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Comparing the outcome of using high-flow nasal cannula oxygen therapy versus noninvasive ventilation for chronic obstructive pulmonary disease patients with acute hypercapnic respiratory failure

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Abstract

Background Noninvasive ventilation (NIV) is frequently employed as a treatment option for acute hypercapnic respiratory failure (AHRF) resulting from chronic obstructive pulmonary disease (COPD). Limited research has substantiated the claims made in recent studies regarding the feasibility of employing high flow nasal cannula (HFNC).

Aim Our study assessed the outcome of using HFNC versus NIV for COPD patients with AHRF.

Patients and methods Eighty COPD patients with AHRF were confined to the respiratory intensive care unit (RICU) at Ain-Shams University Hospitals from December 2021 to 2023 and subdivided into two groups (40/group), where the first group was placed on NIV while the second group was placed on HFNC. Data during their hospital stay as demographic data, vital data, arterial blood gases, device duration, treatment failure, and mortality were recorded.

Results The majority were males with mean age 63.75 ± 9.05 years along with treatment failure and complications 25%, 12.5.% in NIV versus 45%, and zero% in HFNC, respectively, with longer hospital stay in NIV 10–15 days to 7–10 days in HFNC, and with no difference in mortality rate in both groups.

Conclusion Both modalities NIV and HFNC were effective for treating COPD with AHRF. However, NIV group was significantly superior than HFNC along with apparently faster improvement in ventilatory and respiratory status especially in high CO2 level while less complications and duration of hospital stay in HFNC with no difference in mortality in both groups.

Keywords COPD, Noninvasive ventilation, Nasal cannula, Respiratory failure, Treatment failure

Introduction

Globally, chronic obstructive pulmonary disease (COPD) continues to be a leading cause of morbidity and mortality. Acute respiratory failure (ARF) accompanied by hypercapnia is characterized by a significant requirement for respiratory support and an elevated risk of death among COPD patients [1].

Noninvasive ventilation (NIV) is regarded as the cornerstone of treatment for hypercapnic ARF patients and COPD [2]. Although NIV may not be suitable for all patients, nearly a quarter of them have contraindications to its use [3].

Therapy with high-flow nasal cannula (HFNC) oxygen is considered more acceptable than NIV [4], and over the

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past few years, it has been assessed as a potential replacement for NIV in ARF [5–7]. In stable COPD patients, HFNC increases exercise tolerance and decreases partial pressure of carbon dioxide (PaCO2), respiratory rate, and work of breathing [8, 9]. Nonetheless, the efficacy of HFNC in hypercapnic ARF has not been comprehensively evaluated [10].

Thus, our study assessed the outcome of using HFNC versus NIV for COPD patients with acute hypercapnic respiratory failure.

Methods

Our present prospective randomized control study was performed on COPD patients with AHRF who were admitted to the Respiratory Intensive Care Unit (RICU) at Ain Shams University Hospitals from December 2021 to December 2023. Eighty patients participated in the investigation; they were randomly divided into 2 groups of 40 each; in the first group, noninvasive ventilation was implemented, whereas in the second group, high-flow nasal cannula was utilized.

Participants

After the approval of Ain Shams University Ethical Committee (FMASU MD195/2020), and obtaining written informed consent, COPD patients diagnosed by global initiative for obstructive lung disease (GOLD) 2020 [11] with acute respiratory failure (defined as respiratory acidosis "pH ≤ 7.35 and PaCO2 ≥ 50 mmHg" or exacerbation of dyspnea with accessory respiratory muscle use or persistent hypoxemia inspite of oxygen therapy) [12] were collected by convenience sample, while patients with severe respiratory failure necessitating instant endotracheal intubation or contraindication to NIV or patients who had previously used any of those two devices (NIV or HFNC) were excluded.

The patients who were included in the study were classified into two distinct categories upon their admission to the RICU: individuals who commenced noninvasive ventilation (NIV) within the initial 4 h of their admission were classified as part of the NIV group. This group utilized the Nellcor Puritan Bennett 840 ventilator system, manufactured in Minnesota, USA, and employed an oronasal interface with bilevel-positive airway pressure (BiPAP). Specifically, inspiratory-positive airway pressure was set at 10–12 cm H_2O, and expiratory positive airway pressure was initiated at 4–5 cm H_2O, with subsequent adjustments made based on the patients' arterial blood gases and physiological responses.

Patients who commenced HFNC within the initial 4 h of their admission were likewise classified as members of the HFNC group (using Fisher & Paykel Airvo 2 HFNC device made in Tamaki, New Zealand) with fraction of inspired oxygen adjusted to sustain oxygen saturation (spO_2) between 88 and 92%, with adjusted flow, while the humidifier temperature was set to 37 °C. Furthermore, in the event where the patient subsequently underwent invasive mechanical ventilation or another ventilatory support device during their admission, their group classification remained unchanged.

Data collection

All patients were subjected to detailed medical history (age, gender & smoking status, relevant comorbidities) and past history (previous hospital and ICU admission, need of long-term oxygen therapy), and then general and local examination was done for all patients as well as laboratory and radiological investigation (complete blood count, Chest X-ray). Clinical parameters like respiratory rate, heart rate, blood pressure, Sequential Organ Failure Assessment "SOFA" score, and arterial blood gases were assessed at the moment of admittance, 4 h and 24 h subsequent to the initiation of NIV or HFNC therapy (4 h and 24 h were chosen as time of recording vital data and arterial blood gases as they were considered to serve as a predictive factor for the success of the device utilized in our patients) [13]. Also, the duration of using the device, length of hospital and ICU stays, complications, treatment failure, and switch were recorded.

NB: Treatment failure refers to a deterioration in clinical parameters after 4-h post-treatment requiring treatment switch or escalation to invasive mechanical ventilation (IMV) directly. Treatment switch was defined as a change in ventilation modality due to a lack of improvement in clinical parameters within 4 h of treatment initiation, without meeting the criteria for IMV — criteria for IMV: respiratory or cardiac arrest, development of condition that requires intubation to guard the airway as coma or seizure, progressive respiratory muscle fatigue, and hemodynamic instability which lack response to fluids and vasoactive agents [14].

And to avoid any biases, one researcher collected data about NIV group, another researcher collected data about HFNC group, and then data was coded and sent for statistical analysis.

Statistical analysis

The quantitative data were analyzed utilizing IBM SPSS version 27. For parametric data, the results were presented as means, standard deviations, and ranges; for nonparametric data, the median and interquartile range were utilized. The values of qualitative variables were represented as percentages and numerals. Group comparisons for qualities of data utilized the chi-square or Fisher exact test, while for quantitative data, the independent *t*-test was used for parametric distribution and

the Mann–Whitney test for nonparametric distribution. Repeated measures ANOVA and Friedman tests were employed for comparisons among more than two paired groups with parametric and nonparametric distribution, respectively. Univariate and multivariate logistic regression analyses were conducted to identify predictors of treatment failure in the HFNC group, and Kaplan–Meier analysis was used to assess overall survival. A confidence interval of 95% and a significance level of < 0.05 were considered to be statistically significant.

Results

Our results showed that there was treatment failure in nearly half the patients of HFNC in comparison to nearly quarter the patients of NIV. Among the 18 patients experiencing treatment failure in the HFNC group, 10 patients (55.0%) were switched to NIV, of whom 8 patients (80.0%) achieved successful treatment, while 2 (20.0%) required mechanical ventilation. In contrary, no patients in the NIV group who experienced treatment failure were switched to HFNC; instead, they were all promptly shifted to invasive mechanical ventilation as shown in Fig. 1.

Table 1 showed that there were no significant differences observed in demographic data and characteristics between the NIV and HFNC groups.

Vital signs, arterial blood gases, and SOFA score were recorded at baseline and 4 h in both groups, but after 24 h, the data was recorded in all NIV group and only succeeded patients in HFNC group (22 patients). There were no significant differences between both studied groups regarding vital signs, SOFA score, and PiO_2/FiO_2%, while regarding the arterial blood gases parameters, the improvement was faster in NIV group in Table 2.

In Table 3, treatment failure rate was lower in the NIV group compared to the HFNC, although this difference did not reach statistical significance ($p = 0.061$), and circulatory failure was a significant cause of failure in NIV group. As regards the mortality rate between both groups, it was nearly the same. There was also a high statistical significance regarding duration of device application and total hospital stay between both groups, as NIV group had longer duration of device application and longer hospital stay. Also, number of patients who had complications on NIV (five patients) was higher than those on HFNC (0 patient) (p 0.065) but not reaching statistical significance. Psychosis exhibited a notably higher incidence rate among patients in the NIV group compared to those in the HFNC group (p 0.040).

In Table 4, in the univariate analysis, several factors showed significant associations with the outcome. These include hypertension (HTN) ($p = 0.007$), baseline and 4-h SOFA score > 2 ($p = 0.016$, 0.000) respectively, 4-h respiratory rate > 24 ($p = 0.000$), heart rate > 95 ($p = 0.000$), pCO2 > 58 ($p = 0.001$), PaO2/FiO2% $< = 171$ ($p = 0.000$), duration of device application $< = 5$ h ($p = 0.000$), and oxygen flow rate > 35 ($p = 0.028$). These results indicate that these variables may play a significant role in predicting the outcome. In the multivariate analysis, baseline only PaO2/FiO2% $< = 171$ at 4 h ($p = 0.000$) remained significant predictor, while other variables did not show

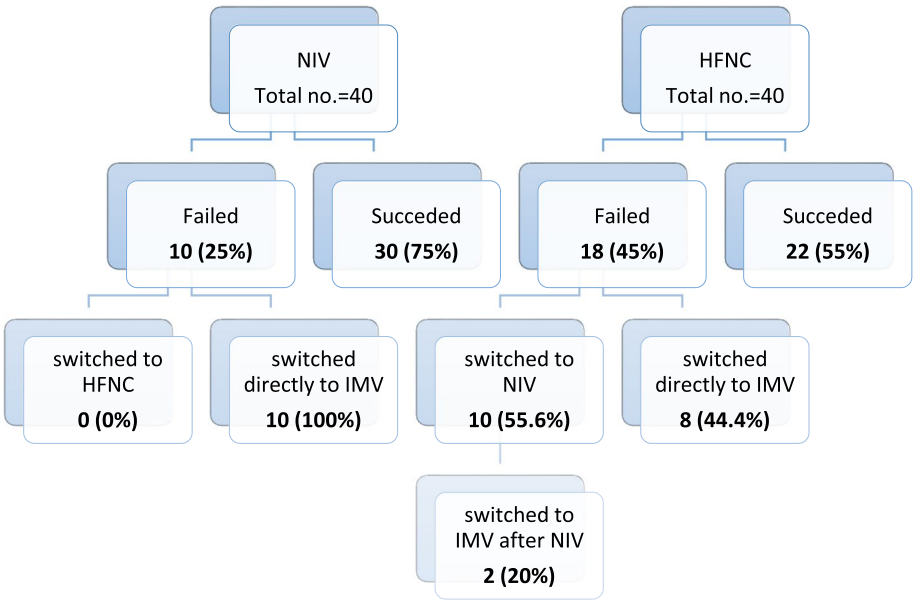

Fig. 1 Flowchart for treatment outcome in NIV and HFNC

Table 1 Comparison between NIV and HFNC groups regarding demographic data and characteristics of both groups

		NIV group No. = 40	HFNC group No. = 40	Test value	*P*-value	Sig.
Age	Mean ± SD	65.13 ± 8.97	62.38 ± 9.04	1.366[b]	0.176	NS
	Range	51 – 85	43 – 73			
Gender	Female	7 (17.5%)	11 (27.5%)	1.147[a]	0.284	NS
	Male	33 (82.5%)	29 (72.5%)			
Co-morbidities	No	16 (40.0%)	12 (30.0%)	0.879[a]	0.348	NS
	Yes	24 (60.0%)	28 (70.0%)			
	DM	15 (37.5%)	9 (22.5%)	2.143[a]	0.143	NS
	HTN	14 (35.0%)	17 (42.5%)	0.474[a]	0.491	NS
	ISHD	3 (7.5%)	3 (7.5%)	0.000[a]	1.000	NS
	AF	4 (10.0%)	2 (5.0%)	0.721[a]	0.396	NS
	HF	3 (7.5%)	6 (15.0%)	1.127[a]	0.288	NS
	CKD	2 (5.0%)	2 (5.0%)	0.000[a]	1.000	NS
Type of smoking	Shisha	1 (2.5%)	2 (5.0%)			
	Cigarettes	32 (80.0%)	29 (72.5%)	0.731[a]	0.694	NS
	Biomass	7 (17.5%)	9 (22.5%)			
Smoking pack year	Median (IQR)	60 (40 – 80)	46 (40 – 80)	-0.989[c]	0.322	NS
	Range	20 – 200	20 – 100			
Previous hospital admission		21 (52.5%)	21 (52.5%)	0.000[a]	1.000	NS
Number of previous hospital admission	No	19(47.5%)	19(47.5%)	0.865[a]	0.352	NS
	Once	8 (38.1%)	11 (52.4%)			
	Multiple	13 (61.9%)	10 (47.6%)			
Previous ICU admission		16 (40.0%)	8 (20.0%)	3.810[a]	0.051	NS
LTOT		11 (27.5%)	6 (15.0%)	1.867[a]	0.172	NS

Data are presented as mean ± standard deviation, median (inter quartile range), no (%), or %. *p*-value > 0.05, non significant; *p*-value < 0.05, significant; *p*-value< 0.01, highly significant

DM Diabetes mellites, *HTN* Hypertension, *ISHD* Ischemic heart disease, *AF* Atrial fibrillation, *HF* Heart failure, *CKD* Chronic kidney disease, *NIV* Non invasive ventilation, *HFNC* High-flow nasal cannula, *ICU* Intensive care unit, *LTOT* Long-term oxygen therapy

[a] Chi-square test

[b] Independent t-test

[c] Mann-Whitney test

significant associations with the outcome in the multivariate analysis.

In Fig. 2, the Kaplan–Meier curve analysis for cumulative survival rate showed comparable outcomes between the NIV and HFNC groups, with no statistically significant difference observed. Both groups had similar mean total hospital stays, suggesting similar overall mortality rates. The log-rank test further confirmed the lack of statistical significance between the two groups, indicating that the choice of ventilatory support did not significantly impact mortality outcomes in this study population.

Discussion

Nowadays, NIV is on the top of interventions in order to manage respiratory failure caused by COPD. However, NIV intolerance, however, is prevalent, as well as elevated intubation rates and overall mortality [15]. In contrast, HFNC is a new method of oxygen therapy with a high tolerance profile. However, many literatures on HFNC have excluded patients with ARF and hypercapnia [16].

So, our study investigated the outcome of using HFNC versus NIV for COPD patients with AHRF, and it was found that treatment failure rate was 25% in NIV versus 45% in HFNC, but this difference did not reach a significant statistical level ($p=0.061$), and by reviewing other literatures on this topic, it was found that treatment failure was also higher in HFNC (56%, 38.6%) than NIV (41%, 11.4%) respectively as mentioned in both retrospective studies of *Koga* et al. and *Wang* et al. [17, 18].

In contrast to the above mentioned studies, *Sun et al.* demonstrated a reduced treatment failure rate in the HFNC cohort relative to NIV. However, all of the above mentioned studies and ours did not reach statistical significance except that of Wang et al., so up until now, no

Table 2 Comparison between NIV and HFNC groups regarding vital signs, SOFA score, and arterial blood gases at baseline, 4 h, and 24 h among the studied patients

		NIV group No. = 40	HFNC group No. = 40	Test value	*p*-value	Sig
Respiratory rate						
Baseline	**Mean ± SD**	**25.68 ± 2.10**	**26.45 ± 2.66**	**− 1.445[a]**	**0.152**	**NS**
4 h	Mean ± SD	24.05 ± 2.73	24.80 ± 3.15	− 1.118[a]	0.267	NS
24 h	Mean ± SD	21.41 ± 3.25	21.25 ± 2.41	0.177[a]	0.86	NS
Repeated measures ANOVA	**F**	4050.778	2476.708			
	***p*-value**	0.000	0.000			
Heart rate						
Baseline	Mean ± SD	102.38 ± 10.31	98.00 ± 9.73	1.952[a]	0.055	NS
4 h	Mean ± SD	97.63 ± 9.43	96.25 ± 10.07	0.625[a]	0.534	NS
24 h	Mean ± SD	88.97 ± 8.77	86.88 ± 5.44	0.877[a]	0.385	NS
Repeated measures ANOVA	**F**	5778.076	3031.818			
	***p*-value**	0.000	0.000			
MAP						
Baseline	Mean ± SD	90.83 ± 9.72	90.25 ± 11.41	0.246[a]	0.806	NS
4 h	Mean ± SD	87.11 ± 10.20	84.42 ± 7.71	1.317[a]	0.192	NS
24 h	Mean ± SD	87.41 ± 6.58	88.08 ± 6.34	− 0.340[a]	0.735	NS
Repeated measures ANOVA	**F**	4.009	0.563			
	***p*-value**	0.032	0.501			
SOFA score						
Baseline	Mean ± SD	3 (2–3)	2 (2–3)	− 1.340b	0.18	NS
4 h	Mean ± SD	2 (2–3)	2.5 (2–3)	− 0.556[b]	0.578	NS
24 h	Mean ± SD	2 (2–3)	2 (2–2.5)	− 0.046b	0.963	NS
Friedman test	**χ^2**	7.143	2.000			
	***p*-value**	0.028	0.368			
PH						
Baseline	Mean ± SD	7.29 ± 0.07	7.31 ± 0.08	− 1.517[a]	0.133	NS
4 h	Mean ± SD	7.34 ± 0.06	7.31 ± 0.09	1.997[a]	0.049	S
24 h	Mean ± SD	7.40 ± 0.06	7.40 ± 0.06	0.108[a]	0.914	NS
Repeated measures ANOVA	**F**	1,014,378	165,869.78			
	***p*-value**	0.000	0.000			
CO2						
Baseline	Mean ± SD	84.03 ± 15.51	65.88 ± 13.42	5.597[a]	0	HS
4 h	Mean ± SD	74.92 ± 15.29	69.70 ± 19.24	1.311[a]	0.194	NS
24 h	Mean ± SD	63.47 ± 11.88	57.13 ± 15.14	1.589[a]	0.119	NS
Repeated measures ANOVA	**F**	1186.633	372.794			
	***p*-value**	0.000	0.000			
PiO2/FiO2%						
Baseline	Median (IQR)	177.5 (121.5–246)	190 (141.5–237)	− 0.529[b]	0.597	NS
4 h	Median (IQR)	205 (171–242)	195.5 (120.5–233)	− 0.933[b]	0.351	NS
24 h	Median (IQR)	220 (185–261)	236 (176–238.5)	− 0.526[b]	0.599	NS
Friedman test	**χ^2**	15.168	2.625			
	***p*-value**	0.000	0.269			

Data are presented as mean ± standard deviation, median (interquartile range), no (%), or %. *p*-value > 0.05, nonsignificant; *p*-value < 0.05, significant; *p*-value < 0.01, highly significant

MAP Mean arterial pressure, *SOFA* Sequential Organ Failure Assessment

[a] Independent *t*-test

[b] Mann–Whitney test

Table 3 Comparison between NIV and HFNC groups regarding duration of device application and outcome among the studied patients

		NIV group No. = 40	HFNC group No. = 40	Test value	*p*-value	Sig
Treatment failure		10 (25.0%)	18 (45.0%)	3.516[a]	0.061	NS
Mechanical ventilation		10 (25.0%)	10 (25.0%)	0.000[a]	1.000	NS
Treatment switch		0	10	10	0	HS
Treatment failure cause	Hypoxia	4 (10.0%)	8 (20.0%)	1.569[a]	0.210	NS
	Hypercapnia	8 (20.0%)	16 (40.0%)	3.810[a]	0.051	NS
	Circulatory failure	5 (12.5%)	0 (0.0%)	5.333[a]	0.021	S
mortality		4 (10.0%)	6 (15.0%)	0.457[a]	0.499	NS
Duration of device	Median (IQR)	72 (24–96)	8.5 (4–48)	−3.667[b]	0.000	HS
Application (h)	Range	2–336	4–96			
Complications	Yes	5 (12.5%)	0 (0%)	3.41	0.065	NS
	Pneumothorax	1 (2.5%)	0 (0.0%)	1.013[a]	0.314	NS
	Psychosis	4 (10.0%)	0 (0.0%)	4.211[a]	0.040	S
	Nasal facial skin breakdown	0 (0.0%)	0 (0.0%)	–	–	–
ICU stay (days)	Median (IQR)	7 (6–10)	7 (4.5–9)	−1.647[b]	0.100	NS
	Range	2–21	2–16			
Total hospital stays (days)	Median (IQR)	13.5 (10–15)	10 (7–14)	−2.241[b]	0.025	S
	Range	6–28	6–30			

ICU Intensive care unit

p-value > 0.05, nonsignificant, *p*-value < 0.05, significant; *p*-value < 0.01, highly significant

[a] Chi-square test

bMann–Whitney test

Table 4 Univariate and multivariate logistic regression analysis to assess predictors of treatment failure among HFNC group

		Univariate				Multivariate			
		p-value	Odds ratio (OR)	95% *CI* for OR		*p*-value	Odds ratio (OR)	95% *CI* for OR	
				Lower	Upper			Lower	Upper
HTN		**0.007**	6.800	1.680	27.522	–	–	–	–
Baseline	SOFA score > 2	**0.016**	5.333	1.373	20.712				
4 h	Respiratory rate > 24	**0.000**	15.750	3.336	74.350	–	–	–	–
	Heart rate > 95	**0.000**	35.000	5.617	218.106	–	–	–	–
	SOFA score > 2	**0.000**	36.000	5.798	223.544	–	–	–	–
	PCO2 > 58	**0.001**	21.333	3.730	122.017	–	–	–	–
	PaO2/FiO2% < = 171	**0.000**	80.000	10.122	632.260	0.000	80.000	10.122	632.260
Duration of device application < = 5 (h)		**0.000**	36.000	5.798	223.544	–	–	–	–
Oxygen flow rate > 35		**0.028**	6.667	1.227	36.226	–	–	–	–

HTN Hypertension, *SOFA* Sequential Organ Failure Assessment

device of them showed superiority in management of COPD with AHRF [18, 19].

Our study observed no significant differences in demographics and baseline characteristics between the NIV and HFNC groups. These findings resonate with the conducted research by *Lee* et al., who reported no baseline characteristic difference between the two groups, and this is considered as point of strength in our study to avoid any confounding factor that might affect the outcome of any of both devices [20].

A total of 80% were either current or ex-smokers with an average of 50 pack-years, closely resembling the study

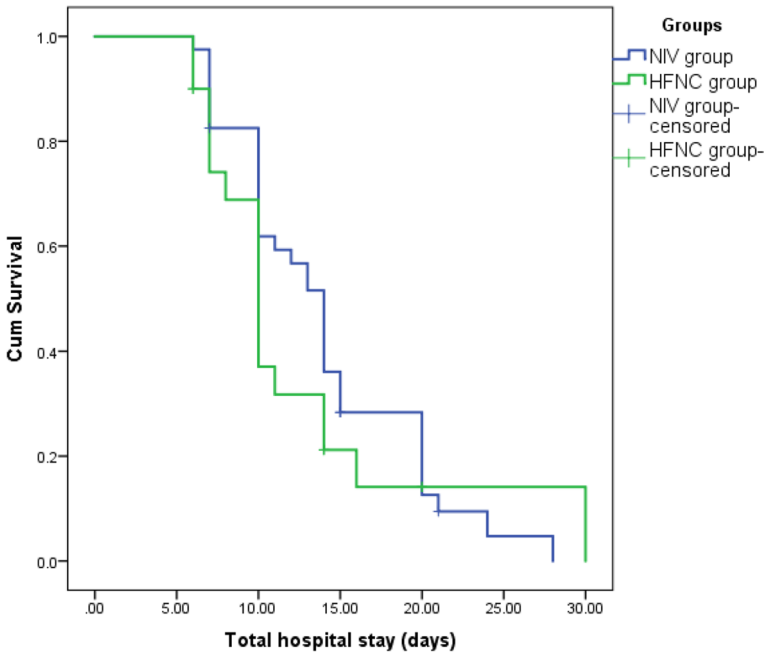

Fig. 2 Kaplan–Meier curve analysis for cumulative survival rate

done by *Sun* et al., where 61.4% of the studied patients were either current or ex-smokers [19]; these findings correlate with *Kohansal* et al., who reported that individuals who smoke cigarettes experience a greater incidence of respiratory symptoms and lung function abnormalities, exhibit a more rapid annual decrease in FEV1, and have a higher mortality rate from COPD compared to non-smokers [21]. Also, hypertension was the most common comorbidity, observed in both our study (38.8%) and theirs (56.1%) [19]. This finding aligns with the latest COPD guidelines, which suggest that hypertension is likely the most prevalent comorbidity in COPD and may affect prognosis [22].

Analysis of vital data parameters attained no statistically significant differences between the HFNC and NIV groups 4- and 24-h post-treatment. These results are consistent with the study conducted by *Cortegiani* et al., who compared HFNC versus NIV as initial ventilatory strategy during COPD exacerbation in a non-inferiority randomized multicentric trial, and reported that no differences in vital data parameters were found between both groups after 2- and 6-h post-treatment. It also agrees with the study carried out by *Sun* et al., who reported no significant differences between the two groups in terms of respiratory rate 24-h post-treatment [19, 23].

Additionally, analysis of respiratory parameters revealed no substantial differences in pH, PaCO2, or PaO2/FiO2 between HFNC group and NIV group after 4 and 24 h. These findings agree with the study conducted by *Lee* et al. who reported similar improvement in both groups with no significant differences in respiratory parameters after 6- and 24-h post-treatment, but in contrary to *Lee* et al., this study showed faster improvement in respiratory parameter after 4 h in NIV in comparison to HFNC [20].

In our study, the HFNC group exhibited a shorter duration of device application along with shorter total hospital stay; these findings corroborate the results of the retrospective study performed by Wang et al., who found that HFNC also was substantially related to shorter length of ICU stay, hospital stay, and total ventilation days than NIV, despite exhibiting more treatment failure in our study and theirs [18].

In our study, complications in the NIV group occurred at twice the rate compared to the HFNC group. This agrees with *Sun* et al. who observed a higher rate of complications in the NIV group compared to the HFNC group. Notably, nasal facial breakdown was the most common complication in their study, whereas psychosis was more prevalent in ours. This may be explained by the diversity in the study population between both studies [19].

In our study, treatment failure was mainly linked to hypoxia, hypercapnia, and circulatory failure. Notably, there was no statistical significance between the two groups regarding hypoxia and hypercapnia as causes of treatment failure, mirroring the observations of *Sun* et

al. who also noted no distinction in respiratory distress, hypoxemia, and carbon dioxide retention between the two groups. However, in our study, hypercapnia significantly contributed to treatment failure in NIV group, though it is not reaching statistical significance [19].

Additionally, in our study, circulatory failure emerged as a significant contributing factor, particularly affecting the NIV group more than the HFNC group; this finding is consistent with the pilot randomized controlled trial conducted by *Jing* et al., comparing effect of HFNC and NIV in hypercapnic COPD patients, and this can be explained that blood pressure decreased significantly after using NIV but not significantly after using HFNC, and this is due to the impact of NIV on affecting venous return than HFNC [24].

Mortality rates were nearly equivalent between the two modalities. Therefore, our study was maintaining consistency with the findings of the meta-analysis performed by *Liu* et al., who reported no significant differences in mortality outcomes between the two modalities. Also, *Wang* et al., reported that the 30-day mortality and 90-day mortality rates for the HFNC and NIV groups were nearly equivalent [18, 25].

Also, the previous nonstatistically significant difference in mortality was confirmed by Kaplan–Meier curve analysis which revealed comparable cumulative survival rates, indicating no significant distinction between both treatment modalities (log-rank test 2.265, $p=0.132$).

Our study identified several predictors of treatment failure with HFNC therapy through performing univariable and multivariable logistic regression analyses. The univariate analysis of the HFNC group unveiled a number of factors that exhibited statistically significant correlations with the outcome. These include hypertension (HTN) ($p=0.007$), baseline and 4-h SOFA score > 2 ($p=0.016$, 0.000) respectively, 4-h respiratory rate > 24 ($p=0.000$), heart rate > 95 ($p=0.000$), pCO2 > 58 ($p=0.001$), PaO2/FiO2% < = 171 ($p=0.000$), duration of device application < = 5 h ($p=0.000$), and oxygen flow rate > 35 ($p=0.028$). According to these findings, these variables might have a substantial impact on the outcome prediction. In the multivariate analysis, only PaO2/FiO2% < = 171 at 4 h ($p=0.000$) remained significant predictor, while other variables did not show significant associations with the outcome in the multivariate analysis.

In contrary to our findings, none of the above factors was significant in the univariable logistic regression analyses of the study conducted by *Wang* et al., who only exhibited NT-proBNP as the sole significant determinant of HFNC failure in the univariate analysis, a variable that was omitted from our analysis [18].

Limitations

Initially, the study was not multicentric hindering larger and more variable sample size with relatively brief duration. Additionally, the decision in the study to start with NIV or HFNC was made on a clinical basis, raising the possibility of selection bias. However, it is worth noting that there were no statistically significant differences in baseline characteristics between the two groups, so this factor did not impact the effectiveness of either device.

Conclusion

Both modalities NIV and HFNC were effective for treating COPD with AHRF. However, NIV group was significantly superior than HFNC along with apparently faster improvement in ventilatory and respiratory status especially in high CO2 level while less complications and duration of hospital stay in HFNC with no difference in mortality in both groups.

Abbreviation

HFNC High-flow nasal cannula oxygen therapy
NIV Noninvasive ventilation

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None

Authors' contributions

The idea and design of the study were contributed to all authors. AM handled the preparation of the materials as well as the data collecting and analysis. MA and DR authored the original draft of the manuscript, while MF revised it. Every author offered feedback on earlier drafts of the work. The final manuscript was read and approved by all writers.

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Availability of data and materials

The datasets utilized or examined in this study can be obtained from the corresponding author upon request.

Declarations

Ethics approval and consent to participate

Ethical approval of Ain Shams University Ethical Committee was acquired (FMASU MD195/2020), and written informed consent from patients' relatives was gained owing to their critical condition.

Consent for publication

None.

Competing interests

The authors declare that they have no competing interests.

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References

1. Brown H, Dodic S, Goh SS, et al. (2018). Factors associated with hospital mortality in critically ill patients with exacerbation of COPD. Int J Chron

Obstruct Pulmon Dis. 2018;13:2361–2366. https://doi.org/10.2147/COPD.S168983.
2. Shah NM, D'Cruz RF, Murphy PB (2018) Update: non-invasive ventilation in chronic obstructive pulmonary disease. J Thoracic Dis 10(Suppl 1):S71
3. Brochard L, Mancebo J, Wysocki M et al (1995) Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. NEJM 333(13):817–822
4. Ischaki E, Pantazopoulos I, Zakynthinos S (2017). Nasal high flow therapy: a novel treatment rather than a more expensive oxygen device. Eur Respir Rev. 2017;26(145):170042. https://doi.org/10.1183/16000617.0028-2017.
5. Frat JP, Thille AW, Mercat A et al (2015) High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. NEJM 372(23):2185–2196
6. Hernández G, Vaquero C, González P et al (2016) Effect of postextubation high-flow nasal cannula vs conventional oxygen therapy on reintubation in low-risk patients: a randomized clinical trial. JAMA 315(13):1354–1361
7. Hernández G, Vaquero C, Colinas L et al (2016) Effect of postextubation high-flow nasal cannula vs noninvasive ventilation on reintubation and postextubation respiratory failure in high-risk patients: a randomized clinical trial. JAMA 316(15):1565–1574
8. Bräunlich J, Köhler M, Wirtz H (2016). Nasal highflow improves ventilation in patients with COPD. Int J Chronic Obstruct Pulm Dis. 2016;11:1077–1085. https://doi.org/10.2147/COPD.S104616.
9. Pisani L, Fasano L, Corcione N et al (2017) Change in pulmonary mechanics and the effect on breathing pattern of high flow oxygen therapy in stable hypercapnic COPD. Thorax 72(4):373–375
10. Millar J, Lutton S, O'Connor P (2014) The use of high-flow nasal oxygen therapy in the management of hypercarbic respiratory failure. Therap Adv Res Dis 8(2):63–64
11. Rabe KF, Hurd S, Anzueto A et al (2007) Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Res Crit Care Med 176(6):532–555
12. Bosnic-Anticevich SZ, Kim DK, Lee J et al (2018) What can we apply to manage acute exacerbation of chronic obstructive pulmonary disease with acute respiratory failure? Tuberc Res Dis 81(2):99–105
13. Chawla RK, Yadav V, Banerjee S et al (2021) Predictors of success and failure of non-invasive ventilation use in type-2 respiratory failure. Indian J Tubercul 68(1):20–24
14. Chen Q, Liu M, Liu B, et al. (2020). Predictive factors for failure of noninvasive ventilation in adult intensive care unit: a retrospective clinical study. Can Respir J. 2020;2020:1324355. https://doi.org/10.1155/2020/1324348.
15. Liu J, Duan J, Bai L et al (2016) Noninvasive ventilation intolerance: characteristics, predictors, and outcomes. Res Care 61(3):277–284
16. Friggeri A, Cazalis MA, Pachot A et al (2016) Decreased CX3CR1 messenger RNA expression is an independent molecular biomarker of early and late mortality in critically ill patients. Crit Care 20:1–13
17. Koga Y, Kaneda K, Fujii N et al (2020) Comparison of high-flow nasal cannula oxygen therapy and non-invasive ventilation as first-line therapy in respiratory failure: a multicenter retrospective study. Acute Medicine & Surgery 7(1):e461
18. Wang M, Zhao F, Sun L, et al. (2023). High-flow nasal cannula versus noninvasive ventilation in AECOPD patients with respiratory acidosis: a retrospective propensity score-matched study. Can Respir J. 2023;2023:6377451. https://doi.org/10.1155/2023/6377441.
19. Sun J, Li Y, Ling B, et al. (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. Int J Chron Obstruct Pulmon Dis. 2019;14:1229–1237. https://doi.org/10.2147/COPD.S206567.
20. Lee MK, Choi J, Park B et al (2018) High flow nasal cannulae oxygen therapy in acute-moderate hypercapnic respiratory failure. Clin Res J 12(6):2046–2056
21. Kohansal R, Martinez-Camblor P, Agustí A et al (2009) The natural history of chronic airflow obstruction revisited: an analysis of the Framingham offspring cohort. Am J Res Crit Care Med 180(1):3–10
22. Divo M, Cote C, de Torres JP et al (2012) Comorbidities and risk of mortality in patients with chronic obstructive pulmonary disease. Am J Res Crit Care Med 186(2):155–161
23. Cortegiani A, Longhini F, Madotto F et al (2020) High flow nasal therapy versus noninvasive ventilation as initial ventilatory strategy in COPD exacerbation: a multicenter non-inferiority randomized trial. Crit Care 24:1–13
24. Jing G, Li J, Hao D et al (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. Res Nurs Health 42(3):217–225
25. Liu Y, Zhang Y, Zeng Y et al (2023) High-flow nasal cannula versus noninvasive ventilation after extubation in hypercapnic patients with COPD: a retrospective analysis. Chinese Med J 136(16):2008–2010

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