The Egyptian Society of Chest Diseases and Tuberculosis

Egyptian Journal of Chest Diseases and Tuberculosis

www.elsevier.com/locate/ejcdt
www.sciencedirect.com

CrossMark

ORIGINAL ARTICLE

Proportional assist ventilation versus pressure support ventilation in the weaning of patients with acute exacerbation of chronic obstructive pulmonary disease

Anwar Ahmed Elganady [a,*], Bassem Nashaat Beshey [b],
Amr Abdelaziz Hassan Abdelaziz [a,b]

[a] *Department of Pulmonology, Faculty of Medicine, Alexandria University, Egypt*
[b] *Department of Critical Care Medicine, Faculty of Medicine, Alexandria University, Egypt*

Abstract *Background:* Patients with COPD are frequently hospitalized for acute exacerbations (AECOPD), which may cause respiratory failure and death. Proportional assist ventilation (PAV) is a relatively new mode of ventilator-based, inspiratory support designed to assist sponta-neous breathing in patients with intact neural drive. It is a form of synchronized partial ventilatory assistance with peculiar characteristic that ventilator generates pressure in proportion to patient's instantaneous effort. Pressure support ventilation (PSV) is an attractive weaning mode, however at higher pressure support levels, many patients displayed expiratory muscle activation indicating that the patient is "fighting the ventilator".

Objective: To compare PAV and PSV in the weaning of AECOPD patients.

Patients and methods: The study was conducted on 60 patients admitted to the Department of Critical Care Medicine, at the Alexandria Main University Hospital with the diagnosis of AECOPD. Exclusion criteria included those with severe cardiac or neurological disease, and those managed by non-invasive ventilation. All patients were subjected on admission to complete history taking, complete physical examination and laboratory investigations and were treated according to guidelines of treatment of AECOPD. At the time of weaning patients were randomly categorized into two equal groups; Group A: patients weaned using PAV and Group B: patients weaned using

* Corresponding author.
E-mail address: a.ganady@hotmail.com (A.A. Elganady).

PSV and the two groups were assessed for weaning success, patient–ventilator dys-synchrony, MV days, ICU, and hospital stay.

Results: The weaning success rate was 90% in group A, and 66.7% in group B. PAV was associated with less patient–ventilator dys-synchrony and was associated with 1.5 day reduction in the mean days of mechanical ventilation, 2 day reduction in the mean days of ICU stay, and 1.8 day reduction in the mean days of hospital stay in comparison to PSV group.

Conclusion: PAV was associated with less patient–ventilator dys-synchrony and associated with reduction of days of mechanical ventilation, ICU, and hospital stay.

Introduction

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines an acute exacerbation of chronic obstructive pulmonary disease (AECOPD) as an acute increase in symptoms beyond normal day-to-day variation [1,2]. This generally includes one or more of three cardinal symptoms: cough increases in frequency and severity, sputum production increases in volume and/or changes character, and/or dyspnea increases [3,4].

In stage IV (Very Severe COPD), the most important sign of AECOPD is a change in the mental status of the patient and [5,6] in the presence of severe underlying airflow obstruction, an exacerbation can cause respiratory failure [1]. The main objective of mechanical ventilation here is to maintain both adequate oxygenation and ventilation, reduces the work of breathing (WOB) and improves the comfort of the patient until the condition that forced the need for this technique has been reversed or alleviated. In an effort to meet these objectives, a variety of ventilatory modes have been developed that can potentially reduce complications, shorten the duration of mechanical ventilation and thus improve clinical outcomes [7].

So long has pressure support ventilation (PSV) been an attractive weaning method because the patient has control over the respiratory frequency and the depth, length, and flow of each breath. During PSV, each breath is augmented by inspiratory pressure which is set by the clinician. The patient triggers each inspiration, which continues until the inspiratory flow decreases to a system-specific minimal level. Exhalation follows. The tidal volume is determined by the pressure support level, effort, and mechanics [8].

During weaning with PSV, the clinician gradually reduces the PS level as long as an appropriate spontaneous respiratory rate and VT are maintained and distress is not evident. When PS is reduced to about 5 cm H_2O, the pressure level is not high enough to contribute significantly to ventilatory support. However, this level of PS usually is sufficient to overcome the work imposed by the ventilator system (i.e., the resistance of the ET, trigger sensitivity, demand-flow capabilities, and the type of humidifier used) [9,10].

Proportional assist ventilation (PAV) is a relatively new mode of ventilator-based, inspiratory support designed to assist spontaneous breathing in patients with intact neural drive. It was invented by M. Younes in the North America in 1992. It has been under experimental and clinical investigation since then. It is a form of synchronized partial ventilatory assistance with peculiar characteristic that ventilator generates pressure in proportion to patient's instantaneous effort. The more the patient pulls, the more pressure the machine generates. Thus, the ventilator amplifies the patient's inspiratory effort without any pre-selected target volume or pressure. It allows the patients to attain whatever ventilator and breathing pattern seem to fit the ventilatory control system and different clinical conditions. It is regarded as an "additional respiratory muscle" which takes over certain proportion of ventilatory workload, under the complete control of the patient's ventilatory drive. That is to say, unlike all other forms of assisted ventilation (e.g. volume controlled, pressure controlled), there is no target flow, volume, or airway pressure and the responsibility of guiding the ventilatory pattern is shifted completely from clinicians to patients, with the purpose of improving the patient–ventilator interaction [11].

Studies performed with PAV+ have revealed that, compared with conventional modes, its application is simple and time saving, while it may more effectively reduce patient–ventilator dys-synchrony, facilitate weaning and improve sleep quality in critically ill patients but with limited studies in weaning mechanically ventilated COPD patients [12].

So in our study we aimed to compare PAV and PSV in weaning mechanically ventilated patients with AECOPD for a better knowledge of the best weaning modality that could help improving the general management of such COPD patients and, ultimately, lead to a greater rate of discontinuation of mechanical ventilation.

Patients and methods

This study was conducted on 60 adult patients; according to sample size calculation, who were admitted to the Critical Care Medicine Departments in Alexandria Main University Hospital with the diagnosis of acute exacerbation of COPD and indicated for invasive mechanical ventilation. Patients were excluded for reasons as follows: pregnancy, hemodynamic instability, severe neurological disease hindering the respiratory drive, and patients on mechanical ventilation for less than 24 h (including self extubation or death).

Informed consent was taken from first degree relative of every patient included in the study. The research was approved from the Ethics Committee of Alexandria faculty of medicine. All selected patients fulfilling the inclusion criteria were subjected to the following on admission: demographic data including: age, sex and height, history, physical examination, chest examination, plain bedside antero-posterior chest X-ray, arterial blood gas (ABG) analysis, and oxygenation index (P_aO_2/F_iO_2). Routine ICU investigations were done on admis-

sion and when needed so that any abnormal values were corrected. All patients were managed according to standard protocols of the management of acute exacerbation of COPD patients [1].

All patients were sedated and mechanically ventilated using a microprocessor-controlled mechanical ventilator (Galileo GOLD; Hamilton Medical AG, Bonaduz, Switzerland) using an assisted volume-controlled ventilation mode with suitable settings according to patients' needs. Weaning was decided when following weaning criteria were met: [8,13,14]

1. Reversal of the cause of mechanical ventilation.
2. Hemodynamic stability: that is, no clinically important hypotension and no requirement for vasopressors or a requirement only for low-dose vasopressor therapy (e.g., dopamine or dobutamine < 5 μ/kg/min).
3. Patient capable of initiating an inspiratory effort.
4. Adequate oxygenation: arterial partial pressure of oxygen (P_aO2) $\geqslant 60$ mmHg with fractional inspired oxygen (F_iO_2) < 0.4, ratio of arterial partial pressure of oxygen to fractional inspired oxygen (P_aO_2/F_iO_2) $\geqslant 150–200$ mmHg, required positive end expiratory pressure (PEEP) $< 5–8$ cm H_2O, F_iO_2 $< 0.4–0.5$.
5. Heart rate < 120, respiratory rate < 35, pH > 7.35, tidal volume (VT) > 5 ml/kg, rapid shallow breathing index (RSBI) (respiratory rate/tidal volume) < 105, minute volume < 10 L/min.
6. No electrolyte disturbances, no sedation or narcotics.
7. Good nutritional status and no clinically evident myopathy or neuropathy.
8. Corrected reversible causes of weaning failure such as sepsis or heart failure.

According to the weaning method used, patients were randomly categorized using the closed envelope method into two groups:

- **Group A:** Including (30) patients who were weaned using proportional assist ventilation mode with the following steps:
  1. Entering the correct ideal body weight (IBW), endotracheal tube (ETT) size and maximum airway pressure (MAP) limit (40 cm H_2O).
  2. Initial settings of PEEP and F_iO_2 were done by the usual criteria.
  3. Setting the percentage % of assist starting at 70% assist.
  4. Monitoring the patient for respiratory distress which included two or more of the following (heart rate > 120% of the usual rate for > 5 min and/or systolic blood pressure > 180 or < 90 mmHg and/or systolic BP changes > 20% of the previous value for > 5 min, RR > 40 bpm for > 5 min, marked use of respiratory muscles, diaphoresis, abdominal paradox, patient complaints of dyspnea).
  5. If no respiratory distress, the assist was reduced by 10–20% every 2 h with monitoring of respiratory distress.
  6. If no respiratory distress at 10–20% assists, extubation was considered.

- **Group B:** Including (30) patients who were weaned using pressure support ventilation mode with the following steps:

1. Starting spontaneous breathing trial with low level of continuous positive airway pressure (e.g., 5 cm H_2O) and low level of pressure support (e.g., 5–8 cm H_2O).
2. The initial few minutes of the trial should be closely monitored for respiratory distress and tolerance before a decision is made to continue.
3. If no signs of respiratory distress or intolerance are evident, the patient should continue the trial to 30 min.
4. If no signs of distress, the trial will be continued for 120 min.
5. If no signs of distress at 120 min, extubation will be considered.
6. If the patient is unable to tolerate or distressed, the patient is fully rested until the next day when the process begins again.

Vital signs and rapid shallow breathing index (RSBI) (respiratory rate/tidal volume) were monitored in both groups during the weaning process for assessment of success. ABG was done 1 h after start of weaning and before extubation. Work of breathing (in J/L) was calculated for both groups before extubation. Patients in the two groups were assessed for the following outcomes:

1. Weaning success as defined as absence of tachypnea > 35, tachycardia > 120, P_aO_2/F_iO_2 > 150, hemodynamic stability (no clinically important hypotension and no requirement for vasopressors or a requirement only for a low dose vasopressor therapy (e.g., dopamine or dobutamine < 5 μ/kg/min), pH > 7.32, and patient is not re-intubated and ventilated within 72 h of extubation [15].
2. Patient–ventilator dys-synchrony: including triggering, flow and cyclic dys-synchrony. It was detected visually on 30-min recordings of flow and airway pressure curves during the weaning period and compared in the two groups using asynchrony index (defined as the percentage of asynchronous to total breaths during recording period) [16].
3. Days of mechanical ventilation.
4. Length of ICU stay.
5. Length of hospital stay.
6. 28-day Mortality rate.

Statistical analysis of the data

Data were analyzed using IBM SPSS software package version 20.0. Qualitative data were described using number and percent. Quantitative data were described using mean, standard deviation median, minimum and maximum. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's Exact test or Monte Carlo correction.

The distributions of quantitative variables were tested for normality using Kolmogorov–Smirnov test, Shapiro–Wilk test and D'Agstino test, also Histogram and QQ plot were used for vision test. If it revealed normal data distribution, parametric tests were applied. If the data were abnormally distributed, non-parametric tests were used. For normally distributed data, comparison between two independent populations was done using independent t-test. For abnormally distributed data,

Table 1 Demographic and clinical criteria on admission in both studied groups.

Variable: Mean ± SD	PAV ($n = 30$)	PSV ($n = 30$)	Test of significance
Age	58.13 ± 7.74	61.20 ± 6.01	$^t p = 0.092$
Male sex (number)	25	24	$^{\chi^2} p = 0.739$
Height	179.63 ± 4.60	177.23 ± 6.22	$^t p = 0.095$
Precipitating factor (N)			
Chest infection	30	27	$p = 0.237$
Irritants	0	3	
Vital signs			
Heart rate	93.20 ± 14.54	98.83 ± 7.62	$p = 0.067$
Respiratory rate	28.17 ± 2.49	26.10 ± 2.51	$p = 0.104$
Temperature	37.74 ± 0.42	37.92 ± 0.39	$p = 0.092$
Mean arterial blood pressure	98.67 ± 9.99	103.40 ± 9.0	$p = 0.059$
Arterial blood gases			
PH	7.21 ± 0.05	7.20 ± 0.11	$p = 0.575$
PCO_2	56.0 ± 15.18	52.13 ± 11.77	$p = 0.275$
PO_2	100.58 ± 16.31	101.80 ± 26.22	$p = 0.830$
HCO_3	39.70 ± 3.24	38.40 ± 3.45	$p = 0.138$
SaO_2	81.43 ± 3.83	81.30 ± 3.69	$p = 0.891$
Hypoxic index	124.97 ± 23.63	120.50 ± 23.17	$p = 0.463$

PAV: proportional assist ventilation, group (A).
PSV: pressure support ventilation, group (B).
p: p value for comparison between the two studied groups.
χ^2: Chi square test.
t: Student's t-test.

Table 2 Eligibility weaning criteria in both studied groups.

Variable: mean ± SD	PAV ($n = 30$)	PSV ($n = 30$)	Test of significance
Arterial blood gases			
PH	7.42 ± 0.03	7.44 ± 0.04	$p = 0.080$
PCO_2	58.30 ± 8.29	62.30 ± 9.84	$p = 0.094$
PO_2	75.37 ± 16.61	81.27 ± 13.80	$p = 0.140$
HCO_3	36.46 ± 5.61	38.47 ± 3.64	$p = 0.107$
SaO_2	93.37 ± 1.65	93.93 ± 1.44	$p = 0.161$
Ventilatory data			
TV	530.67 ± 51.79	539.0 ± 45.44	$p = 0.510$
MV	9.62 ± 0.92	9.27 ± 0.86	$p = 0.132$
F_iO_2	0.34 ± 0.05	0.34 ± 0.05	$p = 0.605$
RSBI	47.67 ± 18.81	37.70 ± 17.23	$^{MW} p = 0.051$
Hypoxic index	220.70 ± 42.81	232.43 ± 33.67	$^t p = 0.243$
Investigations			
Na^+	138.60 ± 3.45	138.20 ± 5.52	$^t p = 0.738$
K^+	4.59 ± 0.49	4.59 ± 0.49	$^{MW} p = 1.000$
Serum albumin	3.71 ± 0.39	3.71 ± 0.34	$^t p = 1.000$
Vital signs			
Heart rate	90.20 ± 11.58	88.67 ± 9.32	$p = 0.574$
Respiratory rate	18.0 ± 1.53	17.63 ± 1.45	$p = 0.345$
Temperature	37.11 ± 0.26	37.18 ± 0.37	$p = 0.129$
Mean arterial blood pressure	94.33 ± 3.92	91.87 ± 6.82	$p = 0.093$

PAV: proportional assist ventilation, group (A).
PSV: pressure support ventilation, group (B).
p: p value for comparison between the two studied groups.
MW: Mann–Whitney test.
t: Student's t-test.

comparison between two independent populations was done using Mann–Whitney test. Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level.

Results

Both groups were homogenous in their age and height distribution. Majority were males. Chest infection was the main precipitating factor of AECOPD, except for three patients (10%) in group B, where the precipitating factor was irritants. Vital signs, ABG and hypoxic index on admission did not show significant differences between the two studied groups; (Table 1).

As regards pre-weaning data; namely ABG, ventilatory data, RSBI, hypoxic index, investigations, and vital signs, they showed improvement toward weaning without significant differences between both studied groups; (Table 2).

During the weaning period there was no significant difference between both groups as regards ABG, RSBI (1 h after start of weaning), hypoxic index, work of breathing, or mean vital signs. Ineffective triggering was the most common cause of dys-synchrony followed by cyclic dys-synchrony; both were significantly noticed in PSV group (B). Flow dys-synchrony, although occurred, was not significant when compared in both groups. An asynchrony index of ($\geqslant 5$ & < 10) and ($\geqslant 10$) was less significantly encountered in PAV group (A), while an asynchrony index of (< 5) was more significantly encountered in the same group; Table 3.

Outcome measures (Table 4)

Weaning success parameters (respiratory rate, heart rate, pH, hypoxic index, no re-intubation) were significantly better in PAV group (A). Weaning success rate was 90% in group A versus 66.7% in group B. The difference was statistically significant.

Total days of mechanical ventilation in the successfully weaned patients were significantly less in PAV group (A) ($p < 0.001$). ICU and hospital stay were significantly less in PAV group as well ($p < 0.001$). No significant difference was found between both groups as regards 28-day mortality ($p = 1.000$).

Discussion

The gradual withdrawal of PSV is a poor predictor of a patient's ability to sustain ventilation after extubation. This was illustrated by Nathan et al. [17] who reduced the level of

Table 3 Weaning data in both studied groups.

Variable: mean ± SD.	PAV ($n = 30$)	PSV ($n = 30$)	Test of significance
Arterial blood gases			
PH	7.41 ± 0.02	7.42 ± 0.04	$p = 0.273$
PCO$_2$	55.53 ± 7.82	59.67 ± 10.21	$p = 0.084$
PO$_2$	79.60 ± 12.53	86.67 ± 12.83	$p = 0.353$
HCO$_3$	35.60 ± 5.35	37.18 ± 3.74	$p = 0.192$
SaO$_2$	93.93 ± 1.82	93.93 ± 1.82	$p = 1.000$
Ventilatory data			
RSBI	44.53 ± 14.53	37.57 ± 13.25	$^{MW}p = 0.057$
Hypoxic index	232.20 ± 46.27	235.63 ± 46.30	$^{t}p = 0.775$
Work of breathing (J/L)	0.47 ± 0.07	0.48 ± 0.08	$p = 0.559$
Vital signs			
Heart rate	88.67 ± 9.32	90.20 ± 11.58	$p = 0.574$
Respiratory rate	16.63 ± 1.63	16.03 ± 1.61	$p = 0.156$
Temperature	37.11 ± 0.37	37.26 ± 0.26	$p = 0.129$
Mean arterial blood pressure	91.87 ± 6.82	94.33 ± 3.92	$p = 0.093$
Patient–ventilator dys-synchrony			
Flow dys-synchrony	1 (3.3%)	3 (10%)	$^{FE}p = 0.612$
Cyclic dys-synchrony	1 (3.3%)	9 (30%)	$^{\chi^2}p = 0.006^*$
Triggering dys-synchrony	4 (13.3%)	11 (36.7%)	$^{\chi^2}p = 0.037^*$
Asynchrony index			
< 5	27 (90%)	17 (56.7%)	$^{MC}p = 0.003^*$
$\geqslant 5$ & < 10	3 (10%)	5 (16.7%)	
$\geqslant 10$	0 (0.0%)	8 (26.7%)	

PAV: proportional assist ventilation, group (A).
PSV: pressure support ventilation, group (B).
p: p value for comparsion between the two studied groups.
MW: Mann–Whitney test.
χ^2: Chi square test.
MC: Monte Carlo test.
FE: Fisher Exact test.
T: Student's t-test.
*Statistically significant at $p \leqslant 0.05$.

PSV step-wise and compared the corresponding tidal volumes among patients who weaned successfully versus patients who failed weaning. The tidal volumes in the two groups overlapped significantly at each level of PSV.

Evidence justifying the role of PAV in mechanically ventilated COPD patients is yet to be fully demonstrated although PAV has been tested in many situations such as weaning of chronically ventilated patients, acute respiratory failure, and acute cardiogenic pulmonary edema in addition, as a non invasive tool for assessing sleep quality in mechanically ventilated patients and exercise capacity in severe COPD patients [18–20].

As regards the baseline parameters including the demographic data, vital signs on admission and etiological diagnosis of respiratory failure, which were not significant in our study, were not also significant in the study of Fernandez-Vivas et al. [20] about non-invasive pressure support versus proportional assist ventilation in acute respiratory failure.

Pre-weaning ventilatory parameters in the present study such as tidal volume, minute ventilation, F_iO_2, and RSBI were almost similar in both groups and also the pre-weaning ABG and HI showed no significant difference between the two groups which was in agreement with a recent study of Aguirre-Bermeo et al. [21] who compared tolerance, duration of mechanical ventilation (MV) and clinical outcomes during weaning from MV in patients subjected to either pressure support ventilation (PSV) or proportional assist ventilation (PAV) in 40 mechanically ventilated critically ill patients.

The finding that there were no significant differences between the two groups regarding the hemodynamic parameters (heart rate and the mean arterial blood pressure), ABG and hypoxemia either at the baseline, during, or at the end of the trial, is matching with results obtained by Costa et al. [18], who conducted a physiological comparison between PAV+ and PSV in difficult to wean patients.

In the current study there were three patients (10%) with weaning failure in PAV group, versus ten patients (33.3%) in PSV group. This was attributed to the higher rate of patient–ventilator dys-synchrony encountered in PSV group. There were ten patients (33.3%) re-intubated in PSV group while only three patients (10%) in PAV group which was mainly due to respiratory acidosis and to a lesser extent due to hypoxemia. The patient–ventilator dys-synchrony was higher in PSV than PAV group which was mainly cyclic and triggering dys-synchrony with high asynchrony index AI $\geqslant 10$ was in PSV group. This was matching with Xirouchaki et al. [22], who observed that ineffective triggering and double triggering are the most common types of dys-synchrony in their study with greater incidence in PSV than PAV group. Thille et al. [16] reported that 24% of patients had asynchrony index $\geqslant 10$ in both the ACV and PSV groups and this was associated with poor outcome.

As regards patient–ventilator dys-synchrony Xirouchaki et al. [22] concluded that the proportion of patients exhibiting major patient–ventilator dys-synchrony at least during one occasion and after adjusting the initial ventilator settings, was

Table 4 Outcome measures in both studied groups.

Variable (number)	PAV (n = 30)	PSV (n = 30)	Test of significance
Weaning success parameters			
Respiratory rate <35	27 (90%)	20 (66.7%)	$\chi^2 p = 0.028^*$
Heart rate <120	27 (90%)	20 (66.7%)	$\chi^2 p = 0.028^*$
$P_H > 7.32$	27 (90%)	20 (66.7%)	$\chi^2 p = 0.028^*$
Hypoxic index >150	27 (90%)	20 (66.7%)	$\chi^2 p = 0.028^*$
No re-intubation	27 (90%)	20 (66.7%)	$\chi^2 p = 0.028^*$
Weaning success			
Success	27 (90%)	20 (66.7%)	$p = 0.028^*$
Failure	3 (10%)	10 (33.3%)	
MV days: mean ± SD			
Success group	2.43 ± 0.91	3.85 ± 1.23	$p < 0.001^*$
Failure group	6.33 ± 0.58	8.90 ± 0.88	$p = 0.041^*$
ICU stay: mean ± SD			
Success group	3.70 ± 0.94	5.45 ± 1.43	$p < 0.001^*$
Failure group	8.33 ± 0.58	10.0 ± 1.05	$p = 0.033^*$
Hospital stay: mean ± SD			
Success group	4.81 ± 1.24	6.65 ± 1.57	$p < 0.001^*$
Failure group	9.67 ± 0.58	11.50 ± 1.60	$p = 0.026^*$
28 day mortality (number)			
Survived	29 (96.7%)	28 (93.3%)	$p = 1.000$
Died	1 (3.3%)	2 (6.7%)	

PAV: proportional assist ventilation, group (A).
PSV: pressure support ventilation, group (B).
p: p value for comparsion between the two studied groups.
χ^2: Chi square test.
*Statistically significant at $p \leqslant 0.05$.

significantly lower in PAV+ than in PS, which was also in agreement with our study, so they concluded that PAV+ may be used as a useful mode of support in critically ill patients. Compared to PSV, PAV+ increases the probability of remaining on spontaneous breathing, while it considerably reduces the incidence of patient–ventilator asynchronies.

In a recent study Hosking et al. [19], assessed the incidence and types of patient–ventilator asynchrony in mechanically ventilated patients on Assist Control (A/C), PSV and PAV and evaluated whether PAV reduces patient–ventilator asynchrony when compared to PS during protocol-based weaning. Thirty-five patients mechanically ventilated > 36 h meeting specific eligibility criteria to start weaning were enrolled in their study once they were able to trigger the ventilator and asynchrony was detected visually by recordings of the flow and airway pressure tracings. The high asynchrony index ⩾ 10 was in 27% of cases in the high PSV group and in 6% in the low PSV group with no cases showing high AI in the PAV group at its different levels of assist and also the low AI was in favor of the PAV group and so their conclusion is that PAV reduces asynchrony at all levels of support.

The finding that days of mechanical ventilation in the successfully weaned patients were significantly less in PAV group (A) with less ICU and hospital stay was in agreement with Xirouchaki et al. [22] who investigated the efficacy of PAV+ and PSV in a randomized controlled study in a group of 208 critically ill patients, recovering from controlled MV. The patients were randomized to receive PAV+ or PSV for 48 h, unless they met failure criteria or were able to breathe without ventilator assistance. The main result of their study was that the failure rate (patient switched back to controlled mode) during the 48 h of trial was significantly lower in the PAV+ group compared to the PSV group.

No significant difference was found between both groups as regards 28-day mortality. In the PAV group one case died from pulmonary embolism and two cases died in the PSV group due to cardiac arrhythmia which was not related to their COPD condition.

Conclusion

PAV was associated with less patient–ventilator dys-synchrony when compared to PSV. So PAV was associated with reduction of mechanical ventilation days, ICU stay, and hospital stay when used for weaning patients with AECOPD.

Conflict of interest

None declared.

References

[1] J. Vestbo, S.S. Hurd, A.G. Agusti, P.W. Jones, C. Vogelmeier, A. Anzueto, et al, Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary, Am. J. Respir. Crit. Care Med. 187 (4) (2013) 347–365.

[2] G.L. Snider, Nosology for our day: its application to chronic obstructive pulmonary disease, Am. J. Respir. Crit. Care Med. 167 (5) (2003) 678–683.

[3] A.D. Lopez, K. Shibuya, C. Rao, C.D. Mathers, A.L. Hansell, L.S. Held, et al, Chronic obstructive pulmonary disease: current burden and future projections, Eur. Respir. J. 27 (2) (2006) 397–412.

[4] C.D. Mathers, D. Loncar, Projections of global mortality and burden of disease from 2002 to 2030, PLoS Med. 3 (11) (2006) e442.

[5] R. Rodriguez-Roisin, Toward a consensus definition for COPD exacerbations, Chest 117 (5 Suppl. 2) (2000) 398S–401S.

[6] S. Burge, J.A. Wedzicha, COPD exacerbations: definitions and classifications, Eur. Respir. J. Suppl. 41 (2003) 46s–53s.

[7] G. Conti, M. Antonelli, P. Navalesi, M. Rocco, M. Bufi, G. Spadetta, et al, Noninvasive vs. conventional mechanical ventilation in patients with chronic obstructive pulmonary disease after failure of medical treatment in the ward: a randomized trial, Intensive Care Med. 28 (12) (2002) 1701–1707.

[8] N.R. MacIntyre, D.J. Cook, E.W. Ely Jr., S.K. Epstein, J.B. Fink, J.E. Heffner, et al, Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine, Chest 120 (6 Suppl.) (2001) 375S–395S.

[9] A. Esteban, I. Alia, J. Ibanez, S. Benito, M.J. Tobin, Modes of mechanical ventilation and weaning. A national survey of Spanish hospitals. The Spanish Lung Failure Collaborative Group, Chest 106 (4) (1994) 1188–1193.

[10] A. Esteban, I. Alia, F. Gordo, R. Fernandez, J.F. Solsona, I. Vallverdu, et al, Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. The Spanish Lung Failure Collaborative Group, Am. J. Resp. Crit. Care Med. 156 (2 Pt 1) (1997) 459–465.

[11] M. Younes, Proportional assist ventilation, a new approach to ventilatory support. Theory, Am. Rev. Respir. Dis. 145 (1) (1992) 114–120.

[12] E. Kondili, G. Prinianakis, C. Alexopoulou, E. Vakouti, M. Klimathianaki, D. Georgopoulos, Respiratory load compensation during mechanical ventilation–proportional assist ventilation with load-adjustable gain factors versus pressure support, Intensive Care Med. 32 (5) (2006) 692–699.

[13] B.P. Krieger, P.F. Ershowsky, D.A. Becker, H.B. Gazeroglu, Evaluation of conventional criteria for predicting successful weaning from mechanical ventilatory support in elderly patients, Crit. Care Med. 17 (9) (1989) 858–861.

[14] M.J. Tobin, W. Perez, S.M. Guenther, B.J. Semmes, M.J. Mador, S.J. Allen, et al, The pattern of breathing during successful and unsuccessful trials of weaning from mechanical ventilation, Am. Rev. Respir. Dis. 134 (6) (1986) 18–111.

[15] K.L. Yang, M.J. Tobin, A prospective study of indexes predicting the outcome of trials of weaning from mechanical ventilation, N. Engl. J. Med. 324 (21) (1991) 1445–1450.

[16] A.W. Thille, P. Rodriguez, B. Cabello, F. Lellouche, L. Brochard, Patient-ventilator asynchrony during assisted mechanical ventilation, Intensive Care Med. 32 (10) (2006) 1515–1522.

[17] S.D. Nathan, A.M. Ishaaya, S.K. Koerner, M.J. Belman, Prediction of minimal pressure support during weaning from mechanical ventilation, Chest 103 (4) (1993) 1215–1219.

[18] R. Costa, G. Spinazzola, F. Cipriani, G. Ferrone, O. Festa, A. Arcangeli, et al, A physiologic comparison of proportional assist ventilation with load-adjustable gain factors (PAV+) versus pressure support ventilation (PSV), Intensive Care Med. 37 (9) (2011) 1494–1500.

[19] B. Hosking, M. Nikoo, K.J. Bosma, The incidence of patient-ventilator asynchrony during weaning from mechanical ventilation: a comparison of proportional assist ventilation

(Pav) to pressure support (Ps) [abstract], Am. J. Respir. Crit. Care Med. 183 (2011) A3197.

[20] M. Fernandez-Vivas, J. Caturla-Such, J. Gonzalez de la Rosa, J. Acosta-Escribano, B. Alvarez-Sanchez, J. Canovas-Robles, Noninvasive pressure support versus proportional assist ventilation in acute respiratory failure, Intensive Care Med. 29 (2003) 1126–1133.

[21] H. Aguirre-Bermeo, M. Bottiroli, S. Italiano, F. Roche-Campo, J.A. Santos, M. Alonso, et al, Pressure support ventilation and proportional assist ventilation during weaning from mechanical ventilation, Med. Intensiva (2013), http://dx.doi.org/10.1016/j.medin.2013.08.003 (pii: S0210-5691(13)00184-8, Epub ahead of print).

[22] N. Xirouchaki, E. Kondili, K. Vaporidi, G. Xirouchakis, M. Klimathianaki, G. Gavriilidis, et al, Proportional assist ventilation with load-adjustable gain factors in critically ill patients: comparison with pressure support, Intensive Care Med. 3-2026 (11) (2008) 4–34.