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Efficacy of Noninvasive Ventilation in the Management of Acute Exacerbations of Chronic Obstructive Pulmonary Disease

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a major global health issue, with Acute exacerbations of COPD (AECOPD) being a key event linked to faster lung function deterioration, worsened health, and increased mortality. Effective management of COPD exacerbations is crucial to improve quality of life and minimize the disease's burden.

Aim: The study aimed to evaluate the efficacy of NIV, delivered via a portable noninvasive ventilator, with standard therapy in patients hospitalized owing to AECOPD.

Patients and Methods: Seventy COPD patients who were hospitalized at Buraidah Central Hospital, Saudi Arabia, and were found to have AECOPD were included in this prospective cohort research. The conventional group and the NPPV group were the two groups into which the patients were split. The primary result was NIPPV failure; other outcomes were the number of hours spent using NIPPV, the length of time spent in the intensive care unit, the rate of death, and complications arising from the use of NIPPV.

Results: Most studied cases were males (86%) and the mean age of AECOPD patients was 61.08 years. The NPPV group showed significantly higher success rates (74%) than the standard group (54%). The main reason for NPPV failure was the deterioration of ABGs (33%), while the main complication of NPPV was facial skin abrasion (17%).

Conclusion: Finally, our findings show that NIV improves AECOPD respiratory metrics. When NIPPV is used as 1st line therapy for respiratory failure exacerbations, acidosis will be corrected quicker, intubation frequency will be lower, and mortality will decrease.

Keywords: Noninvasive Ventilation, Acute Exacerbations, Chronic Obstructive Pulmonary Disease, Standard Oxygen Therapy.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a health issue known for causing ongoing breathing problems and restricted airflow due to abnormalities in the airways or alveoli. COPD is often associated with frequent health problems and frequent flare-ups that can lead to respiratory failure. Managing respiratory failure in COPD-studied cases is a challenge in the Intensive Care Unit (ICU) focusing on easing breathing difficulties, enhancing gas exchange, and minimizing the requirement, for ventilator support [1].

Noninvasive positive airway pressure therapy (NPPV) is considered an element in treating acute exacerbation of chronic obstructive pulmonary disease. NPPV provides breathing support using a mask, which helps avoid the complications linked to inserting an endotracheal tube. Studies have demonstrated that using NPPV for COPD patients experiencing exacerbations can enhance survival rates, reduce the need for mechanical ventilation, and shorten stays in intensive care units. However, the effectiveness of NPPV may vary based on factors such, as disease severity, patient selection, and when treatment is initiated [2].

The burden of COPD and Acute-on-Chronic Respiratory Failure

COPD is seen as an issue for health affecting more than 328 million individuals worldwide. It is known as the cause of death globally with most COPD-related fatalities happening in countries with lower and middle incomes. The gradual advancement of COPD frequently leads to episodes of worsening symptoms, which may lead to acute exacerbation of COPD (AECOPD). A state marked by deteriorating issues and abnormalities, in gas exchange that prompt medical attention [3].

AECOPD poses a risk to life resulting in increasing rates of hospital stays and ICU care. Treating AECOPD involves an approach that includes stabilizing the patient's breathing, addressing health issues and preventing complications related to respiratory failure. The introduction of NPPV has transformed the management of AECOPD by providing an option for invasive ventilation and its potential dangers [4].

Role of NPPV in the Management of ACRF in COPD Patients

NPPV has become widely accepted in treating AECOPD because it can enhance oxygen exchange, lower fatigue in muscles, and ease breathing effort. Using NPPV in AECOPD is backed by studies showing that it helps decrease the necessity, for intubation and enhances survival rates [5]. One key benefit of using NPPV is its capacity to start in cases of AECOPD even before severe acidosis and respiratory distress set in. This timely intervention plays a role in halting the advancement of respiratory failure and the resulting requirement for invasive mechanical ventilation, which

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is linked to increased mortality rates and extended stays in the ICU. Research indicates that initiating NPPV promptly in the ICU environment has been successful, in enhancing patient outcomes [2].

This study aimed to evaluate the efficacy of NIV, delivered via a portable noninvasive ventilator, with standard therapy in patients hospitalized owing to AECOPD.

PATIENTS AND METHODS

In this prospective cohort study, there were 70 COPD studied cases who were admitted to the ICU of Buraidah Central Hospital (BCH), Alqasim Area, Saudi Arabia between May 2023 and March 2024 had AECOPD.

Ethical consent:

The Academic and Ethical Committee of Buraidah Central Hospital granted approval for the research. Each patient agreed to participate in the trial by signing an informed written consent form. The World Medical Association's (Declaration of Helsinki) Code of Ethics for human subjects' research was followed in the conduct of this study.

Including and Excluding Criteria

The study aimed to identify patients with COPD history, type 2 respiratory failure because of AECOPD, and exacerbations of symptoms, such as respiratory rate 30/min, PaO2< 60 mmHg, $PaCO_2$ > 50 mmHg, pH < 7.35, serum HCO_3 normal or elevated, and normal consciousness or moderate signs of respiratory encephalopathy (drowsiness, confusion, flapping tremors). Patients were excluded if they had an immediate indication for endotracheal intubation, hypotension, ventricular or atrial arrhythmia, upper airway obstruction or facial trauma, difficulty clearing secretions, inability to cooperate with mask fitting and wearing, presence of tracheostomy, or refusal to undergo endotracheal intubations.

Demographics and Clinical Data

A comprehensive clinical examination was conducted, focusing on signs of COPD, such as a barrel-shaped chest, increased thoracic kyphosis, hyper resonance on hepatic, cardiac dullness, and diminished breath sound, in addition to signs of respiratory failure including dyspnea, cyanosis, respiratory rate over 30/min, flapping tremors, and contraction of accessory muscles. Patients were evaluated for various factors and if a patient couldn't provide an adequate history, information was obtained from a close relative. For example, we collected demographic factors like age and gender and clinical factors such as heart rate (HR), mean arterial pressure (MAP), respiratory rate (RR), and arterial blood gases (pH, $PaCO_2$, PaO_2, and SaO_2), at baseline, 12 hours, and the second day.

Study Groups

The study divided patients into 2 groups: the standard group, which involved 35 studied cases who refused noninvasive positive pressure ventilation (NPPV) or had ventilators unavailable at admission, and the NPPV group, which included 35 patients treated with standard therapy plus NPPV. The standard group received oxygen inhalators, antibiotics, bronchodilators, corticosteroids, anticoagulants, anti-stress ulcers, and electrolyte abnormality correction. The NPPV group received noninvasive ventilation using a portable noninvasive ventilator, delivered in bed at 30-45° angles, and a full-face mask as an interface for positive pressure delivery.

Study Outcomes

The primary result was NIPPV failure, which is described by the need for endotracheal intubation throughout an ICU stay if gas exchange or dyspnea cannot be improved or stabilized in an hour, or if studied cases who were lethargic from CO_2 retention or agitated from hypoxemia are not able to improve their mental status within sixty minutes of starting NIPPV. The choice to intubate any patient was ultimately made using professional judgment. The NPPV duration in hours, the ICU stay by days, inspiratory positive airway pressure, expiratory positive airway pressure, mortality rate, and complications associated with the use of NIPPV were also secondary outcomes.

Sample Size Calculations

With a power of 0.80, a 90% confidence interval, a 0.055 predicted incidence in unexposed subjects, and an estimated relative risk of 5, a cohort study sample size was calculated using Epitools Epidemiological Calculators [6]. The sample sizes for each group were 33 and the total (both groups) was 66. Patients who meet the inclusion and exclusion criteria were allocated to the study in a convenient sample until the entire sample size was determined.

Statistical Analysis

Categorical variables are shown as numbers and percentages, while continuous normally distributed variables are shown as mean and standard deviation (SD). The T-test was used to assess statistical significance for continuous variables, and chi-square test (X^2) was used for categorical variables. If a p-value was less than 0.05, it was deemed statistically significant. The statistical package for the social sciences (SPSS) was used for our statistical analyses.

RESULTS

Demographics and Clinical Data of the Patients

Most of the AECOPD studied cases were males. No statistically significant difference regarding gender and age was found between the 2 studied groups (Table 1).

Table 1. Demographics and Clinical Data of the Patients (*N = 70*)

Variable		NPPV (n=35)		Standard(n=35)		P-value
		No	%	No	%	
Gender	Male	30	86%	29	83%	0.74
	Female	5	14%	6	17%	
Age by year		61.08	5.56	61.05	4.62	0.98

NPPV: Noninvasive positive airway pressure therapy, Data are expressed as Number of patients (%).

Patient Clinical Follow-up *at admission, 12 hours, and during the second day:* *There* was no statistically significant difference among HR, MAP, RR, pH, PaCO2, PaO2, and SO_2 in both groups at admission time (**Table 2)**. HR mean showed a statistically significant decrease in the NPPV group, more than in the standard group at 12 hours and during the second day. RR mean showed a statistically significant reduction in the NPPV group more than in the standard group at 12 hours and during the second day. pH mean showed a statistically significant increase in the NPPV group more than in the standard group at 12 hours and during the second day. $PaCO_2$ mean showed a statistically significant reduction in the NPPV group more than in the standard group at 12 hours and during the second day. PaO_2 mean showed a statistically significant increase in the NPPV group more than in the standard group at 12 hours and during the second day. SaO_2 mean showed no significant difference between the NPPV group and the standard group at admission, 12 hours and on the second day **(Table 2)**.

Table 2. Patient Clinical Follow-up (*At admission, 12 hours, and during the second day)*

Variable		NPPV(n=35)		Standard(n=35)		P-value
		Mean	SD	Mean	SD	
Heart Rate (HR)	At Admission	105.84	6.75	107.68	7.46	0.393
	At 12 Hours	88.42	5.13	97.42	7.2	0.001
	Second Day	84.73	5.4	92.57	5.02	0.001
Mean Arterial Pressure (MAP)	At Admission	98.99	8.65	98.91	8.78	0.973
	At 12 Hours	94.36	5.74	94.24	4.87	0.944
	Second Day	94.04	3.42	94.48	2.72	0.645
Respiratory Rate (RR)	At Admission	32.15	2.18	32.26	2.55	0.878
	At 12 Hours	21.92	2.44	26.94	2.46	0.001
	Second Day	21.11	2.25	24.26	2.18	0.001
pH	At Admission	7.28	0.024	7.28	0.024	1
	At 12 Hours	7.35	0.037	7.31	0.027	0.001
	Second Day	7.37	0.029	7.33	0.016	0.001
$PaCO_2$	At Admission	74.03	10.87	74.73	9.85	0.826
	At 12 Hours	59.61	7.05	66.57	8.96	0.001
	Second Day	54.8	6.46	63.42	7.91	0.001
PaO_2	At Admission	52.11	7.11	52	6.35	0.955
	At 12 Hours	74.73	12.31	62.36	5.05	0.001
	Second Day	72.73	12.94	61.78	6.18	0.001
SaO_2	At Admission	80.38	7.85	81.52	6.31	0.604
	At 12 Hours	91.34	10.15	89.21	2.48	0.232
	Second Day	92.46	4.31	90.36	2.85	0.019

Statistically significant at $p \leq 0.05$, HR: Heart Rate, MAP: Mean Arterial Pressure, RR: Respiratory Rate, PH: potential of hydrogen, $PaCo_2$: Partial pressure of carbon dioxide, PaO_2: Partial pressure of oxygen, SaO_2: Oxygen saturation of arterial blood.

Secondary Outcome of Patients

Mortality rate showed statistically significant increase in standard group (died cases = 5) more than the NPPV group (died cases = 2). ICU stay mean by days showed a statistically significant increase in the standard group more than the NPPV group. Most of the AECOPD patients showed significant increases in the success of therapy in the NPPV group more than the standard group **(Table 3)**.

Table 3. Secondary Outcome of Patients

Variable		NPPV(n=35)		Standard(n=35)		P-value
		No	%	No	%	
Mortality	Died	2	6%	5	14%	0.232
	Live	33	94%	30	86%	
ICU Stay by days	Mean and SD	3.73	1.11	5.89	1.48	0.001
Succeed		26	74%	19	54%	0.081
Failed		9	26%	16	46%	

Complications and Causes of Failure of NPPV

The main cause of failure of NPPV was the deterioration of ABGs 33%. The main complication of NPPV was the facial skin abrasion 17% **(Table 4).**

Table 4. Complications and Causes of Failure of NPPV

Variable		NPPV (n=35)	
		No	%
Cause of failure	Uncooperating	2	22%
	Deterioration of ABGs	3	33%
	Deterioration of the level of consciousness	2	22%
	Exaggerated signs of respiratory distress	2	22%
Complications of Succeeded NPPV	Facial skin abrasion	2	5.7%
	Eye irritation	2	5.7%
	Gastric distension	1	2.8%
	Air leakage	2	5.7%
	Un cooperation	1	2.8%
Complications of Failed NPPV	Facial skin abrasion	4	11.4%
	Eye irritation	3	8.6%
	Gastric distension	1	2.8%
	Air leakage	3	8.6%
	Un cooperation	4	11.4%

- **Comparison Between Succeeded and Failed Cases in NPPV Group**

Regarding the gender distribution, there was no statistically significant difference among NPPV succeeded and failed cases **(Figure 1)**.

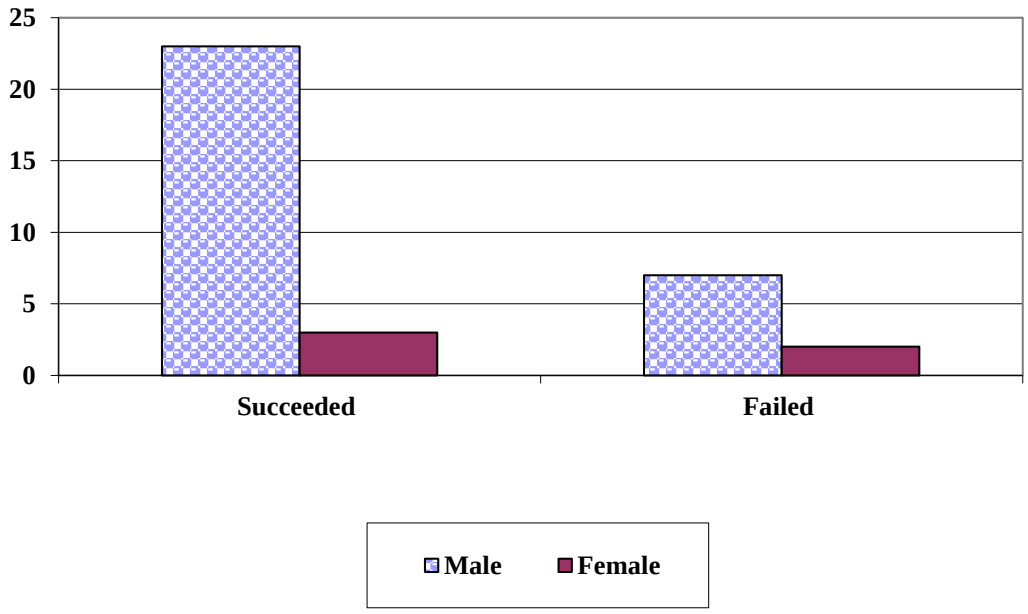

Figure 1. Comparison Between Succeeded and Failed Cases in NPPV Group as Regard Gender.

Regarding age, most NPPV succeed patients were significantly younger than NPPV failed patients. HR mean showed a statistically significant decrease in the NPPV succeed group more than in the NPPV failed group *at admission, 12 hours, and during the second day*. MAP mean showed a statistically significant decrease in the NPPV succeed group more than in the NPPV failed group *at admission only*. RR mean a statistically significant decrease in the NPPV succeed group more than in the NPPV failed group *at admission, 12 hours, and during the second day*. pH mean showed a statistically significant increase in the NPPV succeed group more than in the NPPV failed group *at admission, 12 hours, and during the second day*. $PaCO_2$ mean showed a statistically significant decrease in the NPPV succeed group more than in the NPPV failed group *at admission, 12 hours, and during second day*, respectively. PaO_2 mean showed statistically significant increase in NPPV succeed group more than in NPPV failed group *at 12 hours*, while *during second day* PaO_2 mean showed statistically significant increase in NPPV failed group more than in NPPV succeed group. SaO_2 mean showed statistically significant increase in NPPV succeed group more than in NPPV failed group *at 12 hours*, while *during second day* SaO_2 mean showed statistically significant increase in NPPV failed group more than in NPPV succeed group.

ICU stay mean by days showed statistically significant increase in NPPV failed group more than NPPV succeed group. IPAP level mean showed statistically significant increase in NPPV failed group more than NPPV succeed group. EPAP level mean showed statistically significant increase in NPPV failed group more than NPPV succeed group. NPPV usage duration mean in hours showed statistically significant increase in NPPV failed group more than NPPV succeed group **(Table 5)**.

Table 5. Comparison between Succeeded and Failed Cases in NPPV Group

Variable		NPPV Succeed		NPPV Failed		P-value
		Mean	SD	Mean	SD	
Age	**By year**	58.73	4.24	67.88	2.26	0.001
Heart Rate (HR)	**At admission**	105.84	6.75	121.66	6.1	0.001
	At 12 hours	88.42	5.13	109.77	4.5	0.001
	Second day	84.73	5.4	102.55	9.8	0.001
Mean Arterial Pressure (MAP)	**At admission**	98.99	8.65	109.95	9.5	0.003
	At 12 hours	94.36	5.74	98.65	8.48	0.098
	Second day	94.04	3.42	93.92	4.06	0.271
Respiratory Rate (RR)	**At admission**	32.15	2.18	34.22	2.33	0.022
	At 12 hours	21.92	2.44	29.55	1.94	0.001
	Second day	21.11	2.25	26.11	3.58	0.001
pH	**At admission**	7.28	0.024	7.24	0.033	0.001
	At 12 hours	7.35	0.037	7.21	0.085	0.001
	Second day	7.37	0.029	7.27	0.097	0.001
$PaCO_2$	**At admission**	74.03	10.87	79.44	9.9	0.016
	At 12 hours	59.61	7.05	94.66	31.4	0.001
	Second day	54.8	6.46	64.88	14.5	0.007
PaO_2	**At admission**	52.11	7.11	47.88	7.16	0.13
	At 12 hours	74.73	12.31	63	9.65	0.014
	Second day	72.73	12.94	77	13	0.040
SaO_2	**At admission**	80.38	7.85	74.77	8.7	0.081
	At 12 hours	94.34	10.15	87.44	9.7	0.008
	Second day	92.46	4.13	94	5.54	0.023
ICU Stay	**By Days**	3.73	1.11	7.22	1.64	0.001
IPAP		13.65	1.71	18.77	1.98	0.001
EPAP		5.11	0.76	7.11	0.78	0.001
NPPV Duration	**In hours**	26.15	7.58	33	9.84	0.038

DISCUSSION

When the respiratory system is unable to maintain gas exchange, which is its primary role, respiratory failure is a clinical disease characterized by PaO2 levels that are lower than 60 mmHg and/or $PaCO_2$ levels that are higher than 50 mmHg. Type I and type II respiratory failure are distinguished based on anomalies in blood gas levels [7]. Among the top five reasons people visit the emergency room are dyspnea and severe respiratory failure [8].

Multiple organ failure results from respiratory failure brought on by hypoxia and hypercapnia. To increase a studied case's chances of life, oxygenation is a critical tactic, and ventilators offer traditional respiratory care to sustain and enhance oxygenation. But sedation is frequently needed for respiratory care when using a ventilator, which lengthens ICU stays and raises the risk of ventilator-associated infections [9].

This research was carried out on (70) studied cases with AECOPD (59 males and 11 females) with ages ranging from (51- 71 years) admitted to the intensive care unit of Buraidah Central Hospital, Alqasim Area. Thus, in our work, we aimed to study the effectiveness of NPPV in correcting gas exchange abnormalities and avoiding endotracheal intubation in the management of AECOPD and to recognize simple predictors of success or failure of NPPV. We conducted prospective cohort research to compare the effectiveness of NIV, administered via a portable noninvasive ventilator, with standard oxygen treatment in the management of AECOPD. Our findings show that NPPV led to enhancements in patient outcomes, lowered the necessity for intubation, and reduced the duration of ICU stays when compared to standard treatment alone. Regarding demographic traits, they were similar, in both the NPPV and standard groups showing no variations in age or gender distribution. This similarity in demographics enhances the credibility of comparing outcomes between the two groups. Also **Schmitt *et al.* study [10].** showed that males were nonsignificantly more than females in the NIV group (59%) and standard oxygen therapy (58%) (P-value = 0.99). Previous literature showed that women smokers are roughly fifty percent more likely to acquire COPD than males [11]. In addition, hospitalization and mortality from respiratory failure and comorbidities are higher in women with severe COPD. The average age of patients was around 61 years consistent with the age range of COPD patients facing AECOPD [12].

Schmitt *et al.* study [10] showed that patients in standard oxygen group (mean age = 75.5) were significantly older than patients in NIV group (mean age = 73.8) (P-value = 0.99). In agreement with that previous literature revealed, every ten years of age was found to increase the incidence of acute COPD exacerbations by twenty percent [13].

Detection of changes in vital signs is very important because they are simple and early detectable variables. In this study, it was found that when compared with baseline there was a significant reduction in HR, MAP, and RR **(Table 2)** after one hour in both standard and NPPV groups. But when we compared both NPPV and standard groups with each other, we found that there was a marked significant decrease in the NPPV group than standard groups regarding HR and RR after one hour till the 2nd day of the research, while there were no significant differences among both groups regarding MAP as compared with standard group.

These findings are in accordance with those reported by **Phua et al. [14].** who observed that improvement in respiratory rate, heart rate and systolic blood pressure, one hour after NIV in COPD studied cases with hypercapnic acute respiratory failure. Also, **Liu et al. [15]** found that marked improvement in heart rate and respiratory rate was found only at seventy-two hours after treatment in the standard treatment group, but in NPPV significant improvement in HR and RR was found two hours after the treatment.

The improvement of RR and HR in both groups may be because of medical treatment (bronchodilators, steroids, antibiotics, and oxygen therapy) used in both groups for correction of the reversible precipitating factors, especially bronchospasm, which may be early corrected by medical therapy. The improvement was more marked in the NPPV group due to the additional beneficial effects of NPPV in reducing inspiratory muscle work and avoidance of respiratory muscle fatigue with augmentation of tidal volume.

In agreement with our outcomes, **Brochard *et al.* study [16]** indicated that RR mean statistically significant decrease in NPPV group *after 1 hour* (mean = 25 cycle/min) *versus at admission (*mean = 35 cycle/min*)* (P-value = 0.001). Also, **Wedzicha. [17]** study showed that RR mean statistically significant decrease in NPPV group *after 2 hours*.

In this research there was significant improvement in pH, P_aCO_2, PaO_2 and SaO_2 **(Table 2)** in both NPPV and standard group after one hour of the study when compared with baseline values. But when comparing NPPV with standard groups, there was a significant more improvement in $PaCO_2$, PaO_2 and SO_2 in NPPV than standard group after one hour till the 2nd day of the study, while the improvement in pH became significantly marked after 3 hours till the 2nd day of the study. These outcomes are in accordance with those reported by **Doshi *et al.* [18]**, where the NIV group' mean pH at admission was 7.32 (7.26-7.39). The mean PCO_2 at admission was 64.6 (48-91) and it demonstrated progress in lowering PCO_2 levels over time.

Also, **Golmohamad *et al.* [19]** recorded a mean pH on admission of 7.27±0.09 for NIV group, with baseline PCO2 was 74 ±16 mmHg for the NIV group and it improved after 6 and 12 hours. Also, **Liu *et al.* [15]** evaluated the impact of the early use of NPPV on gas exchange in studied cases with acute exacerbation of COPD. The studied cases were separated randomly into the standard therapy group and the NPPV group. They

showed that, in comparison with baseline values, there was marked improvement in pH and $PaCO_2$ was found only at seventy-two hours after treatment in the standard group, while in the NPPV group, significant improvement in $PaCO_2$ and PaO_2 was found 2 hours after the treatment.

The earlier improvement of PaO_2 and SO_2 after one hour of NPPV than the control group may be related to a greater inspired O_2 concentration delivered under positive pressure or to improved ventilation-perfusion matching. Increased ventilation and improved hypoventilation can be linked to improvements in pH and $PaCO_2$. $PaCO_2$ and pH rise as inspiratory pressure increases because of an increase in tidal volume and a decrease in inspiratory rate, which leads to minute ventilation.

Outcome: comparing the 2 groups of the study from different points of view revealed

(1)- Need for endotracheal intubations:

In this study, it was found that there was a significant decrease in the rate of ETI between patients treated with NPPV (26%) and the studied cases treated with standard treatment (45%) as shown in table (3). This means that the application of the NPPV device significantly reduces the intubation rate in patients presenting with AECOPD who have significant physiological impairment and potential but do not need ETI. These results are in agreement with previously published trials, by **del Castillo *et al.*** [20] who assessed whether studied cases admitted with ARF could benefit more from standard therapy in addition to NPPV than from normal therapy alone. The studied cases were using a regular mask in conjunction with a BiPAP ventilatory assistance device to receive NPPV. According to their findings, the NPPV group required intubation five percent of the time, while the control group required fourteen percent of the time.

On the other hand, **Keenan *et al.*** [21] investigated the impact of adding NPPV to conventional medical treatment on studied cases who arrived at the hospital with minor COPD exacerbations. They came to the conclusion that studied cases with milder exacerbations do not tolerate the addition of NPPV to standard therapy well, and that there is no statistically significant difference in the length of hospital stay or outcome among the two groups.

(2)- Length of ICU stay:

Because ICU stays are more expensive, one of the most significant economic factors is the duration of stay. In this research, it was found that the duration of ICU stay was significantly shorter in the NPPV group than standard group (3.73±1.1 vs 5.89±1.4 days respectively) as shown in **Table (3).** These outcomes are similar to the outcomes reported by **Matuska *et al.*** [22] who observed shorter ICU stay in NPPV group than conservatively treated group (7.1 vs. 9.8 days). The shorter ICU stays in NPPV group than conventional group may be explained by early correction of hypoventilation by application of NPPV in addition to the medical therapy than medical therapy alone.

(3)- Mortality:

In this research, it was found that there was a statistically significant increase in mortality rate in the standard group in comparison with the NPPV group (14.3% vs 5.7% respectively) as shown in **Table (3).** Our outcomes agreed with **Wang *et al.*** [23] and **Papachatzakis *et al*.** [24] regarding mortality and the length of stay among the NIV group, this study was also in accordance with **Liengswangwong *et al.*** [25] who reported that NIV therapy was related to a significantly lower in-hospital mortality rate (risk decrease 10%). Also, **Lee *et al.*** [26] who found that the mortality rate decreased among the NIV group (18.1%).

In contrast to our results **Park *et al.*** [27] reported lower success rate in NIV therapy (41%), longer ICU stay (8 days) and higher mortality rate (21.8%) were recorded. These differences can be because of the difference in number of patients included, and the study design.

Regarding complications of NPPV: The kind and intensity of NPPV problems must be identified to assess the treatment's tolerance and effectiveness. In this research, the following complications were found, facial skin abrasion in 6 patients (17%); eye irritation in 5 patients (14%); gastric distension in 2 patients (5%), air leakage in 5 patients (14%) and incorporation in 5 patients (14%). The previous complications were more significantly common in failed than succeeded patients (66.67% vs. 15.30% respectively), as shown in **Table (4).** These findings are in accordance with **Cheung *et al.*** [28] who found that complications with NPPV were fewer and minor. Facial skin abrasions and/or minor necrosis were common (4/28; 14%); only one patient had nosocomial pneumonia and 6% not tolerate NPPV

Because of its non-invasiveness and lack of ETI, NPPV can be used safely in AECOPD, however, it was found to be related to minimal problems in both the prior and current study's outcomes. If there are no significant difficulties, studied cases will be discharged from the hospital sooner and for a shorter amount of time, which has significant financial implications.

Predictors of success of NPPV:

(a)- Age and sex: in this study, it was found that the age of the failed cases in the NPPV group was significantly older (67.8 ± 2.26 years) than the age of the succeeded cases (58.7±4.24 years) ($p = 0.001$) as shown in **table (5)**. These results reflect the importance of age as a prognostic factor for patients with AECOPD treated with NPPV. These outcomes are in consistent with **Carlucci *et al.*** [29] who showed that the failed cases were older than the succeeded cases with NPPV (68±5 vs 62±14 and 66±15 vs 62±16 years respectively) but these differences were not statistically significant. Also, **Confalonieri *et al.*** [30] showed that succeeded patients were younger than failed cases (69.1±9.1 vs. 71.0±8.5 years).

(b)- Vital signs: The changes in the vital signs play important predictors of the success of NPPV. In this study, it was found that when compared with the baseline, there was a significant reduction in HR and RR, after one hour till the 2nd day in both succeeded and failed patients, while in MAP there was a significant decrease in the failed cases from 1st hour till the 2nd day and only at 1st hour in the succeeded cases. But when we compared both succeeded and failed cases with each other, we found that there was a significant decrease in succeeded cases than failed from 1st hour till 2nd day regarding HR and RR while there were no significant differences regarding MAP between succeeded and failed cases. Also, there was higher HR, MAP, and RR in failed cases than in succeeded cases at admission as shown in **(table 5).** These findings are like those reported by **Confalonieri *et al.*** [30] who carried out a large multicenter study on unselected studied cases with exacerbation of COPD and showed that studied cases with respiratory rate ≥ 30 breath/min have a predicted risk of failure of NPPV.

The improvement of RR and HR with NPPV may be explained by correction of hypoventilation with mask ventilation, which leads to the relief of dyspnea with resolution of sympathetic activity leading to decrease in RR and HR in both succeeded and failed cases. The significant decrease of MAP in failed cases after one hour till 2nd day may be explained using high-pressure support (IPAP and EPAP) in failed than succeeded patients (18.77±1.98 and 7.11±0.78 for failed versus 13.65±1.71 and 5.11±0.76 for succeeded patients respectively), which may lead to the decrease in MAP of failed patients.

2- Arterial blood gases (ABGs):

ABGs measurements can be used as simple and easily detectable predictors of the outcome of patients with AECOPD treated by NPPV. This research showed that when compared with the baseline, in the succeeded cases, there was a significant improvement in pH, $PaCO_2$, PaO_2, and SaO_2 after one hour till the 2nd day of the study **(Table 5)**, while in the failed cases, there was a significant worsening in pH and $PaCO_2$ after one hour till 12 hours of the study; but PaO_2 and SO_2 increased after one hour till 2nd day of the study. When comparing succeeded and failed cases as regards PaO_2 and SO_2 there was a significant more improvement in succeeded than failed cases from admission till 12 hours after admission. Also, it was shown that failed cases had lower pH and higher $PaCO_2$ at admission than succeeded cases. These findings are like those found by **Antón *et al.*** [31] who concluded that improvement in pH, $PaCO_2$, and level of consciousness values after one hour of NIV was related to successful responses to NIV in COPD studied cases with acute hypercapnic respiratory failure.

4- Mechanical ventilatory related variables:

(1)- Duration of NPPV and length of ICU stay:

This research observed that the duration of NPPV (26.15±7.58 in succeeded vs. 33.00±9.84 hours in failed respectively) and the length of ICU stay (3.73±1.11 vs. 7.22±1.64 days respectively) was significantly shorter in succeeded than failed patients as shown in **(Table 5).** These findings are in accordance with **Alsous *et al.*** [32] who found that the BiPAP success was related to a lower ICU length of stay (5.8±0.9 vs 10.6±1.6 days).

(2)-Level of pressure support

In this study, it was found that the IPAP and EPAP were higher in failed than succeeded patients (18.77±1.96, 7.11±0.78 vs 13.65 ± 1.71, 5.11±0.76 CmH_2O respectively) as shown in **(Table 5).** These findings are similar to **Yamauchi *et al.*** [33] showed that one of the important predictors of failure was the highest value of IPAP required as most of the failed cases were on IPAP level of 20 CmH_2O.

The previous results reflect the importance of the level of pressure support as a prognostic factor, when the patient was not responding to the lower pressure values and needed a higher level of pressure support, it is considered a bad prognostic variable, which may be explained by a more severe form of the disease, which may need higher levels of pressure support that can be given by ETI and invasive MV and not available in the NPPV devices.

In conclusion, NIV improves AECOPD respiratory metrics. When NIPPV is used as 1st line therapy for respiratory failure exacerbations, acidosis will be corrected quicker, intubation frequency will be lower, and mortality will decrease.

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