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Effect of High-velocity Nasal Cannula compared with Noninvasive Positive Pressure Ventilation in Patients with COPD Exacerbation

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Abstract

Aim: we conducted this study to evaluate the effect of high-velocity nasal cannula (HVNC) compared with noninvasive positive pressure ventilation (NIPPV) in reducing the need for endotracheal intubation in patients with respiratory failure due to COPD exacerbation and the outcome in both methods. **Patients and methods:** Our study is a randomized controlled trial that was conducted on patients admitted to the ICU by COPD exacerbation in the critical care department and chest department in Beni-Suef University, from February 2022 to January 2023, with a sample size of 40 patients divided into two groups, group (A) consists of 20 patients subjected to NIPPV, and group (B) consists of 20 patients subjected to HVNC. **Results:** SO_2 significantly increased from 1st hour (80.8±7.9%) to 2nd hour (93.9±1.5%). PH increased significantly in both groups, with no significant difference between the two groups after 2 hours. PCO_2 decreased significantly in both groups, with more improvement in HVNC. PO_2 and HCO_3 didn't differ significantly after 2 hours, and there were no significant differences between the two groups. There were insignificant differences between the studied groups regarding the need for intubation, mortality, length of stay, and SAPS score, but the Borg scale was higher in the NIPPV group than the HVNC group. **Conclusion:** in conclusion, both HVNC and NIPPV are effective in COPD exacerbation in decreasing the carbon dioxide with more improvement in the HVNC group. There was a significant role of HVNC in decreasing intolerance and respiratory distress and the Borg dyspnea scale.

Keywords: HVNC, NIPPV, Type II RF, COPD

1. Introduction:

As of right now, noninvasive ventilation (NIV) is the mainstay of care for patients with AECOPD who also have respiratory acidosis and respiratory failure [1].

It has been shown that people with stable COPD may benefit from high-velocity nasal treatment (HVNT) [2]. It produces a distending pressure that may counteract intrinsic PEEP by creating a positive end-expiratory pressure (PEEP) effect [3], a washout of the nasopharyngeal dead space, which improves respiratory acidosis by increasing ventilatory efficiency and allows the elimination of carbon dioxide [4], less resistance to inspiration, allowing for sufficient Flow and warm gases to minimize bronchial spasm in reaction to dryness [5,6], improving the lung's mucociliary clearance [7,8] and ultimately, in a manner akin to NIV, lowering diaphragmatic effort [9].

We conducted this study to evaluate the effect of high-velocity nasal cannula (HVNC) compared with noninvasive positive pressure ventilation (NIPPV) in reducing the need for endotracheal intubation in patients with respiratory failure due to COPD exacerbation and the outcome of both methods.

2. Patients and Methods:

Our study is a randomized controlled trial that was conducted on patients admitted to the ICU by COPD exacerbation in the critical care department and chest department in Beni-Suef University, starting from February 2022 to January 2023, with a sample size of 40 patients divided into two groups, group (A) consists of 20 patients subjected to noninvasive positive pressure ventilation and group (B) consists of 20 patients subjected to high-velocity nasal cannula.

Patients:

Inclusion criteria: patients previously diagnosed with COPD with acute type-2 respiratory failure (COPD exacerbation) with PCO_2 more than 60 mmHg, respiratory rate more than 30 breaths /min, and signs of respiratory distress.

Exclusion criteria: patients aged below 18 years, patients with disturbed consciousness level in the form of a Glasgow coma score of less than 12 points, patients with hemodynamic instability in the form of a systolic blood pressure less than 90 mmHg, mean arterial blood pressure less than 65 mm Hg, or on vasopressors, patients who need immediate endotracheal intubation, patients with nasopharyngeal blockage and patients with epistaxis or nasal septum fracture or any anomalies.

We classified patients randomly into 2 groups; group (A) consisted of 20 patients subjected to noninvasive positive pressure ventilation (NIPPV), and group (B) consisted of 20 patients subjected to high-velocity nasal cannula (HVNC).

The devices used for the group (A) NIPPV device Puritan Bennett™ 840 Ventilator, its brand was Medtronic with the type of used interface was an oronasal mask. For group (B), the HVNC device was used, the High velocity nasal cannula vapotherm, including the DPC, aerogen part, and a triple lumen delivery tube, which allows delivery of heated humidified air at high Flow.

Methodology:

Every participant in the research had a complete clinical examination, which included a general assessment of vital signs and a history taking, local examination abdominal, cardiac, and focusing on complete chest examination. Routine laboratory tests in the form of CBC, RBS, electrolytes, kidney function tests, liver function tests, and ABG were withdrawn on admission, 2 hours after admission, and for follow-up whenever needed .Chest X-rays or CT chest were done on admission and throughout the disease if needed.

Intervention:

Through the intervention, patients were treated in a randomized manner with either noninvasive ventilation (NIPPV) or with high-velocity nasal cannula HVNC .

Noninvasive positive pressure ventilation group (A): Noninvasive positive pressure ventilation was applied to the patient through a CPAP mask connected to a ventilator in a noninvasive ventilation mode with pressure support adjusted according to the Spo_2 and the patient responsiveness. Aiming to obtain an expiratory tidal volume between 8-10 ml/kg starting with an initial positive end-expiratory pressure (PEEP) between 5-10 mmHg. The targeted Spo_2 is 93% or more, recorded through a bedside monitor. The required duration for CPAP was 6 hours per day for at least 2 days. Noninvasive ventilation was used often for at least two hours. It may be used again if the patient had symptoms of respiratory distress, such as breathing more quickly than thirty breaths per minute or having an SPO2 below 90%.

High-velocity nasal cannula group (B): High-velocity nasal cannula was applied continuously through a large-bore nasal cannula, with a gas flow rate of 20 -40 liters per minute and a FiO_2 of 40% at the initiation. The FiO_2 and the Flow in the system were adjusted to maintain the SpO_2 of

92%. High-velocity oxygen was applied for 12 hours.

Ethical considerations*:*

The patients gave their informed written permission. The research protocol obtained clearance from the ethics committee of Beni-Suef University's College of Medicine No. FMBSUREC/01022022.

Statistical analysis:

A social science statistical software was used to analyze the data (SPSS). The mean, standard deviation was used to characterize the quantitative variables, and for comparing groups, the Chi-square test or Fisher exact was used when needed. A comparison between normally distributed means was done using an independent T-test. Following up the scale data in the same group was done using paired T-test. P value was calculated as either non-significant if >or equal to 0.05 or significant if <0.05.

3. Results:

Both groups were matched regarding their age and sex. The mean age of the group (A) was 64.9±8.7 years, and in group (B) was 67.7±11.2 years. Half of the group (A) were males, and 60% of the group (B) were males. There were a number of comorbidities and risk factors related to the patients involved in both groups; in group (A), 6 pts (30%) were hypertensive while in group (B) were 5 pts (25%), group (A) there was 1 diabetic pt (5%) while in group (B) 4 pts (20%), in group (A) 9 pts (45%) were smokers while in group (B) 4 pts (20%), in group (A) 2pts (10%) had ischemic heart disease and the same percent was in group (B). GCS and arterial blood pressure didn't differ significantly in both groups. The basal laboratory findings and the CT findings for both groups didn't differ significantly (**Table 1).**

Table (1) Laboratory and CT findings of the studied groups:

Items	NIPPV (no=20)	HVNC (no=20)	P-value
HB	12.7±2.7	11.7±1.9	0.220
TLC	10.7±3.8	11.7±5.9	0.524
PLT	256.6±103	245.1±111.1	0.735
UREA	60.3±36.6	56.3±21.6	0.673
Creatnine	1.7±1.6	1.2±0.7	0.289
Na	138.5±4.6	140.9±5.3	0.138
K	4.5±1	4.4±0.7	0.804
ALT	52.3±29.2	49.9±11.7	0.730
AST	54.7±31.3	51.6±15.7	0.695
PO4	3.6±0.7	3.4±0.7	0.324
Mg	2.8±0.6	2.6±0.7	0.368
CT Chest **Consolidation** **Emphysematous chest** **Hyper inflated chest** **pleural effusion** **pneumonia**	 2(10.0%) 9(45.0%) 0(0.0%) 3(15.0%) 1(5.0%)	 1(5.0%) 5(25.0%) 2(10.0%) 2(10.0%) 2(10.0%)	0.453

NIPPV parameters:

Initially, on admission, parameters of noninvasive ventilation (mean value ± SD) were (PEEP 5.2±1 mmHg, PS 13.3±3 cmH_2o, Fio_2 47.7±12.9%, and TV 426.7±54.2 ml). After 2 hours, were (PEEP 5.2±1.2 mmHg, PS 12.4±3.3 cmH_2o, Fio247.9±10.9%and TV 415.5±52 ml). There was no statistically significant difference between 1st and 2nd settings regarding PEEP, PS, FIO_2, and TV (P-value>0.05).

HVNC parameters:

Initial parameters of HVNC (mean value± SD) were;(Flow 30.2±8.44L/Sec, $Fio_2$40.3±13.2 %and So_2 80.8±7.9%) then at the end intervention (mean value ± SD) were; (Flow 29.7±7.1 L/Sec, So_2 93.9±1.5 %). There was no statistically significant difference between 1st and 2nd settings regarding Flow and Fio_2 (P-value>0.05). SO_2 increased significantly in 1st hour (80.8±7.9%) than after 2 hours (93.9±1.5%).

Arterial blood gases:

On-admission and follow-up of ABG were mentioned in **(Table 2).**

Follow up ABG on admission &after two hours intervention in both groups

Items	**NIPPV (no=20)**	**HVNC (no=20)**	**P-value**
PH1	7.28±0.05	7.32±0.07	0.040*
PH2	7.36±0.09	7.38±0.08	0.482
Mean difference	-0.077	-0.054	
P-value (pre-post)	<0.001*	0.001*	
PCo_2 1	73.1±15.3mmHg	65.1±12.6mmHg	0.078
PCO_2 2	62.6±13.2mmHg	53.9±11.1mmHg	0.030*
Mean difference	10.5	11.140	
P-value (pre-post)	0.002*	0.006*	
$PO_2$1	63.4±27.3mmHg	80.5±30.6mmHg	0.070
$PO_2$2	70.1±23.8mmHg	79.2±21.2 mmHg	0.208
Mean difference	-6.7	1.235	
P-value (pre-post)	0.069	0.873	
$HCO_3$1	35.2±8.9 meq/L	34.8±9.8 meq/L	0.882
$HCO_3$2	34.4±9.6 meq/L	33.2±8.1 meq/L	0.672
Mean difference	0.825	1.575	
P-value (pre-post)	0.621	0.322	

1: Refers to on admission. **2**: Refers to after two hours. Minus sign means increase after 2 hours
*P-value is significant

Regarding the study outcomes, there were insignificant differences between the studied groups regarding the need for intubate, mortality, length of stay and SAPS score. However, the Borg scale was higher in the NIPPV group than the HVNC group. Our study showed that there was no significant difference between the studied groups regarding the increase in hypercapnia (P-value>0.05), but intolerance to respiratory distress was significantly lower in the HVNC group than in NIPPV (P-value<0.001) (**Table 3).**

Comparison between the two groups regarding the study outcomes:

Items	**NIPPV(no=20)**	**HVNC(no=20)**	**P-value**
Need intubation			
No	13(65%)	16(80%)	0.288
Yes	7(35.0%)	4(20.0%)	
Mortality			
Alive	16(80%)	17(85%)	0.677
Died	4(20.0%)	3(15.0%)	
Length ICU stay	11.3±4.6	9.5±5.5	0.273
SAPS score	55.1±10.8	57.2±10.2	0.534
Borg scale	9±0.8	3.8±1.57614	<0.001*
Cause of failure			
Intolerance	13(65.0%)	2(10.0%)	<0.001*
RD	11(55.0%)	3(15.0%)	<0.001*
Inc. hypercapnia	4(20.0%)	2(10.0%)	0.376

*P-value is significant

4. Discussion:

We conducted this randomized clinical study on 40 patients admitted by COPD exacerbation complicated by type II respiratory failure in the critical care department at Beni-Suef University. As regards NIPPV parameters, initially on admission, the parameters were of mean value±SD (PEEP5.2±1mmHg, PS13.3±3mm Hg, Fio_2 47.7±12.9% and TV 426.7±54.2 ml) while at the end of intervention after 2 hours it was (PEEP 5.2±1.2 mmHg, PS 12.4±3.3 mmHg, $Fio_2$47.9±10.9% and TV 415.5±52 ml). There was no statistically significant difference between the 1st and 2nd

settings (after 2 hours). Regarding HVNC parameters, initially, the parameters were of mean value ± SD (Flow 30.2±8.4 L/sec, Fio_2 40.3±13.2 %, and So_2 80.8±7.9%); then at the end of intervention after 2 hours, the mean value ± SD were (Flow 29.7±7.1 L/sec and So_2 93.9±1.5%). There was no statistically significant difference between the 1st and 2nd settings (P-value>0.05). While the SO_2 increased significantly from 1st hour (80.8±7.9%) to 2nd hour (93.9±1.5%) respectively (P-value <0.001). In the current study, PH increased significantly in both groups with no significant difference between the two groups after 2 hours; PCO_2 decreased significantly in both groups with more improvement in HVNC.

Jing et al. detected that NIV settings had a mean of IPAP 11.4±2 cmH_2O and a mean EPAP of 4.6 ± 0.5 cmH_2O. HVNC settings were of mean Flow, 52.4 ±6.3 L/Sec, and mean FIO_2 of 0.4 ±0.1. The difference between our results and those of Jing et al. [10] was due to our parameters being recorded on admission and after 2 hours, when they recorded their parameters near extubation.

In addition, Jing et al. detected that HVNC settings were the mean Flow52.4 ±6.3 L/Sec and the mean Fio_2 0.4 ±0.1. Meanwhile, a 12-bed respiratory intensive care unit at Beijing Chao-Yang Hospital Western Branch in China was the site of a prospective, randomized controlled study (RCT). The observed metrics and ventilator settings were not substantially different between the two groups at randomization. Within the first 24 hours after randomization, the high-intensity NIPPV group showed considerably greater levels of IPAP, VT, and MV. Meanwhile, RR was significantly lower in the low-intensity NIPPV group [10]. In addition, Luo et al., found the high-intensity NIPPV group, VT 24 hours after randomization was more than 10 mL/kg of predicted body weight. In contrast, it was lower in the low-intensity NIPPV group. The high-intensity NIPPV group experienced NIPPV for a much more extended period than the low-intensity NPPV group during the first 24 hours (21.8 ± 2.1 vs. 15.3 ± 4.7 h; p = 0.001) [11].

Regarding the effect of both procedures on PH, after two hours, the PH showed no significant difference between the two groups as there was a significant increase in both. In agreement with our study, a recent meta-analysis found that HVNC may not be less effective than NIV in raising pH [12]. In addition, according to Mittal et al., a patient who had an exacerbation of COPD along with hypercapnia and acidosis was treated

with HVNC since they could not tolerate NIV and did not give permission to be intubated. Acute hypercapnia and acidosis were effectively treated in this instance by HVNC [13].

Similarly, Plotnikow et al., carried out research to assess the impact of high-flow oxygen implementation on the respiratory rate in patients with acute hypercapnic respiratory failure as a first-line ventilation support. When the patients were admitted, their respiratory rates were 29 breaths per minute and ranged from 27 to 31 breaths/minute; 90% of them used the accessory respiratory muscles.ABG showed a pH of 7.32, a Pao_2 of 67.5 mm Hg, a $Paco_2$ of 57 mm Hg, and Sao_2 of 92% [14].

Plant et al., in a revolutionary study on 236 patients, half of them received NIPPV added to the standard therapy; it was shown that early NIPPV reduced the requirement for invasive mechanical ventilation in COPD patients. NIPPV may address improper gas exchange and lessen respiratory distress indicators[15].

Regarding the PCO_2, both groups didn't differ significantly on admission, with a significant decrease in both groups. Still, the improvement was more in the HVNC group (P-value was 0.078 and, after 2 hours, was 0.030).

While Luo et al. detected that $PaCO_2$ was significantly lower 24 hours after randomization in the high-intensity NIPPV group than in the low-intensity NIPPV group. PaCO2, the main outcome dropped to 54.0 ± 11.6 mmHg in the high-intensity NIPPVgroup24 hours after randomization, while it only dropped to 67.4 ± 10.6 mmHg in the low-intensity NIPPV group (P-value 0.008). The high-intensity NIPPV group showed higher differences in PaCO2 between baseline and 24 hours post-randomization (P-value = 0.093) compared to the low-intensity NIPPV group [11].

According to research by Dreher et al. and Lukácsovits et al., with stable COPD patients, high-intensity NPPV decreased PaCO2 more than low-intensity NIPPV [16, 17].

The explanation of the suggested superiority of HVNC to NIPPV in the reduction of PCO_2 is that maximal $PaCO_2$ reduction is only possible if patients are able to consistently tolerate high-intensity NPPV. The HVNC offers more pressure support and a higher VT, enhancing alveolar ventilation and offsetting the additional dead space brought on by the face mask. Conversely, low-

intensity NPPV limits the drop in $PaCO_2$ and offers a smaller VT and comparatively less pressure support. [15, 18, 19].

Contrary to our results, the meta-analysis done by Ovtcharenko et al., when the findings from seven trials involving 487 patients were pooled, it was found that there was no difference in the change in $PaCO_2$ between the patients treated with HVNC and those treated with NIV [20]. The difference between our study and this meta-analysis may be due to the study heterogeneity of the studied patients collected in this meta-analysis.

Concerning the need for intubation in our study, there was no significant difference between the two groups regarding their need for intubation (P-value>0.05).

This was consistent with Ovtcharenko et al. [20] found that four studies including 275 patients reported no significant difference between HVNC and NIPPV regarding the endotracheal intubation outcomes [20]. Also, Xu et al. carried out a meta-analysis to assess the safety and effectiveness of HVNC treatment in patients with type II respiratory failure and COPD and found no significant difference between them [21]. In related research, Yang et al. evaluated HVNC and traditional NIV to assess the intubation risk in AECOPD in 8 RCTs with 492 patients. The study's findings provided low-quality evidence that HVNC did not raise the risk of intubation or death [22].

With reference to mortality, there was no significant difference between the two groups regarding the incidence proportion of mortality (P-value>0.05). Regardings length of ICU stay, it showed that there was no significant difference between the studied groups regarding the length of ICU stay (P-value>0.05).

This was in agreement with Hancı et al. [23], who illustrated no significant difference between the studied groups regarding length of ICU stay and mortality. Also, Ovtcharenko et al. [20] found that there were no significant differences between HVNC (High-velocity nasal cannula) and NIV (Noninvasive ventilation) regarding mortality and length of ICU stay.

In a comparison between the studied groups in our study regarding the SAPS score and Borg scale, there was no significant difference between the studied groups regarding the SAPS score (P-value>0.05), but the Borg scale was significantly lower in the HVNC group. This was in line with Tan et al findings' that the two groups' SAPS II and APACHE II, were comparable [24].

In a similar result, Cortegiani et al. carried out an investigator-initiated multicenter, randomized, unblinded, non-inferiority-controlled study on 80 patients, 40 of whom were in each group, between February 15, 2018, and March 25, 2020. According to this research, there was no discernible variation in SAPS II across the study groups [25].

Regarding Borg scale, our results were similar to a randomized controlled trial conducted by Agmy et al., which assigned 100 consecutive ARF patients at random to the HVNC and NIV groups. At 24 hours, 48 hours, 72 hours, and 96 hours, the HVNC group's median modified Borg scale was statistically significantly lower than NIV's (P<0.05 at all 4 settings) [26].

In a meta-analysis, they reported the effect of both procedures on dyspnea using a Borg scale or equivalent [21]. After therapy, there was no statistically significant difference in dyspnea ratings between HFNC and NIV, according to the pooled estimate [25, 27,28,29]

In comparison between the studied groups in our study regarding the causes of disease failure, there was no significant difference between the studied groups regarding the increase of hypercapnia (P-value>0.05), but the intolerance and the respiratory distress were significantly lower in the HVNC group (P-value<0.001). However, a multicenter retrospective analysis of 200 and 378 patients with respiratory failure received HVNC and NIV, respectively. It was found that the most common cause of respiratory failure in each group was pneumonia in HVNC and cardiogenic pulmonary edema in the NIV group [30].

Some limitations had to be disclosed in our study. First, we reported no data regarding medical management of COPD; it was a single-centered study. Second, The HVNC gas flow parameters in this investigation were determined by the subjective tolerance level of each patient. Lastly, this research had a relatively limited sample size.

5. Conclusion:

In conclusion, both HVNC and NIPPV are effective in treating patients with COPD exacerbation in decreasing the carbon dioxide with more improvement in the the HVNC group. There was a significant role of HVNC in decreasing intolerance, respiratory distress, and the Borg dyspnea scale.

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