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Pediatric Tracheotomy: Indications, Timing, and Clinical Outcomes

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ABSTRACT

This study aimed to evaluate the indications, timing, and clinical outcomes of pediatric tracheotomy cases managed at a single tertiary center over a 13-year period.

A retrospective review was conducted of 110 pediatric patients (1 day–18 years) who underwent tracheotomy between 2010 and 2023. Demographic data, indications, tracheotomy timing (TIT), duration of hospitalization, complications, and mortality were analyzed. Statistical analyses included Mann-Whitney U, Kruskal-Wallis, and chi-square tests, with $p<0.05$ considered significant.

Among 110 pediatric patients, 66 were male, and 44 were female. The most common indication for tracheotomy was prolonged mechanical ventilation (80.9%), followed by airway obstruction (19.1%), which was more frequent in newborns ($p=0.004$). Hospital stay duration and tracheotomy timing were significantly shorter in airway obstruction cases than in prolonged ventilation ($p<0.001$), with significant differences among age groups ($p=0.008$ and $p<0.001$). Overall mortality was 31.8%, predominantly among patients with congenital or neurological comorbidities; no statistically significant association was found between mortality and tracheotomy indication ($p=0.445$).

Pediatric tracheotomy remains a safe and effective intervention when performed with appropriate timing and multidisciplinary care. Our study reveals that early tracheotomy does not impact mortality rates; however, it does shorten hospital stay duration and reduce complications.

Keywords: Tracheotomy, Tracheotomy timing, Pediatric, Indications, Outcomes

Introduction

Pediatric tracheotomy is a life-saving surgical procedure performed in children in life-threatening situations such as upper airway obstruction or the need for prolonged mechanical ventilation (1). Although tracheotomy is life-saving, studies have suggested that the risks involved are greater in children than in adults (2). With advances in medicine and the development of pediatric intensive care, there have been significant changes in the follow-up care of tracheostomies. Therefore, it can be said that the survival rates of premature infants and those with severe congenital anomalies are higher today (3).

Today, the most common indications for pediatric tracheotomy include the need for long-term mechanical ventilation, congenital or acquired upper airway anomalies, neuromuscular diseases, and traumatic airway injuries. Particularly in premature infants, ventilator dependence due to bronchopulmonary dysplasia and chronic lung disease are among the main factors increasing the need for tracheotomy (3,4).

Tracheotomy is technically more difficult in children than in adults and carries a higher risk of complications. The narrow diameter of the trachea in children, the sensitivity of surrounding tissues, and anatomical variations can lead to serious complications during and after surgery. The most common complications include bleeding, infection, tracheal stenosis, granulation tissue formation, and tube obstruction (5,6). However, with appropriate patient selection, timing, and a multidisciplinary approach, both life expectancy and quality of life can be significantly improved

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(7). Additionally, post-tracheotomy care and family education are critical for the safe monitoring of patients at home and the success of decannulation.

In the literature, the timing of tracheotomy, changes in indications, prevention of complications, decannulation criteria, and long-term outcomes are still debated. In particular, whether early tracheotomy shortens the length of hospital stay, its effect on neurodevelopmental outcomes, and its impact on complication rates are among the main topics of current research (8,9).

In recent years, tracheotomy indications in pediatric intensive care practice have become increasingly diverse, and there is no consensus on the optimal criteria for the timing of the procedure. Although the literature reports that early tracheotomy may reduce the duration of mechanical ventilation and intensive care unit stay, its effect on complication rates and mortality is unclear. This study aims to evaluate the effect of tracheotomy procedures on clinical outcomes and mortality in pediatric patients undergoing tracheotomy at our center, and to contribute to the existing literature on the timing of tracheotomy based on the data obtained.

Material and Methods

The study was approved by the Non-Interventional Clinical Research Ethics Committee of Van Yüzüncü Yıl University (approval no: 2024/11-15, approval date: 18/10/2024). Pediatric cases who underwent tracheotomy at our hospital between 2010 and 2023 were included in the study. Patients with missing information in their records and the epicrisis report, patients over 18 years of age, and patients who underwent tracheotomy at an external center and were admitted to our hospital were excluded. All patient information was recorded by reviewing patient files, the epicrisis, and archive records. Patient records were screened based on initial diagnosis, indication, age, gender, complications, length of stay in the hospital and intensive care unit, duration of intubation before tracheotomy, and duration of cannulation and decannulation.

Statistical Analysis: Statistical analyses were performed using the SPSS (IBM, Armonk, NY) program. The Shapiro-Wilk test was used to check whether the data were normally distributed. Since the data were not normally distributed, non-parametric tests were applied. Changes in parameters according to gender, mortality, and indication were analyzed using the Mann-Whitney U test. Patients were divided into three groups: Group 1: newborn group (0-30 days), Group 2: infant group (1-24 months), and Group 3: childhood and adolescence group (2-18 years). Changes in parameters according to age groups were analyzed using the Kruskal-Wallis test. After significance was found in the Kruskal–Wallis test, pairwise comparisons between groups were performed using the Mann–Whitney U test, and Bonferroni correction was applied. The discharge status and indications of patients according to age groups were examined using the chi-square test. $p<0,05$ was accepted as the statistical threshold.

Results

Demographic Data: The study population consisted of 110 patients (age range: 1 day–18 years), 66 males and 44 females. Of the 110 cases, 22 were in group 1 (age: 19.91±10.92 days, range: 1-30 days), 50 were in group 2 (age: 4.50±3.14 months, range: 1-16 months), and 37 were in group 3 (age: 8.28±5.69 years, range: 2-18 years). There was no statistically significant difference in age between males and females in any of the three groups (group 1: $p=0.448$, group 2: $p=0.574$, and group 3: $p=0.392$).

Hospital Stay Duration and Tracheotomy Timing By Age and Gender: The duration of hospital stay ($p=0.793$) and tracheotomy timing ($p=0.493$) for males were similar to those for females (Table 1). When age groups were considered, cases in group 2 had a longer hospital stay ($p=0.008$), and tracheotomy was performed later ($p<0,001$) in these cases (Table 1). Hospital stay duration ($p=0.529$) and the time between intubation and tracheotomy ($p=0.326$) were statistically similar in patients in groups 1 and 3.

Indications: The most common indication for tracheotomy was prolonged ventilation (55 males and 34 females, a total of 89 cases, 80.9%). In the remaining 21 patients (19.1%, 11 males and 10 females), tracheotomy was performed urgently due to airway obstruction. No statistically significant relationship between indication and gender was found ($p=0.428$). The distribution of patients by age group according to indication is shown in Table 2. This table shows a relationship between indication and age ($p=0.004$). Prolonged ventilation is the predominant indication in all three groups. However, tracheotomy due to airway obstruction is significantly more common in the newborn group than in the other groups.

Table 1: Duration of Hospital Stay and Time of Tracheotomy According to Age (Kruskal-Wallis test) and Gender (Mann-Whitney U test). Since The Data Were Not Normally Distributed, The Median (Minimum-Maximum) Was Given

Gender	Duration of hospitalization	TIT
Male	60 (2-720)	19 (1-210)
Female	68 (2-900)	25 (1-210)
p	0,793	0,493
Age	Duration of hospitalization	TIT
Group 1	35.50 (2-900)	14 (1-37)
Group 2	78 (3-540)	40 (1-210)
Group 3	55 (2-240)	13 (1-90)
p	0,008	< 0,001

* TIT: The time between intubation and tracheotomy

Table 2: Distribution of Patients By Age Group According To Indication (Chi-square test)

Age group	Long-term ventilation	Airway obstruction	Total	p
Group 1	13 (59.1%)	9 (40.9%)	22	
Group 2	46 (92%)	4 (8%)	50	0,004
Group 3	30 (78.9%)	8 (21.1%)	38	
Total	89 (80.9%)	21 (19.1%)	110	

Table 3: Hospital Stay Duration and Tracheotomy Date According To Indication (Mann-Whitney U Test). Since The Data Are Not Normally Distributed, The Median (Minimum-Maximum) is provided.

	Parameters	Long-term ventilation	Airway obstruction	p
All cases	Duration of hospitalization	71 (11-900)	28 (2-240)	< 0,001
	TIT	25 (4-210)	4 (1-8)	< 0,001
Group 1	Duration of hospitalization	50 (11-900)	25 (2-110)	0,004
	TIT	19 (12-37)	3.50 (1-7)	< 0,001
Group 2	Duration of hospitalization	79 (30-540)	35 (3-200)	0,002
	TIT	40.50 (4-210)	1 (1-4)	< 0,001
Group 3	Duration of hospitalization	59 (12-210)	34 (2-240)	0,008
	TIT	16 (7-90)	5.50 (1-8)	< 0,001
Male	Duration of hospitalization	70 (11-720)	31 (2-240)	0,004
	TIT	22 (7-210)	4.50 (1-8)	< 0,001
Female	Duration of hospitalization	73 (30-900)	23 (2-200)	0,001
	TIT	32.50 (4-210)	3 (1-7)	< 0,001

* TIT: The Time Between Intubation and Tracheotomy

It was determined that patients who underwent tracheotomy due to airway obstruction, independent of age and gender, had shorter hospital stays and underwent tracheotomy earlier (Table 3).

Hospitalization Unit: Of the 110 cases, 27 (10 males and 17 females, 24.5%) were hospitalized in the neonatal intensive care unit, while 83 (56 males and 27 females, 75.5%) were hospitalized in the pediatric intensive care unit.

Complications: Complications such as peristomal and tracheal granuloma (30%), decannulation (21%), bleeding (8.1%), subglottic stenosis (6.3%), tracheitis (4.5%), and wound site infection (6.4%) were observed.

Mortality: Thirty-five patients (31.8%, 23 men and 12 women) died, while 75 (68.2%, 43 men and 32 women) were discharged. No statistically significant relationship between mortality and gender was found (p=0.531). When age groups were considered, 9 cases (40.9%) from group 1, 17

cases (34%) from group 2, and 9 cases (23.7%) from group 3 died. No statistically significant relationship was found between age and mortality rate (p=0.349). Thirty (33.7%) of the patients who underwent tracheotomy due to prolonged ventilation and 5 (23.8%) of the patients who underwent emergency tracheotomy due to airway obstruction died. No statistically significant relationship was found between the indication and the mortality rate (p=0.445). Patients who died stayed in the hospital for 73 days (2-720 days), while those who were discharged stayed for 60 days (3-900 days). Furthermore, tracheotomy was performed on average on the 21st day (range: 1-210 days) in deceased patients and on average on the 20th day in discharged patients. Deceased patients were found to have statistically similar hospitalization duration (p=0.533) or tracheotomy timing (p=0.945) to discharged patients. All deceased cases were found to have additional pathologies (hydrocephalus, Trisomy 18, Trisomy 21, Pierre Robin syndrome, Patau syndrome, corpus callosum agenesis, meningomyelocele, CP, PDA, SMA, etc.).

Surgical Technique: Björk flap was performed in 40 cases (36.4%), classic tracheotomy in 53 cases (48.2%), and cross-shaped tracheotomy in 17 cases (15.4%). No association was found between the choice of technique and gender (p=0.921), age (p=0.075), or indication (p=0.912) (Table 4).

Discussion

In our study, the most common indication for pediatric tracheotomy was determined to be the need for long-term mechanical ventilation (80.9%). This finding aligns with the current literature, as reported in recent multicenter and large-scale studies, particularly because tracheotomy is often necessary in the treatment of chronic respiratory failure in children when continuous ventilation is required. (10, 11, 12). Ventilator dependence has become an increasingly important indication, particularly in premature infants and children with neuromuscular disorders. In the past, upper airway infections and acute obstructions were more common indications; however, with the improvement of intensive care facilities and a decrease in infections, these rates have decreased significantly (4,11).

In our study, the rate of patients undergoing tracheotomy due to airway obstruction was 19.1%, and this rate was particularly higher in the newborn group. Congenital anomalies and airway pathologies, such as congenital choanal atresia, significantly contribute to airway obstruction in this age group (13, 14). The challenges of managing such conditions underscore the necessity for surgical intervention early in life, where prompt airway stabilization is vital for survival (15, 16). This situation can be explained by the fact that congenital anomalies and congenital airway pathologies are more common in the newborn period. The literature also reports that the rates of tracheotomy due to airway obstruction in newborns are higher than in other age groups (11,17).

The timing of tracheotomy is critically important in terms of both hospital stay duration and the development of complications. In our study, tracheotomy was performed later in the infant group, and hospital stay duration was found to be significantly longer. Earlier tracheotomy could lead to reduced lengths of stay in the Intensive Care Unit (ICU) and decrease the incidence of pneumonia (18, 19). Contemporary reviews further substantiate that delaying tracheotomy may worsen clinical outcomes, highlighting the importance of timing in surgical management (20,21). In particular, in patients who underwent emergency tracheotomy due to airway obstruction, both the length of hospital stay and the timing of tracheotomy were significantly shorter. This finding is consistent with the literature showing that early tracheotomy shortens the length of hospital stay and may reduce the risk of complications (22, 23).

Recent studies have reported that early tracheotomy reduces complications such as sedation and ventilator-associated pneumonia, particularly in premature and low birth weight infants, and improves neurodevelopmental outcomes (23,24). However, it is emphasized that the timing of tracheotomy should be determined on a patient-by-patient basis, taking into account the underlying disease and overall clinical condition. Furthermore, it has been determined that with increasing age, especially in adults, early tracheotomy after prolonged intubation does not alter mortality but reduces potential complications.

The overall mortality rate was found to be 31.8%. Such mortality rates can rise significantly in patients with underlying congenital conditions and those requiring emergency procedures. The complexity of these patients emphasizes the need for a multidisciplinary approach, involving careful preoperative evaluation and postoperative management to mitigate risks and improve outcomes (25,26). Although this rate is close to

the upper limits of the wide range reported in the literature (approximately 2–59%), it is noteworthy that all deceased patients had serious additional pathologies (hydrocephalus, trisomy 18/21, SMA, Patau syndrome, CP, etc.). This situation indicates that mortality in children undergoing tracheotomy is largely due to underlying diseases and that tracheotomy itself has a limited contribution to mortality (5,27,28).

In our study, the Björk flap, classic, and cross techniques were used, and no significant relationship was found between the choice of technique and age, gender, or indication. The literature also reports that the choice of surgical technique is generally determined by the surgeon's experience, the patient's anatomical features, and the indication (29,30). Although percutaneous tracheotomy techniques have been introduced in some centers in recent years, surgical tracheotomy remains the gold standard in young children and newborns (6,31).

Postoperative care following pediatric tracheotomy requires a multidisciplinary team approach. Coordination among intensive care, otolaryngology, pulmonology, physical therapy, speech therapy, nutrition, and social services specialists is critical for safe discharge and successful home care. Comprehensive training of families in tracheotomy care, emergency management, and device use is essential for preventing complications and achieving successful decannulation (30,32).

In the current literature, topics such as optimizing the timing of tracheotomy, decannulation criteria, long-term neurodevelopmental and quality of life outcomes, prevention of complications, and family education are at the forefront (24, 30). In addition, the effectiveness of new surgical techniques and care protocols needs to be evaluated in multicenter, prospective studies.

The main limitations of our study are its retrospective design, single-center data, and lack of long-term follow-up. The retrospective design and incomplete documentation of complication onset timing limited the classification of complications as early or late. Another limitation of this study is the absence of a standardized institutional protocol for determining tracheotomy timing, as decisions were made on an individual, case-by-case basis according to clinical judgment. This variability may have influenced comparisons between early and late tracheotomy outcomes. However, the high number of patients and the consistency of the findings with the current literature increase the value of the study.

In conclusion, pediatric tracheotomy is a safe and effective procedure with appropriate patient selection, timing, surgical technique, and multidisciplinary care. Early tracheotomy may shorten the hospital stay and reduce complications. Family education and psychosocial support are essential for long-term success for both the patient and the family. In the future, multidisciplinary approaches and care protocols need to be developed to achieve better outcomes.

Conflicts of Interest: The authors have no conflicts of interest associated with the publication of this article.

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