Frequency and outcomes of mechanical ventilation in the pediatric ICU of Assiut University Children Hospital

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Received 18 August 2022
Revised 09 October 2022
Accepted 10 October 2022
Published 21 June 2023

Journal of Current Medical Research and Practice
2023, 8:96–100

Background and aim
Mechanical ventilation (MV) is one of the most often carried out procedures in pediatric ICU. There are multiple indications of MV. The diseased state, infrastructure, and hospital protocols all influence different management options. Although there is no question that MV has many advantages, it can also be harmful when used. To enhance management procedures and outcomes, this study evaluated the frequency, indications, complications, and immediate outcomes of children receiving MV.

Patients and methods
A prospective study of children (1 month to 18 years) needing invasive MV in pediatric ICU was conducted. MV was performed after evaluation of its indication. Complications and outcome were monitored.

Results
Of 561 patients admitted to the pediatric ICU, 283 (50.4%) required MV. The most common cause of admission to pediatric ICU was respiratory system diseases (46.3%). The most frequent indication of MV was respiratory failure (38.2%). Of the 283 patients who required MV, 60 (21.2%) had complications. The commonest complication was ventilator-associated pneumonia (5.3%). The mortality rate of mechanically ventilated children was 53.7%. There was higher mortality in patients admitted with gastrointestinal tract system diseases (65.9%).

Conclusion
The commonest cause of admission to pediatric ICU was respiratory system diseases. The commonest indication of connection to MV was respiratory failure. The most common complication of MV was ventilator-associated pneumonia. Several factors affect the outcomes of mechanical ventilation. These factors were age, sex, and etiology of admission to pediatric ICU.

Keywords:
complications, frequency, mechanicall ventilation, outcomes

J Curr Med Res Pract 8:96–100

2357-0121

Introduction

Respiration is essential for the survival of any living organism because it delivers oxygen and nutrients to the end organs, allowing them to function normally. This is the result of a complex mechanism that includes breathing air into and out of the lungs (ventilation), 'gas exchange' at the alveolar–capillary interface, and gas transport to and from the lungs by the blood and its components. External respiration refers to the entire process of ventilation and gas exchange. Internal respiration refers to the removal of carbon dioxide from tissues [1].

Mechanical ventilation (MV) is indicated by respiratory failure, whether hypoxic (type 1) or hypercapnic (type 2), or both; loss of upper airway protective reflexes; apnea; and when high doses of anticonvulsants and anxiolytics are required, which may impair oxygenation and ventilation, as in the treatment of status epilepticus. Controlling pH and $PaCO_2$, as in a patient with a head injury and increased intracranial pressure; breathing muscle fatigue secondary to increased work of breathing; and assisting in the reduction of afterload for left ventricle heart failure are all necessary. Moreover, MV can provide complete support, as in a paralyzed patient, or partial support to reduce work of breathing [2].

There are numerous conditions in which the apparatus of ventilation and gas exchange may not function optimally to meet the metabolic demands of the body, resulting in 'respiratory failure' [3].

In children, respiratory insufficiency is the most common cause of death, emphasizing the importance of respiratory support in preventing such events. MV is a method of artificially supporting the respiratory system

while waiting for natural healing or other therapies to reverse and improve the underlying condition that is causing respiratory failure [4].

MV is a critical medical intervention in the context of critical illness. However, the intervention carries a significant risk of serious, potentially avoidable complications, including ventilator-associated pneumonia (VAP), sepsis, acute respiratory distress syndrome, atelectasis, and pulmonary edema [5].

Aim

The aim of the study was to determine the frequency, indication, and outcomes of MV in the pediatric ICU of Assiut University Children Hospital.

Patients and methods

This was a prospective study carried out at the pediatric ICU of Assiut University Children Hospital (a 12-bed tertiary care unit) during the period from August 1, 2020 to July 30, 2021. This study was conducted on pediatric patients aged from 1 month to 18 years connected to MV.

Inclusion criteria

This study includes all patient aged from 1 month to 18 years who underwent MV.

All included patient were subjected to the following:

(1) Initial cause of admission: this was obtained by history, examination, and initial investigations.
(2) Indication of MV: it includes respiratory failure, apnea, severe acidosis pH less than 7.25, neuromuscular disease, status epilepticus, airway maintenance, and shock.
    Respiratory failure according to blood gas abnormalities is classified into hypoxemic (PaO2 <60 mmHg), hypercapnic ($PaCO_2$ >50 mmHg), and mixed [6].
    Apnea can be defined as cessation of respiratory effort lasting more than 20 s, or if shorter duration, accompanied by bradycardia or cyanosis [7].
(3) Outcome of MV: either died or discharged.
(4) Presence or absence of complications from MV: these include laryngeal edema, endotracheal tubal block, VAP, endotracheal tube displacement, pneumothorax, atelectasis, pulmonary hemorrhage, and circuit failure.
    If a complication did not exist previously and developed during MV, it was attributed to MV. Clinical examination was done daily to detect atelectasis, which was confirmed by a chest radiograph when it was suspected [8].
    VAP was diagnosed when ventilation was greater than 48 h with a new and persistent infiltrate, consolidation on chest radiograph, and at least three of the following: fever, leukopenia or leukocytosis, purulent sputum, rales, cough, or worsening gas exchange [9].
    Pneumothorax and pulmonary hemorrhage were diagnosed by clinical examination and when suspected was confirmed by chest radiograph.
    If stridor occurred within 2 h of extubation, laryngeal edema was suspected. Racemic epinephrine and corticosteroids were administered to all patients. Circuit failure was defined as any interruption in the power source, ventilator, or patient assembly owing to technical reasons.
(5) Frequency of MV: it was calculated by the following equation: (number of patients mechanically ventilated ÷ total number of patients admitted to ICU)×100.

Statistical analysis

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, Chicago, SPSS Inc.), version 21 under Windows 7 operating system. Results were expressed as means ± SD for quantitative data and by number and percentage (%) for qualitative data. Comparisons between groups in qualitative data were performed by χ^2 test or Fisher exact test when appropriate. *P* value was assumed significant only if less than 0.05 and highly significant if *P* value was less than 0.01.

Ethical consideration

The study protocol and all procedures were approved by the ethical committee of the Department of Pediatrics, Faculty of Medicine, Assiut University. A written informed consent for MV was obtained from the parents or guardian of the cases as a routine procedure. Moreover, the research was approved by the Institutional Review Board of the Faculty of medicine, Assiut University, Assuit, Egypt, with IRB local approval number 17100577.

Results

During the study period, 561 patients were admitted to pediatric ICU, and of these, 283 (50.4%) patients were intubated. The study included cases that were admitted in the pediatric ICU and were mechanically ventilated. They consisted of 167 males and 116 females, with age ranging from 1 month to 18 years.

Discussion

MV is one of the most commonly performed procedures

in the pediatric ICU. There are numerous indications of MV. Different management options are influenced by the diseased state, infrastructure, and hospital protocols. Although there is no doubt that MV has many benefits, it can also be harmful when used incorrectly [9].

In pediatric ICU at Assiut University Children Hospital, critically ill infants, children, and adolescents up to the age of 18 receive round-the-clock care, sophisticated monitoring, and highly specialized therapies.

During the study period, 561 patients were admitted in the pediatric ICU, and of these, 283 (50.4%) patients were intubated and mechanically ventilated (167 males and 116 females). The percentage of pediatric patients mechanically ventilated in various pediatric ICU s ranged from 14 to 60% [10].

Regarding sex of the studied cases, male constituted 59.0% of cases and females constituted 41.0% (Table 1). This result is in agreement with Bhori *et al*. [9] and Yurtseven *et al*. [11].

It was found that most of the cases (134 patients) (47.3%) were in the age group from 1 month to 1 year, 82 (29.0%) patients were from 1 to 5 years, 29 (10.2%) patients were from 5 to 10 years, and 38 (13.4%) patients were from 10 to 18 years (Table 1). This is in agreement with Lee *et al*. [12] but in contrast with Yurtseven *et al*. [11], who reported that toddlers (44%) were the largest age group admitted to pediatric ICU. Moreover, it was in contrast to the results reported by Rady [13], where children 1–5 years of age were the commonest age group admitted to pediatric ICU.

Children with respiratory system diseases (n = 131) represented the highest admission etiology in patients mechanically ventilated (46.3%), followed by children with neurological diseases (n = 63) (22.3%) (Table 1). These findings were consistent with a previous research by Yang *et al*. [14] and Rady [13]. However, it is not consistent with another study by Taori *et al*. [15], which reported that cardiovascular disease was the primary etiology.

Respiratory failure (47.7%) was the most common clinical manifestation requiring ETI and MV in this study (Table 2). This finding was consistent with the findings of Bhori *et al*. [9], Yurtseven *et al*. [11], and Bano *et al*. [16].

According to complication of MV, we found that of the 283 patients ventilated, 60 developed complications. Thus, the complication rate in this study was 21.2%. The commonest complication was VAP (5.3% of cases) followed by endotracheal tube block (3.2%). This is in contrast to Bhori *et al*. [9], who showed that the complication rate was 33.33%, and laryngeal edema was the commonest complication. Moreover, it was in contrast to Mukhtar *et al*. [17], who showed that atelectasis was the commonest complication.

Other complications in this study were laryngeal edema (2.8%), endotracheal tube displacement (1.8%), chest infection (1.8%), circuit failure (1.8%), pulmonary hemorrhage (1.2%), atelectasis (0.7%), accidental extubation (0.7%), and pneumothorax (0.4%).

Nosocomial infection is a critical problem during pediatric ICU stay. It accounted for 5.3% of the complications in the present study, which was lower than that observed by Bhori *et al*. [9] (5.5%) and by Vijayakumary *et al*. (11%) [18].

Table 1 Demographic and clinical data of the studied cases

	n (%)
Sex	
Male	167 (59.0)
Female	116 (41.0)
Age	
1 month-1 year	134 (47.3)
>1-5 years	82 (29.0)
>5-10 years	29 (10.2)
>10-18 years	38 (13.4)
Etiology of admission to pediatric ICU	
Respiratory system diseases	131 (46.3)
Neurological diseases	63 (22.3)
GIT diseases	44 (15.6)
Renal diseases	13 (4.6)
Poisoning and intoxication	1 (4.2)
DKA and metabolic diseases	12 (4.2)
Cardiac diseases	8 (2.8)
No	144 (50.9)
Yes	139 (49.1)

DKA, diabetic ketoacidosis; GIT, gastrointestinal tract.

Table 2 Distribution of the studied cases according to indication and complication of mechanical ventilation

	n (%)
Indication of MV	
Respiratory failure	135 (47.7)
Apnea	82 (28.9)
Severe acidosis	21 (7.4)
Status epilepticus	20 (7.1)
Airway maintenance	18 (6.4)
Shock	7 (2.5)
Complications of MV	
Ventilator-associated pneumonia	15 (5.3)
Endotracheal tube block	9 (3.2)
Laryngeal edema	8 (2.8)
Pulmonary hemorrhage	8 (2.8)
Pneumothorax	7 (2.5)
Endotracheal tube displacement	5 (1.8)
Circuit failure	5 (1.8)
Atelectasis	2 (0.7)
Accidental extubation	1 (0.4)

MV, mechanical ventilation.

Mechanical mishaps such ETT blockage, disconnected tubes, unintentional or self-extubation, and device malfunction are mostly avoidable, which emphasizes the necessity of ongoing electrical and human monitoring of both the apparatus and the patient [9].

In terms of MV outcome in relation to age, sex, duration of admission, and etiology of admission to pediatric ICU (predictors of mortality), it was discovered that infants under one year of age had the highest mortality rate (69.4%), as shown in Table 3. This was in agreement with Bhori *et al.* [9] and El-Nawawy [19]. This is in contrast to that reported by Vijayakumary *et al.* [18], where the highest mortality was seen in children more than 5 years of age.

Moreover, it was observed that there was a higher mortality in females (62.9%) than males (47.3%). Moreover, a higher mortality was seen in patients admitted for less than 3 days (75.2%) owing to their very bad condition at presentation. A higher survival rate was sen in patients admitted for 5–10 days (67.5%), with a highly statistically significant difference ($P = 0.001$).

Regarding the effect of etiology of admission to pediatric ICU on the outcome of MV, patients who presented with either gastrointestinal tract diseases or cardiac diseases were more likely to have a poor outcome. Patients who presented with gastrointestinal tract diseases had a mortality rate of 65.9%. Moreover, patients who presented with cardiac diseases had a mortality rate of 62.5%. Better outcomes were seen in patients who presented with diabetic ketoacidosis (Table 3).

The mortality rate of mechanically ventilated patients in pediatric ICU during the study period was 53.7%, which was not statistically significant ($P = 0.094$). This was in agreement with Kendirli [20].

Patients with more severe illnesses are often cared for in pediatric ICU s and have a higher mortality rate, and vice versa. Lower mortality rates, however, do not always translate into better long-term outcomes. Overall mortality rates in mechanically ventilated patients in pediatric ICU s in developed countries were 2% [21].

In the present study, the high mortality rate (53.7%) may be explained by that pediatric ICU at Assiut University Children Hospital is the only tertiary care hospital in Upper Egypt. Therefore, all complicated and advanced cases from all over Upper Egypt are referred to our pediatric ICU, which increases the mortality rate.

The maximum number of deaths [134 (69.4%)] among the mechanically ventilated patients was seen in the age group of 1 month to 1 year (Table 3). This was in agreement with Bhori *et al.* [9] but in contrast to that reported by Vijayakumary *et al.* [18] and Kendirli [20], who reported that the highest mortality was seen in children more than 5 years of age.

Conclusion

The commonest cause of admission to pediatric ICU was respiratory system diseases. The commonest indication of connection to MV was respiratory failure. Several factors affect the outcomes of MV. These factors were age, sex, and etiology of admission to pediatric ICU.

Table 3 Evaluation of the studied cases as regard age, sex, duration of admission and etiology of admission in relation to outcome of mechanical ventilation

	Total	Outcome [*n* (%)]		*P*	χ^2
		Survival (*n*=131)	Mortality (*n*=152)		
Age (years)					
0-1	134	41 (30.6)	93 (69.4)	0.001**	38.80
>1-5	82	52 (63.4)	30 (36.6)	0.001**	26.8
>5-10	29	17 (58.6)	12 (41.4)	0.295	1.097
>10-18	38	21 (55.3)	17 (44.7)	0.487	0.483
Sex					
Male	167	88 (52.7)	79 (47.3)	0.381	0.770
Female	116	43 (37.1)	73 (62.9)	0.001**	14.428
Etiology					
Respiratory system diseases	131	61 (46.6)	70 (53.4)	0.328	0.955
Neurological diseases	63	33 (52.4)	30 (47.6)	0.718	0.130
GIT diseases	44	15 (34.1)	29 (65.9)	0.056	7.672
Renal failure	13	6 (46.2)	7 (53.8)	0.667	0.001
Poisoning and intoxication	12	5 (41.7)	7 (58.3)	0.686	0.164
DKA and metabolic diseases	12	8 (66.7)	4 (33.3)	0.219	1.508
Cardiac diseases	8	3 (37.5)	5 (62.5)	0.617	0.250

DKA, diabetic ketoacidosis; GIT, gastrointestinal tract. χ^2 test. *Statistically significant difference ($P<0.05$). **Highly statistically significant difference ($P<0.01$).

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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