Comparison of bilevel positive airway pressure and average volume-assured pressure support mode in terms of patient compliance and treatment success in hypercapnic patients.

A cross-sectional study

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Gamze Canpolat*, Asu Ozgultekin***, Ömer Faruk Boran**

**Department of Anesthesiology and Intensive Care Unit, Medipol University, Istanbul, Turkey.*
***Department of Anesthesiology and Reanimation, School of Medicine, kahramanmaraş Sütçü İmam Üniversitesi, Kahramanmaras, Turkey.*
****Department of Anesthesiology and Intensive Care Unit, Haydarpaşa Numune Haydarpaşa Numune Education and Research Hospital, Istanbul, Turkey*

Comparison of bilevel positive airway pressure and average volume-assured pressure support mode in terms of patient compliance and treatment success in hypercapnic patients. A cross-sectional study

AIM: *It is necessary for an effective NIV application to provide proper modality selection, sufficient minute ventilation (MV), also the amount of leakage on the circuit must be minimized and patient-ventilator adaptation must be achieved.*
METHODS: *30 patients with acute respiratory failure as a result of either internal or postoperative reasons were included in the study. Patient comfort was analyzed with a scale ranging from 0 to 2. Firstly the patient was used for two hours in BIPAP modality, after then the AVAPS modality (Period Av) was applied by setting the required rates the same mask. During BIPAP and AVAPS, arterial blood gases analysis, comfort scale and hemodynamic parameters were recorded in the 30th minute, 1st hour and 2nd hour.*
RESULTS: *According to the assessment of arterial blood gases, the pH changes of both periods were statistically significant compared to their baseline values (p=0.001). Treatment compliance of the patients was significantly better at AVAPS modality at all times (p = 0.015, p = 0.008, p = 0.008, respectively).*
CONCLUSIONS: *According to the results obtained from this study, the AVAPS modality has positive effects on pH and gas variation and patient comfort; therefore, it can be confidently used in clinical practice.*

KEY WORDS: Average Volume Assured Pressure Support, Bilevel Continuous Positive Airway Pressure, Intensive Care Units, Noninvasive Ventilation, Patients Compliance

Introduction

Noninvasive ventilation (NIV) used in the treatment of acute (AHRI) and chronic (KHRI) hypercapnic respiratory insufficiencies due to different etiologies is an effective method that reduces endotracheal intubation needs and intubation related complications, hospitalization stay, and increases patient comfort[1] .

It is necessary for an effective NIV application to provide proper modality selection, sufficient minute ventilation (MV), also the amount of leakage on the circuit must be minimized and patient-ventilator adaptation must be achieved [2,3].

For this purpose, different modalitys may be used [3-5]. When Bilevel Positive Airway Pressure (BIPAP) modality is applied, respiratory support is provided to the patient with fixed inspiratory positive air pressure (IPAP) and expiratory positive air pressure (EPAP) values. Although this method seems to provide adequate ventilation with constant pressure application, resistance chan-

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Correspondence to: Ömer Faruk Boran, Department of Anesthesiology and Reanimation, Sütçü Imam University School of Medicine, Kahramanmara, Turkey (e-mail: ofboran@ksu.edu.tr)

ges in the system and factors that affect airflow affects success [6,7].

In the Average Volume Assured Pressure Support (AVAPS) modality that can be defined as a volume-targeted variable pressure support, the IPAP values are changed by the device within the predetermined intervals according to the patient's need throughout the entire application to achieve the determined tidal volume target. Therefore, the targeted ventilation can be more effective and less affected by the resistance changes in the circuit [7-9].

In recent years, there are plenty of studies comparing both modes [1,3,4,8-10]. In these studies, each modality were evaluated for oxygenation[1,3,4], sleep quality[9,10], and disease-related quality of life. [1,3,8] But, treatment compliance of patients that is one of important parameters to affect treatment success was not evaluated.

In this study, it is aimed to assess the effect of Average Volume Assured Pressure Support (AVAPS) modality and Bilevel Positive Airway Pressure (BIPAP) modality on treatment compliance and treatment success.

Material and Method

Approval for the study was granted by the Local Ethics Committee and informed constent from each patient's family for the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Thirty three patients (> 18 years old) with acute respiratory failure (Respiratory rate > 35 /minute, PaO_2/FiO_2 <200 mmHg and/or $PaCO_2$> 45 mmHg, pH=7.35-7.25) as a result of either internal or postoperative reasons were observed in this study.

Exclusion criteria included the patients whose Glasgow Coma Scale (GCS) was lower than 13, in whom NIV was contraindicated (maxillofacial trauma, patients with gastrointestinal obstruction, excessive secretion or those patients that were unable to protect the airway), pregnant women and patients with unstable hemodynamics or that have severe irreversible acute organ failure. Diagnosis, co-morbidities, age and body mass indexes were recorded also calculated.

This study was conducted with the Philips V 60 (Philips Healthcare, Best, Netherlands) ventilator which includes both BIPAP and AVAPS modality. Based upon the blood gas rates of the patients, non-invasive pressure support ventilation was applied if the patient was eligible for NIV. Patients were informed before the NIV. Basal arterial blood gase analysis were recorded for each patient. According to ensure each patient's comfort and compliance, an oronasal mask either supporting the forehead or jaw was used at the appropriate size for each patient. In BIPAP modality, the ventilator parameters were adjusted as follows: EPAP: 5-7 cmH_2O, IPAP: 15-20 cmH_2O. Determined ramp time was 15 minutes. Patient comfort was analyzed with a scale ranging from 0 to 2 (0: compatible, 1: medium-compatible, 2: non-compatible). In case of agitation that prevents NIV, patients were sedated by applying 0,4-0,7 mcg/kg/h dose of dexmedetomidine in order to achieve and maintain a RAMSAY sedation score of 2-3.

During BIPAP ventilation, hemodynamic parameters, levels of arterial blood gases and comfort scale were observed at the 30th minute, 1st hour and 2nd hour. After two hours in BIPAP modality, the modality was changed to the AVAPS support modality (Period Av) by setting the required rates without removing the mask. EPAP settings were adjusted as follows for AVAPS: 5-7 cmH_2O, Pmin-max:10-25 cmH_2O, VT (tidal volume): 6-8 ml/kg. In the AVAPS modality, we recorded same parameters in the same times like BIPAP modality.

Patients showing the following rates at any measurements were excluded from the study; pH<7.25, SPO_2<90, systolic blood pressure >180 mmHg or < 80 mmHg, peak heart rate >120 or < 50, respiration rate>35. Also, the patients whose breathing pattern was deteriorated and that needed additional sedation because of non-compliance were not included in the study.

Statistical Analysis

The sample size for the total number of the patients of the study was n=30, Power 0.80, β: 0.20 for the $PaCO_2$ parameter. The average, standard deviation, ratio, and frequency values were used for the descriptive statistics of the data. Data distribution was examined with the Kolmogorov Simirnov test. While quantitative data were analyzed using ANOVA, independent t test, Kruskal-Wallis, and Mann-Whitney U test. The paired sample T test and Wilcoxon test were used for the analysis of repeated measurements, and analyses were conducted with SPSS 22.0 (SPSS, Chicago, IL, USA). p<0.05 was accepted as significant.

Results

Thirty three patients who were under the treatment for acute respiratory failure staying in the intensive care unit of were included in the study. Two the cases who needed additional sedation and one patient in whom the acidotic state was deepened leading to the intubation were excluded from the study (Fig. 1). The study was conducted with the remaining 30 cases. Table 1 shows the demographic results and comorbidities of these patients. There were no differences in the Peak Heart Rate (PHR) and Systolic Arterial Pressure (SAP) between two periods. According to the assessment of arterial blood gases, the pH changes of both periods were statistically significant

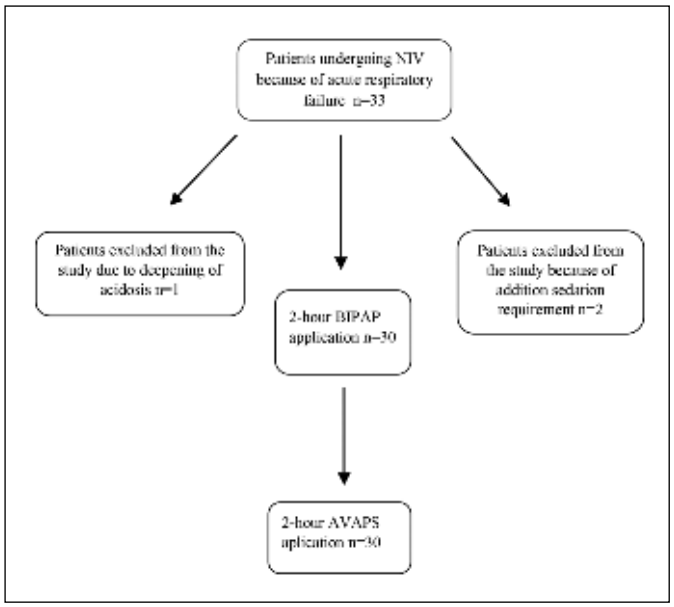

Fig. 1: Schematic diagram showing flow of patients through the study.

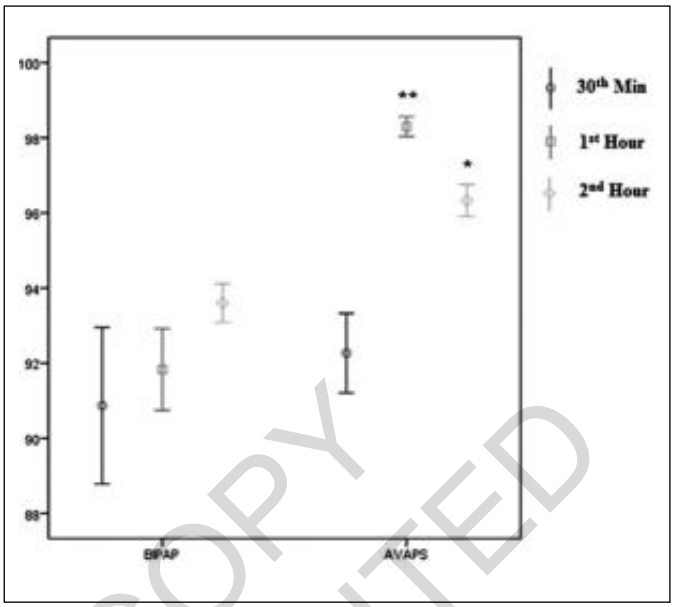

Fig. 2: The change in PO2 saturation values in the treatment periods in both groups (*p <0.05 vs. half hour, ** p<0.01 vs. half hour)

TABLE I - *Demographic data and comorbidities of the patients*

Variables		Patients (n = 30) Avg. ± SD or N (%)
Age (Year)		71,8 ± 14,3
Gender (Male/Female)		15/15 (50/50%)
Body mass index (BMI) (kg/m^2)		30,0 ± 4,9
Comorbidities	Hypertension	13 (30.3%)
	Chronic Obstructive Lung Disease	10 (23.3%)
	Congestive Hearth Failure	9 (21.0%)
	Diabetes Mellitus	4 (9.3%)
	Alzheimers Disease	4 (9.3%)
	Chronic Renal Failure	1 (2.3%)
	Multiple Sclerosis	1 (2.3%)
	Otoimmune Hemolitic Anemia	1 (2.3%)

Numbers are n (%) and average ±SD

compared to their baseline values. Switching to the AVAPS modality provided further improvement on the pH levels compared to the baseline value, that is also BIPAP modality 2nd hour level (p=0.03, p=0.02, p=0.007, p=0.00) (Table II).

Similar changes was observed regarding the $PaCO_2$ rates, there were improvements within both BIPAP and AVAPS periods at the hourly measurements (p<0,001). When $PaCO_2$ rates of the periods were analyzed, the improvement in the AVAPS period was found to be more significant compared to the BIPAP period (p=0.003, p=0.008, p=0.00) (Table II).

Changes in PO_2 rates of BIPAP periods did not show any difference within periods but 1 st and 2 nd hour PO2 values shoved statistical significance with the half hour (p=0.009, p=0.024, respectively) (Fig. 2). Body mass index (BMI), pH and PCO_2 values of the patients with BMI<30 showed a greater improvement in the AVAPS than BIPAP in the all time.

When the patients with a pH <7.35 (n=14) were compared with the patients with pH >7. 35 (n=16), although pH and PCO_2 values improved in both periods, there were better improvements in the patients with the pH rate of < 7. 35 especially at the 2nd hour of AVAPS application compared to BIPAP application (p<0.001).

When treatment compliance which was a main aim of our study was evaluated for, in BIBAP modality, 5 (16.7%) patients were seen to be agitated within the first 30 minutes, while the same patients were moderately in compliance with AVASP modality during the first half-

TABLE II - *Variation of pH rates and $PaCO_2$ values of the periods*

		BIPAP			AVAPS		
		The value in the time period Avg.±SD	Change by the basal value Avg.±SD	P	The value in the time period Avg.±SD	Change by the basal value Avg.±SD	P
$PaCO_2$ (mmHg)	Basal	63.16±13.66					
	30th Min	*58.32±11.54	-4.84±8.32	0.003	*55.03±0.06	-1.15±5.22	0.238
	1st Hour	**56.75±11.26	-6.41±6.87	0.001	**53.34±11.32	-2.84±5.48	0.008
	2nd Hour	***56.18±11.94	-6.98±7.12	0.001	***50.26±12.83	-5.92±6.12	0.001
pH	Basal	7.36±0.07					
	30th Min	*7.41±0.17	0.05±0.17	0.003	*7.40±0.06	0.00±0.01	0.007
	1st Hour	**7.38±0.05	0.03±0.04	0.002	**7.42±0.06	0.02±0.01	0.001
	2nd Hour	***7.40±0.05	0.02±0.01	0.002	***7.44±0.06	0.02±0.02	0.001

Data are expressed as the average ±SD, unless otherwise noted. *The paired sample T test and Wilcoxon test*
AVAPS; Average Volume Assured Pressure Support BIPAP; Bilevel Positive Airway Pressure, $PaCO_2$; Partial pressure of carbon dioxide.

TABLE III - *Variation of patient compliance according to modalitys*

			BIPAP		AVAPS		
			N	%	N	%	P value
Patient Compliance Score	30th Min	Comfortable	20	66.6%	25	83.3%	0.015
		Moderate	5	16.7%	5	16.7%	
		Agitated	5	16.7%	0	16.7%	
	1st Hour	Comfortable	21	70.0%	26	86.7%	0.008
		Moderate	7	23.3%	4	13.3%	
		Agitated	2	6.7%	0	0.0%	
	2nd Hour	Comfortable	21	70.0%	26	86.7%	0.008
		Moderate	7	23.3%	4	13.3%	
		Agitated	2	6.7%	0	0.0%	

The results were expressed as n (%)
AVAPS; Average Volume Assured Pressure Support BIPAP; Bilevel Positive Airway Pressure,

hour period. The patients who were moderately in compliance with BIBAP modality 5 (16.7%) were seen to be in compliance with treatment in AVASP modality during the first half-hour period. When the patients were evaluated for compliance in the first half-hour period, difference was found to be significant (p =0.015), the patients had more treatment compliance in the first and second hours period than in the first half-hour period, which was not significantly different (P>0.05). When the modalities were evaluated among themselves, it was seen that the compliance of patients in the AVASP modality was significantly better (Table III), (p = 0.015, p = 0.008, respectively).

Discussion

AVAPS gives automatically changing pressure support in order to provide a fixed tidal volume to patients. In other words, it fluctuates between actual IPAP, IPAP max and IPAP min in order to ensure adequate tidal volume [11].

Although this is a relatively new method which has been compared with other NIV modalitys in the literature in terms of parameters such as oxygenation [1,3,4], sleep quality [9,10], and disease-related quality of life [1,3,8]. It has never been evaluated in terms of treatment compliance of patients who are directly related to treatment success. Our study is the first study to evaluate treatment compliance of patients in AVAPS and BIPAP modality that its efficacy has been proven and frequently used for NIV in intensive care patients.

Our study was conducted in the same patient group so that the outcomes were not affected by the individual differences of the patients. In addition, one of the points of our study that could be criticized was that evaluation of compliance was performed in only two hours intervals in both modalitys. However, as known, patients' pH

and PCO_2 recovery within the first 2 hours is the most important indicator of NIV success [12,13]. Considering that the changes in the acute phase were better able to emphasize its effectiveness on ventilation modalitys, we deemed it sufficient to determine 2-hour work periods. In support of our view, the changes in arterial blood gas started in the first half hour and showed stabilization towards the second hour.

Although our study's primary aim was not to have an effect on parameters such as oxygenation and carbon dioxide exchange in both treatment modalities, if the results are compared with other studies; In general, the rates given as the failure of NIV range from 5 to 40 %[12]. In the present study, failure was observed in 3 of the 33 patients (9%). We have seen that the results are consistent with the literature.

Despite the limited studies, AVAPS modality was shown to be superior compared to the BIPAP modality with respect to gas exchange parameters [1,3,4]. The study of Claudett B et al. showed that AVAPS delivered pressurechanges progressively allowing the patient to conform much better to those pressures while the target tidal volume was reached. AVAPS facilitates rapid recovery of consciousness when compared to traditional BIPAP in patients with COPD and hypercapnic encephalopathy [8]. The present study also yielded a significant difference between AVAPS and BIPAP in terms of pH and gas exchange. We attribute this to the fact that insufflation of FiO_2 can rapidly increase PO_2 value even without mechanical support [14,15]. In both modalitys we applied, oxygenation values of the patients quickly reached the optimum level [7-9,16,17]. In our study, it was seen that the results of pH, CO_2 and PO_2 were similar to the literature.

When the outcomes were evaluated according to the treatment compliance of the patients; 5 (16.7%) of the patients in BIBAP modality in the first half-hour mode were found to be agitated. The same patients were seen to be in compliance with AVASP modality moderately. In the first half-hour AVAPS modality assured tidal volume more than BIPAP modality in patients with acute respiratory failure. Considering the intra-period and inter-period results, in both periods in the intra-period comparison, significant differences were found in pH and $PaCO_2$ values with respect to the basal period in each of the three measurement periods in BIPAP period. Similarly, pH and $PaCO_2$ values indicated clinical and statistical significance with respect to the baseline, namely the 2nd hour value of BIPAP; in 30th minute, 1st hour and 2nd hour measurement of AVAPS period. This makes us believe the superiority of AVAPS modality with respect to even an optimum situation that BIPAP modality provides in terms of minute ventilation. When evaluating PO_2 values of BIPAP and AVAPS periods, an improvement, which was clinically remarkable but not statistically significant according to the baseline, was observed in both periods in the 1st and 2nd hour values. Oxygenation is relatively independent of alveolar ventilation in comparison to CO_2 excretion. High period, the patients in compliance with BIBAP 5 (16.7%) were also seen to be in compliance with treatment in AVASP modality. When the patients were evaluated for compliance in the first half-hour period, the difference was significant (P = 0.015). In the 1st and 2nd hour periods, when the modalitys were assessed in themselves, it was observed that the patient compliance were seen to improve in both modes. However, in the AVAPS modality, it was observed that the patients were better compliance to the treatment at all hours (P = 0.008, P = 0.008 respectively).

Although we could not compare the compliance of the treatment with data in the literature, we think that this situation is caused by gradual pressure changes in AVAPS modality and allows the patients to better change of compliance to the new pressures when the target tidal volume is reached.

In conclusion, AVAPS is a relatively new method, which affects patients compliance positively and increases success, because the device changes IPAP values within the predetermined intervals according to the need of the patient throughout the procedure in order to reach the determined tidal volume target.

Riassunto

Per ottenere un'efficace ventilazione non invasiva (NIV) è necessaria la scelta di un metodo adeguato per ottenere una ventilazione al minuto (MV) sufficiente, ed inoltre la perdita del circuito deve essere ridotta al minimo e deve ottenersi l'adattamento del paziente al ventilatore.

Sono stati inseriti nello studio 30 pazienti con insufficienza respiratoria acuta o da cause interne oppure per ragioni del postoperatorio. Lo stato di benessere dei pazienti è stato analizzato con una scala da 0 a 2. Inizialmente il paziente è stato impegnato per due ore in modalità Bilevel Positive Airway Pressure (BIPAP), dopo di che è stata applicata la modalità Average Volume Assured Pressure Support (AVAPS) impostando nella stessa maschera i tassi richiesti. Durante la BIPAP e AVAPS, l'emogasanaklisi, la scala di benessere ed i parametri emodinamici sono stati registrati al 30 ° minuto, alla 1a ora e alla 2a ora.

In accordo con la valutazione dei gas ematici arteriosi, i cambiamenti di pH di entrambi i periodi erano statisticamente significativi rispetto ai loro valori basali (p = 0,001). La compliance al trattamento dei pazienti è stata significativamente migliore in modalità AVAPS in ogni momento (p = 0,015, p = 0,008, p = 0,008, rispettivamente).

CONCLUSIONI: In base ai risultati ottenuti da questo studio, la modalità AVAPS ha effetti positivi sulla variazione di pH e dei gas e sul comfort del paziente; pertanto, può essere tranquillamente utilizzato nella pratica clinica.

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