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Outcomes of tracheostomy in a pediatric intensive care unit: A single-center experience

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Abstract

Objectives: This study aims to evaluate the indications and complications of tracheostomy procedures performed in the pediatric intensive care unit (PICU) of a private healthcare institution.

Patients and methods: Twenty-one pediatric patients (13 males, 8 females; mean age: 6.7±4.4 years; range, 3 months to 18 years) who underwent surgical tracheostomy between October 1, 2018, and June 1, 2023, were retrospectively analyzed.

Results: The mean duration of tracheostomy was 38±16.5 days (range, 9 to 75 days). The most common indication for tracheostomy was prolonged mechanical ventilation due to neuromuscular conditions (cerebral palsy-associated pneumonia) in 17 (80.9%) patients, followed by upper airway obstruction in three (14%) patients. One (4.8%) patient underwent tracheostomy due to coronavirus disease 2019 (COVID-19) pneumonia. Eighteen (85.7%) patients were discharged, while three (14.3%) patients died during intensive care follow-up.

Conclusion: Tracheostomy is a surgical procedure that can be safely performed in PICUs, particularly in cases requiring prolonged mechanical ventilation. The timing of tracheostomy should be individually assessed based on the clinical condition of the patient by the pediatric intensive care specialist.

Keywords: Cerebral palsy, mechanical ventilation, pediatric intensive care, tracheostomy.

Tracheostomy is a procedure that involves creating an opening in the trachea to place an artificial airway, either through surgical or percutaneous methods. Its primary purpose, in both pediatric and adult patients, is to secure breathing by bypassing upper airway obstructions causing respiratory distress.[1]

In recent years, there has been a notable increase in pediatric tracheostomies. This trend is largely attributed to advancements in neonatal and pediatric intensive care units, including improvements in ventilatory support and surgical techniques, which have made it possible to save the lives of children with conditions that would have previously resulted in neonatal death, such as congenital malformations, severe head trauma, or asphyxia.[2] Furthermore, the publication of guidelines has facilitated a more systematic approach to the management of pediatric tracheostomy.[3]

Although historical references to tracheostomy date back to 3600 BCE, its modern development has occurred primarily within the past century. From the mid-20th century onward, percutaneous techniques have been successfully applied in adult patients.[4] These techniques are advantageous because they often eliminate the need for general anesthesia and surgical dissection, thereby minimizing the risk of damage to adjacent anatomical structures. However, due to the smaller diameter of the pediatric trachea, its softer cartilage, and the proximity of critical structures, percutaneous techniques are generally not preferred for children and neonates.[5,6]

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In critically ill pediatric patients, tracheostomy is frequently performed in intensive care units. Compared to adults, the procedure is more technically demanding in children due to their smaller and more pliable trachea, the limited surgical field, and higher anesthesia risks. Consequently, pediatric patients face mortality and morbidity rates that are two to three times higher than those of adult patients undergoing the same procedure.[7]

Over time, the indications for tracheostomy have evolved. While upper respiratory tract infections were once the most common indication, long-term mechanical ventilation (MV) has now become the primary reason for tracheostomy in pediatric patients. Other common indications include upper airway obstruction, trauma, and neurological conditions.[7,8] In adult patients, tracheostomy is typically recommended after 10 to 14 days of prolonged intubation. However, there is no consensus on the optimal timing or duration of intubation before tracheostomy in pediatric patients, and the available literature on this topic is limited.[8,9]

This study was conducted to evaluate the indications, complications, and outcomes of tracheostomy in a newly established pediatric intensive care unit (PICU) within a private healthcare institution.

PATIENTS AND METHODS

Using the hospital's database, patients who underwent tracheostomy in a 22-bed PICU at the Private Gebze Yüzyıl Hospital between October 1, 2018, and June 1, 2023, were retrospectively reviewed. Data recorded included patients' age, sex, body weight, admission diagnoses, indications for tracheostomy, the day of tracheostomy during the follow-up period, complications, and prognosis. The indication and optimal timing for tracheostomy were jointly decided by the pediatric surgeon and the pediatric intensivist. The definition of prolonged MV (PMV) was set as 60 days for patients younger than one year and 45 days for those older than one year. The inclusion criteria included children with upper airway obstruction caused by congenital anomalies (e.g., subglottic stenosis, laryngomalacia, or tracheomalacia), acquired conditions (e.g., tracheal tumors, foreign body aspiration, or subglottic hemangioma), or severe infections (e.g., bacterial tracheitis, epiglottitis, or severe croup). Neonates and infants with respiratory distress due to anatomical abnormalities such as Pierre Robin sequence, craniofacial syndromes, or significant facial deformities were also included. Finally, patients requiring long-term MV for conditions, including neuromuscular disorders (e.g., spinal muscular atrophy or Duchenne muscular dystrophy) and chronic respiratory failure secondary to severe bronchopulmonary dysplasia or interstitial lung disease were included in the study. The exclusion criteria were as follows: children with reversible airway obstructions resolved by less invasive methods (e.g., temporary intubation or continuous positive airway pressure); cases where tracheostomy was deemed unnecessary due to improvement in underlying conditions. This study included all pediatric patients who underwent tracheostomy without any age-based selection criteria. The patient population was determined based on clinical conditions necessitating tracheostomy (e.g., upper airway obstruction and long-term MV). Written informed consent was obtained from the parents of the patients. The study protocol was approved by the Okan University Faculty of Medicine, Ethics Committee (date: 11.09.2024, no: 37). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical procedure

All tracheostomies were performed in the operating room under general anesthesia by a pediatric surgeon, accompanied by an anesthesiologist and a pediatric intensivist. Surgical tracheostomy was initiated under general anesthesia in the operating room with the patient in a supine position. The neck was extended, and the procedure was performed under sterile conditions with the surgical field draped. Once airway security was ensured, the patient was positioned with the head and neck in the midline. The cricoid cartilage and sternal notch were identified. The midpoint of the line connecting these two points was selected as the incision site. A transverse skin incision was made, with the size of the incision determined by the shape of the patient's neck, typically 2 to 3 cm being sufficient. Care was taken to place the tracheostomy site at the exact midpoint between these two points to avoid subglottic tracheal stenosis from a high placement and erosion of the innominate

artery from a low placement. The PICU remained operational for a total of 56 months. During this period, patients aged 0 to 18 years requiring intensive care were treated. A total of 2,606 patients were admitted to the unit. Of these, 434 (16.67%) patients required MV support. Tracheostomy was performed on 21 (4.8%; 13 males, 8 females; mean age: 6.7±4.4 years; range, 3 months to 18 years) of these patients. After passing through the skin and subcutaneous tissue, the strap muscles were reached. Blunt dissection was performed through the strap muscles up to the thyroid isthmus. The isthmus was retracted either upward or downward to access the trachea. An incision was made through the second and third tracheal rings to create an opening. The trachea was aspirated, and an appropriately sized cuffed tracheostomy tube was inserted and secured at both sides with extra sutures. Circumferential sutures were placed to suture the edges of the tracheal opening to the skin to facilitate easy recannulation. Correct placement of the cannula was confirmed through tracheal aspiration, monitoring of end-tidal carbon dioxide, and airway pressure.

Statistical analysis

Data analysis was performed using IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). Data were presented as frequency (n), percentage (%), mean ± standard deviation (SD), or median (min-max).

RESULTS

The mean body weight of these patients was 19.3±9.0 kg (range, 4 to 40 kg). The mean duration before tracheostomy was performed was 38±16.5 days (range, 9 to 75 days). The demographic and clinical characteristics of the patients are presented in Table 1.

The most common indication for tracheostomy was PMV secondary to neuromuscular problems (n=18, 85%), followed by upper airway obstruction (n=3, 14.3%). In the PMV group, central nervous system diseases were present in nine (42.8%) patients, muscular diseases in four (19%) patients, congenital heart diseases in two (9.5%) patients, and pneumonia-related sepsis in three (14.2%) patients.

TABLE 1
Demographic and clinical characteristics of patients undergoing tracheostomy (n=21)

Characteristics	n	%	Mean±SD	Range
Age			6.7±4.4	3 month-18 year
Sex Male Female	 13 8	 61.9 38.1		
Body weight (kg)			19.3	4-40
Duration before tracheostomy (day)			38	9-75

TABLE 2
Indications for tracheostomy

Indication	Condition	n	%
Prolonged mechanical ventilation		18	85
	Central nervous system diseases	9	42.8
	Muscular diseases	4	19
	Congenital heart diseases	2	9.5
	Sepsis-pneumonia	3	14.2
Upper airway obstruction		3	14.3
	Laryngeal anomaly	2	9.5
	Cystic hygroma/lymphangioma	1	4.7

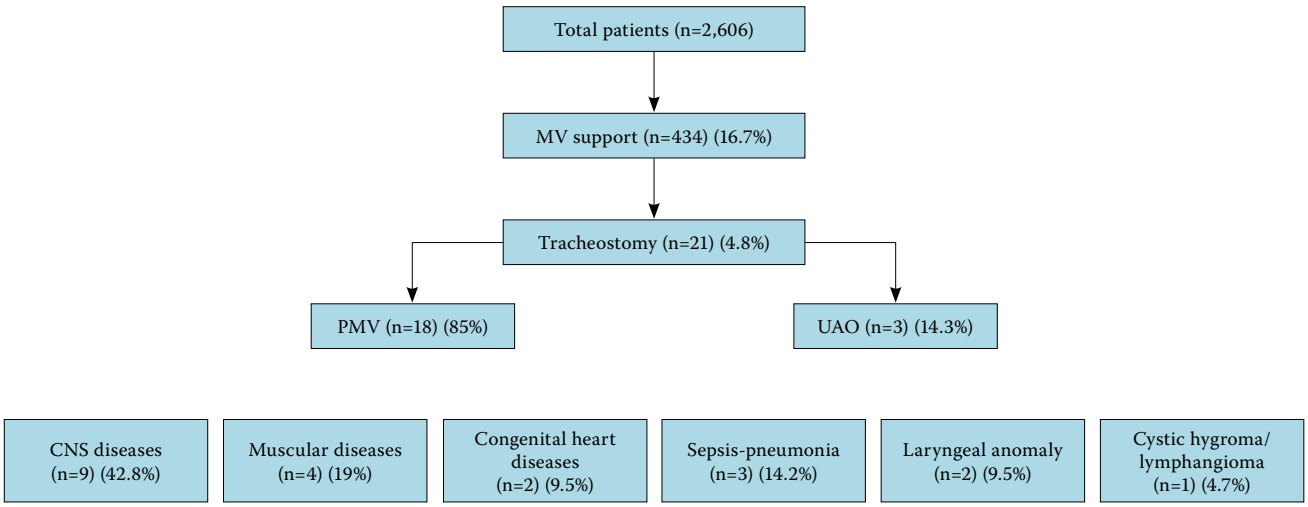

Figure 1. The patient flowchart.

MV: Mechanical ventilation; PMV: Prolonged mechanical ventilation; UAO: Upper airway obstruction; CNS: Central nervous system.

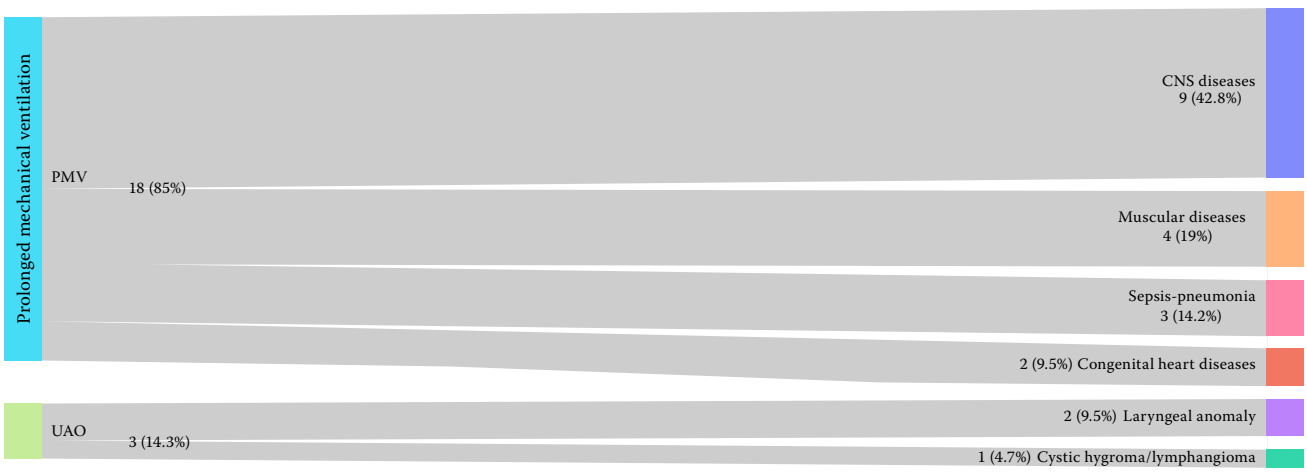

Figure 2. Representation of tracheostomy indications as a Sankey diagram.

PMV: Prolonged mechanical ventilation; UAO: Upper airway obstruction; CNS: Central nervous system.

In the upper airway obstruction group, laryngeal anomaly was found in two (9.5%) patients and cystic hygroma/lymphangioma in one (4.7%) patient (Table 2; Figures 1, 2).

Patients were closely monitored for early complications. Decisions for weaning from MV and decannulation were based on criteria such as adequate vital capacity, the ability to take deep breaths, the ability to protect the airway, and the reduction or disappearance of tracheobronchial secretions. Spontaneous breathing trials were conducted in patients before decannulation. Eighteen (85%) patients were discharged, while three (14.2%) patients died during intensive care monitoring. The causes of death were related to the underlying diseases, with no deaths attributable to tracheostomy complications. Only one (4.7%) patient experienced a complication of skin laceration following tracheostomy.

DISCUSSION

Tracheostomy is one of the most frequently performed surgical procedures in PICUs.[10] The increase in neonatal intensive care units and PICUs, advancements in the diagnosis and treatment of chronic diseases, and the prevention of diseases causing upper respiratory tract obstruction such as diphtheria and influenza B through vaccinations have altered our knowledge regarding pediatric tracheostomy. The most common indications for tracheostomy have shifted from acute inflammatory airway obstructions to PMV.[10,11] Our study supports this change. Literature reviews indicate that the rates of tracheostomy in units vary between 2% and 7%.[12] Recent studies report an increase in this rate. Jain et al.[13] found a tracheostomy rate of 9.1%, with PMV being the most frequent indication at 92%. In our study, the tracheostomy rate was found to be 4.8%. Various studies have also reported that PMV is the most common indication for tracheostomy.[14-16] In our study, PMV was the most common indication at 79.1%.

In adult studies and guidelines, tracheostomy is recommended between the 10th and 14th days of intubation to prevent laryngeal damage. It has been reported that early or late tracheostomy performed after 10 days does not change morbidity and mortality.[17] However, there is no definitive data on when tracheostomy should be performed in pediatric patients. Studies from the USA have shown that the average time to tracheostomy tube insertion is 14.4 days, but this period varies significantly between units, ranging from 4.3 to 30.4 days.[17,18] In our study, the mean time to tracheostomy was 38±16.5 days. We believe that each clinic should have its own protocol and that this procedure should be personalized for each patient. It is known that pediatric patients tolerate intubation for a longer period than adults and that laryngeal damage is less frequent compared to adults. However, early tracheostomy not only reduces respiratory effort, ventilator-associated complications, sedation requirements, length of stay in the intensive care unit, and costs but also improves the quality of care and patient comfort.[19]

Although many studies report a high complication rate associated with tracheostomy,[20] this rate was 4.7% in our study. We believe there may be underreporting of minor complications. In these studies, mortality rates were reported as 11%. Similarly, Schweiger et al.[21] reported mortality rates of 32%, attributing these to underlying diseases rather than the tracheostomy procedure itself.

Tracheostomy is a procedure that creates an artificial shortcut in the airway. Since the trachea is located close to the skin, the complication rate is quite low when meticulous dissection is performed. Attention should be paid to the anatomical positioning of the thyroid and vascular structures in its close proximity. In a mortality study conducted by Marget et al.[22] in 2023, the 30-day mortality rate was found to be 11.8%. In our study, however, no mortality was observed within such a short period. Most tracheostomy complications are related to the patient's existing health condition and underlying pathological conditions rather than the surgical technique. In our study, no mortality related to the surgical intervention was observed, with an overall complication rate of 4.7%. These complications were considered minor complications (bleeding, decannulation, incision site widening, stenosis, and wound site infection).

In a recent 2023 study by Teplitzky et al.,[23] which examined complications following tracheostomy in pediatric patients, 273 tracheostomies were performed, and 46 patients died, resulting in a mortality rate of 16.8%. In this study, 28% of the mortalities occurred during the same hospital admission period. This finding is important as it highlights the close relationship between critically ill patients and tracheostomy. The same study reported a 9% mortality rate related to tracheostomy. In a review study conducted by Dal'Astra et al.,[24] a total of 3,797 articles were selected, with 47 serving as the basis for this review. When the three decades were evaluated as a whole, an increase in tracheostomies in male children under one year of age was observed. Mortality associated with tracheostomy ranged from 0 to 5.9%, while overall mortality varied from 2.2 to 59%.[24] In our study, however, we did not observe any mortality related to tracheostomy. This may be because the patients in our intensive care unit were not in emergency conditions but rather required elective or planned tracheostomy.

The retrospective nature of the study posed some limitations. Additionally, the study was conducted in a private hospital's PICU, which may

have limited the diversity of cases encountered. Despite a relatively high bed capacity and patient volume, the need for tracheostomy was observed to be lower, potentially due to the specific patient demographics and referral patterns of the institution. The limited number of cases analyzed also restricts the generalizability of the findings. Larger prospective studies in more diverse settings are needed to validate these results and provide more comprehensive insightsw.

In conclusion, tracheostomy is a surgical intervention that can be safely performed in PICUs, particularly in PMV cases. It reduces ventilator-associated complications, sedation requirements, length of intensive care unit stay, and improves patient comfort. The timing of tracheostomy should be decided on a case-by-case basis by pediatric intensive care specialists.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conceptualization, data collection, formal analysis, writing manuscript: S.K.; Formal analysis, writing manuscript, data collection, formal analysis, writing manuscript: A.B.K.

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