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Original Research Article

Study on clinical profile of ventilated children in a pediatric intensive care unit of tertiary care centre

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ABSTRACT

Background: Mechanical ventilation constitutes a major therapeutic modality in intensive care, so care of patients requiring ventilatory support is an integral part of the critical care unit. Very less data is available from developing countries regarding use of Mechanical Ventilation, its complication and outcomes which is a challenge for modern day intensivists. Objectives were to study clinical profile of ventilated children in a PICU of tertiary care centre.
Methods: Present prospective cross-sectional study was conducted on ventilated children admitted at PICU of Dr. VMGMC hospital, Solapur. The study included demographics, clinical profile, indication for ventilation, length of hospital stays, outcome.
Results: Out of 300 children, 170 cases were males. Most of them were from age group <5 years. Difficulty in breathing was seen in 188 cases, fever in 165 cases, 100 cases had CNS infections, 82 cases had bronchopneumonia, 28.33% patients' respiratory failure in 85 cases was the indication for intubation. The duration of mechanical ventilation was more in CNS cases, RS cases, sepsis cases. 60% of the cases got recovered successfully.
Conclusions: Mechanical ventilation is one of the major supportive modalities used in critical care all over the world and is also used in many of the sick children in government tertiary care centre. Despite of its life saving advantages, mechanical ventilation is associated with complication. Early use of HHFNC, CPAP/BiPAP and other non-invasive modes of ventilation decrease the need for invasive mechanical ventilation.

Key Words: Clinical Profile, Mechanical Ventilation, Respiratory Failure, PICU.

INTRODUCTION

Respiratory failure is the final common pathway for a variety of disorders that ultimately leads to a deterioration of lung function. Intubation and mechanical ventilatory support then become necessary until the underlying cause of the respiratory failure is improved or resolved.[1,2] Mechanical Ventilation (MV) is a life-supporting device, invasive technology of intensive care unit, to mimic the respiratory physiological function at the time of either impending or acute respiratory failure.[3] The percentage of children receiving mechanical ventilation in PICU ranges from 17-64% in developed countries, where PICU is a mature and established discipline of medicine.[4] Natural spontaneous ventilation occurs when the respiratory muscles (diaphragm, intercostal muscles) create negative intrathoracic pressure, in part by expanding the rib cage, leading to lung expansion, which pulls air into the alveoli and allows gas exchange to occur. In contrast, ventilation is achieved in intubated patients by delivering compressed gas to the lungs by positive pressure ventilation.[5] Complications secondary to MV include air leaks, interstitial emphysema, subglottic stenosis, and ventilator- associated pneumonia (VAP).[6] Conspicuously, the most effective strategy proven to minimize ventilator- associated lung injury consists of

reducing the duration of MV.[7] However, in spite of these recommendations, the rates of endotracheal intubation reported by the National Nosocomial Infection Surveillance System (NNIS) from January 2002 to June 2004 were still 43% in neonates with a birth weight of less than 1,000 g and 16% in newborns with a birth weight between 1,000 and 1,499 gm.[8] Care of critically ill patients challenges nurses to meet each patient's complex physiological and psychological needs. Mechanical ventilation constitutes a major therapeutic modality in intensive care, so care of patients requiring ventilatory support is an integral part of the critical care nurse's role. Most of the clinical research has been conducted on adults and recommendations for practice may be inappropriate for the care of infants or children as major physiological and psychological differences exist in children. It is the paucity of research in this area that has led to the researcher developing this study. Very less data is available from developing countries regarding use of Mechanical Ventilation, its complication and outcomes which is a challenge for modern day intensivists. Judicious use of ventilation when indicated, is essential along with very close monitoring of these critically ill children for a successful outcome.

Objectives

Objectives of current investigation were to study the indication of ventilation in children admitted in PICU and to study clinical profile of children who needed assisted ventilation during PICU stay.

METHODS

The present Prospective Cross-sectional study was done on ventilated children admitted at PICU of Dr. VMGMC hospital, Solapur from September 2019 to August 2021. 300 Children more than 1 month and less than 14 years who were ventilated in Paediatric Intensive Care Unit either manually or mechanically during the study period, who were included in the study. Children who were ventilated outside the hospital and referred for further care and who got admitted repeatedly for ventilation were excluded. Cardiopulmonary assessment was done and entry made in data sheet. All sick children were initially evaluated in the Paediatric Emergency Department of the hospital and initial stabilization of the patient including intubation when needed, fluid resuscitation and inotrope initiation were carried out accordingly. The choice of mechanical ventilation was based on availability of ventilators. If there were no available ventilators, the children were on manual ventilation, until ventilator became available. Once the ventilators were available, the children were managed on mechanical ventilator. 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. The initial parameter (rate, tidal volume, PIP, PEEP, FiO2, 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). 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.

Statistical analysis

Data was analysed by using SPSS v. 11.0 for windows. Categorical data were expressed as percentages. Continuous data were expressed as mean and SD. For the variables in qualitative form, chi square test was used to observe the association between the study variables and the outcome. Data were considered significant at p value of <0.05.

RESULTS

Number of PICU admissions required mechanical ventilation

Total number of PICU admissions during the study was 1571. Total 19.09 % of PICU admissions (300 cases) satisfied the inclusion criteria and were included in the study.

Age and sex wise distribution of children

Out of total children 170 (56.67%) were males and 130 (43.33%) were females. Most the children were from age group less than 5 years which were in a need of mechanical ventilation. The significant difference was observed between age and gender ($p<0.05$).

Clinical characteristics of the patients

From the above table, it is evident that the predominant presenting symptoms in children was difficulty in breathing (188 cases, 62.67%), followed by fever (165 cases, 55%). Most of the cases observed with acute CNS infections (100 cases, 33.33%), following to those 82 (27.33%) cases had bronchopneumonia, 36 (12%) cases had ARDS. Most of the cases (85 cases, 28.33%) had respiratory failure was the indication for intubation. Preceding to those 68 (22.67%) cases had poor GCS score, 40 (13.33%) cases had respiratory muscle paralysis.

Details of ventilation

Out of total cases, 190 cases were on A/C pressure control and 110 cases were on SIMV pressure control. Most of the cases (213 cases, 71%) had peak inspiratory pressure less than 14 cm H_2O followingto those 44 (14.67%) cases had peak inspiratory pressure between 15-18 cm H_2O.

Table 1: Clinical characteristics of the patients.

Clinical characteristics		N (%)
Presenting symptoms	Difficulty breathing	188 (62.7)
	Fever	165 (55)
	Convulsions	111 (37)
	Cough/Cold	89 (29.7)
	Altered Sensorium	42 (14)
	Not accepting feeds	36 (12)
	Choking during feeds	16 (5.3)
	Blurring of vision	8 (2.7)
Clinical diagnosis	Acute CNS Infections	100 (33.3)
	Bronchopneumonia	82 (27.3)
	ARDS	36 (12)
	Septic Shock	32 (10.7)
	Congenital Heart Disease	24 (8)
	Snake Bite	8 (2.7)
	Aspiration Pneumonia	7 (2.3)
	Multisystem	11 (3.7)
Indications for intubation	Respiratory Failure	85 (28.3)
	Poor GCS score (<8/15)	68 (22.7)
	Respiratory muscle paralysis	40 (13.3)
	Status Epilepticus	32 (10.7)
	Congestive cardiac failure	24 (8)
	MODS	10 (3.3)
	Others	41 (13.7)
Total		300

Most of the cases (243 cases, 81%) had PEEP 5, following to those 32 (10.67%) cases had peak end expiratory pressure 4, and 5 (1.67%) cases had peak end expiratory pressure greater than 6.

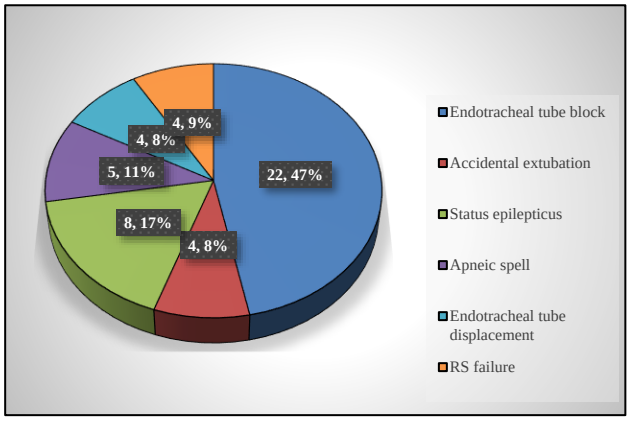

Figure 1: Reasons for reintubation.

Most of the cases had rate of breath between 29-32 per min, preceding to those 75 (25%) cases had breathing rate 20-24 per min. 144 (48%) cases had initial FiO_2 61-80 %, following to those 83 (27.67%) cases had FiO_2 between 40-60. Most of the cases (117 cases, 39%) were observed with initial pH level between 7.35-7.45, following to those 103 (34.33%) cases were observed with initial pH level greater than 7.45 and 80 (26.67%) cases were observed with initial pH level less than 7.35.

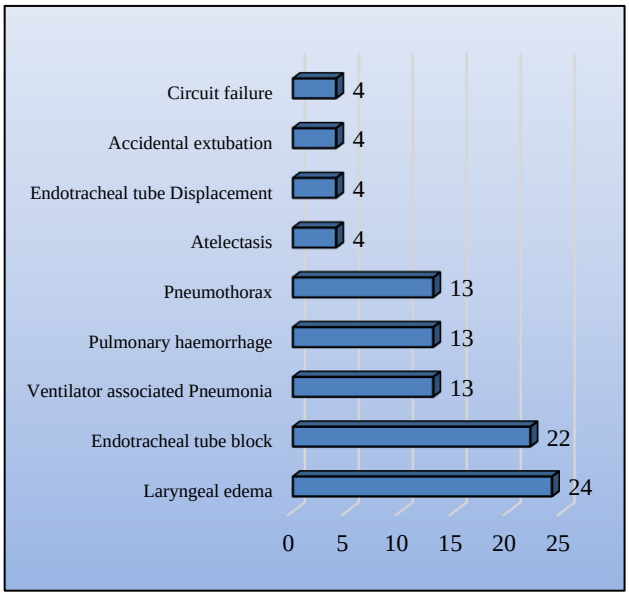

Figure 2: Distribution of patients as per complications developed.

Most of the cases (88 cases, 29.33%) were observed with paO_2 >100, preceding to those 83 (27.67%) cases were observed with paO_2 between 80-100 mmHg. Most of the cases (188 cases, 62.67%) were observed with $paCO_2$ <35

mmHg, preceding to those 62 (20.67%) cases were observed with $paCO_2$ between 35-45 mmHg.

Table 2: Details of ventilation.

Details of ventilation		N	%
Initial mode of ventilation	A/C Pressure control	190	63.33
	SIMV	110	36.67
Peak inspiratory pressure (cm H2O)	≤14	213	71.00
	15-18	44	14.67
	19-22	25	8.33
	>22	18	6.00
Peak end expiratory pressure	4	32	10.67
	5	243	81.00
	6	20	6.67
	>6	05	1.67
Initial rate of breaths	20-24	75	25.00
	25-28	24	8.00
	29-32	101	33.67
	33-36	43	14.33
	>36	57	19.00
FiO_2	40 – 60	83	27.67
	61-80	144	48.00
	81-100	73	24.33
pH	<7.35	80	26.67
	7.35-7.45	117	39.00
	>7.45	103	34.33
paO2 (mmHg) on ABG	<60	58	19.33
	60-80	71	23.67
	80-100	83	27.67
	>100	88	29.33
Initial paCO2 (mmHg)	<35	188	62.67
	35-45	62	20.67
	>45	50	16.67
Total		300	100

Female patients of age group more than 5 years had very lesser duration of ventilation of 1- 3 days. Most of the males from lower age group needed mechanical ventilation for at least more than 3 days. The duration of mechanical ventilation was more in central nervous system involvement, respiratory system involvement, sepsis and multisystem involvement.

Complications associated with mechanical ventilation

Above table shows the reasons for reintubation. Out of 300 cases with mechanical ventilation 47 (15.67%) cases were in need of reintubation. Common indication for intubation was endotracheal tube block. Out of 101 complicated cases most of the cases were of laryngeal edema 24 and endotracheal tube block 22. Following to those 13 (12.87%) cases were of ventilator associated pneumonia, 13 (12.87%) cases were of pulmonary haemorrhage.

DISCUSSION

Number of PICU admissions required mechanical ventilation

Total number of PICU admissions during the study was – 1571, Total 19.09 % of PICU admissions (300 cases) required mechanical ventilation. In a retrospective observational study conducted by Kendirli et al in 2006 in Turkey, medical records of 407 patients were reviewed 91 patients (22.3%) were treated with mechanical ventilation.[9] The Paediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network reported data on the demographics of children who were admitted for mechanical ventilation in 9 PICU's in North America. Over a period of six months, 17.1% of all patients who were admitted to these PICU's required mechanical ventilation.[10] Khemani et al published that 30% of children in a cross-section of United States PICU's were mechanically ventilated.[11] Mukhtar et al reported a total of 605 admissions in PICU in their study, of which 307 (50.7%) patients required mechanical ventilation support for > 24 hours.[12] These variations in admission rates and rates of mechanical ventilation could be explained by different materials and methods used in each study and the diverse infrastructure and individualized admission policies of various centres.

Age and sex wise distribution of children

Our study shows, out of total children 170 (56.67%) were males and 130 (43.33%) were females with male to female ratio 1.31:1. Kendirli T et al reported M:F ratio of 1.02:1 in their study.[9] Jadhav et al reported a Male to Female ratio of 1.58:1 in their study Mukhtaret al & Vijayakumary et al also reported male preponderance in their studies, M:F ratio of 1.48:1 & 1.17:1 respectively.[12-14] In contrast, 48.03% patients were under 1 year age and 84.31% constituting the under-fives in the study conducted by Vijayakumary T et al[(14)] Median age of patients was 3 years in study conducted by Mukhtar et al.[12] The mean age of patients in the study reported by Chiru et al was 2.3 years with 57% having age less than one year.[15]

System affected

Most of the cases observed were acute CNS infections (100 cases, 33.33%), following to those 82 (27.33%) cases had bronchopneumonia, 36 (12%) cases were ARDS, 07 (2.33%) cases had aspiration pneumonia, 32 (10.67%) cases had septic shock, 24(8%) cases had congenital heart disease, 8 (2.67%) cases were of snake poisoning, 11 (3.67%) cases had multisystem. Similarly, Wolfier et al reported that CNS is the most common system affected in PICU's.[16] Mukhtar et al also reported CNS is major system affected (35.8%) in children in their study, followed by respiratory disease (20.8%), cardiac disease in 13% and other illness in 30.3% patients.[12] Jadhav et al also reported CNS pathology in 35% of mechanically ventilated children.[13]In contrast, several studies report that respiratory illness was most common system affected in PICU's.[9,17,18]

Table 3: Age and sex-wise distribution of total days of mechanical ventilation.

Age group (years)	1-3 days		>3-5 days		>5-10 days		>10 days		Total
	M	F	M	F	M	F	M	F	
1 month-1 year	08	06	17	13	15	12	22	07	100
>1-5	10	07	21	15	08	10	27	08	106
>5-10	02	04	03	05	02	04	01	03	24
>10	08	05	11	17	08	10	07	04	70
Total	28	22	52	50	33	36	57	22	-
Grand total	50		102		69		79		300

Table 4: Distribution of total days of ventilation days according to the primary system involved at the time of intubation.

System involved	Total days of ventilation				
	1-3 days	>3-5 days	>5-10 days	>10 days	Total
CNS	8	30	21	41	100
RS	30	46	25	24	125
CVS	5	10	8	1	24
Sepsis	4	8	9	11	32
GIT	2	2	0	0	4
Renal	0	2	2	0	4
Multi-system	1	4	4	2	11
Total	50	102	69	79	300

Indications for intubation

Most of the cases (85 cases, 28.33%) had respiratory failure as the indication for intubation. Preceding to those 68 (22.67%) cases had poor GCS score and 40 (13.33%) cases had respiratory muscle paralysis. Few patients had more than one indication for endotracheal intubation and mechanical ventilation as a result of the underlying pathology.

Acute respiratory failure was the most common underlying diagnosis indicating the need for mechanical ventilation in 64.8% of patients in the study by Kendirili T et al.[9] Acute pulmonary conditions were the primary reasons for mechanical ventilation for mechanical ventilation in 57.37% patients in the study by Chiru D et al.[15] Silva et al reported acute 33 respiratory failure (59.18%) as major indication for mechanical ventilation in their study.[19] The most likely explanation for this change in pattern was the increased use of non-invasive ventilation (NIV) through high-flow nasal cannula and Bi-PAP in early phases of acute respiratory illness like bronchiolitis and pneumonia as initial mode of respiratory support. In contrast, Wolfier et al reported that neurological illness was most common cause of MV in PICU's.[16] Mukhtar et al also reported neurological illness (35.8%) as major cause of MV in children in their study, followed by respiratory disease (20.8 %), cardiac disease in 13% and other illness in 30.3% patients.[12]

Initial mode of ventilation

Out of total cases, 190 cases were on A/C pressure control and 110 cases were on SIMV pressure control. This is in accordance with the report by Craciun A et al in their study in 2010, which used similar modes for ventilation of children.[20] Patients were either mechanically ventilated by IMV, SIMV with pressure support or CPAP modes in the study by Kendirli et al.[9] SIMV was the most commonly used as initial mode in the study by Mukhtar et al.[12] Initial peak inspiratory pressure (PIP) and positive end expiratory pressure (PEEP): Most of the cases (213 cases, 71%) had peak respiratory pressure less than 14 cmH_2O following to those 44 (14.67%) cases had peak inspiratory pressure between 15-18 cmH_2O.

Most of the cases (243 cases, 81%) had peak end expiratory pressure 5cmH_2O, following to those 32 (10.67%) cases had peak end expiratory pressure 4cmH_2O. Mean PIP was 17.36±2.71cmH_2O. Mean PEEP was 5.04±0.77cmH_2O. In a study by, Farias et al started mechanical ventilation at mean PIP of 27±11 cm H_2O and PEEP of 5±2.6 cm H_2O.[4] The mean values of initial ventilator parameters, in the study by Chiru et al were, PIP 25.18±2.70 cm H_2O and PEEP 507±0.83 cm H_2O.[15] Rsovac et al started mechanical ventilation in their study at mean PIP of 21.8±3.5 cm H_2O and PEEP of 40±1.4 cm H_2O.[21] Similarly, Principi et al started ventilation in their study at mean PIP of 21.8±4.9 cm H_2O, PEEP of 56±1.3 cm H_2.[2] The initial ventilator parameters used in our study were similar to those reported by many authors.

However, there were studies which differed in the initial parameters, which could be explained by difference in severity of illness of patients studied and the specific working protocols. Concerning selection of ventilator settings, it is difficult to compare them among patients with different pathologies.

Initial FiO_2

144 (48%) cases had initial FiO_2 61-80 %, following to those 83 (27.67%) cases had FiO_2 40-60% and 73 (24.33%) cases had FiO_2 81-100%. Mean FiO_2 was 78.40±15.48. In the study by Chiru et al were, mean FiO_2 0.58±0.20 and Rsovac S et al started mechanical ventilation in their study at mean FiO_2 0.8 ± 0.3.[15,21]

Initial rate of breaths

In Most of the cases, rate of breath was kept between 29-32 per min, preceding to those 75 (25%) cases, breathing rate was 20-24 per min, 57(19%) cases, breathing rate was greater than 36 per min, 43 (14.33%) cases, breathing rate was 33-36 per min and 24 (8%) cases it was 20-24 per min. Mean breathing rate was 31.19±5.60 cycles per min. In their study, Farias et al mean frequency of ventilation of 23±17 cycle/minute ml/kg and Chiru et al kept mean ventilation rate 31.91±11.13 breaths/min.[4,15]

Initial pH, initial partial pressure of oxygen and Initial partial pressure of CO_2 on ABG

Our study shows, most of the cases (117 cases, 39%) were observed with initial pH level between 7.35-7.45, 88 cases, (29.33%) were observed with paO_2 greater than 100 torr. Many patients had partial pressures of oxygen of >100 mmHg. This could be explained by the fact that patients had received some form of supplemental oxygen owing to their critical illness, during transport to our hospital or while in our PICU/ ward, prior to intubation. 188 cases (62.67%) were observed with $paCO_2$ less than 35 mmHg, preceding to those 62 (20.67%) cases were observed with $paCO_2$ between 35-45 mmHg. Majority of patients, 188 (62.67%) were hypocapnia prior to starting mechanical ventilation. This finding corroborates with the fact that most common presenting symptom in our patients was breathing difficulty, which by and large presented as tachypnea and thus leading to hyperventilation. Mean pH, mean paO_2 and mean $paCO_2$ was 7.39±0.14, 95.42±49.27 mm Hg and 39.99±46.12 mm Hg respectively.

Rsovac et al in their study reported that, 22 (52.4%) patients had normal pH, 19 (45.2%) had acidosis and 1 (2.4%) had alkalosis. Hypercapnea ($paCO_2$ > 50 mmHg) was present in 28 (66.7%) patients and hypoxemia (paO_2< 60 mmHg) was present in 26 (61.9%) patients.[19-21] Silva et al in their study, reported a median pH of 7.36 (7.27-7.45) and an oxygenation index of 6 (3.51-849) and most patients in their study were normo or hypocapneic at initiation of mechanical ventilation.[19] The mean arterial blood gas values at initiation of ventilation reported by Chiru et al were pH 7.38±0.09, pao, 89.84± 18.68 mmHg and paCO, 41.09±11.68 mmHg.[9]

Reasons for reintubation

Out of 300 cases with mechanical ventilation 47 (15.67%) cases were in need of reintubation. Common indication for reintubation was endotracheal tube block. It is a common practice to extubate the patient when cardiopulmonary status is deteriorating, due to possibility of ETT complications, and to provide bag and mask ventilation or re-intubate.[22,23]

Chiru et al reported a 13.88% incidence of reintubation in their study This was done due to accidental extubation or tube obstruction with adherent secretions.[15] Farias et al reported that, out of 993 patients who received mechanical ventilation 187 (19%) required reintubation within 48 hours. The rate of accidental extubation was 6.7% and of these patients, only 27 patients (38%) were reintubated and submitted to ventilation again.[4]

Distribution of patients as per complications developed

Out of 101 complicated cases most of the cases were of laryngeal edema 24 cases and 22 cases had endotracheal tube block. Following to those 13 (12.87%) cases were of ventilator associated pneumonia and 13 (12.87%) cases were of pulmonary haemorrhage.

Principi et al reported that, failed extubation occurred on 17 occasions in 14 patients in their study. Impaired respiratory effort (54%) and upper airway obstruction (23%) accounted for the majority of extubation failures in their study, accidental extubation occurred in five patients (3%), two of whom (40%) required reintubation.[22] Rsovac et al reported a total of 61 complications in 42 patients which equated to 97 complications per 1,000 ventilation days.[21]

Kendirli et al reported a complication rate of 42.8% and diversity of complications were as follows atelectasis (26.3%). VAP (17.5%). pneumothorax (13 1%). bleeding (5.4%), tracheal edema (4.3%) and chronic lung disease (2.1%).[9] Mukhtar B et al reported a complication rate of 9.2%, in their study and atelectasis (4.6%) was most common occurrence.[12]

Limitations

Being a Government hospital most of the patients were from rural area that is why data of urban patients is deficient in our study. In our study outcome of the patient was discussed till the patient was at hospital and any longterm sequelae couldnot be assessed due to lack of follow up after discharge.

CONCLUSION

Pediatric intensive care is a distinct but still novice specialty in developing countries. Mechanical ventilation is one of the major supportive modalities used in critical care all over the world and this treatment modality is also used in number of sick children in government tertiary care centre. Despite its life saving advantages, mechanical ventilation is associated with physiologic and mechanical complications. Complications prolong the duration the

MV. 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. To improve the outcome of MV children in PICUs, there is need of effective, organized and structured educational courses from basic concept to clinical application for all physicians and nurses involved in the care of critically ill children receiving mechanical ventilation.

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