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# Intelligent volume assured pressure support (iVAPS) vs. spontaneous/timed mode as a weaning strategy for intubated COPD patients with acute exacerbation

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# Intelligent volume assured pressure support (iVAPS) vs. spontaneous/timed mode as a weaning strategy for intubated COPD patients with acute exacerbation



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**Abstract**

**Introduction:** Noninvasive positive-pressure ventilation (NPPV) is applied to facilitate weaning process and decrease complications associated with prolonged intubation. Interest has emerged in using Intelligent Volume Assured Pressure Support (iVAPS) to facilitate earlier removal of an endotracheal tube.

**Material and methods:** This study was conducted to compare the effectiveness of iVAPS versus standard Spontaneous/timed (S/T) mode in facilitating weaning process of mechanically ventilated chronic obstructive pulmonary disease (COPD) in acute exacerbation**.** In a prospective randomized study, 80 invasively ventilated COPD patients in acute exacerbations were extubated then immediate application of NPPV using either S/T mode (Group I) or iVAPS mode (Group II) was done. Clinical parameters (heart rate, respiratory rate, and arterial blood gas parameters at selected time intervals of treatment were recorded for both groups and analyzed.

**Results:** No significant differences were found between both groups regarding age, sex, mMRC dyspnea scale, CAT score and APACHE II score. Heart rate and mean arterial blood pressure in the two groups decreased with time, but no significant differences were found between the two groups. Likewise, there was no significant

difference in RR between S/T and iVAPS groups. Regarding arterial blood gas analysis, there were no detectable differences in $PaCO_2$ level, $PaO_2$ level or oxygen saturation**.** The successful outcome was achieved in (82.5%) in the S/T group vs (80%) in the iVAPS group. The two modes achieved comparable levels of comfort as assessed by VAS and the total Mask Fitness Score. There was no statistically significant difference in reintubation, the duration of NPPV, duration of ICU stay or in mortality rate.

**Conclusion:** iVAPS mode is as effective as fixed-pressure S/T mode in facilitating weaning of hypercapnic COPD patients.

**Key words:** intelligent volume assured pressure support, weaning, noninvasive positive-pressure ventilation

## Introduction

The role of noninvasive positive pressure ventilation (NPPV) in management of acute hypercapnic respiratory failure (AHRF) has expanded to include facilitation of weaning from mechanical ventilation. Using of NPPV during weaning process has been found to reduce mortality, increase weaning success, decrease the incidence of ventilator-associated pneumonia, shorten the length of ICU and hospital stay, decrease the need for tracheostomy, decrease reintubation and shorten the duration of mechanical ventilation [1].This is achieved through reducing the work of breathing, providing respiratory muscle unloading (including offsetting the effects of intrinsic positive end expiratory pressure (PEEP)), improving alveolar ventilation and increasing oxygenation [2]. Noteworthy, most of the previous studies used the fixed pressure support ventilation (PSV) as the NPPV mode [3].

Intelligent Volume Assured Pressure Support (iVAPS) is a recent mode of NPPV, which relies on applying a target alveolar volume and adjusts pressure and respiratory rate automatically to achieve optimal ventilatory support [4]. The mode takes into account the dead space ventilation — which is predicted through a formula based on the patient's height — thus ensuring adequate ventilation reaching the alveoli themselves, which are — in the end — the main unit of respiration [5]. The delivered pressure support during inspiration is not fixed, but it ranges between a minimum and a maximum value to reach the target alveolar ventilation in spite of

variations in patient's ventilatory drive or respiratory mechanics [6, 7]. This new mode has been investigated in stable chronic obstructive airway disease (COPD) patients with domiciliary NPPV, in which iVAPS was comparable to PSV regarding improvement in partial pressure of oxygen in arterial blood ($PaO_2$), partial pressure of carbon dioxide in arterial blood ($PaCO_2$), oxygen saturation by pulse oximetry ($SpO_2$) and therapy compliance at 3 months, along significant improvement in both Medical Research Council (MRC) dyspnea scale and health-related quality of life measures [8, 9]. Recently, studies that investigated the outcomes in AHRF due to acute exacerbations of chronic obstructive airway disease (AECOPD) found that iVAPS showed improvement in $PaCO_2$ and pH and also achieved a minute ventilation, pressure support, respiratory rate and hemodynamics that were comparable to PSV [10, 11].

Yet, the performance of iVAPS mode as a weaning modality has not been addressed. Thus, the purpose of this study was to compare the outcomes of NPPV as a weaning strategy using iVAPS mode to those using standard spontaneous /timed (S/T) mode in COPD patients with acute exacerbation; regarding arterial blood gases (ABGs) parameters, patient comfort, need for re-intubation, duration of NPPV, length of stay (LOS) in ICU and mortality.

**Patients**

This prospective randomized controlled study was conducted on 80 mechanically ventilated COPD patients in acute exacerbation from October 2017 to October 2020. A written consent was obtained after extubation and before application of NPPV. The study was approved by the Ethical Committee of Faculty of Medicine, Assiut University and registered on *Clinical Trial* protocol registration system, ID: *NCT03222271*. All COPD patients who were intubated for acute exacerbation, were hypercapnic ($PaCO_2$ > 45 mmHg) and had planned extubation following a spontaneous breathing trial (SBT) were eligible for this study. Exclusion criteria included age <18 years, contraindications to NPPV (Haemodynamic instability, facial injuries or deformities interfering with application of NPPV interface, repeated vomiting), tracheostomy or other chest diseases (pneumonia, bronchiectasis, pulmonary embolism, pulmonary fibrosis) and inability to give informed consent.

## Materials and methods

### *Study Protocol*

All patients were subjected to history and clinical examination (including age, sex, smoking history, presence of comorbidities, and number of exacerbations during the last year). Severity was assessed using modified Medical Research Council dyspnea scale (mMRC) (12), COPD Assessment Tool (CAT) score [13] and Acute Physiology and Chronic Health Evaluation (APACHE II) score [14].

- **Spontaneous Breathing Trial (SBT):**

SBT was attempted once the patients achieved stability regarding clinical, neurological and biochemical parameters (Alertness and cooperation, systolic blood pressure (SBP) > 90 mmHg without positive inotropes, heart rate (HR) < 110 with no significant arrhythmia, respiratory rate (RR) < 25 breath/min., ability to initiate respiratory effort, pH ≥ 7.35, $PaO_2$ ≥ 60mmHg and $SaO_2$ ≥ 90% on FiO2 ≤ 40%, serum haemoglobin and electrolytes' levels within the normal range). The SBT was done using minimal inspiratory pressure augmentation of 8 cm $H_2O$ and PEEP of 5 cm $H_2O$ and patients were assessed after 30 minutes. Failure of SBT was considered if pH was < 7.35, $PaCO_2$ > 50 mmHg or increased > 15–20% above baseline, $PaO_2$ < 50 mmHg, HR > 100 bpm or respiratory rate RR > 35 cycle/min [15]. The following parameters were recorded from the monitoring screen of the ventilator for the patients while on SBT: Respiratory rate (breath/min.), exhaled tidal volume (VTe) (mL) and exhaled minute ventilation (MV) (L/min.), Rapid Shallow Breathing Index (RSBI) (ratio of respiratory frequency to tidal volume expressed in breaths/min/L) [16], Airway Occlusion Pressure 0.1 second after start of inspiration (P 0.1) [17] and Negative Inspiratory force (NIF) (cm $H_2O$) (pressure that can be generated against an occluded airway during one second of maximal inspiratory effort, initiated near residual volume) [18].

- **Weaning to NPPV:**

The patients were randomized to receive NPPV using either S/T mode (Group I) (40 patients) or iVAPS mode (Group II) (40 patients) via a portable noninvasive ventilator (Res MED (S9 VPAPTM ST), ResMed Inc., Sydney, Australia). Randomization was performed using the random assignment technique formally prepared by a computer-generated program.

The following settings were adjusted for S/T mode with the: Inspiratory Positive Airway Pressure (IPAP): 12–20 cm $H_2O$, Expiratory Positive Airway Pressure (EPAP): 5–8 cm $H_2O$, Respiratory rate (RR): 10–12 breath/minute [11].

The following parameters were used for iVAPS mode **:** minimum Pressure Support: 8–10 cm$H_2O$**,** maximum Pressure Support: 13–15 cm $H_2O$, Expiratory Positive Airway Pressure (EPAP): 5–8 cm $H_2O$**,** Respiratory rate: 10–12 breath/min. The Patient's height in cm was introduced. The equivalent target alveolar ventilation was calculated based on the patient's height using a special formula that calculates dead space [19], where *Dead Space Ventilation (VD) =120x(h/175)*$^{2.363}$. Target alveolar ventilation was adjusted provided that tidal volume was 6–8 mL/kg of ideal body weight [11]**.**

Oxygen supply was provided using a connection between a central oxygen source and the oxygen port of the NPPV interface (oronasal vented mask (Mirage QuattroTM mask, ResMed Inc., Sydney, Australia). The flow (4–8 L/min.) was adjusted to ensure $SaO_2$ of > 92 %.

***Outcome measures***

The patients were kept under a strict observation and monitoring; where continuous monitoring of HR, RR and mean arterial blood pressure (MAP) was done and ABGs analysis was performed at selected time intervals (1, 2 , 12 , 24 and 48 hs) after initiation of NPPV therapy. Also, the duration of respiratory support, hospital and ICU length of stay were assessed, as well as the level of patient's comfort. The patient's comfort was assessed using Visual Analogue Scale (VAS) and the mask fitness score. VAS ranged from 0–10 cm, with 0 value representing maximum comfort and 10 representing maximum discomfort [20]. The mask fitness score is a questionnaire in which patients are asked about feeling pain in the forehead, nose, cheeks, and chin, air leak at eyes and mouth, dry nose and mouth, skin inflammation and claustrophobia. Each item is scored 0 to 3 in terms of intensity. The total score (36 points) is calculated by adding the individual scores of the individual item [21]. Both scores were recorded at 1, 2, 12, 24 and 48 hours of NPPV initiation.

Success of NPPV was considered when the patients were able to achieve the following: pH > 7.35, decrease in $PaCO_2$ of > 15–20%, $PaO_2$ > 60 mmHg, $SaO_2$ >

90% on $FiO_2$ < 40%, respiratory rate < 24 bpm and no signs of respiratory distress [22]. Failure was defined by failure to achieve all the mentioned criteria by the end of a 48-hour time window or if re-intubation was needed at any point within the next 48 hours after extubation. Endotracheal intubation (ETI) was performed in the presence of one major criterion including cardiac or respiratory arrest; hemodynamic instability, life threatening arrhythmias, inability to protect the airways; coma or psychomotor agitation and intolerance to NPPV interface; and two of the following minor criteria: RR > 35/min., $PaO_2/FiO_2$ < 200 mmHg, and respiratory acidosis (pH < 7.30) [11].

***Statistical Analysis***

Statistical analysis was performed using the Scientific Package of Social Statistics (SPSS) software, version 20. For descriptive statistics, quantitative data were expressed in terms of mean $\pm$ SD while qualitative data were expressed in terms of frequency and percentage. For inferential statistics, parametric tests were employed for analysis of normally distributed data and non-parametric tests were used for abnormally distributed data. For quantitative data, Student's t-test or Mann-Whitney's tests were used for comparing means between Group I and Group II, while qui square test was used for comparing qualitative data. For repeated measures of vital signs and ABG parameters in both study groups, repeated measures ANOVA test was used to detect within-group and between-group statistical difference.

***Ethical approval and consent to participate***

The research received ethical approval from the Ethics Committee of the Faculty of Medicine. The data were confidential. All procedures in the current study were performed according to the ethical standards of the institutional research committee.

**Results**

Totally, the study included 80 COPD under IMV. The mean age of the patients was 64 years, 58 (72.5%) of them were males and 22 (27.5%) were females, 28.7% were nonsmokers, 43.8 % were ex-smokers and 27.5% were current smokers. The mean smoking index among smokers was 52.8 (+ 27.2 SD). The mean mMRC score of

studied population was 2.8 + 0.7 and the mean CAT score was 26.5 + 8.3 (Data are not shown in the tables). There were no significant differences between patients in group I (S/T mode) and group II (iVAPS mode) regarding age, sex, smoking status, mMRC dyspnea scale, CAT scores, APACHE II score and the number of exacerbations (Table 1)**.** No differences were observed between the two groups regarding the duration of mechanical ventilation, VTe, MV, NIF or P0.1 during the SBT (Table 1). Ventilatory settings used for each group are presented in Table 2.

***Vital Signs and Arterial Blood Gas Analyses***

Vital signs in both groups at 1,2, 12, 24, and 48 h are presented in Table 3. The results suggested that the HR and the MAP in the two groups decreased with time, but the decrease throughout time was not statistically significant. Also, no significant differences were found between the two groups when compared to each other. The RR remained fairly stable over time in both groups and showed no significant difference between the S/T group and the iVAPS group.

ABGs analyses showed a slight increase in $PaCO_2$ level, with no significant difference between both groups. Also, There was no detectable difference regarding $PaO_2$ level and arterial blood oxygen saturation throughout time in either group or between the two groups (Table 3).

***Outcome measures***

As shown in Table 4, There was no statistically significant difference between the two groups as regards success rate 82.5 % in S/T mode vs 80% in iVAPS mode. The incidence of reintubation (17.5 %) in ST mode vs. (20%) in iVAPS mode**.** Reasons for reintubation included pneumonia (13 patients; 16.25%), hypertensive crisis and pulmonary oedema (1 patient; 1.25%) and stridor (1 patient; 1.25%). The two modes achieved comparable levels of comfort as assessed by VAS and the total Mask Fitness Score. There was no statistically significant difference in duration of NPPV, in the duration of ICU stay or mortality rate.

**Discussion**

In the present study, iVAPS mode was found to be comparable to the standard S/T mode regarding changes in vital signs and arterial blood gases after extubation. Also, iVAPS mode achieved a similar level of comfort when compared by S/T mode. The overall success, frequency of intubation and mortality rates didn't differ significantly between the two modes.

The use of iVAPS mode had a similar effect on physiological parameters over time as compared with S/T mode. This is in line with Cao et al. who used a prospective, randomized controlled trial in the general respiratory wards to establish whether the ventilatory strategy with volume-targeted noninvasive ventilation (VT-NIV) was more effective than pressure limited. The authors randomized subjects with acute-on-chronic hypercapnic respiratory failure, (e.g., COPD, bronchiectasis, and obstructive sleep apnea syndrome). The authors reported that none of the physiological parameters including HR, systolic blood pressure (SBP), diastolic blood pressure (DBP) or blood gases differed significantly between the two groups, suggesting that NPPV is the cornerstone in acute hypercapnic respiratory failure, whatever mode is used (23). On the other hand, other studies demonstrated no advantage of iVAPS versus PS in chronic stable COPD patients [24, 25].

In contrast, statistically significant differences in terms of higher pH ($7.34 \pm 0.02$ vs $7.31 \pm 0.02$ for PS group) and significantly ($p < 0.001$) lower $PaCO_2$ ($74.00 \pm 2.3$ vs $79.00 \pm 3.7$ for PS group) after 1 h ventilation were found by Hussein et al, who studied forty patients with hypercapnic respiratory failure and respiratory acidosis due to AECOPD after failure of conventional medical treatment including oxygen therapy, who received iVAPS or S/T. The author demonstrated that using iVAPS was characterized by stable alveolar ventilation with lower and variable inspiratory pressure and earlier improvement of respiratory acidosis when compared with conventional pressure support [11]. Also, Claudette et al. revealed statistically significant differences in favor of the average volume-assured pressure support (AVAPS) group in pH and $PaCO_2$ [26].

iVAPS was studied for hypercapnic COPD patients in a limited number of previous recent clinical trials. El-Abdin et al, compared non invasive iVAPS mode and PS in patients with AHRF due to different causes and revealed that there was a greater decrease in $PaCO_2$ during iVAPS [27]. In chronic hypercapnic patients with obstructive sleep apnea and alveolar hypoventilation syndrome, some authors

reported a rapid improvement in $PaCO_2$ and sleep quality using VAPS [28, 29], while others reported no difference between AVAPS and PSV [30].

Also, there was no statistically significant difference between the two study groups as regards the frequency of re-intubation, duration of NPPV or ICU stay or in mortality rate. This was in line with Hussein et al., who reported a successful outcome in 15 patients (75%) of S/T mode users vs. 16 patients (80%) of iVAPS mode users [11]. Similarly, El-Abdin AZ. et al. found a success rate of 66.7 % of patients in S/T group were successfully treated vs. 56.7% of the patients in the AVAPS group, with the difference being statistically insignificant [27].

The two modes achieved a comparable level of comfort and tolerance to NPPV interface. The VAS was similar in both groups. These findings are in-line with those published by Cao et al. [23] and also in the study conducted by Nilius et al, in which iVAPS mode allowed application of higher pressures to meet the target $PaCO_2$ without affecting sleep quality or inducing ventilation-associated events [31]. However, iVAPS was found to supersede ST mode in other studies [32, 33]. Still, it's to be noted that the above studies used different measures of comfort than what was used in the current study. Also, they reported their outcomes after an extended period of time 3-6 months, which may have allowed more acclimatization to iVAPS settings.

**Conclusion**

iVAPS mode is as effective as fixed-pressure S/T mode in facilitating weaning of hypercapnic COPD patients.

The study has a number of limitations. First, it included a relatively small number of patients because of the emergence of COVID-19 pandemic, which limited the number of available patients considerably as the focus of ICU teams shifted to management of patients suffering from acute respiratory failure due to the novel virus. Second, the majority of patients had at least one -if not multiple- comorbidities, which may have influenced the final outcome. However this reflects the real life situation, where most COPD patients suffer other comorbidities. Third, the inspiratory pressures used in iVAPS mode were relatively lower than what has been used in published work, which might have negatively affected its performance. Yet, given the conflicting results of the use of high pressures in acute exacerbations of COPD and concerns about gastric insufflation and subsequent asynchrony with NPPV, the use of

moderate ventilatory pressures as recommended by NPPV guidelines was preferred. Moreover, several studies that used higher ventilatory pressures for both ST mode and iVAPS mode found no statistically significant difference in the outcomes between the two modes.

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**Conflict of interests**

None declared.

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**Table 1.** Demographic Data & Data at time of SBT of COPD patients weaned by ST mode (Group I) and iVAPS mode (Group II)

| **Parameter** | **Group I (ST)** *N = 40* | | **Group II (iVAPS)** *N = 40* | | P Value |
|---|---|---|---|---|---|
| **Age** *(Years)* | 64.4 ± 10.6 | | 62.7 ± 8.5 | | 0.433 |
| **Gender** | | | | | |
| *Males* | 30 | 75% | 28 | 70% | |
| *Females* | 10 | 25% | 12 | 30% | 0.617 |
| **Smoking History** | | | | | |
| *Ex-smokers* | 15 | 37.5% | 20 | 50% | |
| *Current smoker* | 12 | 30% | 10 | 25% | 0.524 |
| *Non smoker* | 13 | 32.5% | 10 | 25% | |
| **Comorbidities N (%):** | | | | | |
| *No Comorbidities* | 10 | 25% | 10 | 25% | |
| *One Comorbidity* | 8 | 20% | 20 | 50% | 0.008 |
| *≥ Two Comorbidities* | 22 | 55% | 10 | 25% | |
| **mMRC Score** | 2.7 ± 0.6 | | 2.7 ± 0.6 | | 0.961 |
| **CAT Score** | 24.9 ± 7.5 | | 26.5 ± 8.7 | | 0.410 |

| | | | |
|---|---|---|---|
| **APACHE II score** | 23.2 ±4.1 | 23.3 ± 3.1 | 0.880 |
| **No. of Exacerbations** | 3.6 ± 2.5 | 4.3 ± 1.6 | 0.132 |
| **Duration of MV** (Days) | 4.4 ± 2.4 | 4.7 ± 2.8 | 0.665 |
| **VTe *(mL)*** | 362.5 ± 115.8 | 381 ± 106.1 | 0.361 |
| **MVe *(L/min)*** | 8.3 ± 2.6 | 8.7 ± 2.4 | 0.473 |
| **RSBI** | 73.6 ± 31.3 | 66.9 ± 26.7 | 0.296 |
| **NIF** ($cmH_2O$) | -25.7 ± 9.9 | -24.8 ± 8.3 | 0.711 |
| **P0.1** | -3.4 ± 1.5 | -3.6 ± 1.4 | 0.490 |

APACHE II — Acute Physiology&Chronic Health Evaluation II; CAT — COPD Assessment Tool; iVAPS — intelligent Volume Assured Pressure Support; mMRC — modified Medical Research Council Score; MV — mechanical ventilation; MVe — exhaled minute ventilation; NIF — negative inspiratory force; P0.1 — Occlusion Pressure 0.1 sec after beginning of inspiration; RSBI — Rapid Shallow Breathing Index; SBT — Spontaneous Breathing Trial; ST — spontaneous-timed; VTe — exhaled tidal volume

**Table 2. NPPV Settings used in ST mode vs. iVAPS mode**

| | **(Group I (ST** *N = 40* | **(Group II (iVAPS** ***N = 40*** |
|---|---|---|
| **(RR (breath/min** | 1.3 ± 11 | 1.3 ± 10.9 |
| **Inspiratory Pressure ($cmH_2O$)** | | |
| *IPAP* | 19 ± 1.8 | **NA** |
| *PS Max.* | NA | **$PS_{Max}$=14.6 ±0.95** |
| *PS Min* | NA | **$PS_{Min}$ = 8.1 ±0.98** |
| **(PEEP ($cmH_2O$** | 1.1 ± 6.1 | **1.1 ± 5.7** |
| **(Target Va (L/min** | NA | **0.75 ± 3.9** |

| | | |
|---|---|---|
| **(Target MV (L/min** | NA | **0.6 ± 5.46** |
| **(Target TV (ml** | NA | **46.9 ± 479.9** |
| **(Target TV (ml/kg/IBW** | NA | **1.07 ± 7.78** |

All data are expressed as Mean + SD. IPAP — Inspiratory Positive Airway Pressure; MV — Minute Ventilation; NA — not applicable in this mode; PEEP — Positive End Expiratory Pressure; PS — Pressure Support; RR — Respiratory Rate; TV — Tidal Volume; Va — alveolar Ventilation

**Table 3.** Changes in vital signs over time between COPD patients weaned by ST mode and iVAPS mode

| **Parameter** ***(Mean +SD)*** | | **1 hour** | **2 hours** | **12 hours** | **24 hours** | **48 hours** | **P-value** |
|---|---|---|---|---|---|---|---|
| **Vital Signs** | | | | | | | |
| **HR** ***(bpm)*** | **ST** | 95 ± 18.4 | 92.6 ± 14.6 | 87 ± 13.1 | 89.6 ±16 | 89.5 ±16 | $P_1 = 0.080$ $P_2 = 0.067$ |
| | **iVAPS** | 93.3 ± 14.3 | 93.3 ± 15.4 | 92 ± 14.7 | 90.6 ±13.8 | 90.9 ±14 | |
| **MBP** ***(mmHg)*** | **ST** | 90 ± 10.8 | 90 ± 10.8 | 89.2 ± 7.4 | 89.7 ± 6.7 | 89.6 ± 8.8 | $P_1 = 0.838$ $P_2 = 0.547$ |
| | **iVAPS** | 90.2 ± 9.1 | 90.2 ± 9.1 | 88.5 ± 7.9 | 88.5 ± 9.7 | 88.5 ± 10.3 | |
| **RR** ***(bpm)*** | **ST** | 22.1 ± 4.8 | 21.8 ± 5.1 | 20.6 ± 5.4 | 20.8 ± 4 | 21.3 ± 3.5 | $P_1 = 0.925$ $P_2 = 0.188$ |
| | **iVAPS** | 21.3 ± 4.7 | 22.1 ± 5 | 23.1 ± 8.6 | 22.4 ± 3.8 | 22.7 ± 4.8 | |
| **ABGs** | | | | | | | |
| **pH** | **ST** | 7.46 ± 0.07 | 7.46 ± 0.05 | 7.45 ± 0.04 | 7.44 ± 0.05 | 7.43 ± 0.07 | $\mathbf{P_1 < 0.001^*}$ $P_2 = 0.089$ |
| | **iVAPS** | 7.45 ± 0.05 | 7.44 ± 0.06 | 7.42 ± 0.06 | 7.42 ± 0.05 | 7.41 ± 0.06 | |
| **$PaCO_2$** ***(mmHg)*** | **ST** | 50.9 ± 12.2 | 49.5 ± 10.6 | 50 ± 11.5 | 51.1 ± 11.1 | 51 ± 10.5 | $P_1 = 0.123$ $P_2 = 0.089$ |
| | **iVAPS** | 50.7 ± 11.4 | 52.1 ± 12.4 | 51.9 ± 11.4 | 50.7 ± 12.4 | 51 ± 11 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **$PaO_2$ *(mmHg)*** | **ST** | 71.3 ± 10.2 | 74.6 ± 13.2 | 75.4 ± 12.4 | 74.4 ± 13.6 | 70 ± 6.8 | $P_1$ = 0.326 $P_2$ = 0.277 |
| | **iVAPS** | 71.5 ± 11.2 | 74.8 ± 11.7 | 73.1 ± 11.6 | 72.9 ± 10.7 | 70.1 ± 7.6 | |
| **$HCO_3$** | **ST** | 34.5 ± 6.6 | 35 ± 6.9 | 34.6 ± 7.8 | 35.8 ± 6 | 35.9 ± 6.8 | $P_1$ = 0.771 $P_2$ = 0.268 |
| | **iVAPS** | 37.4 ± 10 | 36.2 ± 7.1 | 36.3 ± 6.6 | 36.9 ± 9.3 | 36.1 ± 5.3 | |
| **$SaO_2$ *(%)*** | **ST** | 94.4 ± 2.6 | 95.1 ± 2.1 | 95.5 ± 2.0 | 94.1 ± 5.3 | 93.6 ± 2.9 | $P_1$ = 0.129 $P_2$ = 0.051 |
| | **iVAPS** | 93 ± 2.8 | 95 ± 2.7 | 94 ± 3.0 | 93.2 ± 3.1 | 93 ± 3.3 | |

All data are expressed as Mean ± SD. $HCO_3$ — Bicarbonate level; HR — heart rate, MBP — mean Blood Pressure, $P_1$ — P value within the same group, $P_2$ — P Value between the two groups; $PaCO_2$ — partial pressure of $CO_2$; $PaO_2$ — Partial Pressure of $O_2$; RR — respiratory rate; $SaO_2$ — arterial blood oxygen saturation

**Table 4.** Outcomes Analysis (ST vs. iVAPS)

| | **Group I (ST)** *N = 40* | **Group II (iVAPS)** *N = 40* | **P-value** |
|---|---|---|---|
| **Treatment Outcome** | | | |
| Success | 33 (82.5%) | 32 (80%) | |
| Re-intubation | 7 (17.5%) | 8 (20%) | 0.777 |
| **Level of Comfort** | | | |
| VAS | 2.6 ± 2.8 | 2.7 ± 2.2 | 0.564 |
| Total Mask Fitness Score | 5.0 ± 6.0 | 3.6 ± 4.6 | 0.604 |

| | | | |
|---|---|---|---|
| **Mortality in ICU** | | | |
| No mortality | 30 (75%) | 29 (72.5%) | |
| Within 1 week | 4 (10%) | 6 (15%) | 0.737 |
| After 1 week | 6 (15%) | 5 (12.5%) | |
| **NPPV duration** *(Days)* | 1.33 ± 0.70 | 1.43 ± 0.63 | 0.301 |
| **ICU duration** *(Days)* | 8.68 ± 5.72 | 8.65 ± 4.89 | 0.938 |

ICU — Intensive care Unit; NPPV — Noninvasive Positive Pressure Ventilation; VAS — Visual Analogue Scale