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Pediatric intensive care unit tracheostomy experiences in Ondokuz Mayıs University Faculty of Medicine

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Abstract

In this study; patients who underwent conventional tracheostomy while being followed up on a mechanical ventilator with endotracheal intubation in their pediatric intensive care unit were evaluated retrospectively. It was aimed to share the positive changes observed in clinical-mechanical ventilator parameters with the literature. Study data were obtained from the hospital information management system and recorded in the "Child Patient Evaluation Form with Tracheostomy" as follows: Demographic data, diagnosis of admission to pediatric intensive care unit, indications for mechanical ventilation and tracheostomy, changes in post-procedure mechanical ventilation parameters, tracheostomy complications, decannulation, survival and death rates etc. Post-discharge medical records were created by telephone interviews with parents. IBM SPSS 21 (Statistical Package for Social Sciences) program was used for statistical analysis. In our study; the most common indication (67.0%) for tracheostomy was the need for prolonged mechanical ventilation. Peak inspiratory pressure requirement on mechanical ventilator decreased statistically and tidal volume increased significantly in those who underwent tracheostomy due to prolonged mechanical ventilation requirement (both $p<0.001$). On the other hand, the mean length of stay in the pediatric intensive care unit after the procedure was statistically significantly shorter ($p<0.001$). Decannulation success was statistically significantly higher in those who underwent tracheostomy due to upper airway obstruction ($p<0.02$). In our study; only four (6.2%) patients died due to tracheotomy (cannula occlusion, unplanned decannulation, etc.). Clinicians should consider tracheostomy if extubation cannot be achieved in children and adolescents who have been given mechanical ventilation for a long time (>2-4 weeks) due to progressive primary disease. Tracheotomy should definitely be performed within appropriate medical indications in order to shorten the length of stay in the hospital/Pediatric intensive care unit and to provide medical care outside the hospital (e.g.; a suitable home environment) in order to create general psychosocial-physical well-being in the patients.

Keywords: pediatric intensive care unit, prolonged mechanical ventilation, tracheostomy, decannulation

1. Introduction

Tracheostomy is a procedure that creates a surgical airway in the cervical trachea in order to facilitate the passage of air or evacuation of secretions. It is relatively common in the pediatric age group today (1). The most common indications of tracheostomy are life-threatening upper airway obstruction, need for prolonged mechanical ventilation, and provision of an efficient pulmonary toilet (2-4). In the last 40 years, pediatric tracheostomy indications have shown a considerable change from upper airway obstruction to prolonged mechanical ventilation need (1, 5). Today, the need for prolonged mechanical ventilation is the most common indication in the Pediatric Intensive Care Unit (PICU) setting (2, 6, 7). About half of the airway resistance is caused by the upper airway. Tracheostomy has reduced the work of breathing via bypassing the upper airway and facilitating the pulmonary toilet (8). When compared to endotracheal intubation, laryngeal injury risk is lower with a tracheostomy. Other advantages of tracheostomy include decreased need for sedoanalgesia, increase patient mobilization and facilitate care and transport of patients (9-11). Finally, tracheostomy can provide to shortening of mechanical ventilation duration, reducing stay in hospital and intensive care unit (8, 12).

This procedure is technically more difficult and morbidity and mortality are higher in pediatric patients than adults (12). Complication rate after tracheostomy has been reported to be 10-20% with a death rate of 0.5-5% (13). There is no consensus on the timing of decannulation, decannulation procedure, and affecting factors of decannulation success rate in pediatric patients (1).

There are limited studies in the literature investigating the long-term outcome of pediatric tracheostomy and its effects on respiratory dynamics. In this study, the results of tracheostomy including decannulation were mainly investigated in addition to the demographic clinical characteristics of the patients who underwent surgical tracheostomy when they were followed up in PICU. In addition, the early effects of tracheostomy on ventilator parameters were also investigated in patients

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undergoing mechanical ventilation. A true emergency tracheostomy is relatively uncommon and the most likely cause is upper airway obstruction, where the patient cannot be intubated (14).

2. Material and Methods

Patients who underwent tracheostomy with the conventional surgical method in the operating room for 3 (three) main indications while receiving respiratory support on a mechanical ventilator in the PICU between January 2006 and May 2013 were included in this study. The decision for tracheostomy is given by an intensive care specialist and an otolaryngologist in our unit. The procedure is performed by an otolaryngologist who is experienced in pediatric tracheostomy.

The clinical and demographic characteristics of the patients, indication for mechanical ventilation and tracheostomy, early and late complications of tracheostomy, the effect of tracheostomy on mechanical ventilator parameters in ventilated patients, attempts of decannulation, and outcomes were recorded. Medical records; demographic characteristics (age, gender, chronic disease, etc.), indication for PICU admission, indication for mechanical ventilation and surgical tracheostomy, clinical and laboratory data before and after the procedure, and changes in mechanical ventilator follow-up parameters after the procedure [Positive end-expiratory pressure (PEEP), peak inspiratory pressure (PIP), expiratory tidal volume (TV) and a fraction of inspired oxygen (FiO_2) needs before and 24 hours after tracheostomy], complications of tracheostomy, length of stay in the PICU before and after the procedure, analyzes of discharged patients, how decannulation was performed, duration and results of decannulation, survival and death rates of patients, etc. form were created. Post-discharge medical information was added to the patient evaluation form by making phone calls to the parents.

Prolonged mechanical ventilation (PMV) is defined as greater than 21 consecutive days of mechanical ventilation requirement for at least six hours per day. (15, 16) Pulmonary lung hygiene, formerly known as a pulmonary toilet; refers to exercises (cough or chest physiotherapy) and other procedures that help clear the respiratory tract from mucus and other secretions. PEEP, PIP, (TV), and FiO_2 needs before and 24 hours after tracheostomy were recorded in patients under mechanical ventilation. Complications within the first 7 days of tracheostomy were defined as early complications, complications after 7 days were defined as late complications.

Local ethical committee approval was obtained. Statistical analysis was done with Statistical Package for the Social Sciences software version 21.0 (IBM SPSS Statistics; New York, USA). The normal distribution of values was tested with the Kolmogorov-Smirnov test. Other tests used for statistical analysis were; the Kruskal-Wallis test, Mann-Whitney U test with Bonferroni correction, Chi-Square test, Wilcoxon test, and Two Proportion Z test. Numerical values were calculated as number (%), median (minimum-maximum), mean ± standard deviation. Statistical significance was accepted as $p<0.05$ for all tests.

3. Results

Surgical tracheostomy was performed in 104 (4.3%) of 2406 patients who were hospitalized in the Pediatric Intensive Care Unit (PICU) at the time of this study. At the beginning of the study, the medical data of a total of 104 patients were included in the retrospective evaluation, but four patients were excluded due to incomplete medical records. The most common reason for admission to the PICU was Acute Respiratory Failure. Only 13.0% of the patients had no known chronic disease. The most common accompanying chronic diseases were neurological-neuromuscular diseases. In our study, the average number of patients who underwent surgical tracheostomy per year among the patients followed in the PICU was 14.2 (4.3%) and 62 (62.0%) men. The median tracheostomy age was 13.5 (2-215) months.

Forty-eight (48.0%) patients were younger than one year of age when the surgical procedure was performed; the proportion of male patients was higher in females in both age groups (61.0% and 59.0% respectively). The demographic and clinical characteristics of the patients are shown below in Table 1.

Table 1. Clinical and demographic characteristics of study patients

Age (month) [median (minimum-maximum)]	**13.5 (2-215)**
• <1 years	48 (48.0%)
Male gender [n (%)]	**62 (62.0%)**
Comorbidity [n (%)]	**87 (87.0%)**
• Chronic neurological or neuromuscular disorders	45 (45.0%)
• Inherited metabolic disorders	11 (11.0%)
• Chromosomal abnormalities	8 (8.0%)
• Malignancy	8 (8.0%)
• Others	15 (15.0%)
Cause of PICU admission [n (%)]	
• Respiratory failure	48 (48.0%)
• Systemic infections, sepsis or septic shock	19 (19.0%)
• Neurological or neuromuscular disorders	13 (13.0%)
• Poisoning, trauma, near-drowning	9 (9.0%)
• Heart failure, cardiac arrhythmias	4 (4.0%)
• Metabolic disorders attack	4 (4.0%)
• Others	3 (3.0%)

In our study, surgical tracheostomy was performed in 67.0% of patients due to the need for prolonged mechanical ventilation 21.0% of patients due to upper airway obstruction, and 12.0% of patients due to the need for pulmonary care. In the patient group requiring prolonged mechanical ventilation, those with primary neurological/neuromuscular diseases (cerebral palsy, spinal muscular atrophy type-1, subacute sclerosing panencephalitis, metabolic-infectious encephalopathy, central hypoventilation syndrome, Duchenne muscular dystrophy, etc.) were in the majority 56.0%. Conditions that cause upper airway obstruction; craniofacial dysmorphism (Pierre Robin sequence, hypoplastic mandible-retrognathia, etc.), head and neck tumors (juvenile papilloma, subglottic hemangioma, etc.), laryngeal web-trauma, subglottic stenosis-vocal cord hypertrophy due to endotracheal intubation, vocal cord hypertrophy (Fabry disease) and laryngomalacia (congenital). Frequent endotracheal aspiration and inadequate airway protective reflexes (e.g.; cough) were the main indications in a small number of patients who underwent tracheostomy due to the need for pulmonary lung hygiene.

The time from the date of hospitalization to the opening of a tracheostomy was longer than two weeks in 80.0% of patients. This period was shorter than 7 days in only 5.0% of patients; tracheostomy indication in these patients was acute upper airway obstruction. Emergency tracheostomy was performed in only five patients due to acute upper airway obstruction within the first 24 hours of admission to the PICU; all other patients were treated in an elective condition. In this study, no patient underwent emergency tracheostomy due to acute upper respiratory tract infection (e.g.; epiglottitis). Except for one patient with an emergency tracheostomy, the other patients received respiratory support with a mechanical ventilator before the tracheostomy was applied during their follow-up in the PICU.

Tracheostomy indications in our study; the need for prolonged mechanical ventilation, upper airway obstruction, and pulmonary lung hygiene. Five patients underwent emergency tracheostomy within their first 24 hours in the PICU, other patients had the procedure done under the elective situation. Barring one, all patients had received mechanical ventilation prior to tracheostomy. None of our patients underwent tracheostomy due to acute airway obstruction resulting from upper airway infection. The elapsed time from admission to tracheostomy was longer than two weeks in 80 patients. This is timeless than 7 days in only five patients. All of these five patients have upper airway obstruction. Length of stay in PICU before tracheostomy was shorter in patients who had upper airway obstruction than other indications. Indications for tracheostomy and elapsed time for tracheostomy are shown in Table 2.

Surgery-related pneumothorax developed in two patients; both cases were successfully treated with tube thoracotomy. One patient experienced accidental decannulation in the first 24 hours after surgery. A total of 12.0% of patients received erythrocyte transfusion in the first 24 hours after the procedure. The early (<7 days) complication rate of tracheostomy in this study was 20.0% and the late period (≥7 days) complication rate was 38.0%. While the most common early complications were minor (leakage) bleeding at the incision site and cannula obstruction, the most common late complication was granulation tissue formation at the wound site. Surgical tracheostomy-related complications are shown in Table 3.

The most interesting feature of this study; positive changes in mechanical ventilator follow-up parameters occurred quickly in the post-tracheostomy period in these patients who underwent conventional mechanical ventilation.

Table 2. Indications and timing of tracheostomy

Tracheostomy indications [n (%)]	
Prolonged mechanical ventilation	67 (67.0%)
Upper air way obstruction	21 (21.0%)
Pulmonary toilet	12 (12.0%)
Time (form) of tracheostomy [n (%)]	
Emergency tracheostomy	5 (5.0%)
Elective tracheostomy	95 (95.0%)
Elapsed time from admission to tracheostomy (day) [median (minimum-maximum)]	**27.5 (1-132)**
Upper airway obstruction	12.0 (1-56)
Prolonged mechanical ventilation	28.0 (1-132)
Pulmonary toilet	36 (9-60)

Timing of tracheostomy	**Prolonged mechanical ventilation (n=67)**	**Upper airway obstruction (n=21)**	**Pulmonary toilet (n=12)**	**N (%)**
First week	0	5	0	5 (5%)
Second week	7	7	1	15 (15%)
Third week	7	4	2	13 (13%)
Fourth week	32	-	1	33 (33%)
>fourth week	21	5	8	34 (34%)

Table 3. Early and late complications associated with tracheostomy

Complication	**Early**	**Late**
Minor bleeding from incision area	12 (12.0%)	1 (1.0%)
Obstruction	5 (5.0%)	4 (4.0%)
Granulation formation	-	14 (14.0%)
Pneumothorax, subcutaneous emphysema	2 (2.0%)	-
Accidental decannulation	1 (1.0%)	9 (9.0%)
Soft tissue infection	-	6 (6.0%)
Total	**20 (20.0%)**	**38 (38.0%)**

Compared to pre-tracheostomy, it was noteworthy that the mean PIP requirement on a mechanical ventilator was statistically significantly decreased and mean TV significantly increased after 24 hours in the procedure (both $p<0.001$). Differences in other conventional mechanical ventilation monitoring parameters were not statistically significant. Changes in mechanical ventilator parameters with tracheostomy are shown in Table 4.

Tracheotomy was performed in 86.0% of patients, excluding 12.0% of patients who died in pre-discharge follow-up after tracheostomy during hospitalization in the PICU and 2.0% of patients transferred to other Healthcare Institutions for the effective treatment of their severe chronic disease. The patient was discharged from our unit. There were 1.2% patients who were discharged with planned decannulation at first discharge 36 (41.8%) patients with tracheostomy discharged with free-flow oxygen support and 49 (57.0%) patients with tracheostomy discharged with a home mechanical ventilator. In 12.0% of patients who died during pre-discharge follow-up after tracheostomy deaths were due to progressive primary disease and septic shock; none of them were tracheostomy related (e.g.; accidental decannulation, cannula obstruction, pneumothorax hypovolemic shock) deaths.

Table 4. Tracheostomy related changes in mechanical ventilator parameters

Mechanical ventilation parameters	Before tracheostomy	24 hours after the tracheostomy	p
PIP (cmH_2O) (mean ± SD)	18.8 ± 3.5	16.7 ± 3.7	**<0.001**
PEEP (cmH_2O) (mean ± SD)	5.0 ± 0.4	4.9 ± 0.3	>0.05
Respiratory rate (breaths/minute) [median (minimum-maximum)]	22.0 (14-40)	21.0 (13-40)	>0.05
Expiratory TV (ml/kg) (mean ± SD)	77.5 ± 107.6	108.1 ± 109.3	**<0.001**
FiO_2 (%) [median (minimum-maximum)]	50.0 (35-80)	50.0 (30-70)	>0.05
Duration of mechanical ventilation	**Upper air way obstruction**	15.00 (1-66)	**<0.05**
	Prolonged mechanical ventilation	28.00 (7-126)	
	Pulmonary lung hygiene	34.50 (9-59)	

PIP: Peak inspiratory pressure, **PEEP:** Positive end expiratory pressure, **TV:** Tidal volume, **FiO_2:** Fraction of inspired oxygen

In our study; 73 (83.9%) of the patients with tracheostomy (with free-flow oxygen support and home-type mechanical ventilator) at discharge were admitted to the hospital again for various reasons. Airway-related causes were found in 56.6% of repeated hospitalizations (treatment of primary chronic disease, bacteremia-sepsis, etc.), and in 43.4% there were airway-related causes pneumonia 50.8% and elective planned decannulation 27.0% were the most common causes of airway-related hospitalization. In this study; 17.0% of the patients who underwent surgical tracheostomy underwent planned decannulation. The median follow-up period with a tracheostomy was 3.8 (2-9) months in patients who underwent planned decannulation. During follow-up, accidental decannulation was observed in nine patients. In our study, tracheostomy decannulation success was 10/26(38.5%). Decannulation success was undoubtedly higher in those that were planned; this situation was statistically significant ($p<0.05$). Decannulation attempts and success rate according to indications are shown in Table 5.

Decannulation success was also statistically significantly different according to tracheostomy indications ($p<0.02$). The decannulation success rate was 6/8 (75.0%) in patients with tracheostomy due to upper airway obstruction while this rate was 1/2 (50.0%) in patients with tracheostomy due to pulmonary care. The decannulation success rate was at least 2/7 (28.6%) in patients with tracheostomy due to the need for prolonged mechanical ventilation.

Table 5. Results of decannulation attempts

	Follow-up period with tracheostomy (month) [median (minimum-maximum)]	Planned decannulation	Accidental decannulation
		Successful [n (%)]	**Successful [n (%)]**
Upper air way obstruction (n:67)	2.5 (0 - 9)	7/9 (77.8%)	1/2 (50.0%)
Prolonged mechanical ventilation (n:21)	4.0 (2 - 6)	1/2 (50.0%)	0/7 (0.0%)
Pulmonary toilet (n:12)	4.0 (4 - 4)	2/7 (28.6%)	-
Total (n:100)	3.8 (2 - 9)	10/18 (55.6%)	1/9 (11.1%)

In our study, the median follow-up time on a mechanical ventilator during hospitalization in the PICU of the cases with successful decannulation was statistically significantly shorter after tracheostomy when compared to before tracheostomy ($p<0.01$). The overall survival analyses of the patients after the first discharge were evaluated with the "Log-Rank Test". In our study, the median survival time of patients with a tracheostomy was 7 months (according to gender; it was 8 months for boys and 5 months for girls).

4. Discussion

Tracheostomy is a procedure that is being used increasingly in pediatric intensive care units. Patients subject to tracheostomy in various centers are reported to be 0.1-5.7% of total patients (10, 16). In our study this percentage was 4.3%. Indications for pediatric tracheostomy have changed drastically in time (2, 3). Tracheostomy due to upper airway infections such as epiglottitis and diphtheria, which cause airway obstruction, has decreased while tracheostomy due to craniofacial anomalies has increased. Today, the leading reason for tracheostomy is the need for prolonged mechanical ventilation (2, 6, 7, 16). None of the patients in our study underwent tracheostomy due to airway obstruction resulting from acute upper airway infection.

Although different clinical studies provide different reports, the most common indication for tracheostomy in the childhood age group is the need for prolonged mechanical ventilation. If endotracheal extubation cannot be achieved in ≥2 weeks of follow-up in children and adolescents who require respiratory support on mechanical ventilation due to progressive primary disease, the application of tracheostomy should be evaluated by clinicians. Prolonged endotracheal intubation increases the risk for complication; however, there is a lack of consensus on optimal tracheostomy timing in children (10, 17, 18). When extubation time cannot be immediately foreseen, early tracheostomy (within the first 7-10 days) is preferred for older children and adolescents (17, 19). There are some studies that support early tracheostomy for children in selected indications (17, 20-23). Although many studies have been published in the literature supporting early tracheostomy application in patients with endotracheal intubation and respiratory support in mechanical ventilators in PICU, our recommendation will be for focused (individually) decision making.

Various studies have shown the positive effect tracheostomy has on pulmonary functions (24-26). When compared to endotracheal intubation, tracheostomy has been shown to reduce work of breathing thus easing transition to spontaneous breathing. In turn, this could shorten mechanical ventilation duration and length of stay (LOS) in the Intensive Care Unit. Namdar et al. have reported a significant reduction in 8th hour PIP, PEEP, and FiO2 values post-tracheostomy for adult burn patients. They also report a significant decrease in pulmonary resistance and a significant increase in arterial partial oxygen pressure/FiO2 ratio (25). Sofi et al. report that compared to pre-tracheostomy, 24th hour PIP demand was reduced, dynamic compliance and oxygenation were increased after tracheostomy. However, they did not find a significant change in plateau pressure, static compliance, or PaCO2. One of the important results of this study that will contribute to the literature was the demonstration that tracheostomy in pediatric patients positively changed respiratory parameters in mechanical ventilators (26). In our study; compared with before tracheostomy, we found that the PIP value decreased statistically from the first 24 hours after the procedure and the expiratory TV increased statistically significantly. However, we could not find any statistically significant difference in other mechanical ventilator parameters.

Complication rates related to tracheostomy are reported in a wide range in the literature (3, 4, 7, 10, 13-18). We did not observe death due to tracheostomy in our study. Prolonged tracheostomy may increase the risk of complications, while early or accidental decannulation may increase the potential for unsuccessful decannulation (27). Therefore, the primary goal in patients undergoing tracheostomy due to treatable conditions should be decannulation at the most appropriate time. The literature on pediatric tracheotomy currently contains limited objective data on decannulation outcomes. Various studies report successful decannulation rates between 14.8% and 85.0% (21, 28-30). In our study, the planned decannulation success rate was found to be 55.6%, but the random decannulation success rate was found to be very low. We could not find any study in the literature comparing the success rates of planned decannulation and accidental decannulation in our study. Previous studies show that decannulation time is shorter and decannulation success is higher in upper airway obstructions compared to other indications (10, 29, 30). Our findings were consistent with the literature. In our study; the success rate was found to be higher in tracheostomies and planned decannulations performed due to upper airway obstruction.

The results of this study show tracheostomy can improve pulmonary mechanics in ventilated pediatric patients. Accidental decannulation should be avoided because of life-threatening complications and high failure rates. Further prospective studies are needed to evaluate the early and late effects of tracheostomy on pulmonary mechanics. This study is one of the few studies evaluating the effect of tracheostomy on pulmonary mechanics in pediatric patients. Limitations of the study include the retrospective nature of the study and the lack of evaluation for the late-stage effects tracheostomy has on pulmonary dynamics.

Conflict of interest

None to declare.

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None to declare.

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