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Original Article

# Predictors of Weaning Failure in Patients with Chronic Obstructive Pulmonary Disease

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**Objective:** To research the clinically ventilator weaning value of Rapid Shallow Breathing Index (RSBI) of patients with Chronic Obstructive Pulmonary Disease (COPD) in medical intensive care unit (MICU).

**Methods:** With reference to the MICU of Taiwan hospital, from Jan. 2008 to Dec. 2014 we used retrospective method to collect the subjects diagnosed of COPD (ICD 9) with ventilator due to acute respiratory failure. Grouped into successful ventilator group and failed ventilator group. The patient characteristics, including Gender, Age, BMI, APACHE II score, Hospital day, ICU day, ventilator using days, Rapid Shallow Breathing Index (RSBI), Maximum inspiratory pressure (MIP), Maximum expiratory pressure (MEP).

**Results:** In total, 169 patients were enrolled, 127 of which are men (75.1%) while 42 of which are women (24.9%). The mean age of the patients was  $74.66 \pm 11.97$  years. 115 people of them weaned the ventilator successfully whereas 54 people of which failed weaning. The failed weaning for a higher RSBI ( $97.08 \pm 65.24$  vs  $79.33 \pm 48.52$ ,  $p < 0.001$ ), a lower MIP, and MEP ( $-27.75 \pm 13.82$  vs  $-33.77 \pm 12.72$ ,  $p < 0.001$  and  $33.13 \pm 13.61$  vs  $39.15 \pm 12.73$ ,  $p < 0.001$ , respectively).

**Conclusions:** On the basis of our research, a high successful weaning rate involves RSBI  $< 79$  breaths/min/L, MIP  $< -33$  cmH<sub>2</sub>O, and MEP  $> 39.15$  cmH<sub>2</sub>O.

**Key words:** chronic obstructive pulmonary disease (COPD), rapid shallow breathing index(RSBI), maximum inspiratory pressure (MIP), maximum expiratory pressure (MEP)

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## Introduction

Chronic Obstructive Pulmonary Disease (COPD) is the fourth among the top

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ten leading causes of death, it is an essential public issue, as well as a main reason of global chronic disease breaking and death. The symptom of COPD exacerbation (AE) is progressive dyspnea or cough, even develop respiratory failure caused by respiratory acidosis and hypoxia. Noninvasive positive pressure ventilator is the treatment which is the COPD Guidelines first suggested. By using it we could decrease the span of hospitalization of COPD AE, furthermore, decrease the rate of intubation and death<sup>1</sup>. There are approximately 42 – 52.9% patients of COPD AE need to be intubated with invasive ventilator, presented by clinical research<sup>2-3</sup>. The main problem of COPD is the limitation of expiration flow, if we assess the patient incorrectly when caring intubated patient with COPD respiratory failure and not to wean the ventilator in time, we may put him in the danger of complications such as infection, causing a difficult weaning<sup>4</sup>. When the problem of respiratory failure is resolved, it is time to start the weaning plan. We must assess the patient that whether he is able to wean or not by using the weaning profile and remove the endotracheal tube as soon as possible. The weaning plan will be started once the cause of respiratory failure is resolved; research said that around 20 – 30% patients are difficult weaning, especially patients who is over 65 years old, having heart disease or COPD,<sup>4</sup> because they have a high risk of failed extubation, which may induce plenty of complications such as death, ventilator-associated pneumonia (VAP), prolonged hospitalization and ventilator using.<sup>5</sup> COPD AE patient with ventilator using has a high rate of death, which is around 37 – 64%, in ICU.<sup>6-7</sup> There is over 40% of ventilator using time to wean the ventilator in COPD cases, and 4% to 5% of the time is unable to weaning successfully for the first time, refers that patients have to continuously using the ventilator, even to become ventilator-dependent.

In addition, some research says it is diffi-

cult to wean ventilator for a COPD patient.<sup>8</sup> Weaning profile is applied at bed side to predict the possibility of weaning, including rapid shallow breathing index (RSBI), maximum inspiratory pressure (MIP), minute ventilation (MV); and if  $RSBI (= \text{respiratory rate}/\text{tidal volume}) > 105 \text{ breaths}/\text{min}/\text{L}$ , it tends to fail the weaning.<sup>9-10</sup> Many literatures aim to research the practicality of using RSBI for predicting ventilator weaning, so far, the value of RSBI is widely acceptable as less than 105 breaths/min/L. However, there's a research pointed that when the value is less than 50 breaths/min/L, the more successful a patient weans the ventilator.<sup>10</sup> And another one said that the value should be less than 78 breaths/min/L to have a higher weaning rate.<sup>11</sup> In fact, it is hard to wean the ventilator for COPD patients, yet no one has been researched RSBI value before. Therefore, we aim to realize the relationship between COPD and weaning index like RSBI so that we could raise the weaning rate at bed side.

## Methods

### Subjects

With reference to the medical intensive care unit (MICU) of Taiwan hospital, from Jan. 2008 to Dec. 2014 we used retrospective method to collect the subjects diagnosed of COPD (ICD 9) . All the patients are older than 18 years old, having acute respiratory failure and have been under invasive mechanical ventilation for at least 48 hours. They will be applied weaning profile by respiratory therapist after the physician considers that they are able to be weaned. The exclusion criteria are post operation, or using invasive or noninvasive ventilator at home. We collected 198 cases, excluded 29 of them, so the final number of our objects is 169. They are divided into two groups, one is successful weaning group and the other is the failed one.

A successful ventilator weaning defined

as the absence of ventilator within 72 hours, and vice versa. The information collected includes the gender, age, body mass index (BMI), acute physiology and chronic health evaluation II (APACHE II) score, total days of hospitalization, days in ICU hospitalization, ventilator using days, RSBI, maximal inspiratory pressure (MIP), and minimum expiratory pressure (MEP).

### Ethical approval

The study protocol was approved by the institution's Ethics Committee of E-Da Hospital (EDAH IRB No. EMRP-104-135).

### Statistical analysis

The characteristics of patients including age, BMI, APACHE II score, days of hospitalization, days in ICU, days of mechanical ventilation using are calculated by independent samples t test. RSBI, MIP, MEP are compared by Mann-Whitney U-test. *p* value less than 0.05 is considered significant. Analysis are performed by using SPSS 12.0 software.

## Results

### Comparison of patients with successful and failed weaning ventilator

There are 169 patients in our research, 127 of which are men (75.1%) while 42 of which are women (24.9%). The mean age is  $74.66 \pm 11.97$  years old. 115 people of them weaned

the ventilator successfully whereas 54 people failed. The gender, BMI, and APACHE II score of both groups exist no difference. At the same time, compare the span of hospitalization, days of ICU care, and ventilator using days, there are significant difference between the two groups (Table 1).

17 of 115 subjects in the successful weaning group use noninvasive ventilator after being extubated, and 12 subjects of which receive the tracheostomy surgery. Among 54 subjects who failed weaning, there are 12 subjects use noninvasive ventilator after being extubated, 5 subjects eventually turn to home care, and 3 subjects use invasive ventilator after their tracheostomy and being transferred to respiratory care ward (RCW).

### Weaning index

According to the analysis of compared weaning profile, among RSBI, MIP, and MEP do exist apparent difference, that is, successful group has a lower RSBI, higher MIP and MEP than the failed group (Table 2).

## Discussion

Our research reveals that RSBI in both successful and failed weaning COPD groups have statistically difference. Yet the index are both less than 105 breaths/min/L in two groups. Mean value of RSBI is 79.33 breaths/min/L in successful weaning group. Thus, our

Table 1. Comparison of patients with successful and failed weaning ventilator

Variable	Total patient (n = 169)	Success (n = 115)	Failure (n = 54)	<i>p</i> value
BMI, kg/m <sup>2</sup>	21.88 ± 5.25	21.75 ± 5.26	22.16 ± 5.27	0.572
Age, y	74.66 ± 11.97	74.25 ± 11.72	75.51 ± 12.55	0.484
APACHE score	24.38 ± 7.79	23.96 ± 7.66	25.25 ± 8.05	0.290
Ventilator day	13.75 ± 15.58	9.1 ± 10.1	23.5 ± 20.04	< 0.001
Hospitality day	26.79 ± 19.59	22.05 ± 15.98	36.87 ± 22.69	< 0.001
ICU day	9.07 ± 5.71	7.53 ± 4.65	12.31 ± 6.4	< 0.001

BMI: body mass index; APACHE score: acute physiology and chronic health evaluation score

Table 2. Weaning index

Variable	Total patient (n = 169)	Success (n = 115)	Failure (n = 54)	p value
RSBI(breaths/min/L)	83.39 ± 55.14	79.33 ± 48.52	97.08 ± 65.24	0.01
MIP(cmH <sub>2</sub> O)	-32.18 ± 12.52	-33.77 ± 12.72	-27.75 ± 13.82	< 0.001
MEP(cmH <sub>2</sub> O)	37.29 ± 13.06	39.15 ± 12.73	33.13 ± 13.61	< 0.001

RSBI: rapid shallow breathing index; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure

research suggests the weaning rate would be higher in COPD patients whose RSBI is less than 80 breaths/min/L.

RSBI is initially propounded by Yang et al. at 1991<sup>10</sup>, it reflects the fact that rapid and shallow respiratory pattern occurs when one is respiratory failure and is intubated or re-intubated; therefore, they regard RSBI as a predict standard of weaning which can be calculated easily. The accuracy of RSBI accounts for 60% of predicting weaning result. In recent years many research have propounded different standards of RSBI. Danaga et al. found that the classical cut-off value of RSBI (105 breaths/min/L) predicted only 20% of the cases that were ready for extubation while a cut-off value of 76.5 breaths/min/L provided substantial improvement in sensitivity (66%), with an acceptable loss of specificity (74%).<sup>12</sup>

Among patients who are long-term ventilator using, there are 56% of which have RSBI less than 80 breaths/min/L.<sup>13</sup> COPD patients whose RSBI < 105 breaths/min/L have 33.96% successful weaning rate, yet patients whose RSBI < 85 breath/min/L have the rate as 60%.

Maximal inspiratory pressure (MIP or Pimax), and the maximal expiratory pressure (MEP or Pemax) are index of assessing respiratory muscle power. We use MIP to realize the strength of diaphragm and other inspiratory muscle. In our research, however, the Pimax in successful group is less than -33 cmH<sub>2</sub>O so it still can be valuable. The initial research said that MIP being less than -30 cmH<sub>2</sub>O results in a higher weaning rate.<sup>16</sup> Pimax was less accurate in predicting the weaning outcome. Once the diaphragm is predominantly an endur-

ance muscle, satisfactory inspiratory muscular strength alone may not be enough for a successful weaning.<sup>16</sup>

MEP is what we use to assess the cough power. It tends to fail the extubation when patient have much amount of secretion and hard to throw them out by himself. Furthermore, we also found that if MEP is 39 cmH<sub>2</sub>O or more it has the best predictive performance of successful weaning. Karl L. Yang et. al suggested that it is considered to extubate while the MEP is more than 28 cmH<sub>2</sub>O.<sup>11</sup>

In conclusion, our research On the basis of our research, COPD patient who use ventilator can be successful weaning when one's RSBI < 79 breaths/min/L, MIP < -33 cmH<sub>2</sub>O, MEP > 39 cmH<sub>2</sub>O. Nevertheless, at bedside the weaning profile is merely taken as a reference, other data should be considered as well to assess the patient overall.

### Research limitation

The objectives we selected are all in one specific hospital, so we cannot suppose the result must be the same in other hospital. Also, this retrospective research has limited number of cases since some having incomplete records are excluded. We hope that we could expand the case number and analyze the level of COPD for enhancing the strength of evidence.

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