

OUTCOME OF CHILDREN TREATED WITH INVASIVE MECHANICAL VENTILATION IN PICU IN A TERTIARY CARE CENTRE, KERALA

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ABSTRACT

BACKGROUND

Mechanical ventilation (MV) has become one of the major indications for admission to paediatric ICUs and often a lifesaving strategy. However, use of MV can be associated with various complications including patient's mortality. Management of children with invasive ventilation necessitates facility for intensive monitoring as well as supportive care, which is challenging in a limited resource setup.

Aims and Objectives- The study aimed to assess the clinical profile and outcome of children treated with invasive mechanical ventilation.

MATERIALS AND METHODS

A prospective cohort study conducted in the PICU of the Department of Paediatrics, Government Medical College, Kozhikode during the period of January 2014 to June 2015. Clinical details of children given invasive mechanical ventilation for more than 24 hours were analysed.

RESULTS

Study group included 130 children, 54.6% males and mean age of 27 months. Most had respiratory diseases with other comorbid conditions. Respiratory failure (62.3%) was the most common indication for MV followed by airway protection (28.5%) and persistent shock (9.2%). Most common initial ventilatory mode used was SIMV. Mean (SD) duration of ventilation was 5.1 (5.24) days. Reintubation was required in 59.2% children, mostly due to ET tube obstruction. Among 130 children, 63 children (48.5%) developed a total of 116 complications equating to 175 complications per 1,000 days of ventilation. Failed extubation (22.3%), VAP (16.9%) and post extubation stridor (13.8%) were the common complications. Total mortality was 54.6% and majority were infants. Pneumonia with sepsis (54.8%) was the admitting diagnosis in most of those expired. Duration of MV, prolonged requirement of higher FiO₂ and development of complications were associated with mortality.

CONCLUSION

Prolonged duration of ventilation was significantly associated with complications as well as mortality related to mechanical ventilation. High rate mortality occurred in infants and in those with underlying chronic diseases.

KEY WORDS

Mechanical Ventilation, Bronchopneumonia, Respiratory Failure, Ventilator Associated Pneumonia, Atelectasis, Complications, Clinical Outcome.

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BACKGROUND

Mechanical Ventilation (MV) has become a crucial interventional strategy in the management of critically ill children. Ventilatory support may be needed not only in respiratory system diseases but in situations such as sepsis and septic shock, neuromuscular diseases, during postoperative state and in cases of altered mental status with loss of consciousness as well. In many cases, mechanical ventilation can be lifesaving. Thus, mechanical ventilation

(MV) has become one of the major indications for admission to intensive care units.

However, use of mechanical ventilation can be associated with complications and adverse physiologic effects^[1] which may prolong the duration of MV itself, duration of hospitalisation and increased patient mortality.^[2,3] Also, its use necessitate intensive monitoring, both invasive and non-invasive as well as additional supportive care adding to the treatment cost. Most Paediatric Intensive Care Units (PICU) are equipped with limited number of ventilators compared to the number of sick children they cater. In this circumstance selection of appropriate patient for ventilatory support is crucial, especially in a limited resource setup. Hence, knowing the clinical profile, pattern of complications and risk for mortality in children requiring mechanical ventilation will be useful in planning a tertiary level PICU. There is paucity of studies regarding the clinical profile, outcome of children treated with MV in PICU from Indian subcontinent.^[1,3]

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While a number of clinical trials have detailed the complications of MV, most of these were conducted in adults more than a decade ago.^[4] In children, most studies were conducted before the widespread adoption of lung protective ventilation strategies or are limited to the selective consideration of Ventilator Associated Pneumonia (VAP)^[5] and extubation failure.^[6-8] According to Albuali et al,^[9] children are currently ventilated with a lower tidal volume (8.1 vs. 10.2 mL/kg), a lower peak inspiratory pressure (27.2 vs. 31.5 cm H₂O) and a higher peak expiratory pressure (7.1 vs. 6.1 cm H₂O) than 20 years ago. The impact of these recent changes in ventilatory practice and general patient care (e.g. an increase in the number of dedicated paediatric critical care beds,^[10] the implementation of different modalities and protective strategies of ventilation,^[11] patient positioning and general care) on the epidemiology and incidence of MV associated complications is less well characterised. Hence, we conducted a study at the Department of Paediatrics, Government Medical College, Kozhikode, to assess the clinical profile and outcome of children treated with invasive mechanical ventilation in PICU. Government Medical College, Kozhikode is a premier teaching institute, located in the city of Kozhikode, Kerala and is a tertiary care referral centre with a well-equipped Paediatric intensive care unit.

MATERIALS AND METHODS

A prospective, cohort study was conducted in the PICU of the Department of Paediatrics, Government Medical College, Kozhikode during the period of January 2014 to June 2015. All children between age group > 28 days to ≤ 12 years admitted in PICU and requiring invasive ventilation for more than 24 hours were taken up for the study. Postoperative cases requiring ventilator support as well as those ventilated from another hospital for more than 24 hours and transferred to our PICU were not included.

Socio-demographic as well as clinical details of the cases included in the study were recorded using a semi-structured proforma which contained the details like age, gender, immunisation status, weight, admitting diagnosis, presence of chronic disease and immunosuppression, reason for mechanical ventilation, duration of ventilation and PICU stay, ventilator settings, complications, outcome including mortality were recorded. To complete the outcome analysis, details of the medical records of review upto one month, after discharge from the hospital were also noted.

The standard ventilator devices of the PICU were used for ventilation and the different modes used were pressure control ventilation (PCV), volume control (VCV) and synchronised intermittent ventilatory settings were done by residents on duty. The details of procedure including endotracheal (ET) tube size, initial settings of ventilator, drugs and other supports used etc. were recorded. General care of patients on ventilator were done by the nursing staff on duty. Each event of tube obstruction, suction, displacement, accidental extubation (non-elective extubation by the patient or occurring during patient care, irrespective of the need for reintubation), elective or planned extubation, need for reintubation and details of failed extubation (Reintubation within 48 hrs. of a planned extubation; excluding accidental extubation) were also recorded in detail.

Statistical Analysis

Data was entered in excel sheet and was analysed using SPSS software. Categorical data were expressed as absolute counts and percentages and continuous data were expressed as mean (SD) or median (Range).

RESULTS

Study group included 130 children, between age group > 28 days to ≤ 12 yrs., who were admitted in PICU and given invasive mechanical ventilation for more than 24 hours. Of this, 54.6% were males.

Mean age was 27 months with minimum age of 1 month and maximum age of 12 years. Of 130 children 59.2% were below 1 yr. of age, 26.2% between 1 - 5 yrs., 10% between 5 - 10 yrs. and 4.5% above 10 yrs. Regarding weight of children, 44.6% were below 5 kg, 27.7% between 5 - 10 kg, 20.8% between 10 - 20 kg and 6.9% above 20 kg. About 29.3% of the children were unimmunised or partially immunised. Eleven children (8.5%) were having congenital or acquired immunosuppression.

Admitting Diagnosis: In the present study, most of the children were admitted for respiratory system diseases. The system wise data is shown in Table 1.

System: Total and Percentage	Disease	Frequency	%
Respiratory 55 (42.3%)	Bronchopneumonia	25	19.2
	Aspiration pneumonia	17	13.1
	Acute bronchiolitis	6	4.6
	ARDS	4	3.1
	Upper airway obstruction	1	0.8
CVS: 5 (3.8%)	CCHD	3	2.3
	ACHD	1	0.8
	Aortic stenosis	1	0.8
CNS: 37 (28.5%)	Meningitis	21	8.5
	Seizure disorder	8	6.2
	Encephalitis	7	5.4
	Neuromuscular	3	2.3
	Meningoencephalitis	2	1.5
	Demyelination	2	1.5
	Intracranial bleed	2	1.5
	Status epilepticus	1	0.8
	Brain abscess	1	0.8
GIT: 8 (6.2%)	Liver failure	8	6.2
Haematological: 3 (2.3%)	HLH	3	2.3
	Others		
	Sepsis	21	16.2
	IEM	2	1.5
	Cervical spine dislocation	1	0.8

Table 1. Diagnostic Data of Patients

Among 130 children 50.8% had underlying chronic disease, affecting cardiovascular system in 16.2% (21), GIT in 2.3% (3), nervous system in 26 (20%) and other conditions such as Acute leukaemia (ALL) in 4, Immunodeficiency in 4 and Inborn error of metabolism (IEM) in 2 cases.

Indication for Mechanical Ventilation: Respiratory failure (62.3%) was the most common cause for mechanical ventilation followed by airway protection (28.5%) and persistent shock (9.2%). In most of the cases decision to give

MV was taken electively, whereas 33% of cases were intubated and ventilated on an emergency basis.

All children were orally intubated. Most of the children were intubated with uncuffed endotracheal tubes (ETT) (79.2%). Inotropes were used in 57.7% children. Tracheostomy was done later in 3 (2.3%) children. Most commonly used ventilatory mode was SIMV-PC (58.5%) followed by SIMV-VC (28.5%). Mean value of PEEP (Positive End Expiratory Pressure), PIP (Peak Inspiratory Pressure), Tidal volume per kg were 5.31, 16.9, 6.41 respectively.

Reintubation was required in 59.2% children due to tube obstruction, accidental or spontaneous extubation and failed extubation. ETT obstruction occurred in 52.3% of cases and was the important reason for reintubation. Accidental extubation occurred in 31.5%.

Regarding the complications, among 130 children 63 children (48.5%) developed a total of 116 complications related to the delivery of MV. This equated to 175 complications per 1,000 days of ventilation. Failed extubation (Reintubation within 48 hrs. of a planned extubation) occurred in 29 (22.3%) children. VAP was developed in 22 (16.9%) children. Eighteen children (13.8%) had post extubation stridor occurring within 2 hours of extubation. Endobronchial intubation occurred in 16 children (12.3%). Most episodes of endobronchial intubation were diagnosed clinically, and appropriate changes were made prior to chest x-ray taken. Perioral tissue damage occurred in 14 children (10.8%). Twelve children (10.2%) developed atelectasis and five (3.2%) developed pneumothorax during the course of ventilation. All the children with pneumothorax required chest tube insertion.

Mean (SD) duration of MV was 5.1 (5.24) days. Minimum period was one day and maximum 30 days. The overall period of ventilation was 663 days. The mean (SD) duration of PICU stay was 10.2 (8.9) days.

Mortality: Total mortality among the study group was 54.6% (71 out of 130). Of this, 60% children belonged to less than 1 year and 26% between 1 - 5 years' age groups. Mortality was more among females (52 compared to 29 males) and in children with weight less than 5 kg (48%) compared to other weight categories (20%- between 5 - 10 kg, 21%- between 10 - 20 kg and 11% in above 20 kg).

Pneumonia with sepsis was the admitting diagnosis in majority of children (54.8%) who expired. Also, there was some underlying chronic disease in 42 out of 71 (59.1%) children (Congenital heart disease: 16, Cerebral palsy: 11, Acute leukaemia: 4).

Mortality was 52.6% for children with MV duration \leq 10 days and 83.3% for MV duration $>$ 10 days and this was significant ($p < 0.05$). In children who received $FiO_2 > 60\%$ for a period of > 6 days, mortality was significantly higher compared to those who received $FiO_2 > 60\%$ for ≤ 3 days (100% vs. 48.1% with p -value < 0.05). These observations suggest that the duration of mechanical ventilation and prolonged requirement of higher FiO_2 are associated with mortality. Duration of PICU stay showed no significant difference.

Mortality among children who developed various complications related to MV was analysed. Failed extubation was associated with high mortality (21 out of 29 - 72.4%). The mortality among other complications were 40.9% for

Ventilator Associated Pneumonia, 40.9% for pneumothorax, 60% for atelectasis and 33.3% for post extubation stridor.

DISCUSSION

Mechanical ventilation is a frequently applied therapy in critically ill children and in many cases can be lifesaving. In the present study conducted to assess the clinical profile and outcome of children treated with invasive mechanical ventilation, most of the children were male (54.6%) and male-to-female ratio was 1.2: 1. Also, majority of children were below 1 yr. of age (59.2%) and had weight below 5 kg (48%). Studies done by Tanil Kendril et al,^[12] Beenish Mukhtar^[13] and Snezana Rsovac et al^[14] also found high incidence in male children.

SIMV pressure control with pressure support (58.5%) was most commonly used in the present study as an initial mode of ventilator support followed by SIMV volume control with pressure support (28.5%). SIMV mode was the most commonly used initial ventilator setting in many reported studies.^[12,13,15]

Most common indication for ventilation in our study was respiratory failure, which accounted for 82.4% of cases. Respiratory failure was the most common indication for MV in many studies.^[14,15,16] Farias et al^[17] in the study published in 2004 observed acute respiratory failure as the cause for initiation of invasive ventilation in 72% of the cases, whereas it was 64.8% in the study by Tanil Kendril et al^[12] and 59.18% in a study from Brazil.^[18]

Acute pulmonary disease has been reported as the main reason for the initiation of MV in developing countries, whereas postoperative state seems to be the main indication for ventilatory support in developed countries.^[19] In the present study, most of the children were admitted for Respiratory system diseases (42.3%) followed by CNS related diseases (29.2%). Bronchopneumonia (19.2%, $n = 25$) was the most common admitting diagnosis which required invasive ventilation. We have excluded post-operative cases requiring MV in our study. In studies by Tania Principi et al^[16] and Tanil Kendril et al,^[12] most of the children given mechanical ventilation were admitted for respiratory diseases.

The duration of mechanical ventilation was 4 - 6 days in different studies.^[20,21] Mean duration of mechanical ventilation in our study was 5.1 ± 5.24 days. Mean duration of mechanical ventilation in Snezana Rsovac et al^[14] and Tania Principi et al^[12] were 8.9 and 3.1 days, respectively.

Complications

Complications are common among children given invasive mechanical ventilation in PICU. Tanil Kendril et al^[12] and Tania Principi et al^[16] reported high rate of complications in mechanically ventilated children and was 42.8% and 40% respectively. In the present study, 48.5% children ($n = 63$) developed various complications related to MV. Rate of complications are comparable with other studies.

In the present study, MV was given for a total of 663 days. During this period a total of 116 episodes of different complications, related to invasive ventilation were noted. This equated to 175 complications per 1,000 days of ventilation. In 2011, Tania Principi et al^[16] observed 114 complications per 1,000 days of ventilation.

Most common complication was failed extubation (22.3%) and was followed by VAP (16.9%) and post

extubation stridor (13.8%). Atelectasis (16.7%) was the most common complication in the study by Tania Principi et al^[16] followed by post extubation stridor (13.3%). Tanil Kendril et al^[12] reported that most common complication was atelectasis (26.3%) followed by VAP (17.5%). The frequency of atelectasis in the present study was 9.2%. A low atelectasis rate was reported (3.0 – 7.8%) in different studies.^[1,3] The low incidence of atelectasis in the present study was due to the lung protective ventilation strategies with low PIP and TV,^[9,22] that we adopted in our children. Incidence of failed extubation in the present study was 22.3%. In previous paediatric studies,^[20] the reported incidence of failed extubation has ranged from 4.9% and 29%. Differences in study population, extubation policy and definition of failed extubation applied between studies may in part account for the considerable variation in reported rate.

The major reason for reintubation in our study was impaired respiratory effort. Failed extubation was significantly associated (p value < 0.05) with post extubation stridor, prolonged duration of MV, reintubation, prolonged duration of FiO₂ > 60% and VAP. Failed extubation was also significantly associated (p value < 0.05) with mortality among children given MV.

VAP is one of the important complications associated with MV. In the report by Srinivasan et al^[23] frequency of VAP was 32%, whereas the frequency of VAP in the present study was 16.9%. Wang et al,^[24] Tanil Kendril et al^[12] and Tullu et al^[25] reported a VAP frequency of 13.8%, 17.5% and 27.4% respectively. In our study, the occurrence of VAP was significantly associated (p value < 0.05) with reintubation, prolonged requirement of FiO₂ > 60% and prolonged duration of mechanical ventilation. The mortality related to VAP in the present study was 40.9%. Tullu et al^[25] reported that the mortality rate was 47% in VAP-developed patients.

Post extubation stridor was significantly associated with (p value < 0.05) prolonged duration MV in our study.

Mortality

The mortality rates of children with MV were different in different studies.^[12,13,21,26] In the present study, mortality was 54.6%. Tanil Kendril et al^[12] reported a mortality rate of 58.3% and Traiber C et al^[26] of 48% among mechanically ventilated children, which are close to our result. Majority of cases in the present study presented late in the advanced state of disease. In the studies by Beenish Mukhtar et al^[13] and Snezana Rsovac et al,^[14] mortalities were 30.3% and 38% respectively. The most likely explanation for lower rate is that in the study by Beenish Mukhtar et al from Pakistan, acute neurological illnesses (35.8%) was the most common indication of MV and also adoption of non-invasive ventilation in the early phases of acute respiratory illness as initial mode of respiratory support, both contributing to low mortality.

In developed countries, the mortality rates of mechanically ventilated patients in PICUs were very low.^[27] Mortality rate as low as 4.5% was observed by Tan et al.^[28] There are several factors for this major difference in the mortality rate of MV children including higher number of postoperative cases in their PICUs, trained staff, availability of respiratory therapist for ventilatory management and early presentation of illness. Pneumonia with sepsis was the admitting diagnosis in 54.8% of our children who expired.

Also, there was some underlying chronic disease in 59.1% of mortality cases with underlying congenital heart disease in majority. Volakli et al^[29] observed that 41.3% of their cases had comorbidity in their study. Congenital heart disease was the major comorbidity observed by Payen V et al,^[30] which is similar to the present study.

Failed extubation, prolonged requirement of FiO₂ > 60% and prolonged duration of MV are significantly associated with high mortality (p value < 0.05) in the present study.

CONCLUSION

Most common indications for mechanical ventilation in our children was respiratory failure (62.3%) followed by airway protection (28.5%). Failed extubation (22.3%) and VAP (16.9%) were the most common complications that occurred related to invasive ventilation. The mortality (54.6%) and complications (48.5%) of present study are comparable with other studies. Prolonged duration of ventilation was significantly associated with complications as well as mortality related to mechanical ventilation. High rate mortality occurred in children with underlying chronic diseases.

Mechanical ventilation has become one of the major indications for admission to paediatric ICUs and often a lifesaving strategy. However, use of mechanical ventilation can be associated with various complications including patient mortality. Its use necessitates intensive monitoring as well as additional supportive care adding to the treatment cost. Most PICUs are equipped with limited number of ventilators compared to the number of sick children they cater. In this circumstance, selection of appropriate patient for ventilator support is crucial, especially in a limited resource setup.

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