

Optimal Time Needed for Withdrawal of Mechanical Ventilation in Patients with Chronic Obstructive Pulmonary Disease

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ABSTRACT: **Background:** Exacerbations of chronic obstructive pulmonary disease (COPD) are a major problem worldwide and are usually the main indication for mechanical ventilation (MV), especially in the intensive care unit (ICU). The rate of weaning failure is also high and prolonged MV leads to complications of intubation. The goal is to wean these patients as soon as possible.

Objective: To determine the optimal time necessary to start the weaning process.

Methods: In an attempt to determine the length of MV and stay in the ICU, we compared the length of MV, weaning, reintubations and discharge during a 10 month period. This study included 122 patients on MV due to severe exacerbation of COPD who were not suitable for non-invasive ventilation. For each patient serial arterial blood gases were measured at admission and during hospitalization. PeCO_2 (mixed expired CO_2) was tested using a Datex S/5 instrument at follow-up.

Results: The study population comprised all patients who required MV; of these 122, 108 were ventilated from 6 to 140 hours (mean 48 ± 42), 9 needed more than 168 hours, and 5 died due to severe ventilation-associated pneumonia. No correlation was found between pH, PCO_2 and length of MV; these findings did not contribute to evaluation of the patient's condition nor did they enable us to predict the length of treatment necessary.

Conclusion: Most of the patients (93%) ventilated for acute respiratory failure due to COPD required MV for only 6–90 hours.

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KEY WORDS: chronic obstructive pulmonary disease (COPD), weaning, mechanical ventilation (MV), respiratory intensive care unit

ment and outcome [2]. Acute exacerbations of COPD with decompensated respiratory acidosis lead to repeated hospital admissions and are associated with high mortality. Chronic obstructive pulmonary disease is a leading cause of worldwide disability and mortality. In approximately 5–15% of adults in industrialized countries COPD is defined by spirometry [3–5]. In 1990, there was an increase in the prevalence of and mortality from COPD, even in industrialized countries. The World Health Organization predicts that by 2020 COPD will rise from its current ranking as the 12th most prevalent disease worldwide to the fifth, and from the sixth most common cause of death to the third [3]. COPD has a chronic long-lasting course characterized by an irreversible decline of forced expiratory volume in one second, increasing presence of dyspnea and other respiratory symptoms, and progressive deterioration of health status. After diagnosis, the 10 year survival rate is approximately 50% with more than one-third of patients dying due to respiratory insufficiency [4]. The etiology of COPD is overwhelmingly dominated by smoking, although many other factors can play a role. Particular genetic variants are likely to increase the susceptibility to environmental factors but little is known about the relevant genes. Although there is accumulating evidence that oxygen therapy, pharmacological treatment and rehabilitation may improve the course of COPD, abstaining from smoking continues to be the most relevant measure not only to prevent COPD but to arrest its development as well [6–8]. Admitting COPD patients to an intensive care unit is common, since 26–74% of them need mechanical ventilation support. Despite the increasing use of non-invasive MV, many patients still require MV. The aim of this study was to determine the optimal time to begin the weaning process in patients with COPD.

PATIENTS AND METHODS

This was a prospective study conducted in the Respiratory Intensive Care Unit of Nahariya Hospital during one year.

COPD = chronic obstructive pulmonary disease
MV = mechanical ventilation

The prevalence of chronic obstructive pulmonary disease is progressively increasing in industrialized countries due to the aging of populations [1]. Furthermore, other chronic disorders often coexist in the elderly population, enhancing the risk of functional decline and influencing the patient's manage-

Our respiratory ICU admits about 1000 patients a year, 12% of whom suffer from COPD. During the period October 2008 to October 2009, 122 ventilated patients with exacerbation of COPD were admitted. The study excluded patients with asthma, pneumonia, pulmonary edema, coma, malignancy, renal failure, and those receiving kidney replacement therapy (peritoneal or hemodialysis). Thus the study included patients with a history and clinical findings of COPD who were admitted to the respiratory ICU with respiratory failure due to COPD exacerbation and in need of MV. The mean age of the patients, 92 males (75%) and 30 females (25%), was 73.59 years (SD \pm 11.33, range 34–97 years). Patients were transferred to the ICU from the department of internal medicine and the emergency room; all of them had been on mechanical ventilation. Before being intubated, a trial of non-invasive ventilation had failed in most of them due to the severity of disease. Patients were ventilated on SIMV mode (synchronized intermittent mandatory ventilation) with pressure support of 15–20 cmH₂O and received propofol as a sedative therapy. Data were collected in all patients requiring MV; the criteria used were similar to the GOLD guidelines for intubations [9]. The following information was recorded: age, gender, smoking history, comorbidity, and pulmonary function tests. Nine patients needed prolonged MV lasting more than 168 hours and five of them died due to pneumonia. COPD was clinically evaluated and diagnosed according to known criteria (exacerbation of cough, purulent sputum production, severe dyspnea, and negative response to bronchodilators). Radiological imaging showed no signs of pneumonia or congestive heart failure. Each patient's arterial blood gases were measured upon admission and an electrocardiograph was performed; PeCO₂ (mixed expired CO₂) was tested using a Datex S/5 instrument. The PeCO₂ is the partial pressure of carbon dioxide in mixed expired gas that helps us to monitor the changes in PeCO₂ and not as an absolute value.

The weaning process was conducted according to known clinical and laboratory criteria. The study was performed after each patient signed an informed consent form for blood sampling and data analysis and was approved by the institutional committee in accordance with the Helsinki Declaration and the institutional review board.

STATISTICAL ANALYSIS

Statistical analysis was performed using the SPSS-11 program. Data are expressed as means \pm SD. Differences in mean values were tested by two-way analysis of variance (ANOVA) and by the Bonferroni Multiple comparison test, using Prism version 3.0 statistical software (GraphPad software, San Diego, CA, USA). Correlations between different study parameters were performed alone using Pearson correlation coefficients. $P < 0.05$ was considered significant.

Table 1. Parameters of ventilated COPD patients on admission to the ICU

Gender	
Male	92 (75%)
Female	30 (25%)
Age (yrs)	34–97 (average 74)
pH	
Mean SD	7.12 \pm 0.08
Range	6.95–7.28
PaO₂ (mmHg)	
Mean SD	91.47 \pm 60.25
Range	33–395
PaCO₂ (mmHg)	
Mean SD	90.16 \pm 16.2
Range	49–126
Bicarbonate (mEq/L)	
Mean SD	30.8 \pm 6.68
Range	17.5–47.5
Saturation (%)	
Mean SD	86.2 \pm 10.9
Range	56–99
PeCO₂ (mmHg)	
Mean SD	45.0 \pm 11.29
Range	25–70
Respiratory rate	
Mean SD	18.18 \pm 7.9
Range	10–38
Hours of ventilation	
Mean SD	47.39 \pm 40.07
Range	5–161

RESULTS

The clinical and biochemical parameters of intubated patients with COPD during the admission are depicted in Table 1. The duration of MV was between 6 and 140 hours in most of the patients (93%, mean 48 \pm 42). Most patients were weaned from MV after 70 hours (82%), 46 (63%) within 24 hours. Blood pH in all patients varied between 6.98 and 7.25 (mean 7.12 \pm 0.08). There was no correlation between pH value and the duration of MV and statistically was not significant ($P = 0.179$). Patients with very low pH were weaned within 5–7 hours from MV. Arterial pO₂ was 33–395 mmHg (mean 91 \pm 60). Patients were ventilated with a different oxygen concentration to maintain acceptable blood saturation (86%). During the initial period of admission O₂ saturation was 56–99% (mean 86 \pm 11). Arterial pCO₂ was 49–126 mmHg (mean 90 \pm 16). There was no correlation between these values and the duration of MV.

For all patients in the study PeCO₂ was measured in expired air using a Datex S/5 instrument (Datex-Ohmeda Finland); this tool gave us a picture of the ventilated lung. High values indicate poor lung ventilation that requires prolonging the MV. The values in this study were 25–70 mmHg (mean 45 \pm 11). There was a strict correlation between PCO₂ and PeCO₂.

peCO₂ = mixed expired CO₂

DISCUSSION

Patients with COPD may still require mechanical ventilation for the treatment of respiratory failure during acute exacerbations despite the common use of non-invasive MV. The major physiological defects in COPD are increased dead space, severe ventilation-perfusion misdistributions, marked air-flow limitation, air trapping and hyperinflation. Such defects frequently result in poor oxygenation and hypercapnia.

Weaning was begun immediately after the initiation of MV. Some patients can be successfully weaned from MV within hours while for others it may take longer, possibly days or weeks. However, when MV is prolonged, especially in COPD patients, the likelihood of weaning is poor [10-12]. Complications such as pneumonia are frequently encountered in COPD patients with prolonged MV [13,14].

Patients with severe exacerbation of COPD usually require mechanical ventilation. In the present study we assessed 122 patients ventilated in the ICU, where the optimal time of weaning from mechanical ventilation was dependent on the closely related aspects of care, discontinuation of mechanical ventilation, and removal of any artificial airway. The first problem the clinician faces is how to determine when a patient is ready to resume ventilation on his or her own. Several studies have shown that a direct method of assessing readiness to maintain spontaneous breathing is simply to initiate a trial of unassisted breathing. Once a patient is able to sustain spontaneous breathing, the artificial airway can be removed. This decision is based on the patient's mental status, airway protective mechanisms, ability to cough, type of secretions, and other known criteria. A number of patients with COPD need re-intubation immediately or within a short time after extubation, with rates of 13–19% at 48 hours [15]. Several studies have evaluated the ability to predict the combined outcome of a successful trial of unassisted breathing followed by successful extubation in patients with COPD, and have predicted the prognosis and the optimal time for weaning.

Physiologically, COPD is characterized by abnormalities in ventilation and gas exchange, which lead to an increase in physiologic dead space and an impaired ability to excrete carbon dioxide [16]. Lung and cardiovascular diseases can lead to elevation in the pulmonary dead space fraction and consequently to an increase in respiration work and fatigability. These can cause difficulty and failure in the weaning process due to abnormalities in the alveolar dead space more than the anatomical dead space, and to elevation in the physiologic dead space. Prediction of dead space can be used sometimes as an index to estimate whether weaning will be successful in ventilated patients; furthermore, it is an objective monitor of pulmonary disease progression [17-19].

In this study the aim was to calculate the optimal time for weaning patients from MV. Few studies have focused on extu-

bation outcome in patients with COPD requiring mechanical ventilation, and most of them used an invasive procedure to measure gastric intramucosal pH or following evaluation of dead space fraction [18-21]. Any of these methods gives us clear information about the optimum time. It seems that the best way to program weaning from MV is to follow the simple clinical and biochemical parameters. It is crucial that the weaning procedure be initiated very early to prevent complications of prolonged intubation, including localized edema and/or ventilator-associated pneumonia. In the current study we encountered 122 COPD patients who were admitted to the ICU after intubation; most of them were weaned within a short time (2–4 days, two-thirds of them during the first 24 hours). Five patients died due to pneumonia and another three needed more MV time (more than 1 week). Two patients suffered from severe emphysema and underwent tracheostomy 2 weeks after admission; 1 month later they were weaned from MV. Our previous study demonstrated the same results but with a small number of patients, but we continued the study with a large number to verify the results [22].

In the present study we found a good and significant correlation between clinical improvement and the reduction of PaCO₂, and normalization of pH. These findings do not contribute to the evaluation of the patient's condition, nor do they enable us to predict the length of treatment necessary for patients with acute respiratory failure due to COPD. More research is necessary to explore the reasons for the difference in patient management and outcome.

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