye Çakabay.*

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