ACUTE EFFECTS OF BIPAP-CPAP ON HEMODYNAMICS AND RESPIRATORY PARAMETERS IN MANAGEMENT OF TYPE 2 RESPIRATORY FAILURE PATIENTS

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ABSTRACT

Objective: To determine the acute effects of bi-level positive airway pressure vs. continuous positive airway pressure, on hemodynamics and respiratory parameters in management of type-2 respiratory failure in post coronary artery bypass surgery patients.

Study Design: Comparative cross sectional study.

Place and Duration of Study: Adult Cardiac Intensive department, Armed Forces Institute of Cardiology/National Institute of Heart Disease, Rawalpindi, from Dec 2020 to Feb 2021.

Methodology: A total of 60 patients were included in study. Patients were allocated into two groups Bi-level positive airway pressure (n=30) and continuous positive airway pressure, (n=30). Age >18 years of males and females patients with type 2 respiratory failure having PaO2 of <8 kpa and pCO2 of >6kpa guidelines provided by british thoracic society were included.

Results: Results showed no significant differences from baseline to 3rd day for all outcome measures for both groups but patient's condition get improved clinically. Outcomes measures pCO2, pO2, oxygen saturation with mask, showed (p>0.001), no significant difference was found between groups. pCO2 with (p=0.355), pO2 (p=0.475) and oxygen saturation with mask showed no significant differences between groups.

Conclusion: The outcomes of our study show that both the Bi-level positive airway pressure group and continuous positive airway pressure group have shown improvement in respiratory parameters. We conclude that noninvasive ventilation can be effectively and safely used in type 2 respiratory post coronary artery bypass graft surgery patients to improve oxygenation in mild to moderate level of respiratory insufficiency. It is predominantly useful in patients whose underlying condition warrants avoidance of intubation.

Keywords: Bi-level positive airway pressure, Coronary artery bypass graft surgery, Continuous positive airway pressure, Respiratory failure.

INTRODUCTION

The respiratory system fails to work properly and the pump becomes less efficient so oxygenation of blood in the arteries and removal of carbon dioxide out of the body is not proper. This condition is defined as ventilatory failure. Patient presents with arterial hypoxemia (PaO2 <60 mm Hg) and hypercapnia and this respiratory failure condition is categorized as type-II[1]. The other respiratory failure condition in which PaO2 reduces and becomes less than 8.0k Pa with level of PaCO2 either normal or less is categorized as type-I and should be differentiated from type-II[2].

The system of respiration works to exchange oxygen and carbon dioxide between the blood and the environment. There is ventilation-perfusion mismatch when there is failure of respiratory system and proper exchange does not take place causing disturbance in oxygen metabolic demands and acid-base balance of the body. Severe tissue hypoxia, hypoxemia and cellular anoxia occur as a result of this failure[3].

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Respiratory diseases are reported to be a widely known cause in terms of mortality and disability with the aging of population globally. Although obstructive diseases are not more common in low-income areas such as black Africa and south Asia, measure of age-related mortality rates from COPD square is highest[4].

Death rate due to COPD is more-high if forced vital capacity is found to be low and rate of poverty is high. In areas with high smoking rate, airway obstructive diseases are common to be found. Mortality rate of asthma is not as common as COPD mortality rate but it is found to be more prevalent in areas with poverty such as Africa, Middle East and South-East Asia[5].

Type-1 respiratory failure occurs because of injury to lung tissue. This lung injury prevents adequate oxygenation of the blood however, the residual normal lung is still enough to excrete the carbon dioxide being produced by tissue metabolism. This is possible as less functional lung tissue is required for carbon dioxide emission than is needed for oxygenation of the blood[6].

Type-II respiratory failure is known as 'ventilatory failure'. It occurs when alveolar ventilation is in-

sufficient to expel the carbon dioxide being produced. Insufficient ventilation is due to reduced ventilatory effort or incapability to overcome increased resistance to ventilation. It affects the overall lung as a result carbon dioxide accumulates. Complications include injury to vital organs due to low level of oxygen in blood, CNS depression due to raised carbon dioxide level, respiratory acidosis. This is eventually lethal if not treated[7].

Regardless of the etiology of respiratory failure, virtually all patients with acute hypoxia will require oxygen supplementation. Oxygen therapy aims to supplement the inspired oxygen concentration to prevent tissue hypoxia and resultant cellular dysfunction[8].

Ventilatory support is required in type 1 or type 2 respiratory failure. This may take in form of continuous positive airway pressure, non-invasive ventilation (mask ventilation) or invasive ventilation (endotracheal ventilation)[9].

The technique for noninvasive ventilation does not involve the tracheotomy, tracheal tube or laryngeal mask bypassing the airway but it involves giving ventilator support by the use of mask. Non-invasive positive pressure ventilation is referred as NIV and applying positive airway pressure invasively using the face mask or nasal mask is referred as continuous positive airway pressure[10].

In COPD patients presenting with acute exacerbations and respiratory failure related to hypercapnia, non invasive ventilation if used in addition to standard protocol reduces the mortality rate and the need for endotracheal intubation is also decreased[11].

An arterial blood gas (ABG) test measures oxygen and carbon dioxide levels in blood. It also measures your body's acid-base (pH) level, in some diseases such as respiratory distress syndrome, renal failure, and pneumonia ABG analysis showed a good validity[7].

METHODOLOGY

This comparative cross sectional study, a semi-structured questionnaire was designed after review from the experts. Data was collected directly from patients after taking consent from them. The participants were approached from ICU and post-surgical wards of Armed Forces Institute of Cardiology and National Institute of Heart Diseases Rawalpindi. Greater than18 years age of male and female participants with type 2 respiratory failure PaO2 of <8 kPa and pCO2 of >6 kPa with a respiratory acidosis pH <7.35 (H ± >45 nmol/L) guidelines provided by british thoracic society were included[8]. Non prob-ability consecutive sampling technique was used. Total 60 patients were enrolled, out of 8 patients excluded due to ventilation. Twenty five patients were in Bi-level positive airway pressure (BIPAP) group and 27 in continuous positive airway pressure (CPAP) group.

Data was analyzed on SPSS-24. Descriptive analysis of variables was done. Shapiro-Wilk test was applied to check the normality. Following variables show *p*-value>0.05 showing normally distributed data includes (baseline and post intervention pCO2, SBP and DBP) and rest of the variables shows *p*-value <0.05 showing skewed data includes (PH, pO2, Supplemental oxygen, Saturation with mask). For the analysis of between the group for parametric variables Independent T-test was used and for non-parametric variables Man Whitney U-test was used. Data was collected pre and post intervention from the participants.

RESULTS

Study included 60 post CABG/valve patients were allocated into Bi-PAP and CPAP group. The demographic profile of our study population is tabulated as table-I.

Table-I: Demographics of study population.

Variable		Group BIPAP n=25, n (%)	Group CPAP n=27, n (%)
Age (years)		61.20 ± 7.69	57.26 ± 9.93
Type of Surgery	CABG	24 (96%)	23 (85.2%)
	Valve	1 (4%)	4 (14.8%)
Gender	Male	20 (80%)	22 (81.5%)
	Female	5 (20%)	5 (18.5%)

Contributing factors like pre-op renal disease 4 (16%) patients in Bi-PAP group and 21 (84%) patients in CPAP group were with the pre-op renal disease history, patients with pre-op lung disease in Bi-PAP group were 9 (36%) and 7 (25.9%) in CPAP group. Two (8%) in Bi-PAP group and 2 (7.4%) in CPAP group patients were with pre-op liver disease. In Modifiable risk factors 10 (40%) in Bi-PAP group and 15 (55.6%) in CPAP group were with post-op pleural effusion. Fifteen (60%) in Bi-PAP group and 14 (51.9%) in CPAP group were having pre-op diabetes. Fifteen (60%) patients were with the history of smoking in Bi-PAP group and 20 (74.1%) in CPAP group. Patients with pre-op history of addictions other than smoking were 6 (24%) in Bi-PAP group while 8 (29.6%) in CPAP group were calculated as modifiable risk factors (table-II).

To analyze vitals parametric Man Whitney U test was applied on bothgroups. It proved that pre inter-

vention diastolic Bp with mean ± SD value of Bi-PAP and CPAP group were 72.28 ± 8.89 and 75.30 ± 10.43 correspondingly with *p*-value of 0.269, that proved that results were not statistically substantial. And post intervention diastolic BP with mean ± SD value in BiPAP and CPAP group was 81.44 ± 4.86 and 79.11 ± 5.39 with *p*-value of 0.109 indicates that results were statistically insignificant. Systolic Bp pre intervention and post intervention results with mean ± SD value of Bi-PAP and CPAP group was 117.84 ± 14.76 and 133.67 ± 14.43 correspondingly with *p*-value of 0.032. Between both the group's results were not found statistically substantial (table-III).

Table-II: Clinical variables of study participants.

Variable		Group BIPAP n=25, n(%)	Group CPAP n=27, n(%)
Myocardial Infarction	Yes	7 (28)	14 (51.9)
	No	18 (72)	13 (48.1)
Asthma	Yes	-	1 (3.7)
	No	25 (100)	26 (96.3)
COPD	Yes	-	-
	No	25 (100)	27 (100)
Liver Disease	Yes	2 (8)	2 (7.4)
	No	23 (92)	25 (92.6)
Lung Disease	Yes	9 (36)	7 (25.9)
	No	16 (64)	20 (74.1)
Renal Disease	Yes	4 (16)	21 (84)
	No	6 (22.2)	21 (77.8)
Diabetes	Yes	15 (60)	14 (51.9)
	No	10 (40)	13 (48.1)
History of Smoking	Yes	15 (60)	20 (74.1)
	No	10 (40)	7 (25.9)
Addiction	Yes	6 (24)	8 (29.6)
	No	19 (76)	19 (70.4)
Pleural Effusion	Yes	10 (40)	15 (55.6)
	No	15 (60)	12 (44.4)
Pneumonia	Yes	1 (4)	-
	No	24 (96)	27 (100)

Table-III: Systolic & diastolic BP before and after treatment with their mean ± SD at baseline and 3rd post op day between BiPAP and CPAP groups.

Variable Systolic & Diastolic Blood Pressure	Group BIPAP n=25 Mean ± SD	Group CPAP n=27 Mean ± SD	*p*-value
dBP-Baseline	72.28 ± 8.89	75.30 ± 10.43	0.269
dBP-Post treatment	81.44 ± 4.86	79.11 ± 5.39	0.109
SBP baseline	117.84 ± 14.76	124.07 ± 26.85	0.310
SBP post treatment	145.36 ± 23.04	133.67 ± 14.43	0.032

Respiratory parameters arterial blood gases (ABGs) were analyzed applying a Non parametric test i.e. Man Whitney U-test was applied for the analysis of pre intervention pCO2 of BiPAP and CPAP group. For pre-intervention value of pCO2 mean ± SD 46.81 ± 6.30 for BiPAP group and 49.16 ± 6.34 for CPAP group with *p*-value of 0.187. For postintervention value of pCO2 mean ± SD 33.01 ± 2.81 for BiPAP group and 34.04 ± 4.30 for CPAP group with *p*-value of 0.355. This result showed that values did not change statistically values but improved clinically additionally there was gradual improvement in PCO2 values, as initially pCO2 levels were high but improved gradually. Also for both groups non parametric Man Whitney U test was applied for the analysis of pO2. Pre intervention pO2 for both groups median (IQ) value of BiPAP and CPAP group was 66.00 (10.1) and 64.00 (10.1) respectively with *p*-value 0.474, and post intervention pO2 median (IQ) value of Bi-PAP and CPAP 149.00 (49) and 146.00 (34) with *p*-value of 0.475. This result showed that pre and post intervention there was no change found statistically but clinically improve with time, initially pO2 values were low but with time values gets improved (table-IV).

Table-IV: PCO2 & PO2 values before and after treatment mean ± SD at baseline and 3rd post op day between BiPAP and CPAP groups. (*p*>0.05) showed no substantial difference while clinically values are gradually moving towards normal ranges.

Variable PCO2 & PO2	Group BIPAP n=25 Mean SD	Group CPAP n=27 Mean ± SD	*p*-value
Baseline PCO2	46.81+ 6.30	49.16 ± 6.34	0.187
Post treatment PCO2	33.01 ± 2.81	34.04 ± 4.30	0.355
Baseline PO2	66.00 (10.1)	64.00 (10.1)	0.474
Post treatment PO2	149.00 (49)	146.00 (34)	0.475

Table-V: Oxygen saturation value before and after treatment mean ± SD at baseline and 3rd post op day between BiPAP and CPAP groups. (*p*>0.05) showed no substantial difference while clinically values are gradually moving towards normal ranges.

Variable SaO2 with mask	Group BIPAP n=25 Median (IQ)	Group CPAP n=27 Median IQ	*p*-value
Baseline	90.00 (5.5)	89.00 (7)	0.194
Post treatment	100.00 (1.5)	99.00 (1)	0.937

To analyze oxygen saturation with mask values of both groups non parametric test was used with their pre-intervention median (IQ) value of Bi-PAP 90.00 (5.5) and CPAP median (IQ) value of 89.00 (7) with *p*-value 0.194, with their post intervention oxygen saturation median (IQ) value of Bi-PAP and CPAP 100.00

(1.5) and 99.00 (1) with *p*-value of 0.937 that proved results were not statistically significant before and after treatment protocol. While oxygen saturation gets improved for both groups and level of required oxygen were gradually decreasing (table-V).

DISCUSION

In postoperative cardiac surgery patients respiratory failure is a consistent finding and also main cause of discomfort to the patients as well as hospital staff and family of the patient[12]. The intention of the study was to identify effects of BiPAP vs CPAP on respiratory failure patients after open heart surgery. The variables considered in this study were age, gender, marital status, type of surgery, diabetes, asthma, COPD, smoking, MI, Dyspnea, lung disease, renal disease, hypertension and use of antihypertensive, pre-operative renal dysfunction, type of surgery, total bypass time, cross clamp time, EF%, time of mechanical ventilation and respiratory parameters ABGs. The total numbers of participants in this study were 60.

In this comparative cross sectional survey we determine effects of BiPAP vs CPAP on respiratory failure patients after open heart surgery, as current study showed that systolic BP had statistically significant difference in both groups but with BiPAP increase in systolic BP is more as compare to CPAP in post treatment period. A study was done in 2018 published in American College of Chest Physicians Journal by Elsevier proved that NIV had immediate increase in blood pressure[13].

Diastolic Bp had statistically no significant difference in CPAP group but with BiPAP increase in systolic Bp is seen as compare to CPAP in post treatment period. A study on effects of NIV on hemodynamics in ARDS patients showed that NIV did not have a significant effect on the hemodynamics by MoretIurilli in 2018 was done. The outcomes of previous studies also correlate with our current study results[14].

Respiratory parameter is measured in this study by ABGs at base line, pre and post of every session for 3 consecutive days results show that there is no statistical significant difference on PH (p>0.001) in both groups. A study was done in 2012 at medical ICU of Henri Mondor Hospital by François Lellouche on acute hypoxemic respiratory distress this study gives evidence that non invasive ventilation have no effect on PH results extended the same with our study[15].

Current study extended significant difference between both groups on pCO2 it showed that there was marked difference between both groups current study results showed that statistical significant difference on pCO2 in both groups. A study was done in 2016 at European Bioinformatics Institute by Waldhorn on respiratory failure patients to compare bi-level positive airway pressure with nasal intermittent positive pres-sure ventilation this study also correlate with this study[16].

A recent study has proved that there was statistically significant difference in pO2 values between both control and experimental group done by Pinhoon effect of continuous positive airway pressure ventilation on PaO2 and PaO2/FiO2 ratio in extubated obese patients. In this study it has been proved that before interventional protocol patients pO2 values were low i.e. below normal ranges but after the application of non invasive ventilation program it was observed that pO2 values starts gradually increasing moving towards normal ranges and clinically patients were stable. The outcomes of both studies also correlate with our current study results[17].

Level of oxygen saturation is measured in our study by saturation probe at base line,pre and post of every session for 3 consecutive days, results show that there is no statistical considerable difference in both groups but clinically patients were improving their oxygen saturation level were improving and their requirement of supplemental oxygen were also decreasing. A study done in 2017 by flenique on ventilatory effects of continuous positive airway pressure in left heart failure patients they have concluded that 2 weeks of continuous positive airway pressure program brings increase oxygen saturation in left heart failure patients who were on medical treatment of left heart failure also. this study concluded same outcomes as proved in our study[18].

RECOMMENDATION

Pre operative identification of patient's that are at high risk of developing post operative respiratory failure can help in early management of respiratory issues and this early management will helpful in patient quick recovery and will prevent pt re-intubation rates due to respiratory issues.

CONCLUSION

The outcomes of our study show that both the BiPAP group and CPAP group have shown improvement in respiratory parameters. We conclude that non-invasive ventilation can be effectively and safely used in type 2 respiratory post coronary artery bypass graft surgery (CABG) patients to improve oxygenation in

mild to moderate level of respiratory insufficiency. It is predominantly useful in patients whose underlying condition warrants avoidance of intubation.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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