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Original Research Article

A study of mechanical ventilation in children

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ABSTRACT

Background: Mechanical ventilation (MV) is one of the most commonly performed procedures in PICU. The indications of MV are multiple. The management strategies also vary depending upon the diseased state, infrastructure and hospital protocols. Although benefits of MV are unquestionable, its use can also cause harm. This study was done to assess the frequency, indications, complications and immediate outcome of mechanically ventilated children, with an aim to improve management protocols and outcome.
Methods: A prospective observational study of children (1 month to 13 years), needing invasive MV in PICU of a medical college. MV was initiated after assessment of indication/s. All patients were ventilated with pressure support modes. Complications and outcome were assessed.
Results: Of 452 patients admitted to PICU, 72 (15.93%) needed MV. Most common indication was respiratory failure (20.83%). Mean duration of MV was 4.2±4.32 days. Mean hospital stay was 11.89±12.8 days. Of 72, 24 (33.33%) developed complication/s, commonest being laryngeal edema (11.11%). Mean duration of ventilation and hospital stay were significantly higher ($p < 0.01$) in those who developed complication/s. The mortality rate of mechanically ventilated children was 38.89%. Initial mode of MV used was significantly associated ($p < 0.05$) with mortality.
Conclusion: Complications prolong the duration of mechanical ventilation and hospital stay. They increase mortality and health care cost in a developing country. Alternatives should be tried before starting invasive MV in children.

Keywords: Children, Mechanical ventilation, Pediatric intensive care, Respiratory failure

INTRODUCTION

Critically ill children generally have a disease process that affects more than one organ system. These children are managed in PICU with aim of achieving a better outcome. Most of these patients also require mechanical ventilation at some point during their stay. Mechanical ventilation (MV) is one of the most common procedures performed in PICU, with 20% to 64% of patients admitted requiring ventilator support.[1]

The reasons for mechanical ventilation and management strategies vary depending not only on disease state, but also on PICU's size, patient population served, clinician's experience and local protocols.[2,3] Since its introduction into the modern PICUs, mechanical ventilation has undergone continuous evolution. Newer modes of mechanical ventilation have been introduced in an attempt to reduce barotrauma/volutrauma. No data exist so far to determine the ventilatory mode that provides the greatest benefit with the minimum risk of ventilator-induced lung injury. Each model has precise indication which allows better application on one hand, while avoiding side effects on the other.

Though it has lifesaving benefits, mechanical ventilation can result in important complications and adverse physiologic effects which may prolong duration of MV itself, duration of hospitalisation and increase patient mortality.[4,5]

In this study, we report the clinical profile of patients, indications, complications and end results of mechanical ventilation in children who were followed in our PICU. This may aid changes in management protocols and devise measures to be taken to reduce factors which contribute to poor outcome of patients.

METHODS

All the patients aged 1 month to 13 years, admitted to 8-bedded PICU from 1st January 2015 to 30th September 2016 and required endotracheal intubation and mechanical ventilation were prospectively evaluated. A detailed history was taken and examination done. A preliminary diagnosis and possible etiology was thus formulated. All patients were closely monitored and as the need arose, were intubated and mechanically ventilated.

Indication of intubation and mechanical ventilation:

- Apnea
- Acute lung injury/Acute respiratory distress syndrome
- Persisting tachypnea trending towards respiratory failure
- Respiratory failure (severe refractory hypoxemia, PaO_2 <60 mm Hg, hypercapnia $PaCO_2$ >50 mm Hg)
- Severe acidosis pH <7.25
- Neuromuscular disease (Guillian Barre syndrome, neuroparalytic snake envenomation etc.)
- Poor score on Glasgow coma scale (< 8/15)
- Status epilepticus
- Airway maintenance
- Cardiorespiratory failure
- Congestive cardiac failure.

Decision to start mechanical ventilation, change in ventilator settings and timing and mode of weaning was taken based on clinical findings, monitoring and arterial blood gas analysis. Mechanical ventilation in all patients was initiated through an orotracheal tube. Cuffed endotracheal tubes were used whenever available.

We used iVent201 computerized ventilation system (Model: 1.4.5) for mechanical ventilation. In these devices, following modes were available: pressure control ventilation (PCV), volume control ventilation (VCV), assist control (A/C), Synchronized Intermittent Mandatory Ventilation (SIMV) and Continuous Positive Airway Pressure/Pressure Support Ventilation (CPAP/PSV).

All patients were ventilated with pressure support modes, either A/C (assist control) or SIMV (Synchronized Intermittent Mandatory Ventilation). Criteria for using A/C mode was severity of illness: the more severe the illness, the greater the necessity for resting the respiratory muscles.

The initial parameter (rate, tidal volume, PIP, PEEP, FiO_2, I time) was set according to need of the patients and adjusted according to clinical variables, chest X ray and arterial blood gas analysis (ABG) as described by Rotta et al.[6] Then subsequent parameters on mechanical ventilation were modified according to the need of oxygenation and ventilation through SpO_2 monitoring or blood gas analysis.

Mechanically ventilated patients were sedated and/or paralyzed when needed. The goal was to achieve patient comfort and patient-ventilator synchrony. We used either frequent bolus doses or continuous infusion of midazolam for sedation and vecuronium as a paralyzing agent. The standard suctioning practices of ETT and saline/mucolytic nebulizer were used as needed. ETT were retaped as needed.

A complication was attributed to mechanical ventilation if it was not present before and it developed during mechanical ventilation. Atelectasis was identified by the daily clinical examination and when suspected was confirmed by chest radiograph.[7] VAP was diagnosed when ventilation greater than 48 hours with a new and persistent infiltrate, consolidation, on chest radiograph and at least 3 of the following: fever, leucopenia or leukocytosis, purulent sputum, rales, cough or worsening gas exchange, were present.[8]

Laryngeal edema was deemed to be present if stridor occurred within 2 hours of extubation. All patients were treated with racemic epinephrine and corticosteroids. Any disruption in power source, ventilator, patient assembly, due to technical reasons was included as circuit failure.

All patients were liberated from mechanical ventilation when clinical condition had improved and after passing spontaneous breathing trial. Extubated patients were monitored for sign of clinical deterioration for 48 hours in PICU. After extubation the respiratory care continued in the form of upper airway toilet, suction of secretions, chest physiotherapy and non-invasive supplemental oxygen till needed.

Data was collected on a structured proforma and included the basic demographic profile (age, gender, weight), date of admission, presenting complaints, preliminary diagnosis, investigation results, indication of intubation and mechanical ventilation, date of initiating ventilation, mode of ventilation and initial ventilator parameters (RR, VT, PIP, PEEP, FiO_2, I time), need for sedation, length of MV and hospital stay, complication of MV, and outcome (recovered, death, discharge against medical advice).

Data was entered in and statistical analysis was performed using Microsoft Excel 2010. Normally distributed continuous variables were reported as mean ± standard deviation (SD). Categorical data were summarized as percentage. Chi square and Fisher's exact test was used for association. The independent sample t-

test (unpaired t test) was used to compare mean difference in normally distributed continuous variables between groups. A p-value of <0.05 was taken as significant and p <0.01 was considered highly significant, statistically.

RESULTS

A total of 452 patients were admitted to PICU. Of these patients, 72 (15.93%) needed mechanical ventilation. Male:female ratio was 1.25:1. Of the 72, 49 (68.06%) patients were under-fives.

Table 1: Presenting symptoms/symptom complex in patients (multiple responses).

Symptoms	Number of patients (%)
Difficulty breathing	45 (62.50)
Fever	39 (54.17)
Convulsions	26 (36.11)
Cough/cold	21 (29.17)
Altered sensorium	10 (13.89)
Not accepting feeds	8 (11.11)
Abdominal pain	6 (8.33)
Choking during feeds	6 (8.33)
Blurring of vision	5 (6.94)
Muscular weakness	4 (5.56)

The immediate events/condition arising as a consequence of underlying systemic illness that formed the basis for intubation and mechanical ventilation are shown in Table 2.

Table 2: Indications for endotracheal intubation and mechanical ventilation.

Indication for intubation and MV	Number of patients (%)
Respiratory failure	15 (20.83)
Poor Glasgow coma scale score (≤8/15)	14 (19.44)
Apnoea	13 (18.06)
Status epilepticus	13 (18.06)
Respiratory muscle paralysis	13 (18.06)
Impending respiratory failure	8 (11.11)
Congestive cardiac failure	5 (6.94)
Airway maintenance	4 (5.56)
Severe acidosis	3 (4.17)
Cardiorespiratory failure	3 (4.17)

Of the 72 patients ventilated, 24 developed complication/s. Thus, the complication rate in the present study was 33.33%.

A total of 27 complications were observed in 24 patients, which equated to 89 complications per 1000 ventilation days. VAP was caused by *Klebsiella pneumoniae* in 2 patients and the other 2 cases were caused by *Acinetobacter* and *Pseudomonas aeruginosa* respectively. All these were nosocomial acquired infections.

Table 3: Initial mode of mechanical ventilation.

Initial mode of MV	Number of patients (%)
A/C pressure control	46 (63.89)
SIMV	26 (36.11)

Table 4: Distribution of patients as per complications (multiple responses).

Complication	Number of patients (%)
Laryngeal edema	8 (11.11)
Endotracheal tube block	5 (6.94)
Ventilator associated pneumonia	4 (5.56)
Pulmonary haemorrhage	3 (4.17)
Atelectasis	1 (1.39)
Endotracheal tube displacement	1 (1.39)
Pneumothorax	3 (4.17)
Accidental extubation	1 (1.39)
Circuit failure	1 (1.39)
Total	27

The mean duration of mechanical ventilation was 4.2±4.32 days.

A total of 37 patients (51.39%) patients required sedation. Mean duration of MV in sedated patients (5.16±5.46 days) was significantly higher than that in non-sedated patients (3.2±2.21 days). Unpaired 't' test. t=1.95 (p <0.05). The mean duration of mechanical ventilation in patients who developed complication/s (7.33±6.07 days) was significantly higher than in those who did not develop complication/s (2.65±1.48 days).

Table 5: The duration of hospital stays of patients.

Duration of hospital stay	Number of patients (%)
1-3 days	9 (12.5)
>3-5 days	9 (12.5)
>5-10 days	30 (41.67)
>10 days	24 (33.33)
Total	72 (100)

Table 6: Distribution of length of hospital stay as per the complications occurred.

Days of hospital stay	No complication	Complication	Total
1-3 days	8	1	9
>3-5 days	7	2	9
>5-10 days	24	6	30
>10days	9	15	24
Total	48	24	72

Fisher exact test p=0.0032

Unpaired 't' test. t=4.98 p < 0.01. The mean hospital stay of all the patients was 11.89±12.80 days. The mean duration of hospital stays of patients who developed complication/s (19.33±18.58 days) was significantly higher than of those who did not develop any complication (8.17±5.61 days). Unpaired 't' test. t=2.84 p < 0.01.

The mortality rate of mechanically ventilated patients in our PICU during the study period was 38.89%. Maximum number of deaths, 15 (53.57%) amongst the mechanically ventilated patients was seen in the age group of 1 month to 1 year.

Assist control mode of ventilation was significantly associated with higher mortality. This was probably because patients with more severe systemic dysfunction were ventilated with A/C mode to provide rest to the respiratory muscles. Those who recovered had significantly higher length of hospital stay.

Table 7: Distribution of outcome of patients as per mode of mechanical ventilation.

Mode of MV (n)	Recovered	Death	Survival rate (%)	Mortality rate (%)	DAMA
A/C P control (46)	21	22	45.65	47.83	3
SIMV P control (26)	18	6	69.23	23.08	2
Total	39	28	-	-	5

Fisher's exact test (p=0.0433)

Table 8: Distribution of patients as per the hospital and outcome.

Days of hospital stay	Recovered	Death	DAMA	Total
1-3 days	-	8	1	9
>3-5 days	-	6	3	9
>5-10 days	20	9	1	30
>10 days	19	5		24
Total	39	28	5	72

$X^2 = 35.0575$ p <0.00001

DISCUSSION

We found that 15.93% (72/452) of patients admitted to our PICU received mechanical ventilation. The percentage of pediatric patients mechanically ventilated in different PICU's varied from 14-60%.[1,9,10] The most common indication for mechanical ventilation in the present series was respiratory failure (22.22%) either due to affection of the central nervous system or the respiratory system. Several reports mention respiratory failure due to respiratory illness was the most common indication of MV in PICU's.[9,11,12] Other studies report acute neurological illnesses as the most common reason for MV in PICU's.[10,13] The mean duration of mechanical ventilation of our patients was 4.2±4.32 days. Kendrili T et al reported the period of mechanical ventilation in their study to be 18.8±14.1 days.[11] In the present study, the complication rate was 33.33%. Unlike other studies which reported atelectasis, laryngeal edema was the most common complication (11.11%) to occur in the present study.[11,13] This might probably be explained by the interrupted supply of cuffed ETT at our PICU and the age group of patients in the present study. Post extubation stridor was observed in 20 (13%) patients in a study by Principi T et al.[14] Nosocomial infection is a critical problem during PICU stay. It accounted for 5.56% of the complications in the present study, which was lower than that observed (11%) by Vijayakumary T et al.[15] The occurrence of mechanical misadventures such as ETT obstruction, disconnected tubes, unplanned/self extubation and apparatus malfunction are largely preventable and underscore the need for continuous electrical and human monitoring of both the machine and the patient.[16]

The mortality rate of our ventilated children was 38.89% with age related mortality highest in infants. Kendirli T et al reported a mortality rate of 58.3% whereas that reported by Vijayakumary T et al was 27.6% with highest mortality in children >5 years age.[11,15] Studies in developing countries have reported significant variability between PICU's in age and in percentage of morbidity and mortality.[17,18]

PICU's with higher mortality may be caring for patients with more severe illnesses and vice versa. However, lower mortality rates do not necessarily translate into better long-term outcomes. In developed countries, the overall mortality rates in mechanically ventilated patients in PICU's were <2%.[2]

Higher number of postoperative cases, trained staff, availability of respiratory therapists for ventilatory management, early presentation of illnesses may be some

of the reasons for the lower mortality rates. In the present study, the duration of MV was significantly higher in those who were sedated during MV. This reinforces the need for judicious use of sedation and drug holidays in the PICU.

CONCLUSION

Despite its life saving advantages, mechanical ventilation is associated with physiologic and mechanical complications. Complications prolong the duration the MV and the hospital stay. Thus, increasing the health care cost in terms of emotional and economic burden on the patient and its family, man hours and machine hours to the provider. It puts strain on the already burdened health care system in developing countries. Alternatives must be tried before proceeding to invasive MV, wherever feasible. Early use of HHFNC, CPAP/BiPAP and other non-invasive modes of ventilation may help decrease the need for invasive MV.

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