ORIGINAL PAPERS

Adv Clin Exp Med 2014, **23**, 1, 57–61
ISSN 1899–5276

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Complications of Mechanical Ventilation in Pediatric Patients in Serbia

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article; **G** – other

Abstract

Background. Mechanical ventilation is a frequently applied therapy in critically ill children and can be lifesaving in many cases. Clinical use of this technique has well documented benefits, but can be associated with different complications and adverse physiologic effects.
Objectives. The aim of this study was to investigate the complications and clinical outcome of mechanical ventilation in Serbian pediatric patients.
Material and Methods. The study encompassed 42 children with respiratory insufficiency that underwent mechanical ventilation during hospitalization over a period of 12 consecutive months. The influence of clinical and mechanical parameters on the occurrence of complications and clinical outcome were analyzed.
Results. The patients were ventilated for a total of 432 days and a total of 61 complications were observed in 42 patients (97 complications per 1000 ventilation days). The most common complications associated with mechanical ventilation in Serbian pediatric patients with respiratory insufficiency were cardiovascular insufficiency (52.4%) and multiple organ failure (35.7%). High values of applied PIP (> 26 cm H_2O), PEEP (> 6 cm H_2O) and Tv (> 6 mL/kg) were associated with the occurrence of complications and negative clinical outcome.
Conclusions. Complications of mechanical ventilation in the pediatric population occur frequently, but lower volumes/pressures of ventilation contribute to a decrease in incidence. Further studies are needed to examine associated risk factors and strategies to reduce the occurrence of complications and improve clinical outcome (**Adv Clin Exp Med 2014, 23, 1, 57–61**).

Key words: mechanical ventilation, respiratory insufficiency, complications, clinical outcome.

Mechanical ventilation is a frequently applied therapy in critically ill children and can be lifesaving in many cases. It is used to increase alveolar ventilation by supplying pressurized air through an oral-nasal or nasal mask. The basis of the technique is an increase in ventilation through a transpulmonary pressure gradient without an indwelling artificial airway. Clinical use of this technique has well documented benefits, but can be associated with different complications and adverse physiologic effects. Studying the clinical complications of mechanical ventilation may influence its outcome, considering that the occurrence of complications may prolong the duration of ventilation itself and/or hospitalization and increase patient mortality.

A number of clinical trials have detailed the complications of mechanical ventilation, but they were mostly conducted a decade ago in adults. Complications accompanying mechanical ventilation in children are less well characterized. Studies conducted in pediatric patients are rare and were mostly conducted before the widespread adoption of lung protective ventilation strategies [1–5]. Recent studies have been limited to certain complications, such as ventilator associated pneumonia and extubation failure [6–9]. There is obvious need for further investigations in this field of study, and

they should also consider the potential impact of recent changes in ventilatory practice and general patient care on the epidemiology and incidence of ventilation-associated complications [10].

The aim of this study was to investigate the complications and clinical outcome of mechanical ventilation in Serbian pediatric patients.

Materials and Methods

Patients

This study encompassed 42 children who were hospitalized over a period of 12 consecutive months in the Intensive Care Unit of the University Children's Hospital in Belgrade. Written informed consent was obtained from all the patients' parents and the research was approved by the hospital's ethics committee. All patients experienced respiratory insufficiency, diagnosed based on the criteria proposed by the Acute Respiratory Distress Syndrome Network and arterial blood gas analyses (PaO_2, $PaCO_2$, PaO_2/FiO_2), and underwent mechanical ventilation during hospitalization [11].

On admission to the intensive care unit, all patients were subjected to thorax radiography, bacteriological analyses (hemoculture and tracheal aspirate), determination of leukocytosis and biochemical analyses (urea, creatinine and CRP). The patients were clinically monitored on a daily basis and they all had an arterial line for blood gas analysis sampling. In all patients, the mean arterial pressure, heart rate and body weight percentile were measured.

Data Collection

In all patients, the following data was noted: demographics, reason for intubation, pulmonary status on ICU admission, clinical parameters, intubation parameters and ventilation parameters.

The following parameters of mechanical ventilation were monitored: duration, airway pressure (Paw), positive end-expiratory pressure (PEEP), peak inspiratory pressure (PIP), fraction of inspired oxygen (FiO_2) and tidal volume (Tv).

The occurrence of each complication was verified along with the clinical and ventilation parameters at complication onset. Multiple organ failure was established based on the criteria by Wilkinson et al. [12]. Sepsis and septic shock were defined according to the guidelines of the American College of Chest Physicians and Intensive Care [13].

Statistical Analysis

The following descriptive statistical methods were applied for data processing: central tendency measures (arithmetical mean and median values), variability measures (variation interval, standard deviation and interquartile range) and relative numbers. Statistical significance was calculated based on the following inferential statistical methods: the Student *t*-test, chi-square test and Wilcoxon rank sum test. Values of $p \leq 0.05$ were considered statistically significant. Statistical analysis was performed using SPSS statistical software (SPSS for Windows, release 17.0, SPSS, Chicago, IL).

Results

Forty-two patients (median age 2.5, 61.9% male) were ventilated for a total of 432 days. The median duration of ventilation was 8.9 ± 12.4 days. The clinical characteristics of the patients, including intubation and ventilation parameters, are given in Table 1. In the majority of patients (25 cases), the reason for intubation was pulmonary disease and in these patients, atelectasis and pneumothorax were common. Among these patients, there were 16 with pneumonia, 7 with acute respiratory distress syndrome (ARDS) and 2 with bronchiolitis.

A total of 61 complications were observed in 42 patients, which equated to 97 complications per 1000 ventilation days. The following complications were registered: cardiovascular insufficiency, gastric bleeding, ventilator-associated pneumonia, sepsis and multiple organ failure. The incidence of each complication is given in Table 2.

A statistically significant association of each complication with several clinical parameters was observed. The presence of respiratory disease at ICU admission was statistically significant for each of the complications. Also, cardiovascular insufficiency was associated with low body weight percentile, positive hemoculture, hypoxemia and hypercapnia, while sepsis was associated with acidosis and hypoxemia.

The observed association of certain ventilation parameters with the occurrence of complications was also statistically significant. The values of Paw, PEEP, PIP and FiO_2 differed statistically significantly between the groups of patients with and without cardiovascular insufficiency, as well as between those with and without sepsis, while the values of PEEP and FiO_2 were significantly different between the groups of patients with and without multiple organ failure.

Sixteen patients out of the 42 included in the study died (38%). Clinical outcome in the

Table 1. Baseline clinical characteristics of the patients

Total number	42
Demographics	
age range (years)	0.2–17
mean age (years ± SD)	4.6 ± 5.1
median age (years)	2.5
male gender, N (%)	26 (61.9)
Clinical parameters	
leukocyte number ($\times 10^9$, mean ± SD)	17.3 ± 8.7
fiO_2/PaO_2, N (%)	
< 200	12 (28.6)
200–300	12 (28.6)
> 300	18 (42.8)
pH, N (%)	
< 7.35 (decreased)	19 (45.2)
7.35–7.45 (normal)	22 (52.4)
> 7.45 (increased)	1 (2.4)
Hypercapnia ($PaCO_2$ > 50 mm Hg), N (%)	28 (66.7)
Hypoxemia (PaO_2 < 60 mm Hg), N (%)	26 (61.9)
body weight percentile, N (%)	
< P50	14 (33.3)
P50	6 (14.3)
> P50	22 (52.4)
Reason for intubation, N (%)	
pulmonary disease	25 (59.5)
cardiovascular disease	4 (9.5)
neurological disease	12 (28.6)
acute alcohol intoxication	1 (2.4)
Pulmonary status on ICU admission, N (%)	
pathological pulmonary radiography	27 (64.3)
signs of infiltrations and pneumonia	16 (38.1)
Intubation parameters, N (%)	
orotracheal	40 (95.2)
tracheostomy	2 (4.8)
damage of the larynx	5 (11.9)
tracheal injury	3 (7.1)
reintubation	21 (50.0)
Ventilation parameters	
time before ventilation onset	2.5 ± 3.1
(days ± SD)	8.9 ± 12.4
ventilation duration (days ± SD)	11.2 ± 2.0
airway pressure (Paw), cm H_2O	
(mean ± SD)	4.0 ± 1.4
positive end-expiratory pressure	
(PEEP), cm H_2O (mean ± SD)	21.8 ± 3.5
peak inspiratory pressure (PIP), cm	
H_2O (mean ± SD)	0.8 ± 0.3
fraction of inspired oxygen (FiO_2),	
mm H_2O (mean ± SD)	7.5 ± 2.0
tidal volume (Tv), mL/kg	
(mean ± SD)	

Table 2. Incidence of complications in mechanically ventilated patients

Complication	**Number of patients (%)**	**Complications per 1000 ventilation days**
Cardiovascular insufficiency	22 (52.4)	109
Gastric bleeding	11 (26.2)	92
Multiple organ failure	15 (35.7)	71
Sepsis	6 (14.3)	56
Ventilator-associated pneumonia	7 (16.7)	38

ventilated patients was significantly associated with the presence of respiratory disease at ICU admission, positive hemoculture and hypoxemia. The values of Paw, PEEP and Tv differed statistically significantly between the groups of patients with positive and negative outcome. The results of the statistical analysis are given in Table 3. Low values of PIP (< 26 cm H_2O), PEEP (< 6 cm H_2O) and Tv (< 6 mL/kg) were associated with a positive outcome.

Discussion

Mechanical ventilation is used as a first-line treatment in acute respiratory failure in adult patients with different pathologies [14]. The results of controlled trials have proven the beneficial effects of this technique and it has been associated with a significant reduction in endotracheal intubation and fatal complications [15]. It has proven effective in decreasing mortality rates and improving overall survival [14, 15]. However, the experience of mechanical ventilation in a pediatric setting is limited and the majority of evidence is based on case reports [16]. It has been well established as an acceptable form of ventilation in children with chronic respiratory failures due to neuromuscular disease or cystic fibrosis, but is underinvestigated in children with respiratory insufficiency [17].

This study, to our knowledge, represents the first report specifically detailing the incidence, patient characteristics and outcome of mechanical ventilation in Serbian pediatric patients who experienced respiratory insufficiency. A total of 61 adverse events were observed in 42 patients, equating to 97 complications per 1000 days of ventilation. In the majority of patients (59.5%), the reason for intubation was pulmonary disease. The incidence of

Table 3. Statistical parameters for association between ventilation parameter values and clinical outcome

Ventilation parameter (mean ± SD)	Positive outcome	Negative outcome	t	p-value
Paw, mm H_2O	10.65 ± 1.91	12.00 ± 1.96	–2.19	0.035
PEEP, cm H_2O	3.58 ± 1.42	4.63 ± 0.96	–2.61	0.013
PIP, cm H_2O	21.00 ± 3.23	23.06 ± 3.64	–1.91	0.060
FiO_2, cm H_2O	0.67 ± 0.29	0.88 ± 0.23	–2.39	0.022
Tv, mL/kg	7.00 ± 1.74	8.25 ± 2.17	–2.05	0.047

ventilation complications observed in Serbian pediatric patients corresponds to previous findings. The most commonly encountered complication, observed in 52.4% of cases, was cardiovascular insufficiency, a frequently encountered problem in patients with acute bronchospastic disease who require mechanical ventilation [18]. Multiple organ failure, another common complication of mechanical ventilation, was observed with a frequency of 35.7% [19]. Gastrointestinal bleeding was observed with a frequency of 26.2%, similar to those reported by previous studies [20]. Sepsis and ventilator-associated pneumonia were detected with relatively low frequencies, 14.3% and 16.7%, respectively. The rate of ventilator-associated pneumonia observed in this study was 37.8 episodes per 1000 days of ventilation and this figure is higher than reported in previous pediatric studies (5.6–12 episodes per 1000 days of ventilation) [21, 22].

Mortality in adult and pediatric patients with acute respiratory distress syndrome has been declining in the last two decades to 40–45% for the western part of the world, which has been attributed to an overall improvement of intensive care treatment and the changes in ventilation strategies [23]. Clinical outcome was negative for 38% of the ventilated patients in this study and was significantly associated with the presence of respiratory disease at ICU admission, positive hemoculture and hypoxemia. The values of Paw, PEEP, FiO_2 and Tv differed statistically significantly between the groups of patients with positive and negative outcome. Application of mechanical ventilation using PIP < 26 cm H_2O, PEEP < 6 cm H_2O and Tv < 6 mL/kg was found to reduce the incidence of complications and to be associated with positive clinical outcome in ventilated patients. This study supports previous findings, mostly for adult populations, that implementation of lung protective strategies lowers the mortality rate [24–26]. Ventilation with lower tidal volumes has proven to decrease mortality and increase ventilation-free days [24, 27]. Complications of mechanical ventilation in the pediatric population occur frequently, but lower volumes/pressures of ventilation contribute to a decrease in incidence.

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Conflict of interest: None declared

Received: 25.02.2013
Revised: 9.05.2013
Accepted: 20.02.2014