North Clin Istanb 2023;10(5):597–601
doi: 10.14744/nci.2023.90767

ORIGINAL ARTICLE PEDIATRICS

Clinical characteristics of mechanically ventilated children in pediatric intensive care unit: A single-center study

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ABSTRACT

OBJECTIVE: Mechanical ventilation (MV) remains the most challenging and important issue in the field of pediatrics. It is a life-saving, invasive procedure that supports the cardiovascular and respiratory systems until the underlying disease is cured. The aim of this study was to evaluate the demographic profile, clinical aspects, indications and complications of MV, and outcome of the children in the pediatric intensive care unit (PICU) of a tertiary hospital in a developing country.

METHODS: The demographic profile, clinical aspects, MV indications and complications, and outcomes of pediatric patients (0–18 years of age) who required MV in the Sancaktepe Sehit Prof. Dr. Ilhan Varank Training and Research Hospital PICU from February 2022 to January 2023 were retrospectively reviewed.

RESULTS: A total of 139 patients were analyzed, of whom 79 (56.8%) were males. The median age was 36 months (1–214). Respiratory diseases (38.8%) were the most common indication for MV. We observed a 19.4% mortality rate with a statistically significant association with sepsis (p=0.001). Compared to other diseases, a large number of sepsis patients were found to require a variety of critical care treatment modalities and prolonged respiratory support.

CONCLUSION: Although MV is an indispensable treatment method in PICUs, it should not be forgotten that it carries the risk of morbidity and mortality in addition to the underlying disease. Therefore, the establishment of experienced teams in PICUs could make an important contribution to the prognosis of the patients.

Keywords: Critical care; critical illness; mechanical ventilation; mortality.

Cite this article as: *Durak C, Boydag Guvenc K. Clinical characteristics of mechanically ventilated children in pediatric intensive care unit: A single-center study. North Clin Istanb 2023;10(5):597–601.*

Pediatric critical care is growing rapidly, making it readily available to treat extremely complex cases in pediatric intensive care units (PICUs). However, pediatric ventilation remains the most challenging and important issue in the field of pediatrics. With the advancing technological developments, mechanical ventilation (MV) has become simple, easy, and accessible [1].

In developed countries, the rate of mechanically ventilated children in PICUs varies between 17 and 64% [1, 2]. The mortality rate is higher in children who require MV than in those who do not require respiratory support [3]. The mortality of a ventilated patient depends on the patient's clinical condition, complications during follow-up, and co-morbidities [4].

Received: June 01, 2023 *Revised:* July 12, 2023 *Accepted:* August 17, 2023 *Online:* September 13, 2023

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Although patients receiving MV account for only a small proportion of hospitalizations, it is a life-saving, invasive procedure that supports the cardiovascular and respiratory systems until the underlying disease is cured [5]. However, data on the indications, and outcomes of children treated with invasive MV (IMV) are still lacking. This study aimed to evaluate the demographic profile, clinical aspects, indications and complications of MV and the outcome of the children in the PICU of a tertiary hospital in a developing country.

MATERIALS AND METHODS

A retrospective evaluation of 139 mechanically ventilated pediatric patients (between 0 and 18 years of age) was performed at Sancaktepe Sehit Prof. Dr. Ilhan Varank Training and Research Hospital PICU from February 2022 to January 2023. Healthcare provision for children aged from 1 month to 18 years is provided in our PICU, which is equipped with 12 beds, 12 ventilators, and 9 isolation rooms. A total of 456 patients were hospitalized and followed up during the study period. Patients extubated within the first 24 h were excluded from the study. We obtained informed consent from all parents before hospitalization and during all procedures. Clinical Research Ethics Committee approval was received from the Sehit Prof. Dr. Ilhan Varank Training and Research Hospital on February 17, 2023 (E-46059653-050.99-209536825). This study was planned in accordance with the ethical rules of the Declaration of Helsinki Principles.

A detailed form was used for data collection regarding the patient's age, gender, comorbid disease, etiologies of admission, length of stay in the PICU, duration of IMV, extracorporeal treatment, inotropic treatment, tracheostomy and noninvasive ventilation (NIV) requirement, laboratory parameters, treatment outcomes, and mortality. For the calculation of the Pediatric Risk of Mortality III (PRISM III) Score, it was recorded within 24 h of PICU admission [6].

Statistical Analysis

SPSS statistical software 20.0 for Windows (Armonk, New York: IBM Corp.) was used for statistical analyses. Numbers, frequencies (%), ratios, medians, and standard deviation values were used in the descriptive statistics of the data. The distribution of variables was checked by using the Kolmogorov-Smirnov test. The χ^2 test was used to compare categorical variables, and the Fischer test was used when chi-square conditions could not be met.

Highlight key points

- Mechanical ventilation is a life-saving treatment method in PICUs, but it should not be forgotten that it carries the risk of morbidity and mortality in addition to the underlying disease.
- The care of the ventilated pediatric patient requires a comprehensive understanding of the clinical condition, follow-up, and management of underlying diseases.

RESULTS

A total of 456 patients were admitted to the PICU during the 1-year study period. One hundred and thirty-nine patients (30.4%) who required MV for more than 24 h were included in the study.

The median age was 36 (1–214) months, with most of the patients being male (56.8%). The median duration of PICU stay was 13 (2–114) days, and 69.8% had hospitalizations longer than 7 days. The median PRISM score was 8 (5–40). While 59 patients had co-morbid diseases (42.4%), neurologic (47.5%) diseases were the most common, followed by hemato-oncological diseases (16.9%). Respiratory diseases such as pneumonia and asthma attacks were the most common reasons for admission to the PICU in ventilated patients, followed by sepsis (22.3%), neurological diseases (12.9%), and trauma (9.4%). Given that we are in the pandemic period, only 4.3% of patients were coronavirus disease (COVID-19) polymerase chain reaction positive (Table 1).

The median duration of IMV was 6 (1–102) days, with most patients receiving IMV support for more than 3 days (67.6%). The indication for intubation was mostly respiratory failure (51.8%). A total of 90 patients required NIV support during their stay in the PICU. NIV was the initial ventilation method for 29 patients, but they were intubated because they could not tolerate NIV. While 10 patients had a tracheostomy at admission, 11 patients underwent a tracheostomy during their stay in the PICU. Twenty-eight (20.1%) patients experienced a total of 46 complications related to IMV. The incidence of each complication and the salient clinical characteristics of patients included in the study are shown in Table 2.

Univariate analyses were done on mechanically ventilated patients. There was a statistically significant relationship between etiologies of admission and mortality, PRISM III score, IMV duration, presence of acute renal failure, inotropic agent requirement, continuous renal replacement therapy, and therapeutic plasma exchange (Table 3). We found that indications of IMV were sta-

Table 1. Demographics of mechanically ventilated patients

	%
Gender n=139 (%)	
Male	56.8
Female	43.2
Age (month), median (range)	36 (1.0–214.0)
Weight, median (range)	15.0 (2.5–115.0)
Comorbid diseases (n=59, %42.4)	
Neurological diseases	47.5
Hematology-oncological diseases	16.9
Metabolic diseases	6.8
Immunodeficiency	6.8
Genetic syndromes	6.8
Chronic renal failure	5.1
Others	10.1
Etiologies of admission n=139 (%)	
Respiratory diseases	38.8
Sepsis	22.3
Neurological diseases	12.9
Trauma	9.4
Intoxication	5.0
Cardiological diseases	4.3
Others	7.2
Length of stay (day), median (range)	13 (2–114)
Length of stay-wise distribution	
≤7 days	30.2
>7 days	69.8
COVID-19 PCR positivity	4.3

COVID-19: Coronavirus 19; PCR: Polymerase chain reaction.

Table 2. Clinical characteristics of mechanically ventilated patients

	(n=139) (%)
Duration of IMV (day), median (range)	6 (1–102)
Duration of IMV-wise distribution	
≤3 days	32.4
>3 days	67.6
Indication of IMV	
Respiratory failure	51.8
Decreased GCS	25.2
Circulatory failure	19.4
Postoperative	3.6
Requirement of NIV (n=90)	64.7
NIV duration, median (range)	4 (1–25)
NIV modality	
HFOT	72.2
NIV-PCV	15.6
NIV-PSV	12.2
NIMV	
Initial	32.2
Postextubation	67.8
Tracheostomy, n (%) (n=21, %15.1)	
On admission	47.6
Requirement during PICU stay	52.4
Complications of IMV, (n=28) (%)	
Ventilator-associated pneumonia	20 (14.4)
Atelectasis	17 (12.2)
Pneumothorax	8 (5.8)
Tracheal stenosis	1 (0.7)
Sepsis (n=79)	56.8
Development of acute renal failure	27 (19.4)
Requirement of CRRT	28 (20.1)
Requirement of inotropic agents	59 (42.4)
Requirement of TPE	32 (23.0)
PRISM III score, median (range)	8 (5–40)
Mortality	27 (19.4)

CRRT: Continuous renal replacement therapy; GCS: Glasgow Coma Scale; HFOT: High-flow nasal therapy; IMV: Invasive mechanical ventilation; NIV: Noninvasive mechanical ventilation; PCV: Pressure control ventilation; PSV: Pressure support ventilation; PRISM III: Pediatric risk of mortality; TPE: Therapeutic plasma exchange.

tistically significant in terms of mortality (Table 4). Accordingly, the mortality rate was found to be significantly higher in patients who were intubated due to circulatory failure. In addition, the analysis showed that prolonged duration of MV (>3 days) was significantly associated with IMV-related complications and prolonged length of stay in NIV failure (Table 5, 6).

DISCUSSION

Although the incidence of mechanically ventilated children in different intensive care units varies between 17 and 64%, it is one of the most important tools of critically ill care [2, 7]. In our study, the incidence of pediatric admissions to the PICU requiring MV was 30.4%. As its more widespread use has therefore proven, the indications and management strategies of MV vary not only with underlying diseases but also with PICU size and location, time of year, and patient population served. This heterogeneity makes it difficult to establish guidelines worldwide, and all PICUs must define a protocol based on their own experienced teams, consultant teams, a variety of treatment modalities, and patient profiles.

Table 3. Relationship between etiologies of admission and clinical characteristics

	Etiologies of admission							p
	Respiratory diseases	Sepsis	Neurological diseases	Trauma	Intoxication	Cardiological diseases	Others	
PRISM III score, median (range)	7 (0–25)	17 (0–40)	7 (0–30)	14 (5–35)	7 (0–39)	14 (10–29)	7 (0–18)	<**0.001**
Length of stay >7 days, n (%)	41 (75.9)	21 (67.7)	12 (72.2)	9 (69.2)	2 (28.6)	6 (100.0)	5 (50.0)	0.083
Duration of IMV >3 days, n (%)	37 (68.5)	24 (77.4)	14 (77.8)	8 (61.5)	1 (14.3)	6 (100.0)	4 (40.0)	**0.006**
Mortality, n (%)	3 (5.6)	12 (38.7)	3 (16.7)	5 (38.5)	1 (14.3)	3 (50.0)	0	**0.001**
ARF, n (%)	1 (1.9)	18 (58.1)	1 (5.6)	1 (7.7)	1 (14.3)	3 (50.0)	2 (20.0)	**0.037**
Requirement of inotropic agents, n (%)	10 (18.5)	26 (83.9)	5 (27.8)	8 (61.5)	1 (14.3)	6 (100.0)	3 (30.0)	<**0.001**
Requirement of CRRT, n (%)	0 (0.0)	19 (61.3)	2 (11.1)	1 (7.7)	3 (42.9)	2 (33.3)	1 (10.0)	<**0.001**
Requirement of TPE, n (%)	3 (5.6)	18 (58.1)	3 (16.7)	2 (15.4)	2 (28.6)	2 (33.3)	2 (20.0)	<**0.001**

PRISM III: Pediatric risk of mortality; IMV: Invasive mechanical ventilation; ARF: Acute renal failure; CRRT: Continuous renal replacement therapy; IMV: Invasive mechanical ventilation; TPE: Therapeutic plasma exchange.

Table 4. Relationship between indication of IMV and clinical characteristics

	Indication of IMV				p
	Respiratory failure	Decreased GCS	Circulatory failure	Postoperative	
Duration of IMV >3 days, n (%)	49 (68.1)	23 (65.7)	19 (70.4)	3 (60.0)	0.962
Mortality, n (%)	7 (9.7)	8 (22.9)	12 (44.4)	0 (0.0)	**0.001**

GCS: Glasgow coma scale; IMV: Invasive mechanical ventilation.

Table 5. Relationship between duration of IMV and prognosis

	Duration of IMV		p
	≤3 days	>3 days	
Mortality, n (%)	5 (11.1)	22 (23.4)	0.087
Complications of IMV, n (%)	0 (0.0)	28 (100.0)	<**0.001**

IMV: Invasive mechanical ventilation.

Table 6. Relationship between NIV failure and prognosis

	NIV failure (n=29)	p
Mortality, n (%)	2 (7.4)	0.055
Duration of IMV >3 days, n (%)	22 (23.4)	0.287
Length of stay >7 days, n (%)	26 (26.8)	**0.009**

IMV: Invasive mechanical ventilation; NIV: Noninvasive mechanical ventilation.

The median age was 36 months, comparable to other tertiary PICUs [5]. In the literature, male predominance is reported in general, similar to our study, with a male rate of 56.8% [4, 8]. Similar to our study, Kendirli et al. [9] found that the most common cause of MV in PICUs was respiratory disease. However, neurologic diseases have been reported as the most common cause of MV in some studies in the literature [2, 8]. The most likely explanation for this could be due to the differences in diseases prevalent at the time and region of the study and the variation in patient populations in different studies.

Respiratory diseases were the major underlying cause of ventilated children in our PICU, followed by sepsis and neurological diseases. Similarly, as a result of many studies, respiratory system diseases were reported as the most common reason for MV in intensive care units [2, 10]. However, we encountered a large number of sepsis patients compared to other diseases, requiring various critical care treatment modalities such as inotropes, kidney and liver support, and prolonged respiratory support. Consistent with a study by Payen et al. [11], hemodynamic instability prolonged the duration of IMV.

Although MV is a life-saving method, it should not be forgotten that complications related to MV could occur. While the complication rate was 9.2% in a cohort study conducted in a developing country, it was 20.1% in our study [12]. It has been shown in the literature that this rate can go up to 42.8% [9]. Complications have been shown to prolong the duration of IMV, and studies reported that these complications are considerably reduced in patients followed by clinicians experienced in respiratory support with MV [9, 13, 14].

The mortality rates of mechanically ventilated children in the literature could reach up to 63%. Shaukat et al. [15] reported a mortality rate of 63% in a developing country, but this rate drops to <2% in PICUs in developed countries [16]. Various advantages such as access to health services, availability of trained and experienced doctors and nurses in PICUs, technological advantages, and access to pediatric surgery branches can be counted as making this huge difference in the mortality rates of MV children. The care of the ventilated pediatric patient requires a comprehensive understanding of the clinical condition, follow-up, and management of underlying diseases.

The most important limitation of our study is the small number of patients since our study was conducted with data obtained from a single center.

Conclusion

In conclusion, although MV is an indispensable treatment method in PICUs, it should not be forgotten that it carries the risk of morbidity and mortality in addition to the underlying disease. Therefore, the establishment of experienced teams in PICUs could make an important contribution to the prognosis of the patients. It is also intended that our study could improve the understanding of patients requiring MV and contribute to the literature in the development of therapeutic strategies.

Ethics Committee Approval: The Sehit Prof. Dr. Ilhan Varank Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 17.02.2023, number: E-46059653-050.99-209536825).

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

Authorship Contributions: Concept – CD; Design – CD, KBG; Supervision – KBG; Materials – CD, KBG; Data collection and/or processing – CD; Analysis and/or interpretation – CD; Literature review – KBG; Writing – CD; Critical review – CD.

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