The effects of biphasic positive airway pressure in patients with chronic obstructive pulmonary disease: A comparative study

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Abstract

Background: The ventilatory mode known as biphasic positive airway pressure (BIPAP) was developed by BAUM et al. and first used in clinical settings in the late 1980s. BIPAP is built on the basis of pressure-controlled ventilation and spontaneous breathing. BIPAP's impacts on people with chronic obstructive pulmonary illness have not been well investigated.

Objectives: The study's objective was to identify the effects of biphasic positive airway pressure in COPD patients in comparison to SIMV VC (synchronized intermittent mandatory ventilation volume control).

Patients and Methods: 60 patients diagnosed as acute exacerbation of COPD based on the Gold 2018 and required invasive mechanical ventilation, were assigned to two procedure groups that used two distinct ventilatory techniques: BIPAP group (group A): Thirty patients used BIPAP for ventilation were included in this group.SIMV VC group (group B): Thirty patients used SIMV VC for ventilation were a part of this group.

Results: There was no differences in baseline clinical data, demographic, hemodynamics and arterial blood gases between the two groups except that higher diastolic blood pressure and PaO2 in SIMV VC versus BIPAP. Follow up data after 24 hours showed that SIMV VC group was associated with statistically significant improvement in hemodynamics (P-value<0.001), arterial blood gases (P-value<0.05), ventilator parameters (P-value<0.001) and lung mechanics (P-value<0.05) compared to BIPAP group.

Conclusions: BIPAP is not advised as a mode of ventilation in mechanically ventilated COPD patients due to inadequate pressure support, which results in greater patient efforts and respiratory acidosis.

Keywords: COPD; BIPAP; Mechanical ventilation.

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Introduction

In intensive care medicine, it can be difficult to treat patients with chronic obstructive pulmonary disease (COPD) who are experiencing either acute or chronic respiratory failure. Pump failure results from an imbalance between the respiratory muscles' increased workload and their diminished capability, necessitating artificial ventilatory support. The ability of various partial ventilatory support strategies to lessen respiratory muscle work has been established. By adjusting intrinsic positive end-expiratory pressure (PEEPi) and relieving the inspiratory muscles of their load, continuous positive airway pressure (CPAP) lowers the patient's work of breathing (WOB) **(Petrof et al., 1990).** A well-known standard strategy for reducing respiratory muscle strain is pressure support (PS) ventilation. Each breath is given an inspiratory pressure to make it work. Along with boosting tidal volume (VT) and reducing respiratory frequency (fR), PS support for the inspiratory muscles also makes up for the increased labour the endotracheal tube causes **(Fiastro et al., 1988).** PEEP is also utilized to lessen the WOB component brought on by PEEPi **(Appendini et al., 1994; Nava et al., 1993).**

A more modern ventilatory mode known as biphasic positive airway pressure (BIPAP) was developed by BAUM et al. and first used in clinical settings in the late 1980s. BIPAP is built on the basis of pressure-controlled ventilation and spontaneous breathing. Two variable PEEP levels—higher (Phigh) and lower (Plow), which alternate at specified intervals (length of Phigh (thigh) and length of Plow (tlow)—are utilized to permit passive ventilation of the lung. In a CPAP machine, the patient can also breathe on their own at both PEEP levels. Every stage of the ventilatory cycle is unfettered by these spontaneous breaths. As a result, BIPAP combines independent spontaneous CPAP breaths with pressure-controlled time cycled mechanical breathing **(Baum et al., 1989).** It has a lot in common with airway pressure release ventilation, which also enables CPAP breaths to occur on their own at high pressure levels. BIPAP may enhance the distribution of breathing and perfusion **(Hörmann et al., 1997; Putensen et al., 1995)** and cut back on the use of sedatives and drugs in particular, BIPAP has proven to be useful for ventilating patients with adult respiratory distress syndrome (ARDS) **(Kiehl et al., 1996; Sydow et al., 1994).** BIPAP is routinely utilized, particularly in ARDS and post-surgery patients **(Rathgeber et al., 1997),** however its effectiveness in patients with COPD has not yet been assessed and investigated.

Patients and Methods

Patients: On 60 COPD patients of both sexes, observational, cross-sectional research was done. From April 2019 to November 2021, these individuals were hospitalized to the critical care unit at the hospital affiliated with Qena University.

Inclusion criteria: All intubated adult patients diagnosed as acute exacerbation of COPD are recruited into our study. COPD was diagnosed on previous visits according to Gold 2018. Patients with COPD were assigned to one of two protocol groups, each of which received similar general ventilation measures and treatment:

- **BIPAP group (group A):** Thirty patients who used BIPAP for ventilation were included in this group**.**
- **SIMV VC group (group B):** Thirty patients who used SIMV VC for ventilation were a part of this group**.**

Exclusion criteria:

1. Age < 18 years.
2. Cardiac or respiratory arrest on admission.
3. Morbid obesity with BMI > 40.

4. Acute exacerbation of IPF.
5. Cerebrovascular or neuromuscular disorder.
6. Diabetic ketoacidosis.
7. Hepatic or renal disease.
8.Cardiac disease.

Ethical approval: Our institutional ethics committee initially authorized the study's protocol. Before being recruited, patients gave their informed permission.

Methodology

All selected patients in the study were subjected to the following:

1-A detailed history was taken
2- Clinical examination, including both local and general examinations.
4- Arterial blood gases (ABG).
3- Chest x-ray.
5- Laboratory assessment:
A- Renal function test including, blood urea and creatinine.
B- Complete blood picture.
C- Liver function test including, liver enzymes, total bilirubin and serum albumin.

Ventilatory strategies includes

- The machine used in our study was PURITAN BENNET 840 ventilator system and the biphasic mode was BILEVEL mode on BENNET.
- In all groups, the ventilatory modes were observed nonstop for 24 hours.
- In all groups, the physiological objectives and rationale for the primary ventilatory settings were comparable.

BIPAP parameters

- "P_{low}" was adjusted to 5 cm H2O.
- " P_{high}" was set to achieve a tidal volume of 8 mL/ kg IBW and SO_2 >90 %.
- T high was adjusted to achieve I:E ratio of 1: 4.
- Mean airway pressure was automatically recorded and displayed. **Synchronized intermittent mandatory ventilation volume control (SIMV VC):**

Tidal volume: tidal volume was adjusted at 8 mL/ kg IBW and to achieve I:E ratio of 1: 4 with a square wave form. **Peak inspiratory flow:** was adjusted at 60 L/M. **PEEP:** was adjusted at 5 cm H_2O. **FiO_2 target:** was adjusted to achieve a SO_2 >90 %.

Statistical analysis

The data was entered, reviewed, and coded utilizing IBM SPSS version 20 of the Statistical Package for Social Science. Quantitative data having a parametric dispersion were shown using numbers and percentages, while non-parametric quantitative data were presented using the median and interquartile range (IQR). Where comparing two groups employing qualitative data and when any cell's predicted count was less than 5, the Fisher exact test was substituted for the Chi-square test. In order to compare two groups with quantitative data and a parametric dispersion, an independent t-test was employed, and in order to compare two groups with quantitative data and a non-parametric dispersion, a Mann-Whitney test was employed. The acceptable margin of error was set at 5%, while the confidence interval was set at 95%.

Results

There was no statistically substantial variation between groups as regard age, gender, occupation, special habits and base line clinical parameters (respiratory rate, heart rate, blood pressure) while diastolic blood pressure was significantly ($P<0.05$) greater in SIMV VC versus BIPAP (74.00 ± 13.80 vs 67.33 ± 11.12) **(Table 1)**.

Table 1. Comparison between BIPAP and SIMV VC according to demographic data and clinical parameters in COPD patients

Variables		Mode				Chi square test/ Independent t test*	
		BIPAP		SIMV VC			
		No	%	No	%	x^2\t*	p value
Sex	Male	21	70.0%	23	76.7%	0.341	0.559
	Female	9	30.0%	7	23.3%		
Occupation	No work	9	30.0%	8	26.7%	0.773	0.856
	Farmer	9	30.0%	12	40.0%		
	Employer	8	26.7%	6	20.0%		
	Free business	4	13.3%	4	13.3%		
Special habits	Non-smoker	12	40.0%	9	30.0%	1.534	0.464
	Smoker	18	60.0%	21	70.0%		
Age	Mean± SD	64.43	7.17	65.30	10.14	-0.382*	0.704
		Mean	SD	Mean	SD	t	p value
HR		101.6	16.20	97.23	15.75	1.059	0.294
RR		26.25	1.43	25.89	1.85	0.689	0.495
Blood pressure	Systolic	105	16.76	111.67	22.30	-1.309	0.196
	Diastolic	67.33	11.12	74.00	13.80	-2.061	0.044

On the other hand, vital signs after 24 hours showed that HR and RR were statistically (P<0.001) significant higher in BIPAP versus SIMV VC (105.53 ± 26.74 and 28.70 ± 2.39 vs. 84.63 ± 11.76 and 16.70 ± 3.45) respectively **(Table 2)**.

Table 2. Comparison between BIPAP and SIMV VC according to vital signs after 24 hours in COPD patients

Variables	Mode				Independent t test	
	BIPAP		SIMV VC			
	Mean	SD	Mean	SD	t	p value
Respiratory rate	28.70	2.39	16.70	3.45	15.664	<0.001
Heart rate	105.53	26.74	84.63	11.76	3.918	<0.001

Base line arterial blood gases showed significantly (P <0.01) higher PaO2 in SIMV VC versus BIPAP (51.99 ± 14.53 vs. 42.68 ± 9.59), while other parameters were not significant **(Table 3)**.

Table 3. Comparison between BIPAP and SIMV VC according to baseline arterial blood gases (1 hour) in COPD patients

Variables	Mode				Independent t test	
	BIPAP		SIMV VC			
	Mean	SD	Mean	SD	t	p value
pH	7.21	0.06	7.21	0.05	0.565	0.574
$PaCO_2$	82.23	19.97	81.42	10.48	0.195	0.846
PaO_2	42.68	9.59	51.99	14.53	-2.931	0.005
HCO_3	32.96	4.14	31.57	4.05	1.307	0.196
SO_2	68.25	11.51	74.90	14.26	-1.989	0.051

After 24 hours arterial blood gases revealed that all parameters were significantly (P<0.05) different between BIPAP and SIMV VC except HCO_3. acid base status documented that pH is substantially enhanced (P<0.001) in both groups and $PaCO_2$ is significantly (P<0.001) decrease after 24 hours in both groups, there were a significant (P<0.001) higher pH in SIMV VC (7.40 ± 0.06 vs. 7.34 ± 0.06) and significant (P<0.001) lower $PaCO_2$ in SIMV VC (62.88 ± 11.74 vs 50.92 ± 9.50). Follow up of oxygenation status showed statistically significant (P<0.05) improvement in both partial pressure of oxygen and oxygen saturation in both groups, with significant (P<0.05) higher PaO_2 and SO_2 in SIMV VC after 24 hours **(Table 4)**.

Table 4. Comparison between BIPAP and SIMV VC according arterial blood gases after 24 hours in COPD patients

Variables	Mode				Independent t test	
	BIPAP		SIMV VC			
	Mean	SD	Mean	SD	t	p value
pH	7.34	0.06	7.40	0.06	-4.452	<0.001
PaCO2	62.88	11.74	50.92	9.50	4.340	<0.001
PaO2	71.65	11.10	79.27	16.36	-2.109	0.039
HCO_3	32.46	5.31	31.47	4.71	0.767	0.446
SO2	92.98	3.14	94.49	2.59	-2.031	0.047

Ventilator parameters revealed that all parameters were significantly (P<0.001) different between BIPAP and SIMV VC, Tidal volume showed significant (P<0.001) increase in SIMV VC versus BIPAP (591.40 ± 153.34 vs. 265.91 ± 105.13) respectively, Minute volume showed statistically significant (P <0.001) increase in SIMV VC versus BIPAP (14.60 ± 5.40 vs. 6.67 ± 1.53) respectively and Peak pressure showed statistically significant (P<0.001) increase in BIPAP versus SIMV VC (26.97 ± 3.81 vs. 19.63 ± 4.26) respectively **(Table 5).**

Table 5. Comparison between BIPAP and SIMV VC according ventilator parameters

Variables	Mode				Independent t test	
	BIPAP		SIMV VC			
	Mean	SD	Mean	SD	t	p value
Vt	265.91	105.13	591.40	153.34	-9.589	<0.001
Minute Volume	6.67	1.53	14.60	5.40	-7.740	<0.001
Peak Pressure	26.97	3.81	19.63	4.26	6.956	<0.001

Lung mechanics revealed that all parameters were significantly (P<0.05) different between BIPAP and SIMV VC, Resistance was presented in **(Fig.1)** showed highly significant (p-value = 0.007) increase in BIPAP versus SIMV VC (11.93 ± 7.09 vs. 7.30 ± 5.75) respectively, Compliance was presented in **(Fig.2)** showed highly significant (p-value = 0.025) increase in SIMV VC versus BIPAP (73.03 ± 28.23 vs. 54.73 ± 33.23) respectively.

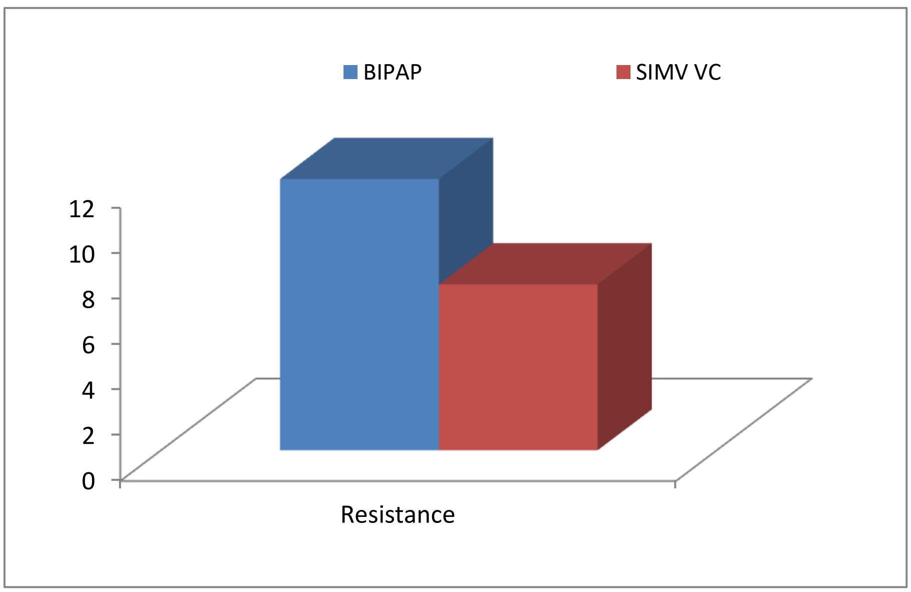

Fig.1. Comparison of resistance between SIMV VC and BIPAP

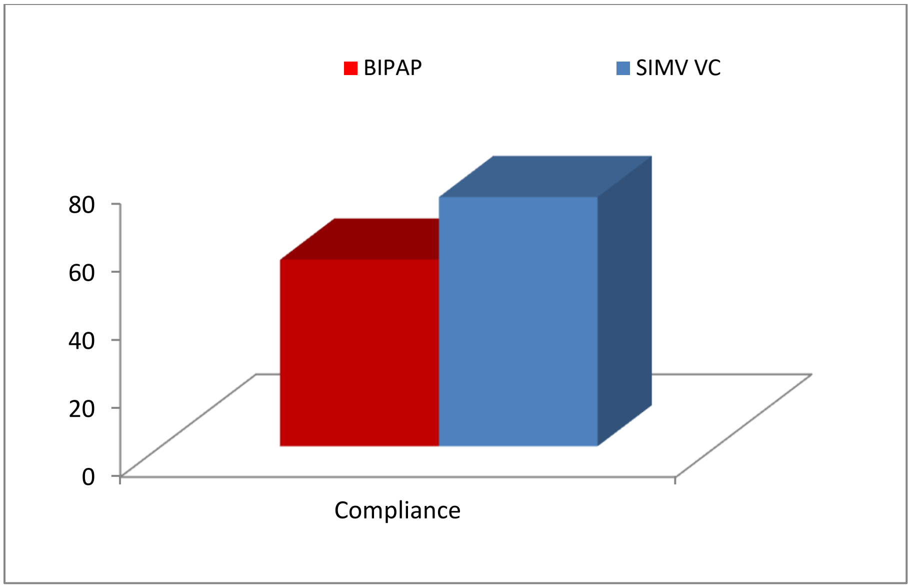

Fig.2. Comparison of compliance between SIMV VC and BIPAP

Discussion

The current study's objective is to evaluate BIPAP's impact on COPD patients. Unrestricted spontaneous breathing while receiving pressure-controlled mechanical ventilation, which is beneficial in cases like ARDS or when weaning patients from anaesthesia, is the main component of BIPAP. However, The primary finding of this study is that BIPAP poses a risk to COPD patients because of these spontaneous breaths. BIPAP is a sort of pressure-controlled mechanical ventilation that may be completely customized to the unique pathophysiology of a COPD patient as long as they are sedated and not capable of breathing on their own. However, when the patient starts breathing on their own, two negative effects actually happen: first, hyperinflation is brought on by Phip breathes, and second, the unsupported breaths increase the strain on the respiratory muscles. Although decreasing Thigh might lower PEEPi, the essential characteristic of BIPAP—spontaneous breathing—would no longer be possible since Thigh would be too short. To ensure that the patient truly breathes spontaneously at Phigh, A Thigh of 2 s is advised for BIPAP **(Baum et al., 1989).**

The ideal is to increase of Tlow, so decreasing ventilatory support, is another idea for adapting BIPAP to spontaneously breathing COPD patients. According to the pathophysiological ideas based on the research of PETROF et al. and RANIERI et al., BIPAP may not be the best mode for people with COPD **(Petrof et al., 1990); (Ranieri et al., 1993).** A number of authors have expressed interest in the topic of comparing PS with BIPAP. **(Putensen et al., 1995; Schirmer et al., 1994; Viale et al., 1998).** Various effects on hemodynamics **(Putensen et al., 1995; Schirmer et al., 1994),** gas exchange **(Putensen et al., 1995),** oxygen cost of breathing **(Staudinger et al., 1998)**and weaning outcome **(Schirmer et al., 1994; Staudinger et al., 1998)** were studied.

This study provides measurements of hemodynamics, arterial blood gases and lung mechanics in COPD patients during BIPAP in comparison to SIMV VC. In the current research there were no variations between studied groups in demographic data and baseline clinical characteristics. On evaluating hemodynamic changes, despite both groups were comparable at base line there were highly significant differences of clinical variables RR and HR between both groups. There was statistically substantial increase in HR and RR in BIPAP group. On the other hand SIMV VC group has decrease in HR and RR after 24 hours of mechanical ventilation and this is illustrated by using longer Tlow in COPD to decrease the intrinsic peep lead to low pressure support and hence increase patient effort with increased RR.

BIPAP group has lower pH and higher $PaCO_2$ which reflect the previously mentioned longer Tlow with low pressure support and decreased alveolar ventilation which lead to this result. On the other hand SIMV VC group has high pH and low $PaCO_2$ which is in agreement with previously reported findings of E. Katz-Papatheophilou and co workers **(Chang et al., 2016; Katz-Papatheophilou et al., 2000).** Oxygenation is improved in both groups after 1 day but is better in SIMV VC group and this is supported with Chang et al results, Results shown a reduction in PaCO2 and a quick, effective improvement in hypoxemia and oxygenation in the SIMV VC group within 2-4 hours and after 24 hours.**(Chang et al., 2016).**

Regarding respiratory mechanics the previous studies concluded that increased tidal volume in SIMV VC versus BIPAP **(Brochard et al., 1989; Kacmarek, 1988; Katz-Papatheophilou et al., 2000; Tokioka et al., 1989)** and this is consistent with the result of the present study.

Regarding lung mechanics resistance is decreased and compliance is increased in SIMV VC which agree with Amr A et al, Who studied 72 adult COPD patients, Using the closed-envelope method, patients were divided into two groups at random: Group I, which consisted of 36 patients who were mechanically ventilated in the BIPAP mode, and Group II, which consisted of 36 patients who were mechanically ventilated in the ASV mode. When compared to BIPAP, the ASV mode of ventilation dramatically increased lung compliance and decreased inspiratory resistance. They assumed that the ASV analysis of respiratory mechanics in COPD patients, which is characterized by low respiratory rate and high tidal volume, was representative of the population in their study. **(Elmorsy et al., 2015).**

These results also fairly well support E's conclusion. BIPAP, which inadequately supports the respiratory muscles and may even burden them by encouraging dynamic hyperinflation, increases the risk of increased WOB in patients with COPD, according to Katz-Papatheophilou and colleagues. In people with COPD, pressure support is still the optimum ventilatory aid mode for minimizing respiratory muscle exertion. **(Katz-Papatheophilou et al., 2000).**

Conclusions: In mechanically ventilated COPD patients BIPAP is not recommended as a mode of ventilation due to poor pressure support with resultant increased patient effort and respiratory acidosis.

Limitations of the current study: BIPAP group patients were shifted to SIMV VC mode of ventilation after 24 hours because the bad effects of BIPAP mode on hemodynamics, arterial blood gases and lung mechanics and there was marked improvement on SIMV VC mode so, the mortality couldn't be estimated in the patients.

Conflict of interest: no conflict of interest.

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