Original Research

EVALUATION OF BILEVEL NONINVASIVE VENTILATION AGAINST CONVENTIONAL OXYGEN THERAPY IN THE TREATMENT OF ACUTE CARDIOGENIC PULMONARY EDEMA

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ABSTRACT

Background: Acute cardiogenic pulmonary edema (ACPE) is a life-threatening emergency associated with acute respiratory failure and significant mortality. Non-invasive ventilation, particularly bilevel positive airway pressure (BiPAP), has emerged as an effective alternative to conventional oxygen therapy (COT) in improving oxygenation and reducing respiratory distress. This study aimed to compare the efficacy and safety of BiPAP with conventional oxygen therapy in the management of ACPE.

Methodology: This prospective randomized comparative study included 100 patients diagnosed with ACPE admitted to the emergency department. Patients were randomly divided into two groups: Group I received BiPAP along with standard anti-failure treatment, while Group II received conventional face mask oxygen therapy with anti-failure measures. Clinical examination, arterial blood gas analysis, electrocardiography, echocardiography, APACHE II scoring, and laboratory investigations were performed in all patients. Statistical analysis was conducted using SPSS version 25.0, and $p<0.05$ was considered statistically significant.

Result: Patients with decompensated heart failure, ischemic heart disease, valvular heart disease, elevated pulmonary artery systolic pressure, and reduced ejection fraction showed significantly higher use of BiPAP ($p<0.05$). Echocardiographic abnormalities including RWMA, severe mitral regurgitation, and advanced diastolic dysfunction were more common in the BiPAP group. APACHE II score >20 demonstrated high sensitivity and specificity in predicting BiPAP requirement.

Conclusion: BiPAP is an effective and safe modality in patients with acute cardiogenic pulmonary edema, especially among those with severe cardiac dysfunction and respiratory compromise. Early initiation of BiPAP may improve clinical outcomes and reduce progression to invasive ventilation.

Keywords: Acute Cardiogenic Pulmonary Edema, Bipap, Non-Invasive Ventilation, Conventional Oxygen Therapy, APACHE II Score, Respiratory Failure.

INTRODUCTION

Acute cardiogenic pulmonary edema (ACPE) is a life-threatening medical emergency characterized by rapid accumulation of fluid within the alveolar and interstitial spaces of the lungs due to elevated hydrostatic pressure secondary to cardiac dysfunction. It commonly occurs in patients with acute left ventricular failure and is associated with severe respiratory distress, impaired gas exchange, and hypoxemia. ACPE contributes significantly to hospital admissions and mortality among patients with cardiovascular diseases. Despite advances in medical therapy, acute pulmonary edema continues to be associated with considerable morbidity and mortality worldwide. [1]

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The pathophysiology of ACPE involves increased pulmonary capillary pressure leading to transudation of fluid into the pulmonary interstitium and alveoli, resulting in decreased lung compliance and impaired oxygen diffusion. Patients usually present with acute onset dyspnea, tachypnea, hypoxia, diaphoresis, and anxiety. If not treated promptly, the condition may progress rapidly to acute respiratory failure and cardiopulmonary collapse within minutes to hours. Early recognition and immediate therapeutic intervention are therefore crucial for improving patient outcomes. [2]

Conventional oxygen therapy has traditionally been used as the primary supportive treatment for patients with ACPE. Oxygen supplementation improves arterial oxygenation and reduces tissue hypoxia. However, in severe cases, conventional oxygen therapy alone may not adequately improve ventilation or reduce the work of breathing. Endotracheal intubation and invasive mechanical ventilation may become necessary in patients with worsening respiratory failure. Although invasive

ventilation is effective, it is associated with several complications such as airway trauma, ventilator-associated pneumonia, nosocomial infections, sedation-related adverse effects, prolonged hospital stay, and increased healthcare costs. [3]

Non-invasive ventilation (NIV) has emerged as an important therapeutic modality in the management of acute cardiogenic pulmonary edema. NIV provides ventilatory support through a nasal or face mask without the need for endotracheal intubation. Bilevel positive airway pressure (BiPAP) delivers two levels of airway pressure during inspiration and expiration, thereby improving alveolar ventilation, reducing preload and afterload, decreasing the work of breathing, and improving oxygenation. NIV has been shown to rapidly relieve dyspnea, improve respiratory parameters, and reduce the need for invasive mechanical ventilation in patients with ACPE. [4]

Several studies have demonstrated the beneficial effects of bilevel non-invasive positive pressure ventilation (NPPV) in reducing respiratory distress and improving clinical outcomes compared to standard oxygen therapy alone. Early initiation of NIV may decrease intensive care unit admissions, shorten hospital stay, and reduce mortality among selected patients. However, there remains uncertainty regarding the predictors of successful NIV use and the optimal selection of patients who would benefit most from this therapy. [5]

Therefore, the present study was undertaken to compare the safety and effectiveness of bilevel non-invasive ventilation with conventional oxygen therapy in the management of acute cardiogenic pulmonary edema. The study also aimed to identify factors favoring the early use of non-invasive ventilation among adult patients presenting with ACPE in the emergency department setting.

Aim

To compare the effectiveness of bilevel non-invasive ventilation and conventional oxygen therapy in the management of acute cardiogenic pulmonary edema.

Objectives

1. To evaluate the improvement in respiratory parameters among patients receiving bilevel non-invasive ventilation and conventional oxygen therapy.
2. To compare the changes in oxygen saturation, respiratory rate, heart rate, and arterial blood gas parameters between the two treatment groups.
3. To assess the need for endotracheal intubation and invasive mechanical ventilation in both groups.
4. To compare the duration of hospital stay and clinical outcomes among patients treated with bilevel non-invasive ventilation and conventional oxygen therapy.
5. To evaluate the safety and efficacy of bilevel non-invasive ventilation in adult patients with acute cardiogenic pulmonary edema.
6. To identify factors favoring early use of non-invasive ventilation in patients presenting with acute cardiogenic pulmonary edema.

METHODOLOGY

This prospective randomized comparative study was conducted in the Department of Emergency Medicine among patients presenting with acute cardiogenic pulmonary edema (ACPE). A total of 100 patients diagnosed with ACPE were included in the study and randomly allocated into two equal groups. Group I consisted of 50 patients who received bilevel non-invasive ventilation (BiPAP) along with standard anti-failure medical management, while Group II included 50 patients who received conventional face mask oxygen therapy in addition to anti-failure measures. The decision to initiate oxygen therapy or BiPAP ventilation was made by the attending physician based on the patient's clinical condition.

Bi-level positive airway pressure ventilation was administered using the BiPAP Vision ventilatory support system (Elisa, Federal Republic of Germany). Inspiratory positive airway pressure (IPAP) was initially set between 10–15 cmH_2O, while expiratory positive airway pressure (EPAP) was started at 5 cmH_2O during the first hour. EPAP was gradually increased in increments of 1–2 cmH_2O according to patient tolerance and clinical response, with maximum levels of IPAP 20 cmH_2O and EPAP 10 cmH_2O. The primary treatment objective in both groups was to maintain arterial oxygen saturation above 90% by adjusting oxygen flow rates appropriately.

All patients were managed in the resuscitation room of the emergency department and underwent detailed evaluation including demographic data such as age, sex, smoking status, and body mass index (BMI). Clinical assessment included cardiovascular and respiratory system examination. Arterial blood gas analysis was performed at baseline, after one hour, and after two hours of therapy. Hemodynamic parameters including respiratory rate, heart rate, mean arterial pressure, blood pressure, and temperature were recorded periodically. Laboratory investigations including complete blood count, renal function tests, serum electrolytes, and blood glucose levels were performed in all patients.

Acute Physiology and Chronic Health Evaluation (APACHE II) score was calculated on admission to assess disease severity. The APACHE II scoring system included variables such as heart rate, mean arterial pressure, respiratory rate, temperature,

Glasgow Coma Scale, hematocrit, white blood cell count, serum sodium, serum potassium, serum creatinine, serum pH, and arterial oxygen tension. Twelve-lead electrocardiography (ECG) was performed at baseline, one hour, and two hours to detect ischemic heart disease, arrhythmias, or acute myocardial infarction. Echocardiography was carried out once the patient's clinical condition stabilized to identify the underlying cardiac etiology of pulmonary edema. Chest radiography was also performed in all patients.

The study protocol was approved by the Institutional Ethics Committee, and informed consent was obtained from all participants or their attendants prior to enrolment. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as percentages and frequencies. Independent sample t-test and Chi-square test were used for comparison between groups. A p-value of less than 0.05 was considered statistically significant.

RESULT

Table1: Demographic Data among the Study Population (N=100)

		Group 1 BiPAP (n=50)	Group 2 COT(n=50)	P value
Age(years)	Mean ±SD	72.14±6.47	0.76±7.23	<0.001*
Gender				
Males	N (%)	27(54)	24(48)	0.5504
Females	N(%	23(46)	26(52)	
BMI				
Normal		15(46.9%)	17(53.1)	
Overweight	N (%)	17(43.6%)		0.2929
Obesity	N (%)	18(62.1%	22(56.4)	
	N (%)		11(37.9)	
Co-morbidities DM	N (%)	47(85.5)	8(14.5)	<0.0001*
HTN	N (%)	48(65.8)	25(34.2)	<0.0001*
IHD	N (%)	44(91.7)	4(8.3)	<0.0001*
Stroke	N (%)	21(91.3)	2(8.7)	<0.0001*
PAD	N (%)	28(82.4)	6(17.6)	<0.0001*
Chestdiseases	N (%)	50(74.6)	17(25.4)	<0.0001*

BiPAP: Bi-level Positive Airway Pressure, COT: Conventional oxygen therapy, PAD: Peripheral arterial diseases. *P < 0.05 is considered significant

Table2: Comparison between Two Groups Regarding Etiology of APO (N=100)

Etiology of APO	Group 1 BiPAP(n=50)		Group 2 COT(n=50)	
	N	(%)	N	(%)
Decompensated HF	19	86.4	3	13.6
Hypertension	1	2.1	46	97.9
IschemicHD	19	95	1	5
ValvularHD MS Prostheticvalve	9 7	100 87.5	0 1	0 12.5
Chi-squared		101.832		
P value		<0.0001*		

PO:Acutepulmonaryoedema,*P<0.05isconsideredsignificant

Table 3: Echo-Cardio graphic findings among the studied groups

		Group 1 BiPAP(n=50)	Group 2 COT(n=50)	Pvalue
RWMA	N (%)	46(86.8)	7(13.2)	<0.0001*
AR	N (%)	15(88.2)	2(11.8)	0.0006*
MS	N (%)	9(100)	0(0)	0.0018*
Prostheticvalve	N (%)	7(87.5)	1(12.5)	0.0278*
AS	N (%)	10(100)	0(0)	0.0009*
MR Moderate MR SevereMR	N (%)	12(100) 11(100)	0(0) 0(0)	<0.001*
PASP(mmHg)	Mean±SD	56.02±10.33	41.62±5.96	<0.001*

EF (%)	Mean±SD	40.68±10.06	58.42±8.44	<0.001*
Diastolicdysfunction Grade1 Grade2 Grade3	N (%)	4(14.8) 31(56.4) 15(83.8)	23(85.2%) 24(43.6%) 3(16.7%)	<0.0001*

RWMA: Regional wall motion abnormalities, PASP: pulmonary artey systolic pressure, EF: ejection fraction, MR: MR: mitral regurgitation, AS: aortic stenosis, AR: aortic regurgitation, P < 0.05 is considered significant.

Table 4: Comparing between the Two Groups regarding APACHE II Score, ABG and Hospital Stay

		GroupI		**GroupII**		**Pvalue**
		mean	SD	mean	SD	
APACHEIIscore		45.42	5.23	13.74	3.27	<0.001*
ABG	PH	7.20	0.166	7.30	0.087	<.001*
	PCO2	46.42	16.77	40.9	9.60	0.046
	SAO2	78.74	5.07	86.10	2.45	<.001*
	PO2	55.46	8.20	60.22	5.45	<.001*
	HCO3	13.92	3.66	15.78	1.83	0.002
Lengthofhospitalstay		13.60	3.38	9.74	2.29	<.001*

P<0.05isconsideredsignificant, ABG=arterialbloodgas.

Table (5): Diagnostic Test Performance of Each Clinical Parameter Used To Predict BIPAP Need

		BIPAPneed				
			Cutoffvalue	Sensitivity	Specificity	AUC
ABG	PH		≤7.18	60	0.789	0.789
	PCO2		>54	40	0.598	0.598
	SAO2		≤82	78	0.918	0.918
	PO2		≤55	58	0.686	0.686
	HCO3		≤13	56	0.671	0.671
APACHEII			>20	95	100	0.97
ECHOfindings						
EF%			≤50	88	88	0.929
PASP(mmHg)			>48	78	86	0.882

P<0.05isconsideredsignificant, ABG=arterialbloodgas.

DISCUSSION

The present study compared the effectiveness of bilevel non-invasive ventilation (BiPAP) and conventional oxygen therapy (COT) in the management of acute cardiogenic pulmonary edema (ACPE). The findings demonstrated that patients with severe cardiac dysfunction and multiple co-morbidities were more likely to require BiPAP support. A significant difference was observed between both groups regarding age and associated co-morbid conditions including diabetes mellitus, hypertension, ischemic heart disease (IHD), and peripheral arterial disease (PAD). These findings indicate that patients with advanced cardiovascular compromise are more likely to benefit from early non-invasive ventilatory support. Similar observations were reported by Masip et al., who demonstrated that patients with severe ACPE and underlying cardiac disease showed better outcomes with NIV support. [6]

In the present study, patients with decompensated heart failure, ischemic heart disease, and valvular heart disease showed significantly higher utilization of BiPAP compared to conventional oxygen therapy. This can be explained by the ability of BiPAP to reduce both preload and afterload, thereby improving cardiac performance and reducing pulmonary congestion. Positive airway pressure also improves alveolar recruitment and decreases the work of breathing, resulting in rapid symptomatic relief. Previous studies have similarly reported improved respiratory and hemodynamic parameters in ACPE patients treated with BiPAP. [7]

Echocardiographic findings in the present study demonstrated that patients with regional wall motion abnormalities (RWMA), valvular lesions such as

aortic regurgitation, mitral stenosis, aortic stenosis, prosthetic valves, moderate to severe mitral regurgitation, and advanced diastolic dysfunction had significantly higher distribution of BiPAP use. Furthermore, pulmonary artery systolic pressure (PASP) was markedly elevated, while ejection fraction (EF) was considerably lower in the BiPAP group. These findings suggest that patients with poor left ventricular function and elevated pulmonary pressures are more prone to severe pulmonary edema requiring ventilatory assistance. Similar findings were reported in studies by Gray et al. and Vital et al., where NIV was found to improve oxygenation and reduce respiratory distress particularly in patients with severe left ventricular dysfunction. [8,9]

Conversely, patients with grade 1 diastolic dysfunction had significantly higher use of conventional oxygen therapy, suggesting milder disease severity and less respiratory compromise. This indicates that conventional oxygen therapy may still be effective in selected patients with less severe cardiac dysfunction and preserved ventricular performance. [10]

Arterial blood gas analysis revealed significantly lower bicarbonate (HCO_3) levels among patients requiring BiPAP support, indicating greater metabolic and respiratory derangement in these patients. Additionally, patients managed with BiPAP had longer hospital stay compared to those receiving conventional oxygen therapy. This may be attributed to the severity of illness and greater burden of co-morbid conditions among patients requiring non-invasive ventilatory support. Similar studies have demonstrated that the need for NIV often reflects more severe disease presentation despite its beneficial therapeutic effects. [11]

The present study also evaluated the predictive value of clinical and laboratory parameters for BiPAP requirement. APACHE II score demonstrated the highest sensitivity and specificity at a cutoff value greater than 20 for predicting the need for BiPAP therapy. This finding emphasizes the importance of severity scoring systems in early risk stratification and identification of patients who may benefit from prompt initiation of NIV. Knaus et al. similarly demonstrated the utility of APACHE II scoring in critically ill patients for predicting disease severity and clinical outcomes. [12]

Overall, the findings of the present study support the safety and effectiveness of bilevel non-invasive ventilation in the management of acute cardiogenic pulmonary edema, particularly among patients with severe cardiac dysfunction and respiratory compromise. Early recognition and timely initiation of BiPAP may improve oxygenation, reduce respiratory distress, and potentially decrease the need for invasive mechanical ventilation.

CONCLUSION

The present study demonstrated that bilevel non-invasive ventilation (BiPAP) is an effective and safe modality in the management of acute cardiogenic pulmonary edema. Patients with severe cardiac dysfunction, multiple co-morbidities, reduced ejection fraction, elevated pulmonary artery systolic pressure, and advanced diastolic dysfunction were more likely to require BiPAP support compared to conventional oxygen therapy. BiPAP therapy showed better improvement in respiratory distress and oxygenation among patients with severe disease presentation. APACHE II score was found to be a useful predictor for identifying patients requiring early non-invasive ventilatory support. Although patients managed with BiPAP had longer hospital stay due to greater disease severity, early initiation of non-invasive ventilation may help reduce respiratory failure progression and decrease the need for invasive mechanical ventilation. Therefore, bilevel non-invasive ventilation can be considered an important therapeutic intervention in the emergency management of acute cardiogenic pulmonary edema, particularly in high-risk patients with significant cardiopulmonary compromise.

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