

# Comparative Study between Modes of Non Invasive Ventilation for the Management of Type 2 Respiratory Failure in Acute Exacerbation of Chronic Obstructive Pulmonary Disease Patients

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**Abstract:** ***Background:** NIV is currently used in a wide range of acute settings, such as critical care and emergency departments, hospital wards, palliative or pediatric units, and in pre-hospital care. The aim of this study was to assess the effectiveness of S/T-mode BiPAP and AVAPS- mode by applying the clinical and ABG parameters at admission and after 3 hours and 6 hours of applying non invasive ventilation (NIV) in management of Type 2 respiratory failure in acute exacerbation of chronic obstructive pulmonary disease patients. **Material & Methods:** A hospital based, prospective, observational study done on 176 patients of AECOPD with type 2 respiratory failure admitted at Institute of Respiratory Diseases SMS Medical College, Jaipur. **Results:** Our study showed that the comparison of mean age was statistically non-significant ( $=0.5979$  NS) and duration of disease was statistically significant ( $P=0.0004^{***}$ ). The mean value of pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and SaO<sub>2</sub> was statistically non-significant at admission and after 3 hours in between groups, but HCO<sub>3</sub><sup>-</sup> & respiratory rate was statistically significant at admission and after 3 hours in between groups. pH and PaCO<sub>2</sub> was statistically significant after 6 hours in between groups. **Conclusion:** We concluded that NPPV should be the first line intervention in addition to usual medical care to manage respiratory failure secondary to an acute exacerbation of chronic obstructive pulmonary disease in all suitable patients.*

**Keywords:** NIV, COPD, NPPV, ABG

## 1. Introduction

Chronic respiratory failure due to chronic obstructive pulmonary disease (COPD) contributes a significant social and economic burden to individuals, families and the healthcare system. The incidences of COPD, in terms of its combined mortality and disability, was the 12th highest for diseases worldwide in 1990 and is expected to become the fifth highest by 2020, with mortality expected to increase fivefold by 2015.<sup>1-3</sup>

Reduced alveolar ventilation in chronic respiratory failure due to COPD results in nocturnal and daytime gas exchange abnormalities, sleep-disordered breathing, dyspnea and increased work of breathing, which in turn lead to significant functional impairment, morbidity and mortality.<sup>4</sup> The eventual development of chronic respiratory failure is characterized by varying degrees of ventilation-perfusion mismatch, hypoxia and hypercapnia.<sup>5</sup> Reduced respiratory reserve associated with ongoing morbidity renders COPD patients at risk of acute respiratory decompensation.<sup>6,7</sup>

Noninvasive mechanical ventilation (NIV) is used in patients with acute respiratory failure for several different etiologies.<sup>8</sup> The heterogeneity of different patient groups leads to varying levels of success, with the best results produced in patients with infectious exacerbations of COPD and congestive heart failure.<sup>9-11</sup> When NIV is initiated in patients with acute respiratory failure due to infectious exacerbations of COPD, ventilatory parameters are typically determined based on clinical assessment and changes in

blood gases. In this manner, NIV support pressures are manually adjusted by an operator.<sup>12</sup>

One of the limitations of traditional NIV is altered levels of consciousness. However, under certain circumstances, especially those produced by hypercapnic conditions<sup>13-15</sup>, traditional NIV has produced very favorable results, even in patients with hypercapnic coma.<sup>16</sup>

Previous studies that recommend the use of NIV in patients with altered consciousness report a rapid recovery as soon as the ventilatory strategy is established, and most of studies recommend early intubation and suspension of treatment if consciousness does not quickly normalize.<sup>17</sup>

Bilevel positive airway pressure-spontaneous/timed (BiPAP S/T) mode with average volume assured pressure support (AVAPS) allows for setting a fixed tidal volume, and the system output automatically adjusts based on variations in inspiratory pressure to ensure the predetermined target value. Its long-term benefits have been demonstrated in patients with chronic respiratory failure, obstructive sleep apnea, and alveolar hypoventilation syndrome.<sup>18-20</sup>

After the institution of positive-pressure ventilation, the use of noninvasive ventilation (NIV) through an interface substantially increased. The first technique was continuous positive airway pressure; but, after the introduction of pressure support ventilation at the end of the 20th century, this became the main modality. Both techniques, and some others that have been recently introduced and which integrate some technological innovations, have extensively

demonstrated a faster improvement of acute respiratory failure in different patient populations, avoiding endotracheal intubation and facilitating the release of conventional invasive mechanical ventilation. NIV is currently used in a wide range of acute settings, such as critical care and emergency departments, hospital wards, palliative or pediatric units, and in pre-hospital care. It is also used as a home care therapy in patients with chronic pulmonary or sleep disorders. The appropriate selection of patients and the adaptation to the technique are the keys to success.<sup>21</sup>

## 2. Material & Methods

A hospital based, prospective, observational study done on 176 patients of AECOPD with type 2 respiratory failure admitted at Institute of Respiratory Diseases, SMS Medical College, Jaipur, Rajasthan, INDIA from January 2018 to December 2019. Necessary permission was taken from Ethical Committee and Research Review Board of SMS Medical College, Jaipur.

### Inclusion Criteria

- 1) All cases of acute exacerbation of COPD with type 2 respiratory failure as per GOLD guidelines 2018,
  - Respiratory acidosis ( $\text{PaCO}_2 > 45$  mm of Hg and arterial pH  $< 7.35$ ).
  - Severe dyspnea with clinical signs suggesting of respiratory muscle fatigue, increased work of breathing, or both, such as use of respiratory accessory muscles, paradoxical motion of abdomen, or retraction of costal spaces.
  - Persistent hypoxemia despite supplemental oxygen therapy.
- 2) Those who give written informed consent.

### Exclusion Criteria:

- 1) Indication for endotracheal intubation,
- 2) Hypotension defines systolic blood pressure  $< 90$  mm of Hg and diastolic blood pressure  $< 60$  mm of Hg,
- 3) Presence of ventricular or atrial arrhythmia,
- 4) Inability to co-operate with the fitting and wearing of the face mask,
- 5) Presence of upper airway obstruction or facial trauma or presence of tracheostomy,
- 6) Unconscious patient,
- 7) Un-drained pneumothorax,
- 8) Vomiting,
- 9) Patient declines treatment,
- 10) Severe co-morbidities.

## 3. Procedure

Patients were classified into 2 groups; Group 1 – S/T Mode BiPAP group and Group 2 – AVAPS Mode group. Ventilatory parameters were initially programmed in the BiPAP S/T mode and AVAPS with an inspiratory positive airway pressure (IPAP) maximum programmed into the device of 26 cm of H<sub>2</sub>O, to IPAP minimum programmed value of 12 cm of H<sub>2</sub>O and an expiratory positive airway pressure (EPAP) of 6 cm of H<sub>2</sub>O. The programmed tidal volume was at 8 to 12 ml/kg of IBW and once the patient

reached clinical stability, the target Vt in our patients were re-programmed to 6–8 ml/kg of IBW according to manufacturer's specifications. The decision was made by the expert physician in charge of patient case dependent, respiratory rate was 15 breaths/min, rise time set at 300–400 ms and inspiratory time was at a minimum of 0.6 second, were given supplement O<sub>2</sub> via an adapter circuit close to the facemask in order to maintain SaO<sub>2</sub> above 90%. Patients were maintained on continuous NIV initially.

### Measurements:

Arterial blood gases were measured at initial values, 3 hours and 6 hours during NIV; the patients were assessed by a respiratory therapist under close supervision of a physician trained in NIV. Mask use, complications, and tolerance were also assessed.

Disease severity was assessed using the Encephalopathy Score (EC) to determine the patient's level of consciousness. Maximum Vt, maximum IPAP, EVT, Vmin, leaks, respiratory rate, heart rate, systolic blood pressure, diastolic blood pressure, and IPAP were measured upon hospitalization, 3 hours, and 6 hours during NIV.

### Outcome variables:

Comparison of pH, PaO<sub>2</sub>, PaCO<sub>2</sub>, HCO<sub>3</sub><sup>-</sup>, SaO<sub>2</sub>, respiratory rate and consciousness level (ENCEPHALOPATHY SCORE) on admission and after 3 and 6 hour of applying Non Invasive Ventilation (NIV).

### Statistical analysis:

The mean values were compared using Student's t-test. For categorical variables  $\chi^2$  or fisher's exact tests were used as appropriate. We used student paired t- test to compare the ability of different variables to predict the outcome of therapy in experimental and control patients. A P value  $< .05$  was considered statistically significant.

## 4. Results

**Table 1:** Comparison between Group 1 (S/T Mode Bi PAP) & Group 2 (AVAPS Mode) regarding arterial blood gas (ABG) analysis at admission of patients

Arterial blood gas analysis (ABG)	Group 1 (S/T Mode Bi PAP)	Group 2 (AVAPS Mode)	P-value
pH	7.309±0.03395	7.311±0.04060	0.7173
PaCO <sub>2</sub>	72.83±53.69	65.01±12.63	0.1877
PaO <sub>2</sub>	58.74±9.952	60.57±9.273	0.2113
SaO <sub>2</sub>	68.44±10.31	70.93±9.214	0.0943
HCO <sub>3</sub> <sup>-</sup>	27.02±5.774	25.21±4.607	0.0235*
Respiratory rate	34.10±4.327	32.52±4.234	0.0155*

Table 1 shows that the mean value of pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and SaO<sub>2</sub> was 7.309 ± 0.03395, 72.83 ± 53.69, 58.74 ± 9.952 & 68.44 ± 10.31 respectively in group 1 and 7.311 ± 0.04060, 65.01 ± 12.63, 60.57 ± 9.273 & 70.93 ± 9.214 respectively in group 2, which was statistical non-significant (P=0.7173, P=0.1877, P=0.2113 & P=0.0943 respectively). The mean value of HCO<sub>3</sub><sup>-</sup> & respiratory rate was 27.02 ± 5.774 & 34.10 ± 4.327 respectively in group 1 and 25.21 ± 4.607 & 32.52 ± 4.234 respectively in group 2, which was statistical significant (P=0.0235\* & P=0.0155\*

respectively) at admission.

**Table 2:** Comparison between Group 1 (S/T Mode Bi PAP) & Group 2 (AVAPS Mode) regarding arterial blood gas analysis after 3 hours

Arterial blood gas analysis (ABG)	Group 1 (S/T Mode Bi PAP)	Group 2 (AVAPS Mode)	P-value
pH	7.345±0.04851	7.338±0.04367	0.3099
PaCO <sub>2</sub>	56.36±8.363	56.77±9.836	0.7698
PaO <sub>2</sub>	68.52±9.876	66.60±10.75	0.2217
SaO <sub>2</sub>	80.09±7.80	78.31±9.817	0.1885
HCO <sub>3</sub> <sup>-</sup>	26.92±5.648	25.34±4.526	0.0432*
Respiratory rate	24.92±3.807	23.20±4.326	0.0059**

Table 2 shows that the mean value of pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and SaO<sub>2</sub> was 7.345 ± 0.04851, 56.36 ± 8.363, 68.52 ± 9.876 & 80.09 ± 7.80 respectively in group 1 and 7.338 ± 0.04367, 56.77 ± 9.836, 66.60 ± 10.75 & 78.31 ± 9.817 respectively in group 2, which was statistical non-significant (P=0.3099, P=0.7698, P=0.2217 & P=0.1885 respectively). The mean value of HCO<sub>3</sub><sup>-</sup> & respiratory rate was 26.92 ± 5.648 & 24.92 ± 3.807 respectively in group 1 and 25.34 ± 4.526 & 23.20 ± 4.326 respectively in group 2, which was statistical significant (P=0.0432\* & P=0.0059\* respectively) after 3 hours.

**Table 3:** Comparison between Group 1 (S/T Mode Bi PAP) & Group 2 (AVAPS Mode) regarding arterial blood gas analysis after 6 hours

Arterial blood gas analysis (ABG)	Group 1 (S/T Mode BiPAP)	Group 2 (AVAPS Mode)	P-value
pH	7.370±0.04861	7.355±0.03950	0.0311*
PaCO <sub>2</sub>	46.03±7.163	50.05±8.543	0.0010***
PaO <sub>2</sub>	76.09±10.73	73.54±11.96	0.1403
SaO <sub>2</sub>	101.9±9.639	87.53±8.356	0.1669
HCO <sub>3</sub> <sup>-</sup>	26.41±5.310	25.26±4.811	0.1372
Respiratory rate	16.09±2.165	16.29±2.282	0.5631

Table 3 shows that that the mean value of PaO<sub>2</sub>, SaO<sub>2</sub>, HCO<sub>3</sub><sup>-</sup> & Respiratory rate was 76.09 ± 10.73, 101.9 ± 9.639, 26.41 ± 5.310 & 16.09 ± 2.165 respectively in group 1 and 73.54 ± 11.96, 87.53 ± 8.356, 25.26 ± 4.811 & 16.29 ± 2.282 respectively in group 2, which was statistical non-significant (P=0.1403, P=0.1669, P=0.1372 & P=0.5631 respectively). The mean value of pH & PaCO<sub>2</sub> was 7.370 ± 0.04861 & 46.03 ± 7.163 respectively in group 1 and 7.355 ± 0.03950 & 50.05 ± 8.543 respectively in group 2, which was statistical significant (P=0.0311\* & P=0.0010\*\*\* respectively) after 6 hours.

**Table 4:** Comparison between Group 1 (S/T Mode Bi PAP) & Group 2 (AVAPS Mode) regarding Consciousness level at various interval

Consciousness level (Encephalopathy Score)	Group 1 (S/T Mode BiPAP)	Group 2 (AVAPS Mode)	P-value
At admission	1.609±0.6534	1.552±0.6779	0.5698
After 3 hours	0.5930±0.6576	0.5647±0.6805	0.7823
After 6 hours	0.1149±0.3552	0.2529±0.487	0.0343*

Table 4 shows that the mean value of consciousness level according to ES score was 1.609 ± 0.6534 in group 1 &

1.552 ± 0.6779 in group 2 at admission, after 3 hours was 0.5930 ± 0.6576 in group 1 & 0.5647 ± 0.6805 in group 2 and after 6 hours was 0.1149 ± 0.3552 in group 1 & 0.2529 ± 0.487 in group 2. The comparison of mean value was statistical non-significant at admission after 3 hours (P=0.5698 & P=0.7823 respectively), but statistical significant after 6 hours (P=0.0343\*) in between groups.

## 5. Discussion

Non invasive ventilation (NIV) is the first option for ventilatory support in acute respiratory failure of COPD exacerbations or acute cardiogenic pulmonary edema and should be considered in immunocompromised patients, prevention of post extubation failure and in difficult weaning. It can also be used in the postoperative period and in cases of pneumonia and asthma or as a palliative treatment. NIV is currently used in a wide range of settings, from the ICU to home care. The requirement for mechanical ventilation (MV) is a common reason for frequent admission to an ICU. The major indication for MV is respiratory failure which is considered the most frequent vital organ failure seen in seriously ill patients.

Our study showed that the mean age of group 1(S/T Mode Bi PAP) was 59.78 years & group 2 was 58.90 yrs, which was statistical non-significant (=0.5979 NS). The majority of patients was male (76.43%) & rest were female (23.57%) in both groups. Killen Harold Briones Claudett et al (2013)<sup>22</sup> found mean age of all patients was 78.68 ± 10.42 years, 9 patients were women (40.9%) and 13 were men (59.1%).

Our study showed that the mean value of pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and SaO<sub>2</sub> was statistical non-significant at admission and after 3 hours in between groups, but HCO<sub>3</sub><sup>-</sup> & Respiratory Rate was statistical significant at admission and after 3 hours in between groups. pH and PaCO<sub>2</sub> was statistical significant after 6 hours in between groups. Plant and colleagues<sup>23</sup> (2000) concluded that patients in the NIV group had a more rapid improvement in arterial pH and respiratory rate. In patients who were more acidotic (pH < 7.30) the benefit from NIV was limited, suggesting that the appropriate location for treatment of this more severely ill subgroup of patients is the intensive care unit (ICU) and not the general ward.

Lightowler JV et al<sup>24</sup> (2003) found greater improvements at 1 hour in pH (weighted mean difference 0.03 (0.02 to 0.04)), PaCO<sub>2</sub> (weighted mean difference -0.40 kPa (-0.78 to -0.03)), and Respiratory rate (weighted mean difference -3.08 breaths per minute (-4.26 to -1.89)).

Killen Harold Briones Claudett et al<sup>22</sup> (2013) observed that statistically significant differences in favor of the BiPAP S/T+AVAPS group in GCS (P = .00001), pCO<sub>2</sub> (P = .03) and maximum inspiratory positive airway pressure (IPAP) (P = .005) among others. BiPAP S/T with AVAPS achieves the required inspiratory pressure for a pre determined tidal volume (Vt), ensuring optimal pressure for the patient and provides a suitable inspiratory volume; this rapidly overcomes alveolar hypoventilation, corrects PaCO<sub>2</sub> levels, and also decreases carbon di oxide level in the brain that improves the level of consciousness of the patients.



We observed a rapid and significant improvement in arterial blood gases and consciousness (ES score) in both groups; however, patients treated with BiPAP S/T improved much faster than patients treated with the AVAPS, with a near-complete recovery within 6 hours. The improvement in the BiPAP ST group was probably linked to the rapid improvement in exhaled tidal volume (EVT) and the fact that, in these patients, IPAP quickly reached the levels needed for maintaining appropriate tidal volume, and hypoventilation was corrected with consequent improvements in alveolar ventilation. Which was compatible with Killen Harold Briones Claudett et al<sup>22</sup> (2013) and RIAZ HUSSAIN et al<sup>25</sup> (2018) concluded that BiPAP S/T+AVAPS facilitates faster recovery of consciousness in comparison of traditional BiPAP S/T mode. We must also consider that patients in both groups experienced a rapid improvement in Encephalopathy Score (ES) of 2 points or more within 3 hours of starting treatment; a lack of improvement of 2 points could be a determining factor for rapid endotracheal intubation, which would obviously constitute an invasive procedure.

## 6. Conclusion

We concluded that NPPV should be the first line intervention in addition to usual medical care to manage respiratory failure secondary to an acute exacerbation of chronic obstructive pulmonary disease in all suitable patients. NPPV should be tried early in the course of respiratory failure and before severe acidosis, to reduce mortality, avoid endotracheal intubation, and decrease treatment.

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