Mechanical ventilation in children

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Mechanical ventilation can be lifesaving, but >50% of complications in conditions that require intensive care are related to ventilatory support, particularly if it is prolonged. We retrospectively evaluated the medical records of patients who had mechanical ventilation in the Pediatric Intensive Care Unit (PICU) during a follow-up period between January 2002-May 2005. Medical records of 407 patients were reviewed. Ninety-one patients (22.3%) were treated with mechanical ventilation. Ages of all patients were between 1-180 (median: 8) months. The mechanical ventilation time was 18.8±14.1 days. Indication of mechanical ventilation could be divided into four groups as respiratory failure (64.8%), cardiovascular failure (19.7%), central nervous system disease (9.8%) and safety airway (5.4%). Tracheostomy was performed in four patients. The complication ratio of mechanically ventilated children was 42.8%, and diversity of complications was as follows: 26.3% atelectasia, 17.5% ventilator-associated pneumonia, 13.1% pneumothorax, 5.4% bleeding, 4.3% tracheal edema, and 2.1% chronic lung disease. The mortality rate of mechanically ventilated patients was 58.3%, but the overall mortality rate in the PICU was 12.2%. In conclusion, there are few published epidemiological data on the follow-up results and mortality in infants and children who are mechanically ventilated.

Key words: mechanical ventilation, children, complication, mortality, pediatric intensive care.

Mechanical ventilation can be lifesaving, but >50% of complications in conditions that require intensive care are related to ventilatory support, particularly if it is prolonged[1,2]. Mechanical ventilation with positive pressure is a technique that has been employed in the pediatric intensive care units (PICUs) with increasing frequency. The percentage of mechanical ventilation varies from 30 to 64% in PICUs[3-6]. Since its introduction into the modern PICUs, mechanical ventilation has undergone continuous evolution. There has been an explosion of new ventilator modes, many of which have been incorporated into routine clinical practice without evidence of their efficacy or their superiority over other modes of ventilation. Currently, pressure modes are generally used for children throughout the world[5,7,8].

The indications of mechanical ventilation are respiratory failure (pneumonia, bronchiolitis, lung hemorrhage, muscle disease, laryngotrach eobronchiolitis), cardiovascular failure together with hypotension (heart failure, myocarditis, spell attack), septic shock, central nervous system disease (meningitis, encephalitis, coma, bleeding, tumor), and safety airway, especially critical situations like sepsis. Though it has lifesaving benefits, mechanical ventilation can result in important complications including pneumothorax, atelectasia, ventilator-associated pneumonia (VAP), obstruction of the tracheal tube during the intubation period, tracheal edema and tracheal stenosis after the extubation period. In this respect, a patient treated with mechanical ventilation must be followed by the pediatric intensive team and in a PICU[9-12]. In this study, we report indications, complications and end results of mechanical ventilation in children who were followed in our PICU.

Material and Methods

We retrospectively evaluated the medical records of patients who had mechanical ventilation in the PICU during a follow-up period between January 2002-May 2005. We

have five beds and four mechanic ventilators (VIPBIRD: Bird Production Corp., Cortland, New York, USA) in our PICU and nearly 150 patients are followed-up in a year, with a 10-15% mortality rate. The decision for mechanical ventilation is made by the pediatric intensivist.

Respiratory failure criteria were hypoxia (pO_2<50 cmH_2O), sudden CO_2 retention (pCO_2>50 cmH_2O), and SO_2<90%. The etiologies of respiratory support were divided in four groups as: respiratory failure [pneumonia, bronchiolitis, lung hemorrhage, upper airway obstruction (laryngitis, foreign body), muscle disease]; cardiovascular failure (heart failure); central nervous system (CNS) diseases (tumor, infection, degenerative brain disease, coma, increased intracranial pressure); and for safety airway (sepsis, shock).

We determined the respiratory support period and noted complications of mechanical ventilation as VAP, pneumothorax, atelectasia, tracheal edema, tracheal stenosis, and chronic lung disease. A complication was attributed to mechanical ventilation if it was not present before and it developed during mechanical ventilation. VAP was considered when clinical and laboratory findings of pneumonia arose at or after 48 hours of mechanical ventilation. Chronic lung disease due to mechanical ventilation was considered when a previously healthy child developed permanent lung problem and permanent oxygen dependence after mechanical ventilation. Mortality rate and tracheostomy percentage were also determined.

All data were analyzed using a Statistical Package for Social Sciences program (SSSP Inc, Chicago, IL). Data were expressed as median (minimum-maximum) when they were not normally distributed and in mean and standard deviation when normally distributed.

Table I. Patient Number According to Each Subgroup

Groups	Patient Number (n)
A-Respiratory failure	59
1. Pneumonia	41
2. Muscle disease	8
3. Bronchiolitis	4
4. Upper respiratory obstruction	4
5. Bleeding	2
B-Cardiovascular failure	18
1. Heart failure	10
2. Circulation failure	8
C-CNS disease	9
1. Meningitis-encephalitis	3
2. Coma (hepatic)	3
3. Hypoxic ischemic encephalopathy	2
4. Tumor	1
D-Safety airway	5
1. Sepsis	4
2. Decompensated metabolic acidosis	1

Results

Medical records of 407 patients who were followed-up in the PICU were reviewed. Ninety-one patients (22.3%) were treated with mechanical ventilation, and the male-female ratio was 1.02. Ages of all patients were between 1-180 (median: 8) months, with a mean age of 41.6±54.2 months (75% of all patients were under 5 years). The period of mechanical ventilation was 18.8±14.1 days. All patients were mechanically ventilated by intermittent mandatory ventilation (IMV), synchronized intermittent mandatory ventilation (SIMV), SIMV with pressure support, or continuous positive airway pressure (CPAP) modes.

Mechanical ventilation indications were divided into four groups including respiratory failure, cardiovascular failure, CNS disease and safety airway (Fig. 1 and Table I). Mortality rate, mechanical ventilation time, and complication frequency of all groups are given in Table II.

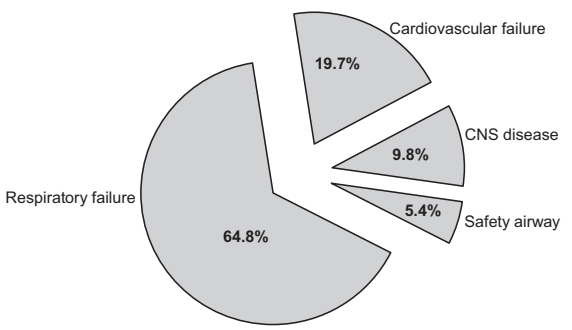

Fig. 1. The etiologies of mechanical ventilation in children.

Seven patients had muscle disease in the respiratory failure group. They were mechanically ventilated eight times. One patient had myasthenia gravis, and she was mechanically ventilated for five days due to two myasthenic crises. Diagnoses in other patients were critical illness polyneuropathy,

Table II. Mortality Rate, Period of Mechanical Ventilation, and Complication Ratio by Group

Groups	Mechanical ventilation time (day)		Complication ratio (%)	Mortality rate (%)
	Mean±SD	Median (Min-Max)		
Respiratory failure	21.42±39.50 *8.50±5.13	34 (1-240) *11 (1-18)	50.8	52.5
Cardiovascular failure	3.45±3.18 (3)	3 (6 hours-9 days)	72.3	21.1
CNS disease	7.44±5.21 (6)	6 (1-14)	66.6	22.2
Safety airway	7.51±4.46 (7)	7 (1-11)	60	

*After exclusion of children with muscle disease.

myotonic dystrophy, spinal muscular atrophy (2 patients), glycogen storage disease with muscle involvement, and congenital myopathy. These children were mechanically ventilated for 240, 210, 35, 220, 150, and 120 days, respectively. Their mechanical ventilation time was 129.31±97.23 days. The patients with spinal muscular atrophy, myotonic dystrophy, and congenital myopathy died. If patients with muscle disease who were in respiratory failure were excluded, the mechanical ventilation time was 8.50±5.13 (median 11) days.

Totally, a complication rate of 42.8% was encountered in mechanically ventilated children. These included atelectasia (26.3%), VAP (17.5%), pneumothorax (13.1%), bleeding (5.4%), tracheal edema (4.3%) and chronic lung disease (2.1%). There was no tracheal stenosis. Tracheostomy was performed in four patients. The mortality rate of mechanically ventilated patients was 58.3% versus the mortality rate of all patients in the PICU of 12.2%.

Discussion

Positive pressure ventilation is associated with numerous physiological and mechanical complications. Most of the adverse physiological responses to positive pressure ventilation result from inappropriately high mean airway pressure[9]. Elevation of airway pressure may decrease the venous return, cardiac filling, and output. Airway and alveolar rupture and their sequelae constitute the most frequent life-threatening complications of ventilatory assistance. Airway pressure >40 to 50 cm H_2O causes barotrauma, with development of air leak syndrome, which includes parenchymal interstitial emphysema, pneumomediastinum, pneumopericardium, and pneumothorax. All pediatric critical care personnel must be able to recognize immediately and treat different manifestations of air leakage[9,13-16]. Wang et al.[10] reported that 31.9% of all patients followed-up in the PICU were mechanically ventilated and atelectasia (13.8%) and VAP (13.8%) developed. In our study, a complication rate of 42.8% was determined, and atelectasia (26.3%) and VAP (17.5%) developed. We were unable to determine the bacteria causing VAP as our study was retrospective.

The occurrence of mechanical misadventures such as endotracheal tube obstruction, disconnected tubes, unplanned extubation, and apparatus malfunction are largely preventable and underscore the need for continuous electrical and human monitoring of both the machine and the patient[9]. Among the wide variety of noncardiopulmonary complications that have been described for mechanical ventilation, perhaps the most important involve dysfunction of the renal, gastrointestinal, and CNS systems, including emotional distress[9,14-21].

The Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network reported data on the demographics of children who were admitted for mechanical ventilation in nine PICUs in North America[4]. Acute respiratory failure was reported secondary to pneumonia, bronchiolitis, trauma, seizures, sepsis, and pulmonary edema. Over a period of six months, 17.1% of all patients who were admitted to these PICUs required mechanical ventilation. In this study, high-risk patients (such as those with complex and cyanotic congenital heart diseases, diaphragmatic hernias, or a history of bone marrow transplantation or lung transplantation) were excluded; cases with bronchiolitis were predominant in this study[4]. Our study is epidemiological, and there are few reported studies about mechanical ventilation in children. The most common indication of mechanical ventilation in our series was

respiratory failure due to pneumonia. The complication frequency was 42.8%, mortality rate was 58.3%, and period of mechanical ventilation was 18.8±14.1 days.

Acute respiratory failure is the most common underlying diagnosis indicating the need for mechanical ventilation, as was the case in 64.8% of our ventilated patients. Among the subgroups of acute respiratory failure, the higher proportions were acute pulmonary disease (pneumonia, bronchiolitis). Acute pulmonary disease has been seen as the main reason for the initiation of mechanical ventilation in developing countries, whereas postoperative state seems to be the main indication for ventilatory support in developed countries[5]. In our hospital, patients are followed in the cardiovascular surgery service in the postoperative period. Only some critical patients with congenital heart disease are followed at our PICU.

Tullu et al.[11] reported the frequency of VAP in 59 mechanically ventilated patients as 27.4%, and the mortality rate was 47% in VAP-developed patients. In our mechanically ventilated children, atelectasia was the most frequent complication, and VAP was seen in 17.5% of those with complications. In our study, the mortality rate of mechanically ventilated patients was 58.3%, but the mortality rate of all patients followed-up in the PICU was 12.2%.

In conclusion, there are few published epidemiological data on mortality in infants and children who were mechanically ventilated. Epidemiological studies focusing on these aspects could cast light on the factors related to survival of infants and children treated with mechanical ventilation. Mechanical ventilation brings important morbidity and mortality risks despite its lifesaving advantages. Children with critical illness must be followed in the PICU by a pediatric intensive care team.

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