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Evaluation of efficiency of high flow nasal cannula versus noninvasive ventilation in patients with acute hypercapnic respiratory failure

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Abstract

Warm and humidified high-flow nasal cannula (HFNC) was developed as alternate to standard oxygenation systems. This research done for evaluating the effectiveness of HFNC in reducing the need of invasive ventilation and early detection of failure in patients with acute type 2 respiratory failure in comparison to non-invasive ventilation. This research was done from September 2020 to February 2022 as a randomized control trail on 100 patients with acute type 2 respiratory failure in Beni-Suef university hospital. The Patients were divided into 2 groups; (Group A) were exposed to HFNC and (Group B) to NIV. This study showed no significant difference in between the 2 groups as regard the clinical endpoints (intubation rate and mortality). NIV had higher statistically significant reduction of $PaCO_2$ after intervention and less ICU stay. A significant difference was detected regarding patients comfort as HFNC has higher tolerance than NIV. HFNC significantly decline complications and removal numbers of device and air way care intervention. HFNC was as effective as NIV in decreasing the need for intubation, mortality, also it reduces incidence of complications and have better tolerance and a higher patient comfort in type 2 respiratory failure patients than NIV.

Keywords: Respiratory failure, High-flow nasal cannula, Non-invasive ventilation.

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1. Introduction

Acute hypercapnic respiratory failure is characterized by increase $PaCO_2$ ($PaCO_2$ >6kPa or >45mmHg) [1]. Development of acute type 2 respiratory failure in patients with COPD is associated with requiring invasive ventilation, with increased death in patients who require intensive care unit admission [2]. NIV was accepted as the standard treatment for patients with type 2 respiratory failure, by correcting acidosis and hypoventilation [3]. However, some disadvantages are presented during noninvasive positive pressure ventilation, such as eye inflammation, interface intolerance, skin irritation, and many interruptions [4]. The high-flow nasal cannula (HFNC) is a device for oxygen supply through air oxygen mixer. The gas is prepared to be heated and humidified and delivered through one limb inspiratory circuit to the patient via nasal cannula with large diameter [5]. Constant delivery of oxygen keeps fixed FiO_2 and reduce dilution of oxygen. It also removes CO_2 from physiologic dead space and improve ventilation through positive end expiration pressure generation. Facilitate secretions removal, and maintain mucosal integrity through heating and humidification [6].

This research was to assess the role of HFNC in reducing endotracheal intubation and the $PaCO_2$ level in adult patients with acute moderate type II respiratory failure in comparison with NIPPV.

2. Patients and methods

2.1. Trial Design and Oversight

This study is a randomized controlled trail which was conducted on 100 patients with acute hypercapnic respiratory failure admitted to respiratory department and critical care department in Beni-Suef university hospital from: September 2020 to February 2022. The Patients in the current study were separated into 2 groups; (Group A) formed of 50 patients were received high flow nasal cannula and (Group B) formed of 50 patients who were received noninvasive ventilation. The study protocol was accepted by the ethical committee of faculty of medicine in Beni-Suef University, Beni-Suef, Egypt under the following number: (FMBSUREC/ 01092020/Ali). An informed consent of participation was obtained from all of the enrolled patients.

2.2. Patients

Patients over the age of 18 who were admitted to the ICU with acute moderate hypercapnic respiratory failure, as indicated by PH values between 7.25 and 7.35 and PCO_2 values more than 45 mmHg, and who were given HFNC or NIV. The primary exclusion criteria were: Patients who required prompt endotracheal intubation ((Hemodynamic instability, Deterioration of neurologic status, Respiratory rate of more than 40 breaths per minute, no evidence of improvement due to high respiratory-muscle workload), and profuse tracheal secretions, a PH of 7.20 with gradually rising $PaCO_2$, uncontrolled hypoxia (defined as a PaO_2 of less than 50 mmHg despite enough oxygen, and cardiac arrest)) are symptoms of uncontrolled hypoxia. and any patient who should not receive NIV [7].

2.3. Randomization and Blinding Allocation

After the inclusion criteria were verified, patients were randomly assigned in a 1:1 ratio to one of the two following strategies: HFNC or NIV. Randomization was computer-performed. Neither the patient nor the researcher was blind; both groups received standard pharmacological therapy in accordance with the etiology of their respective disorders.

2.4. Interventions

Group A: HFNC was either administered by built-in HFNC devices (Airvo 2 device made by Fisher & Paykel Healthcare, Auckland, New Zealand, and built-in HFNC mode in (e Volution ventilator)) or vapotherm. the oxygen content of the gas flowing through the system was changed to keep the SpO_2 between 88 and 92%. When using a vapotherm, (PH 7.30-7.35) the initial flow rate is 40 L/min; however, when using an Airvo 2 device or the built-in HFNC mode in an evolution ventilator (PH 7.25-7.29), the initial flow rate is greater than 40 L/min. Unless patients at the beginning complained that it was too hot, the temperature was first fixed at 37°C. Continual observation and follow-up to determine the best time to wean the patient based on the respiratory parameters, Comfort of the patient and arterial blood gases. Group B through an oro-nasal mask attached to an ICU ventilator (Puritan Bennett TM 840 Ventilator Brand: Medtronic), NIV was administered to the patient. In order to achieve a tidal volume of 6 to 8 ml per kilogram of anticipated body weight and PEEP adjusted to be 5 cm of water, the pressure-support level was modified. The FiO_2 was changed to keep the SpO_2 between 88 and 92%. Application of the NIV was halted for nebulizers, eating, and drinking. All ventilator settings were changed in accordance with the patient's comfort level, the results of continuous oximetry, measurements of arterial blood gases, and ventilator parameters (tidal volume, breathing rate, and mask leakage). NIV withdrawal was initiated when FiO_2 was less than 30%, tidal volume was greater than 6 mL/kg of anticipated body weight, pressure support was equal to or less than 8 cm H_2O, and PEEP level was at 5cm H_2O. At this point, conventional oxygen therapy was continually administered using a nasal cannula.

2.5. Study Outcomes

The main goal was to assess and contrast the risk reduction for endotracheal intubation in the employed techniques in order to guarantee the consistency of intubation indications and lower the risk of delayed intubation by the following pre-specified criteria for endotracheal intubation: Hemodynamic instability, Deterioration of neurologic status, Signs of continuing or worsening respiratory failure (Respiratory rate of more than 40 breaths per minute, No signs of improvement due to high respiratory-muscle workload, Development of copious tracheal secretions, PH 7.20 with gradually increasing $PaCO_2$,Uncontrolled hypoxia defined by a PaO_2< 50mmHg despite ample oxygen), and Cardiac arrest [8]. Comparing and evaluating a secondary outcome Time spent in the ICU, time spent using the device, likelihood of nose or face skin affliction following the entirety of respiratory assistance, and mortality rate following ICU release.

2.6. Sample Size

Sample Size was calculated using G power 3.1 for windows as follows:

t tests - Means: Difference between two independent means (two groups)

Analysis: A priori: Compute required sample size

Input:

Tail(s)	=	Two
Effect size d	=	0.73
α err prob	=	0.05
Power (1-β err prob)	=	0.95
Allocation ratio N2/N1	=	1

Output:

Non-centrality parameter δ	=	3.6500000
Critical t	=	1.9844675
D_f	=	98
Sample size group 1	=	50
Sample size group 2	=	50
Total sample size	=	100
Actual power	=	0.9509402

2.7. Statistical analysis

A statistical tool for social science (SPSS) version 25 for Windows was used to analyze the data. This is how the variables were described: Quantitative variables were described using the terms mean and standard deviation (SD). The qualitative variables were described using numbers (No.) and percentages (%). The independent T test was used to compare normally distributed means, while the Mann Whitney U test was used to compare variables with non-normal distributions. The progression of the scale variable changes was tracked using a paired t-test. Using the chi squared test, categorical data were compared. To connect qualitative variables with a normal distribution, Pearson correlation was used. The results' significance was evaluated using a P-value, which was divided into: Non-significant if P-value is more than 0.05, P-value 0.05 indicates significance, and P-value 0.001 indicates high significance.

3. Results

Out of 500 patients who were admitted to Beni-Suef university hospital with respiratory failure between September 2020 and February 2022, 120 patients met the blood gas analysis criteria for moderate hypercapnic respiratory failure.

Of those 120 patients, 20 were excluded (12 patients had invasive ventilation and 8 patients had other causes preventing the use of NIV), and at the end, only 100 patients met the criteria. In Table 1, regarding their age, sex, occupation, special habits, BMI, diagnosis, chest disease duration, diabetes, hypertension, baseline heart rate, respiratory rate, APACTII score, and expected mortality, there was no statistically significant difference between the two groups (P-value >0.05). In Table 2, Built-in HFNC devices and Vapotherm did not reduce CO_2 at a rate that was statistically different (P-value = 0.7). In Table 3, between admission and 24 hours after applying the device, the RR and HR rates significantly improved in both groups (P-value 0.001). Regarding their baseline ABG measurements, there was no statistically significant difference between the two groups (P-value > 0.05). But the NIV group considerably improved more in terms of $PaCO_2$ and PH (P-value 0.05). Except for the HCO_3, all ABG parameters considerably improved in each group. The rate of comfortability was substantially greater in HFNC. Regarding the requirement for intubation or switching of devices, there was little difference between the two groups. In the NIV group, there were considerably more removals of devices for drinking, eating, or airway care interventions per day. In Table 4, the NIV group had a statistically lower length of stay in the ICU than the HFNC group, but the overall mortality rate was similar in both groups. The baseline values of PH, PaO_2, and SpO_2 had a statistically significant linear negative connection with ICU stay. While we discovered a statistically significant linear negative correlation between the ICU stay and baseline PH, PaO_2, and SpO_2 and a positive linear correlation between the ICU stay and APATCHII, RR, and HR on admission in the NIV group, the ICU stay was significantly positively correlated with the pre HCO_3 in the HFNC group. In Table 5, the probability of intubation was statistically significantly correlated with the presence of diabetes, baseline HR, baseline PaO_2, and baseline SpO_2 in all patients.

4. Discussion

The clinical condition known as acute respiratory failure is significant and life-threatening [9]. An imbalance between the load placed on the respiratory muscles and the capacity of the muscular pump results in acute hypercapnic respiratory failure [10]. For patients with acute hypercapnic respiratory owing to an acute exacerbation of chronic obstructive pulmonary disease (AECOPD), noninvasive ventilation (NIV) is the preferable initial mode [11]. A potential new oxygen delivery system, the high-flow nasal cannula (HFNC), uses an air oxygen blender to give FiO_2 at rates of up to 60 L/min and from 21% to 100% [12]. Since HFNC has been successfully used to treat a wide range of patients with a wide range of diverse illness conditions, it is receiving a lot of interest as a potential replacement for NIV in critically sick patients [13]. Patients in group (A) with mean age of 55.8±3.8 y started with mean flow rate 43.9±5 L/minute and mean FiO_2 37.30±12.2. % While group (B) with mean age 55.8±3.8 y started with mean pressure support 11.34±2.9 and mean FiO_2 33.88±6.7. % In contrast to Lee et al., (2018) and Sun et al., (2019) who did similar studies on higher population age group (Mean age of the studied patients was 73years) [14-15]. Majority of this study patients had obstructive airway diseases 90% similar to the studies done by Lee et al., (2018) and Sun et al., (2019) [14-15]. In this research, the mean of initial PH was lower (HFNC: 7.29±0.02, NIV: 7.28±0.03) than the studied population by Lee et al., (2016) (HFNC: 7.32 ± 0.28, NIV: 7.31 ± 0.29) and Sun et al., (2019) (HFNC: 7.31, NIV: 7.30) [12,15]. In the current study, the RR significantly improved after the device application in both groups (p value = 0.001). There was no significant difference between the two groups (P value = 0.315). In the same context; Cortegiani et al., (2020) and Sun et al., (2019) showed improvement of the respiratory rate after the device application with no significant difference between two groups (P value =0.557 and 0.064 respectively) [15-16]. Regarding PH changes, the Current study showed a statistically significant improvement of PH in both groups (p value =<0.001) the improvement was significantly higher in NIV group (p value=0.003). While Alnajada et al., (2021) in their systemic review, Papachatzakis et al., (2020), and Lee et al., (2018) in their studies found improvement in PH but without significant difference between two groups (p value=0.24, 0.208 ,0.295 respectively) [14,17-18]. The current study showed that there was statistically significant improvement in $PaCO_2$ in both groups (p value =<0.001) but the degree of reduction was higher in NIV group (p value=0.020). Alnajada et al., (2021) found a significant reduction of $PaCO_2$ at four hours in HFNC groups (p value=0.03) and no significant difference between groups at degree of reduction at 24-hours or five days [17]. Many authors in their studies found that a lowering of $PaCO_2$ values in each group but with no significant difference between two groups (p value = 0.1933, 0.078, 0.160 respectively) [14-16]. Regarding oxygenation, the current study showed that there was statistically significant improvement in PaO_2 in both groups (p value =<0.001) with no significant difference between this improvement between HFNC and NIV (p value = 0.131). Many authors are matching our study result as Cortegiani et al., (2020) showed no significant difference in PaO_2 improvement after HFNC or NIV application (p value = 0.1480) also Papachatzakis et al., (2020), and Alnajada et al., (2021) showed no significant difference in PaO_2 improvement after HFNC or NIV application (p value =0.180 and p value = 0.71 respectively) [16-18]. There was a significantly higher rate of comfort (p value = 0.001); in HFNC group than NIV group in the current study. In the same context; several authors found the same results as comfort in the HFNC group was significantly higher than that in the NIV group ($p < 0.001$, 0.001, 0.008 and 0.02 respectively) as conditioning of the gas to be warm and humidified minimizes airway constriction, decreases airway inflammation, reduces the work of breathing, improves mucociliary function of breathing, thereby facilitating clearance of secretions, also heated and humidified gas devices result in better tolerance by patients as well as being more comfortable [16, 19-22]. The number of removals of device for drinking, eating, or air way care intervention/ day was significantly higher in NIV group (P value <0.001), also Tan et al., (2020), and Sun et al., (2019) found that Airway care interventions, per day was significant higher in NIV group (P value < 0.006 and < 0.001) [15,19]. Regarding complication from two modalities, in the current study, the HFNC had a significantly lower rate of nasal facial skin irritation after treatment (p value = 0.001).

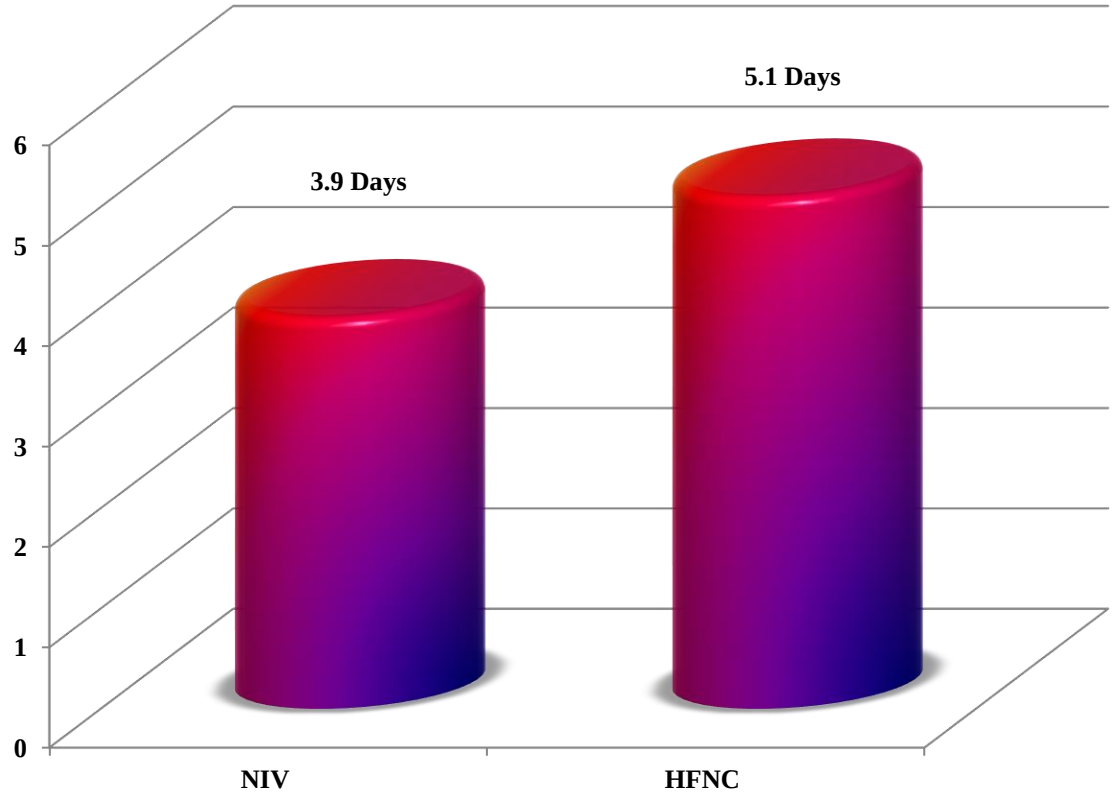

Figure 1: ICU stay in days.

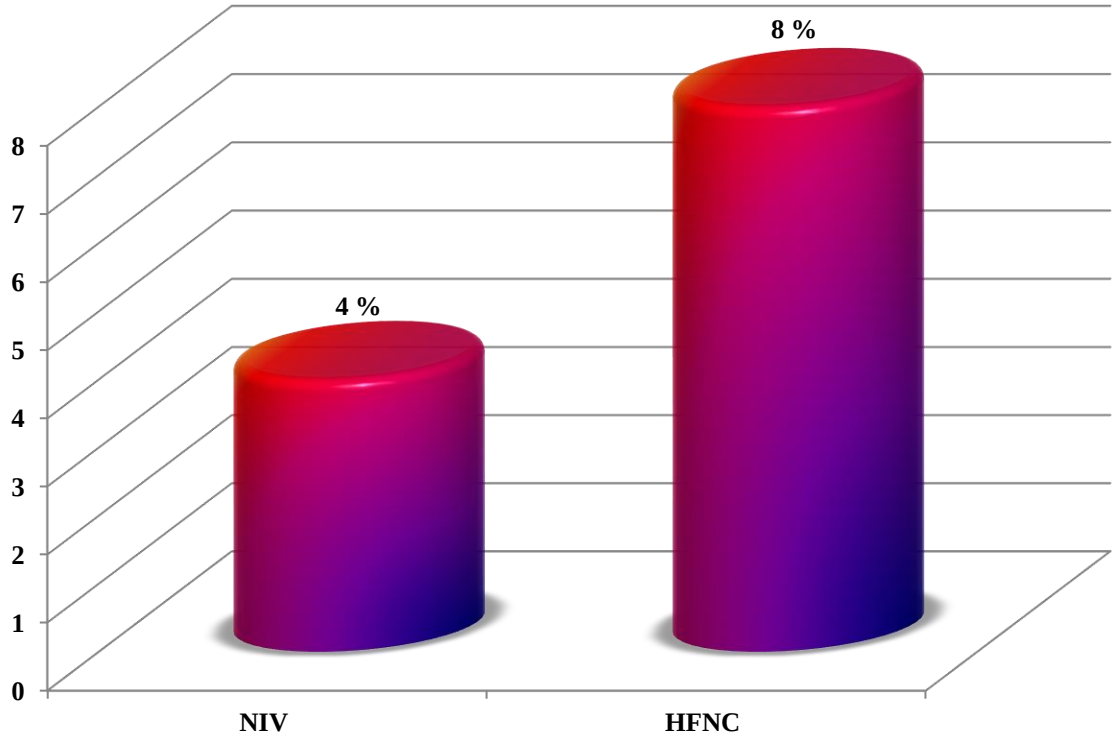

Figure 2: Mortality on discharge (%).

Table 1: Descriptive Baseline Data of the patients.

Items	NIV (no=50)	HFNC (no=50)	P-value
Sex n (%) Female Male	 21(42.0%) 29(58.0%)	 15(30.0%) 35(70.0%)	0.211
Age (mean±SD)	56.5±3.4	55.8±3.8	0.360
Occupation n (%)			
Carpenter Farmer Housewife Bakery On pension Clerk Painter	0(0.0%) 21(42.0%) 21(42.0%) 3(6.0%) 2(4.0%) 2(4.0%) 1(2.0%)	1(2.0%) 23(46.0%) 15(30.0%) 4(8.0%) 1(2.0%) 5(10.0%) 1(2.0%)	0.697
Special habits n (%)			
Smoking Biomass Smoking and biomass	20(40.0%) 22(44.0%) 8(16.0%)	26(52.0%) 15(30.0%) 9(18.0%)	0.339
BMI (mean±SD)	23.5±1	23.4±1.1	0.999
Diagnosis n (%)			
Obstructive diseases Restrictive diseases	45(90.0%) 5(10.0%)	45(90.0%) 5(10.0%)	0.211
Chest disease duration (mean±SD)	10.2±3	10±3.1	0.720
DM n (%)	25(50.0%)	17(34.0%)	0.105
HTN n (%)	39(78.0%)	35(70.0%)	0.362
HR on admission	104.7±8.4	103.1±6.7	0.316
RR on admission	31.3±3.2	30.6±2.2	0.217
APATCHII score	17.2±3.2	18.1±3.8	0.209
Estimated mortality (%)	28.2±10.2	30.6±11.6	0.273
Pressure support	11.34±2.9	NA	-----
PEEP	5±0	NA	-----
Flow	NA	43.9±5	------
FIO_2	33.88±6.7	37.30±12.2	0.085

*P-value is significant.

Table 2: Percentage of reduction of CO_2 between HFNC devices.

	HFNC devices	median	IQR (MW)		P-value
Percentage of reduction of CO_2	**Built in HFNC**	4.8444	-3.5748	6.3112	0.763
	Vapotherm	3.7314	3.0769	6.6769	

Table 3: Follow up data.

Items (mean±SD)	NIV (no=50)	HFNC (no=50)	P-value
HR on admission HR after 1 hr HR after 24 hrs	104.7±8.4 95±9.4 88.7±11.2	103.1±6.7 96±8.6 90.8±13.9	0.316 0.580 0.409
P-value on adm vs 1 hour P-value 1 hour vs 24 hours	<0.001* 0.003*	<0.001* <0.001*	
RR on admission RR after 1 hour RR after 24 hours P-value on adm vs 1 hour P-value 1 hour vs 24 hours	31.3±3.2 27.4±4.5 22.3±2.6 <0.001* <0.001*	30.6±2.2 28.2±5.9 21.9±1.3 <0.001* <0.001*	0.217 0.426 0.315
Pre PH Post PH P-value pre vs post	7.28±0.03 7.34±0.04 <0.001*	7.29±0.02 7.31±0.04 <0.001*	0.194 0.003*
Pre $PaCO_2$ Post $PaCO_2$ P-value pre vs post	70.15±10.21 62.35±7.08 <0.001*	69.35±9.95 65.93±8.02 <0.001*	0.692 0.020*
Pre PaO_2 Post PaO_2 P-value pre vs post	49.07±4.33 60.18±2.28 <0.001*	49.67±4.98 60.72±1.03 <0.001*	0.522 0.131
Pre HCO_3 Post HCO_3 P-value pre vs post	33.00±4.88 32.68±3.07 0.453	33.07±4.85 32.64±3.06 0.299	0.940 0.948
Pre SpO_2 Post SpO_2 P-value pre vs post	78.90±4.34 91.22±1.23	79.38±4.41 90.78±2.57	0.585 0.277
Patient comfort n (%)	18(36.0%)	39(78.0%)	<0.001*
Complications n (%)			
Nasal abrasion Nasal skin redness Mouth Dryness eye irritation Air leak Gastric distention Pneumothorax Nasal congestion Epistaxis Aspiration	11(22.0%) 26(52.0%) 12(24.0%) 3(6.0%) 19(38.0%) 1(2.0%) 0(0%) 0(0%) 0(0%) 0(0%)	0(0%) 0(0%) 0(0%) 0(0%) 0(0%) 0(0%) 0(0%) 4(8.0%) 2(4.0%) 0(0%)	<0.001* <0.001* <0.001* 0.242 <0.001* 0.999 0.999 0.117 0.495 0.999
	2(4.0%)	5(10.0%)	
Need to intubation n (%)	2(4.0%)	5(10.0%)	0.240
Number of removals of device for drinking, eating, or air way care intervention every day (mean±SD)	4.8±1	1.4±0.9	<0.001*
Duration of device Application in days (mean±SD)	2.7±1.3	3.3±1.9	0.088

*P-value is significant.

Table 4: Outcome data, Comparison between the studied groups regarding the outcome.

Items	NIV (no=50)	HFNC (no=50)	P-value
ICU days of stay (mean±SD)	3.9±1.2	5.1±1.6	<0.001*
Mortality on discharge n (%)	2(4.0%)	4(8.0%)	0.678

*P-value is significant.

Table 5: Correlation between the total ICU stay and different baseline patients' characteristics in NIV and HFNC group.

Variables	Total ICU stay/days	NIV group (no=50)	HFNC group (no=50)
Age	Correlation coefficient (r)	0.089	-0.063
	P-value	0.537	0.663
BMI	Correlation coefficient (r)	0.061	-0.070
	P-value	0.672	0.631
APATCH II Score	Correlation coefficient (r)	0.356*	-0.068
	P-value	0.011	0.641
APATCH II mortality estimation	Correlation coefficient (r)	0.392**	-0.072
	P-value	0.005	0.622
Pre PH	Correlation coefficient (r)	-0.569**	-0.426**
	P-value	0.000	0.002
Pre $PaCO_2$	Correlation coefficient (r)	0.241	0.154
	P-value	0.092	0.284
Pre PaO_2	Correlation coefficient (r)	-0.377**	-0.332*
	P-value	0.007	0.018
Pre HCO_3	Correlation coefficient (r)	-0.057	0.034
	P-value	0.695	0.817
Pre SpO_2	Correlation coefficient (r)	-0.360*	-0.425**
	P-value	0.010	0.002
HR on admission	Correlation coefficient (r)	0.346*	0.047
	P-value	0.014	0.744
RR on admission	Correlation coefficient (r)	0.280*	0.241
	P-value	0.049	0.092

*P-value is significant

Table 6: Univariable analysis of factors associated with failure (need to intubation).

Items	Not intubated (no=93)	Intubated (no=7)	P-value
Sex n (%)			
Male Female	34(36.6%) 59(63.4%)	2(28.6%) 5(71.4%)	0.671
Groups n (%)			
NIV HFNC	48(51.6%) 45(48.4%)	2(28.6%) 5(71.4%)	0.463
Special habits n (%)			
Smoking Biomass Smoking and biomass	43(46.2%) 35(37.6%) 15(16.1%)	3(42.9%) 2(28.6%) 2(28.6%)	0.686
Age (mean±SD)	56.2±3.2	55.3±7	0.521
Occupation n (%)			
Carpenter Farmer Housewife Bakery On pension Clerk Painter	1(1.1%) 39(41.9%) 34(36.6%) 7(7.5%) 3(3.2%) 7(7.5%) 2(2.2%)	0(0.0%) 5(71.4%) 2(28.6%) 0(0.0%) 0(0.0%) 0(0.0%) 0(0.0%)	0.820
BMI (mean±SD)	23.4±1.1	24±1.4	0.195
Diagnosis n (%)			
Obstructive diseases Restrictive diseases	83(89.24%) 10(10.75%)	7(100.0%) 0(0.0%)	0.700
Chest disease duration (mean±SD)	10.1±3.1	11±2.4	0.436
DM n (%)	36 (38.7%)	6 (85.7%)	0.039*
HTN n (%)	67 (72.0%)	7 (100.0%)	0.185
HR on admission (mean±SD)	103.5±7.2	110±10.4	0.028*
APATCHII score (mean±SD)	17.6±3.3	19±5.7	0.302
APATCHII mortaility % (mean±SD)	29±10.4	34±17.3	0.245
Pre PH (mean±SD)	7.2±0.02	7.3±0.02	0.065
Pre $PaCO_2$ (mean±SD)	69.8±10.4	68.7±2.9	0.778
Pre PaO_2 (mean±SD)	49.9±4.2	41.4±2.4	<0.001*
Pre HCO_3 (mean±SD)	33.1±4.9	31.7±1.7	0.457
Pre SpO_2 (mean±SD)	79.7±3.9	71.4±2.4	<0.001*

*P-value is significant.

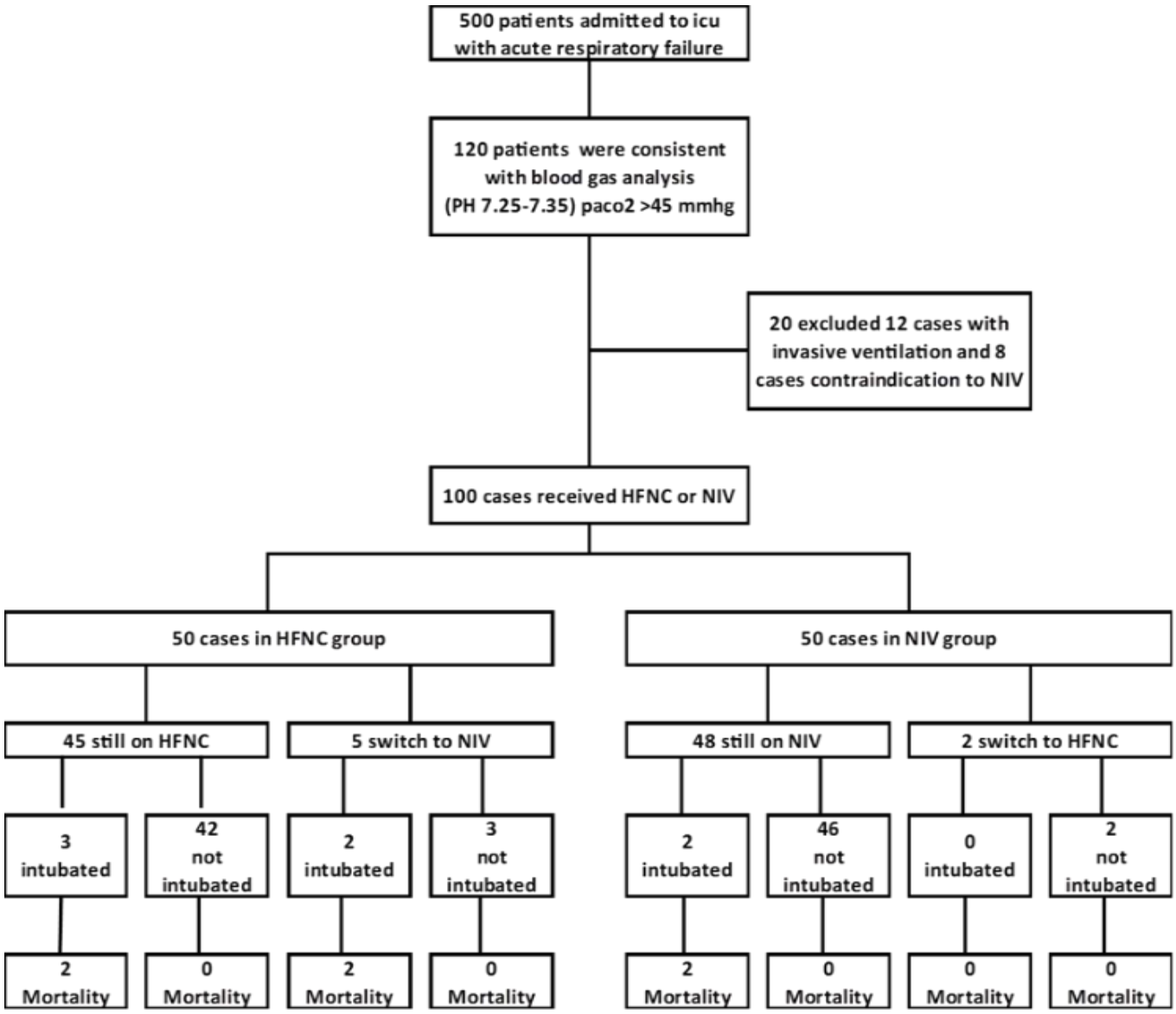

Figure 3: Flow chart of patient enrollment.

Many authors had the same conclusion in their studies as Tan et al., (2020) and Sun et al., (2019) who found that nasal facial skin breakdown after treatment was significant lower in HFNC group (P value = 0.027 and 0.036 respectively) [15,19]. Duration of device Application /Day in the current study was higher in HFNC group than in NIV group (3.3±1.9, 2.7±1.3 respectively) but with no statistically significant difference (p value= 0.088). Many authors also found that no significant difference between two groups regarding duration of device application (p value =0.063, 0.16and 0.978), while Sun et al., (2019) found that duration of device application was significant higher in HFNC group (p value= 0.001) [12,15,17,19]. Regarding the outcome of our patients and the need of intubation, the rate of endotracheal intubation was relatively lower among patients treated with NIV (in NIV group there was 2 patients out of 50 represent 4% and 5 patients out of 50 represent 10% in HFNC group); but on comparing both groups this difference was insignificant regarding the need to intubation or switch to each other (P-value=0.240). So, using HFNC in adult patients with acute hypercapnic respiratory failure decreased the need for endotracheal intubation similar to NIV. Jing et al., (2019), study was done on forty-two COPD patients who had persistent hypercapnia at extubating, HFNC (22) and NIV (20) [21]. Their study showed insignificant difference regarding the need to re-intubation in two groups (P=0.93). Also, Lee et al., (2018) show insignificant difference regarding the need to intubation in two groups with (P =0.857) [14]. Similarly, Papachatzakis et al., (2020) study done on hypercapnic respiratory failure and showed that no need to intubation in two groups 0% in HFNC group and 0% in the NIV group [18]. In the same context; Tan et al., (2020) study that was done on COPD patients with hypercapnic respiratory failure who were randomized to HFNC or NIV at extubating, 44 in HFNC group and 42 in the NIV group they found insignificant difference regarding the need to re intubation in two groups as the intubation rate was 13.6% in the HFNC group and 14.2 % in the NIV group (P = 0.53) [19].

The current study showed that there was a significant lower length of stay in ICU in the NIV group than the HFNC group p value = <0.001. In the same context, Su et al., (2021) retrospective study that was done on adult patients with mild hypercapnia (45 < $PaCO_2$ ≤ 60 mmHg) received either HFNC or NIV as oxygen therapy and showed that there was significant increase in ICU stay in HFNC group (p = 0.019) [23]. In contrary, Tan et al., (2020), Papachatzakis et al., (2020), Sun et al., (2019), and Jing et al., (2019) found no significant difference in the duration of ICU length of stay between the two groups (p value =0.324, 0.655, 0.149, and 0.41 respectively) [15,18-19,21]. The current study showed a statistically significant linear negative correlation between ICU stay and baseline PH, PaO_2, SpO_2 and positive linear correlation with APATCHII, RR, and HR on admission in NIV group also there was a significant linear negative correlation between ICU stay and baseline PH, PaO_2 and SpO_2. The ICU stay was significantly correlated positively with the pretreatment HCO_3 and negatively with BMI and pre-PH in HFNC group respectively. Table 6 shows that univariable analysis of factors associated with failure (need to intubation) was done and revealed that there was a significant association between presence of diabetes, baseline HR, baseline PaO_2 and baseline SpO_2 and the risk of intubation in all patients. The current study showed that the rate of mortality in HFNC group was 8 % and in NIV group was 4 % with no statistical difference between the two groups (P-value=0.678). Many authors matching with our study result as Lee et al., (2018), Sun et al., (2019), Papachatzakis et al., (2020), Tan et al., (2020), and Jing et al., (2019) with p value = 0.758, 0.845 ,0.824 ,0.85, and 0.669 respectively [14-15,18-19,21].

5. Conclusion

HFNC was as effective as NIV in decreasing the need for intubation, mortality, also it reduces incidence of complications with better tolerance and a higher patient comfort in type 2 respiratory failure patients than NIV. ICU stay in NIV group was significantly lower than HFNC group.

6. Limitations and Recommendations

It is important to conduct large multi-center studies to validate the role of HFNC in acute hypercapnic respiratory failure. According to result of our study we recommend start with HFNC in moderate type 2 respiratory failure patients and if failed switch to NIV.

7. Abbreviations

- APACHE II: Acute physiologic assessment and chronic health evaluation II score
- BMI: Body mass index
- COPD: Chronic Obstructive Pulmonary disease
- HFNC: High flow nasal cannula
- HR: Heart rate
- ICU: Intensive Care Unit
- NIV: Non-invasive ventilation
- PaO2: Arterial oxygen tension
- PH: Potential of hydrogen
- SpO2: Peripheral Oxygen saturation

8. Declarations

8.1. Ethical approval and consent to participate

A written informed consent was obtained from the patients' close relatives for the agreement for inclusion in the study. The study protocol was approved by the ethical committee of the faculty of medicine in Beni-Suef University.

8.2. Consent for Publication

The authors provide consent to The Egyptian Journal of Bronchology to publish the materials contained in the manuscripts.

8.3. Availability of data and material

The data will be accessible to the journal and reviewers upon request.

8.4. Competing interests

The authors declare that we have no competing interest.

8.5. Funding

The study received no external funding.

8.6. Authors Contribution

LN, MF and GA conceptualized and supervised the research. WA, MF and GA organized the research site, collected and analysed the data. The final paper was co-written by all authors. All authors read and approved the final manuscript.

8.7. Acknowledgements

'Not applicable'

References

[1] A. Davidson, S. Banham, M. Elliott. (2016). BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults. Thorax. 71 (2): e1-e35.

[2] J. Steer, G. Gibson, S. Bourke. (2010). Predicting outcomes following hospitalization for acute exacerbations of COPD. QJM: An International Journal of Medicine. 1039 (11): e817-e829.

[3] N. M. Shah, R. F. D'Cruz, P. B. Murphy. (2018). Update: non-invasive ventilation in chronic obstructive pulmonary disease. Journal of thoracic disease. 10 (1): e71.

[4] N. S. Hill, J. Brennan, E. Garpestad, S. Nava. (2007). Noninvasive ventilation in acute respiratory failure. Critical care medicine. 35 (10): e2402-e2407.

[5] M. V. Loo, T. Sottiaux. (2016). High Flow Nasal Cannula oxygenation for adult patients in the ICU: a literature review. Acta Anæsthesiologica Belgica. 67 (2): e63-e72.

[6] J. H. Lee, K. J. Rehder, L. Williford, I. M. Cheifetz, D. A. Turner. (2013). Use of high flow nasal cannula in critically ill infants, children, and adults: a critical review of the literature. Intensive care medicine. 39 (1): e247-e257.

[7] R. L. Parke, S. P. McGuinness, M. L. Eccleston. (2011). A preliminary randomized controlled trial to assess effectiveness of nasal high-flow oxygen in intensive care patients. Respiratory Care. 56 (3): e265-e270.

[8] L. Brochard, J. Mancebo, M. Wysocki, F. Lofaso, G. Conti, A. Rauss, G. Simonneau, S. Benito, A. Gasparetto, F. Lemaire. (1995). Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. New England Journal of Medicine. 333 (13): e817-e822.

[9] R. Scala, L. Heunks. (2018). Highlights in acute respiratory failure. European Respiratory Review. 27 (147).

[10] I. Pisani, V. Comellini, S. Nava. (2016). Noninvasive ventilation versus oxygen therapy for the treatment of acute respiratory failure. Expert review of respiratory medicine. 10 (7): e813-e821.

[11] B. Rochwerg, L. Brochard, M. W. Elliott, D. Hess, N. S. Hill, S. Nava, P. Navalesi, M. Antonelli, J. Brozek, G. Conti. (2017). Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure. European Respiratory Journal. 50 (2).

[12] C. C. Lee, D. Mankodi, S. Shaharyar, S. Ravindranathan, M. Danckers, P. Herscovici, M. Moor, G. Ferrer. (2016). High flow nasal cannula versus conventional oxygen therapy and non-invasive ventilation in adults with acute hypoxemic respiratory failure: a systematic review. Respiratory medicine. 121 (1): e100-e108.

[13] R. M. Montanes, D. Hajage, J. Messika, F. Bertrand, S. Gaudry, C. Rafat, V. Labbé, N. Dufour, S. J. Baptiste, A. Bedet. (2015). Use of high-flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild-to-moderate hypoxemia. Critical care medicine. 43 (3): e574-e583.

[14] M. K. Lee, J. Choi, B. Park, B. Kim, S. J. Lee, S. H. Kim, S. J. Yong, E. H. Choi, W. Y. Lee. (2018). High flow nasal cannulae oxygen therapy in acute-moderate hypercapnic respiratory failure. The clinical respiratory journal. 12 (6): e2046-e2056.

[15] J. Sun, Y. Li, B. Ling, Q. Zhu, Y. Hu, D. Tan, P. Geng, J. Xu. (2019). High flow nasal cannula oxygen therapy versus non-invasive ventilation for chronic obstructive pulmonary disease with acute-moderate hypercapnic respiratory failure: an observational cohort study. International Journal of Chronic Obstructive Pulmonary Disease. 1 (1): e1229-e1237.

[16] A. Cortegiani, F. Longhini, F. Madotto, P. Groff, R. Scala, C. Crimi, A. Carlucci, A. Bruni, E. Garofalo, S.M. Raineri. (2020). High flow nasal therapy versus noninvasive ventilation as initial ventilatory strategy in COPD exacerbation: a multicenter non-inferiority randomized trial. Critical Care. 24 (1): e1-e13.

[17] A. A. Alnajada, B. Blackwood, A. Mobrad, A. Akhtar, I. Pavlov, M. Shyamsundar. (2021). High flow nasal oxygen for acute type two respiratory failure: a systematic review. 1000 (10): e482.

[18] Y. Papachatzakis, P. T. Nikolaidis, S. Kontogiannis, G. Trakada. (2020). High-flow oxygen through nasal cannula vs. non-invasive ventilation in hypercapnic respiratory failure: a randomized clinical trial. International Journal of Environmental Research and Public Health. 17 (16): e5994.

[19] D. Tan, J. H. Walline, B. Ling, Y. Xu, J. Sun, B. Wang, X. Shan, Y. Wang, P. Cao, Q. Zhu. (2020). High-flow nasal cannula oxygen therapy versus non-invasive ventilation for chronic obstructive pulmonary disease patients after extubation: a multicenter, randomized controlled trial. Critical Care. 24 (1): e1-e10.

[20] L. Cong, L. Zhou, H. Liu, J. Wang. (2019). Outcomes of high-flow nasal cannula versus non-invasive positive pressure ventilation for patients with acute exacerbations of chronic obstructive pulmonary disease. International Journal of Clinical and Experimental Medicine. 12 (8): e10863-e10867.

[21] G. Jing, J. Li, D. Hao, T. Wang, Y. Sun, H. Tian, Z. Fu, Y. Zhang, X. Wang. (2019). Comparison of high flow nasal cannula with noninvasive ventilation in chronic obstructive pulmonary disease patients with hypercapnia in preventing postextubation respiratory failure: a pilot randomized controlled trial. Research in nursing & health. 42 (3): e217-e225.

[22] G. Y. Chang, C. A. Cox, T. H. Shaffer. (2011). Nasal cannula, CPAP, and high-flow nasal cannula: effect of flow on temperature, humidity, pressure, and resistance. Biomedical Instrumentation & Technology. 45 (1): e69-e74.

[23] L. Su, Q. Zhao, T. Liu, Y. Xu, W. Li, A. Zhang. (2021). Efficacy of high-flow nasal cannula oxygen therapy in patients with mild hypercapnia. Lung. 199 (5): e447-e456.