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Outcomes of mechanical ventilation in Pediatric Intensive Care Unit (PICU) patients: A study from a rural tertiary care center.

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Abstract

Objective: Mechanical Ventilation (MV) is a lifesaving invasive procedure that is used in critical pediatric patients to maintain gaseous exchange. In this study, our aim is to explore the various causes and outcome of MV in our PICU patients with special reference to prolonged ventilation and hospital stay, mean duration of stay and immediate outcome of such patients.

Materials and methods: In this study, we present the data of 72 mechanically ventilated patients out of a total of 907 admissions to our PICU during a period of 15 months. The data has been retrieved from medical records of the hospital.

Results: MV rate was 7.93% with a male to female ratio of 2.4. MV due to respiratory causes was the most common (40.28%) followed by neurological causes (27.78%). Pressure SIMV mode was the most preferred mode of MV (84.72%) and T-piece was the most preferred weaning mode (36.11%) with a mean duration of weaning of 20.14 hours. Prolonged MV (>72 hours) was required in 44.45% and prolonged hospital stay (>10 days) in 59.72%. MV related complications were seen in 26.39%, VAP (6.94%) being the most common. Study subjects with elective intubation and neurological disorders has better outcome. Mean ventilator days were 2.63 (3.6 days in discharged patients). Successful extubation was achieved in 61.11%. Death rate was 26.39%.

Conclusion: Timely availability of adequate services including transport and referral play an important role in reducing the mortality and improving the outcome in terms of morbidity and mortality.

Keywords: Mechanical ventilation, PICU, Complications, Elective/emergency intubation, Children.

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Introduction

Mechanical Ventilation (MV) is a lifesaving invasive procedure to optimize gas exchange at minimum fraction concentration of inspired air oxygen (FiO_2) and ventilator pressure/tidal volume and has many effects on cardiopulmonary system in human body [1].

Patients require MV when the gas exchange capabilities of their respiratory system fail. This failure can be a result of processes both within the lung as well as in any other organ systems, most notably the cardiovascular and central nervous system.

Although there are no absolute criteria of gas exchange, PaO_2 <60 mm of Hg while breathing >60% oxygen, $PaCO_2$ >60 mm of Hg and pH <7.25 are often taken as reasons to initiate mechanical ventilation [2].

Mechanical ventilation is neither intended to normalize gas exchange nor is a form of cure. The goals are to maintain adequate oxygenation and ventilation to safeguard tissue viability until the disease process has resolved [3].

Once the underlying disease has improved and respiratory failure even out and begins to reverse, the ventilator support should be removed as soon as possible.

Prolonged mechanical ventilation is related with longer ICU length of stay and higher mortality and challenging weaning due to complications such as ventilator-associated lung injury and ventilator associated pneumonia [4]. The goals are to minimize the complications of the therapeutic intervention itself. The study aimed to explore rural respective of MV in special reference to its indications, clinic etiological profile of the participants and associated complications due to MV. This study also tried to evaluate the immediate outcome and average length of stay on ventilator and duration of stay in PICU graduates in rural tertiary care hospital.

Materials and Methods

The prospective descriptive study was conducted at a tertiary rural care hospital located in the central part of Gujarat catering

to predominantly rural population, over the period of 15 months (August 2018-Nov 2019). All paediatric patients amongst the age group of 1 month to 18 years admitted to PICU and requiring invasive mechanical ventilation for more than 12 hours were included. All the sick patients diagnosed outside and were referred to our center only for ventilation were excluded. For the study purpose, patient ventilated for more than 72 hours was considered as prolonged ventilation and more than 10 days of hospital stay as prolonged stay. Management of the enrolled patients was carried out as per disease status and departmental protocol. Immediate outcome was recorded till the time of discharge in terms of morbidity, mortality, condition at the time of discharge, mean duration of mechanical ventilation and hospital stay. Prior written informed consent was taken from the parents. The study was approved by institutional ethics committee. Sample size 72 was estimated with prevalence of 50.7% mechanical ventilation amongst patient admitted in PICU with estimated possible error (L) 20% of prevalence. Collected data was compiled in MS office excel. Statistical analysis was performed by the software Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 22.0 for Windows). Continuous variables were explained with mean ± SD and categorical variables as frequencies or percentages.

Chi square test and Fischer exact test was used as the test of significance for categorical variables. P-value<0.05 was considered as statistically significant.

Results

Out of total 907 admissions in the PICU during the study period of 15 months, total eligible participants were 90. However, 9 refused to give consent, 4 and 5 patients went Discharged Against Medical Advice (DAMA) or expired before 72 hours respectively. Thus total 72 (7.93%) eligible participants were enrolled in study. More than half of the participants were males (63.61%) with the ratio of 2.4. Age wise distribution of children in three groups *i.e.,* infancy, 1-5 years and >5 was equal *i.e.,* 24 (33.33%) in each. Majority of the enrolled participants in the study belonged to the lower socioeconomic status (72.22%). Amongst the study subjects who were less than 5 years old, 41.66% (20 out of 48) suffered from severe acute malnutrition while those above 5 years, 33.33% (8 out of 24) had chronic undernutrition.

As expected most common indication for mechanical ventilation was respiratory causes followed by due to various neurological conditions (Table 1).

Indications for mechanical ventilation	**Total=72**
Lower respiratory conditions (pneumonia, ARDS, bronchiolitis)	29 (40.28%)
Neurological conditions (Meningitis, GBS, intracranial SOL)	20 (27.78%)
Sepsis	10 (13.89%)
Cardiovascular conditions (congenital heart disease, congestive heart failure)	6 (8.33%)
Diabetic ketoacidosis	4 (5.56%)
Post-operative	2 (2.77%)
Upper respiratory conditions (laryngomalacia)	1 (1.38%)

Table 1. Indications for mechanical ventilation.

Out of 72 enrolled study participants 44 (61.11%) were successfully weaned off and discharged while 19 (26.39%) expired, 7 (9.72%) of them went DAMA and 2 (2.77%) were referred. Also 32 (44.45%) of our study subjects required prolonged ventilation while 43 (59.72%) had prolonged hospital stay (Table 2).

Stay	**Discharged**	**DAMA**	**Death**
Total number of patients=70*	44 (61.11%)	7 (9.72%)	19 (26.38%)
Mean hospital stay	13.45 days (6 days-1.5 months)	3.5 days (15 hours-4 days)	5.6 days (13 hours-15 days)
Mean PICU stay	6.8 days (3 days-30 days)	2.4 days (13 hours-3 days)	5.6 days (13 hours-15 days)
Mean ventilator days	3.6 days (14 hours-18 days)	0.9 days (18 hours-1 day)	3.4 days (13 hours-13 days)
Note: *: 2 patients were referred, hence not included in the analysis			

Table 2. Immediate outcome of study participants and duration of PICU and hospital stay.

Approximately half of the study participants required emergency intubation (58.33%). On further analysis of data, out of 63 participants (excluding referred and DAMA) 28 had elective intubation out of which 4 (14.28%) expired and 24 (85.71%) survived while 35 had emergency intubation amongst which 15 (42.85%) expired and 20 (57.14%) survived (Table 3). Thus, patients requiring emergency intubation were rather in more decompensated condition hence having a poor outcome which is statistically significant (p value=0.029).

Intubation	Discharged	Expired	P value
Elective (28)	24 (85.71%)	4 (14.28%)	0.029
Emergency (35)	20 (57.14%)	15 (42.85%)	
Total	44	19	
Note: *: 2 referred and 7 DAMA were excluded from analysis			

Table 3. Correlation of elective/emergency intubation with outcome (n=63)*.

Out of 72 study participants, commonest mode of ventilation used was pressure SIMV *i.e.,* 61 (84.72%). Pressure AC mode was used in 5 (6.94%) while volume AC and volume SIMV mode was used in 4 (5.55%) and 2 (2.77%) participants respectively.

19 (26.39%) study participants developed complications due to mechanical ventilation. These complications included ventilator associated pneumonia (6.94%), post-extubation stridor (4.16%), pulmonary hemorrhage (1.38%), tube block partial/complete (4.16%), tube displacement (2.77%), pneumothorax (2.77%) and atelectasis (4.16%). Out of the 72 study subjects, 44 were weaned using various means. 28 (38.88%) were not weaned because either the study participant expired (n=19), went DAMA (n=7) or referred (n=2) while being on ventilator. Out of the 44 weaned participants, 26 (36.11%) were weaned on T-piece, while 11 (15.27%) and 7 (9.72%) were weaned on CPAP and oxygen by hood/mask, respectively. The mean duration required for weaning from mechanical ventilation among the study subjects was 20.14 (SD ± 2.68) hours with a range on 5 hours to 40 hours.

Amongst 44 discharged participants, 18 (40.90%) had respiratory causes, 18 (40.90) had CNS causes, 2 (4.54%) had isolated sepsis, 1 (2.27%) patients had cardiovascular cause 2 (4.54%) had metabolic causes, 2 (4.54%) had post-operative cause and 1 (2.27%) has to be intubated for airway patency (laryngomalacia). Out of 19 patients who expired, 8 (42.10%) patients had respiratory cause, 1 (5.26%) had CNS causes, 5 (26.31%) had isolated sepsis, 3 (15.78%) patients had cardiovascular cause and 2 (10.52%) had metabolic causes. The outcome of the patients with respect to etiology has been enumerated in Table 4.

Etiology	Discharged (44)	Expired (19)	P value
Respiratory (26)	18 (69.23%)	8 (30.70%)	0.003
CNS (19)	18 (94.73%)	1 (5.27%)	
Cardiovascular (4)	1 (25%)	3 (75%)	
Sepsis (7)	2 (28.57%)	5 (71.42%)	
Metabolic (4)	2 (50%)	2 (50%)	
Airway patency (laryngomalacia) (1)	1 (100%)	-	
Post-operative (2)	2 (100%)	-	
Note: *2 referred and 7 DAMA were excluded from analysis			

Table 4. Outcome of discharged and expired participants according to etiology (n=63)*.

The outcome of MV of participants with neurological disorder in comparison to rest of all group was statistically significant with 95% CI 0.0185-0.8957 (P=0.003). Total 32 (44.44%) study participants required prolonged ventilation due to various etiologies with maximum number in the CNS and respiratory group *i.e.,*12 (37.50%) each. Majority of enrolled subjects stayed in PICU for 4-6 days (36.50%) followed by 1-3 days (20.63%) (Table 5).

Duration in PICU	Discharged (44)	Expired (19)	P value
1-3 days	2 (4.54%)	11 (57.89%)	
4-6 days	18 (40.90%)	5 (26.31%)	<0.001
7-9 days	12 (27.27%)	-	

≥ 10 days	12 (27.27%)	3 (15.78%)	
Note: *- 2 referred and 7 DAMA, not included in analysis.			

Table 5. Correlation of duration of stay in PICU with outcome (n=63*).

Participants with 4-6 days of PICU stay had better outcome in terms of discharge when compared to stay for 1-3 days (p<0.001, 95% CI 1.732-8.743). Amongst total of 32 patients having prolonged duration of ventilation (>3 days), 25 (78.12%) had prolonged duration of hospital stay (>10 days). Amongst 40 patients who had short duration of ventilation, 19 (47.5%) required prolong hospital stay while, 21 (52.5%) did not require prolong hospital stay. This difference was statistically significant (p value=0.016).

Discussion

In this study out of total 907 admissions 72 (8%) patients required MV. Similar to other studies conducted in India respiratory disorders (40.28%) were the most common cause of mechanical ventilation in our study. Study depicted that elective intubation (58.33%) *vs.* emergency intubation (41.66%) gives favorable outcome in terms of reducing overall mortality (p=0.029). The outcome of the participants who were electively intubated was better. Preferred mode of MV used in our study was PC-SIMV (84.72%) which was similar to the study by Shanmugham G, et al., as it is a safe mode which prevents barotrauma and other complication related to mechanical ventilation.

However, Meligy, et al., and Farias, et al., used PS SIMV mode in most of their study subjects *i.e.,* 49% and 39% respectively. The total percentage of participants who developed complications in our study was 26.39% of which the most common was Ventilator Associated Pneumonia (6.94%), similar to the study findings of Sahoo b, et al., and Vijayakumary, et al. However, in other studies conducted in India the incidence of VAP was much higher.

The probable reasons for low incidence of VAP in our study could be less crowding of PICU, proper aseptic precaution, favorable healthcare personnel: Bed ratio and above all being located in rural area, most of the patients reached to our center directly without visiting other centres which might have prevented cross contamination and development of cross infection. We had not enrolled any patient who was referred for sole purpose of MV. Most common mode of weaning in our study was through T-piece *i.e.,* 36.11% while in study by Meligy, et al., CPAP was the most common mode of weaning (74.70%) and in Farias, et al., pressure support was the most common mode (66%). Even though CPAP was the most common modality in rest of the studies, our study found good success with T-piece especially in CNS cases. In our study we mostly used CPAP to wean patients on ventilation because of severe pneumonia.

In our study 44.44% had prolonged ventilation (ventilated >72 hours) and the most common cause for prolonged ventilation was CNS causes and respiratory causes (37.50%).

Out of 72 patients ventilated, 61.11% recovered, 9.7% left against medical advice, 2.77% were referred and 26.38% expired which was similar to another study conducted by Vijayakumary, et al.

The mortality rate in our study was quite less as compared to various other studies. There could be several reasons for low mortality rate. Firstly, the patients presented to our hospital at an early stage of the diseases and hence more efficient treatment as per uniform protocol was provided to them. Secondly, most of our patients belong to the rural areas; hence chances of cross infection were much less. Thirdly, most of the patients presenting to us were primarily treated by us and not referred from other health care centers.

The outcome of mechanical ventilation in terms of discharge was better in neurological cases (94.73%, n=19) as compared to other causes of mechanical ventilation. This finding was similar to the study conducted in Pakistan by Shaukat, et al., where 46.3% of the total successful outcome was due to neurological causes. Similar to a study carried out by Nanchal R, et al., patients who underwent elective intubation had better outcome as compared to those with emergency intubation. Amongst the patients requiring prolonged ventilation, majority of them (78.12%) required prolonged hospital stay which is obvious since these patients were sicker at the time of presentation.

Conclusion

Despite of a small sample size in our study, outcome of mechanically ventilated patients was good due to utilization of golden hour of critically sick patients such as timely decision to intubate the patient, early presentation and intervention, favorable healthcare personnel: bed ratio and easy access to tertiary medical services.

We can thus propose that in a rural set up like ours, timely availability of adequate services including transport and referral play an important role in reducing the morbidity and mortality. It will also help in reducing the burden on overcrowded city hospitals and provide a cost effective management.

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