

Clinical outcome of weaning in mechanically ventilated patients with chronic obstructive pulmonary disease

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Background Chronic obstructive pulmonary disease (COPD) represents a significant reason for mortality and morbidity worldwide that induces a high socioeconomic burden, with exacerbations necessitating mechanical ventilation representing a major aspect of illness management. Many patients with COPD frequently presented with troubles in the liberation from mechanical ventilation. The aim of the current study was to verify the validity of the weaning categorization that is classified according to the difficulty and length of the weaning procedure in mechanically ventilated patients with COPD and its effect on the different clinical and mortality outcome variables.

Patients and methods A total of 102 patients with COPD who achieved the weaning criteria were classified according to the length and difficulty of weaning procedure into simple weaning group ($n=60$, 58.8%) and nonsimple weaning group (which include difficult and prolonged weaning categories) ($n=42$, 42.2%). The outcome measures are the length of mechanical ventilation, the duration of ICU stay, and lastly the mortality rate.

Results Regarding baseline data recorded at admission, no significant difference between both weaning groups was found apart from Acute Physiology and Chronic Health

Evaluation score II. The nonsimple weaning group had considerably higher duration of invasive mechanical ventilation, length of ICU stays, and lastly the mortality rate, in comparison with the simple weaning group.

Conclusion Weaning categorization according to the length and the difficulty of the weaning procedure may be used as a suitable predictor of outcome in severe COPD exacerbation with the requirement for invasive mechanical ventilation.

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Introduction

Morbidity and mortality owing to chronic obstructive pulmonary disease (COPD) represents a worldwide pandemic. Severe COPD exacerbations may require mechanical ventilation, which is lifesaving [1]. Once mechanical ventilation is initiated, planning for weaning off should be started. Timing of weaning is crucial to avoid many complications. Weaning off mechanically ventilated patients with COPD is considered a major challenge in critical care practice. Weaning was categorized according to the length and difficulty of the weaning procedure into three categories (simple, difficult, and prolonged weaning categories), according to the latest recommendations [2].

Weaning should be performed early as soon as possible. It is important to recognize those patients at the time of admission who are likely to have poor outcome, so that such patients can be monitored closely and managed aggressively [3].

A topic of constant research for over many years is the difficulty to predict the weaning outcome in patients with COPD undergoing mechanical ventilation [2].

This study aimed to verify the validity of the weaning classification and its effect on the outcome in mechanically ventilated patients with COPD.

Patients and methods

Study design and setting

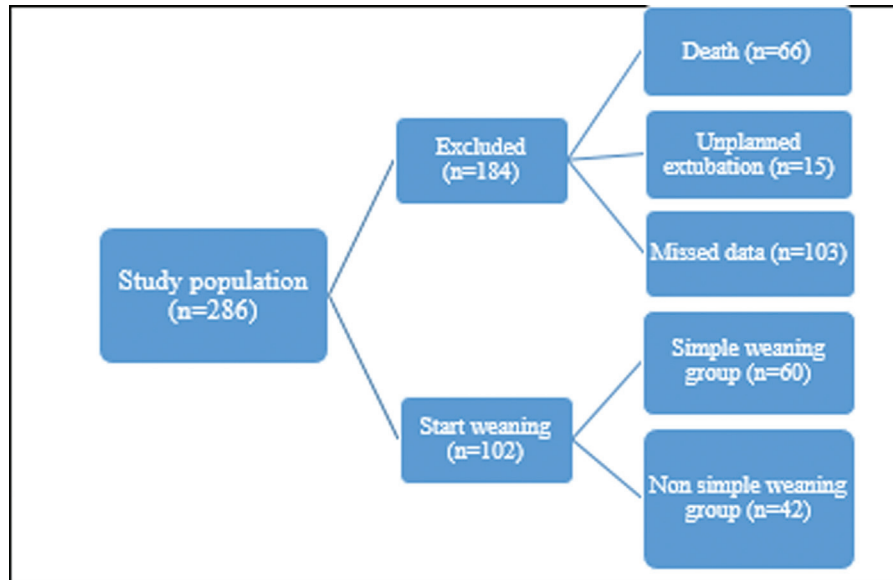
This is an observational study conducted in a RICU, during the period from October 2017 to April 2018.

Study population

A total of 183 patients with COPD requiring invasive mechanical ventilation were admitted in our RICU [ventilation was performed with the Puritan-Bennett 840 ventilator (Nellcor Puritan-Bennett 840 ventilator, Florida, USA)]. Of them, 81 patients did not start weaning either because of death in 66 patients or unplanned extubation in 15 patients. The remaining

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Figure 1



Scheme of the result analysis. The flow chart shows that the study includes 183 patients; however, 81 patients were excluded as 66 patients died before the start of weaning and 15 patients had unplanned extubation. Therefore, the included 102 patients were classified into simple weaning group (60 patients) and nonsimple weaning group (42 patients).

102 patients met the weaning criteria and start weaning, as shown in Fig. 1.

Inclusion criteria

The study included all patients with COPD requiring invasive mechanical ventilation with the following criteria: respiratory rate more than or equal to 35 breath/min, use of accessory muscles of respiration, disturbed conscious level, respiratory acidosis, and $\text{PaO}_2/\text{FiO}_2$ less than 200.

Exclusion criteria

The exclusion criteria include age less than 18 years, patients with central nervous system disorders unrelated to hypercapnic encephalopathy or hypoxemia, patients with postarrest encephalopathy, and patient with previous tracheostomy.

Study classification

Patients were classified according to the duration and difficulty of weaning procedure into two groups: simple weaning group included 60 patients who tolerated the first trial of spontaneous breathing, and nonsimple weaning group (including difficult and prolonged weaning category) included 42 patients, of which the difficult weaning category included 37 patients who failed first spontaneous breathing trial (SBT) but succeeded on second or third trial within 7 days, and the prolonged weaning category included five patients who did not tolerate at least three weaning trials or when weaning duration exceeded 7 days from the first trial of weaning.

The following data were recorded:

- (1) Demographic data including age, sex, smoking, and BMI.
- (2) Arterial blood gases.
- (3) Full laboratory assessment.
- (4) Hemodynamic data, including mean arterial blood pressure, calculated as diastolic pressure+1/3 pulse pressure, respiratory rate (RR), heart rate, and temperature.
- (5) Acute Physiology and Chronic Health Evaluation (APACHE) II score was measured on the day of ICU admission. APACHE II score consists of 12 variables including, vital signs (heart rate, mean arterial blood pressure, RR, temperature, and Glasgow coma score), variables derived from routine venous blood tests (hematocrit, white blood cell count, serum potassium, serum sodium, and serum creatinine), and two variables derived from arterial blood gas tests (serum pH and PaO_2).
- (6) Ventilatory data were recorded at admission and after half hour of SBT, including spontaneous tidal volume, RR, minute ventilation, peak pressure, plateau pressure, and static compliance. Values were displayed on the ventilator and we used the average of three breaths. In addition, weaning indices were recorded including rapid shallow breathing index (RSBI) obtained by dividing spontaneous RR by exhaled tidal volume (l) and the new integrative weaning index (IWI) calculated as $(\text{Cst, rs} \times \text{SaO}_2) / \text{RSBI}$, in which Cst, rs is static compliance and SaO_2 is arterial oxygen saturation.

All patients who fulfilled the subsequent weaning criteria underwent SBT, which comprised the respiratory criteria, including sufficient inspiratory effort, PaO₂ more than 60 mmHg or SaO₂ more than or equal to 90% or more with FiO₂ less than or equal to 0.4, and normal or baseline PaCO₂, and cardiovascular criteria, involving heart rate less than or equal 140 beats/min, absence of myocardial ischemia and within normal mean arterial blood pressure without the necessity for the use of vasopressors, patient is arousable or has Glasgow coma score more than or equal to 13, and there were no electrolyte disturbances.

Ethical consideration

The study was agreed by the Institutional Ethics Committee Faculty of Medicine. Moreover, a written consent was given by the surrogate decision maker.

Statistical analysis

Statistical analysis was done by SPSS, version 21 (IBM Inc., Armonk, New York, USA). Nonparametric tests were used in the current study.

Results

Demographic data and patient characteristics at admission of both groups of weaning are summarized in Table 1. There was a major significant variation between both groups regarding

the APACHE II score, whereas there was no significant difference regarding the other parameters.

Regarding the ventilator parameters at the end of the first SBT, the simple weaning group illustrated highly significant higher values for exhaled tidal volume and static compliance and lower values for RR and exhaled minute ventilation, whereas regarding peak pressure, plateau pressure, and auto-positive end expiratory pressure, no significant differences between both groups were observed (Table 2).

Table 2 Ventilator parameters at the end of the first spontaneous breathing trial

	Simple weaning (N=60)	Nonsimple weaning (N=42)	P value
Exhaled tidal volume (ml)	360±80	280±90	0.000*
RR (breath/min)	23.92±4.60	32.98±5.62	0.000*
P peak (cmH ₂ O)	21.58±3.29	21.02±2.99	0.711
P plateau (cmH ₂ O)	18.02±2.28	17.55±2.32	0.450
V?E(l/min)	7.34±1.54	8.85±2.01	0.000*
Auto-PEEP (cmH ₂ O)	1.34±0.58	1.28±0.60	0.634
Static compliance (ml/mmHg)	49.40±14.09	32.42±11.06	0.000*

Data are expressed as mean±SD. P peak, peak pressure; P plateau, plateau pressure; PEEP, positive end expiratory pressure; RR, respiratory rate; V?E, minute ventilation. P value less than 0.05 is considered statistically significant. *means significant.

Table 1 Demographic data and patient characteristics for the studied groups

	Simple weaning (N=60)	Nonsimple weaning (N=42)	P value
Demographic data			
Age (years)	59.70±12.36	61.19±11.64	0.437
Sex			
Male	42 (70.0)	29 (69.0)	0.918
Female	18 (30.0)	13 (31.0)	
BMI (kg/m ²)	28.64±6.83	27.62±6.32	0.644
Smoking			
Smoker	41 (68.3)	25 (59.5)	0.360
Nonsmoker	19 (31.7)	17 (40.5)	
Smoking index	29.84±6.04	28.88±7.42	0.337
ABG at admission			
pH	7.24±0.07	7.23±0.09	0.746
PaCO ₂ (mmHg)	82.55±19.22	80.79±22.24	0.930
PaO ₂ (mmHg)	52.22±17.51	53.64±22.98	0.806
HCO ₃	37.30±9.75	34.40±10.26	0.132
SaO ₂ (%)	75.57±15.62	73.50±17.63	0.703
PaO ₂ /FiO ₂	130.54±43.77	134.11±57.45	0.806
Hemodynamic data at admission			
Mean blood pressure (mmHg)	86.60±22.46	83.26±21.48	0.528
Respiratory rate (breath/min)	16.39±4.48	20.39±5.38	0.583
Heart rate (beat/min)	116.42±18.94	115.19±17.24	0.528
Temperature (°C)	37.90±0.60	38.04±0.36	0.12
APACHE II score	19.27±2.74	22.62±3.66	0.001*

Data are presented as mean±SD, median (range) or n (%). ABG, arterial blood gases; APACHE, Acute Physiology And Chronic Health Evaluation. Nonsmoker; those who never smokers.

Simple weaning group was associated with higher values of RSBI and IWI (Table 3), whereas nonsimple weaning was associated with higher length of mechanical ventilation, duration of ICU stays, extubation failure percentage, tracheostomy need, need for noninvasive mechanical ventilation after weaning and its duration, and mortality outcome (Table 4).

Discussion

We found that the incidence of simple weaning in our study was 58.8, difficult weaning was 36.3, and prolonged weaning was 4.9. Similar to our results, one previous study found that the prevalence of the three weaning categories was 54, 26, and 19%, respectively [4]. Moreover, another study reported that the simple weaning incidence was three times more common than the other weaning categories [5].

Regarding the demographic data of the studied patients in the current study, both groups matched regarding age, sex, duration of the disease, BMIs, and smoking status ($P>0.05$). Similar results were demonstrated by Elgazzar *et al.* [6] who found that the weaning outcome was not affected by the age, sex, or the state of smoking.

APACHE II score is a major important score used to evaluate the disease severity and the expected mortality. In the current study, there was a major difference between both groups in APACHE II score. This result was in harmony with the results of some previous studies which detected that weaning failure mostly associated with a higher levels of APACHE II score [7,8], but disagree with other studies [9,10].

Regarding the ventilator parameters at the end of the first SBT, we observed that the nonsimple weaning group shows lower levels of the exhaled tidal volume and exhaled minute ventilation, but no significant differences were noted regarding other ventilator parameters. Sellares *et al.* [11] reported similar results. Exhaled tidal volumes above 5 ml/kg have been considered as good weaning predictors [12]. However, Monaco *et al.* [13] found opposite results.

Regarding static compliance measured at the end of the first SBT, we summarized low levels of static compliance in the nonsimple weaning group, and this agrees with one study, which found that there was a significantly decreased respiratory compliance and increased respiratory resistance in the weaning failed group [14], but this result is in contrast with Mabrouk *et al.* [15].

Table 3 Weaning indices

	Simple weaning (N=60)	Nonsimple weaning (N=42)	
RSBI (breath/min/l)	79.47±24.78	142.02±50.74	0.035*
IWI	68.69±39.51	26.45±17.05	0.000*

Data are expressed as mean±SD. IWI, integrative weaning index; RSBI, rapid shallow breathing index. *P* value less than 0.05 is considered statistically significant. *means significant.

Table 4 Outcome variables

	Simple weaning (N=60)	Nonsimple weaning (N=42)	<i>P</i> value
Total duration of mechanical ventilation (days)	3.66±1.31	4.44±2.55	0.042*
Length of ICU stay (days)	7.53±5.26	11.64±7.79	0.000*
Need for NIV			
Yes	19 (31.7)	24 (57.1)	0.010*
No	41 (68.3)	18 (42.9)	
Duration of NIV (days)	1.68±1.19	2.71±1.59	0.004*
Extubation outcome			
Success	52 (86.7)	26 (64.3)	0.003*
Failure	8 (13.3)	16 (35.7)	
Need for tracheostomy			
Yes	2 (3.3)	7 (16.7)	0.031*
No	58 (96.7)	35 (83.3)	
Mortality outcome			
Died	3 (5.0)	18 (42.9)	0.000*
Discharge	57 (95.0)	24 (57.1)	

Data are expressed as mean±SD and *n* (%). NIV, noninvasive mechanical ventilation. *P* value less than 0.05 is considered statistically significant. *means significant.

RSBI was the most commonly studied index to expect the weaning outcome. The value of RSBI in the present study was significantly higher in the nonsimple weaning group (89.9 ± 31.7 vs. 83.7 ± 21.6). These results are concordant with previous studies [15–17], which found that RSBI was significantly less than or equal to 100 in their patients who tolerated the SBT compared with those who failed SBT. However, this result is in contrast with two other studies [10,18]. We observed a significant difference in term of IWI between both groups of weaning, Sellares *et al.* [11] reported similar results.

Ghoneim *et al.* [19] found that there was a significantly shorter duration of mechanical ventilation in the patients who passed the SBT than those who failed ($P < 0.01$). These results agree with our finding.

We also summarize a significant difference between both groups regarding the length of ICU stay, and this agrees with Mahmoud and Mohamad [20] who found that the longer duration of ICU stay was one of the most important factors associated with unsuccessful weaning.

In the present work, we observe a significant difference between both groups regarding the need for noninvasive mechanical ventilation after weaning. Sellares *et al.* [11] documented similar results. ICU mortality in our study was significantly increased in our nonsimple weaning group compared with simple weaning group. In agreement, Boles *et al.* [2] in their study found that there was a difference in the mortality between the three weaning categories.

Limitations of the study

Our study is a single-center study with a small sample of selected patients and also has specific clinical characteristics of the study population (patients with COPD). So we need many future studies with a large numbers of patients to emphasizing our results.

Summary and conclusion

Weaning categorization according to the length and the difficulty of the weaning procedure in mechanically ventilated patients with COPD may be considered as an acceptable predictor of outcome.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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