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ORIGINAL ARTICLE

Role of High flow Nasal Cannula Oxygen Therapy Versus Non-Invasive Ventilation in the Management of Acute Respiratory Failure

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Abstract

Background: ***Noninvasive ventilation (NIV) is widely accepted as the principal treatment for individuals with acute respiratory failure (ARF). The high flow nasal cannula (HFNC) is considered to provide greater comfort in cases where NIV is not compatible.***

Aim of the work: ***To assess the efficacy of HFNC oxygen therapy compared to NIV in the treatment of ARF.***

Patients and methods: ***This prospective randomized controlled study was conducted on fifty patients with ARF due to respiratory etiology. Participants were equally divided, according to the ventilatory aid employed, into HFNC and NIV groups.***

Results: ***The average PaO2 value at 30 minutes exhibited a statistically significant increase in the HFNC group as compared to the NIV group. However, no statistically significant changes were seen between the study groups at the beginning or after 120 minutes. None of the HFNC and NIV groups exhibited statistically significant differences in terms of clinical progression, length of ICU stay, and outcome. A notable increase in mouth dryness was observed in the NIV group, but a significant increase in nasal irritation/dryness was observed in the HFNC group.***

Conclusion: ***HFNC oxygen therapy is as effective as NIV in the management of ARF, with coinciding clinical success, overall ICU stay, clinical outcome, and complications spectrum.***

Keywords: Acute respiratory failure; Non-invasive ventilation; Nasal cannula oxygen therapy

1. Introduction

ICU mortality has ARF as one of its main causes. Primarily, it is caused by pneumonia, acute aggravation of chronic obstructive pulmonary disease (AECOPD), and cardiogenic pulmonary edema (CPE).[1]

The use of noninvasive ventilation (NIV) for acute respiratory failure (ARF) has increased over the past few decades as a simple alternative to invasive mechanical ventilation. [2] About 25% of critically ill patients, however, may not be able to afford or use NIV. Because of this, HFNC oxygen treatment is a new respiratory aid that is more tolerable.3

As a stand-in for NIV in acute hypoxemic respiratory failure or post-extubation, HFNC has recently been studied.[4] Furthermore, in stable COPD patients, HFNC seems to enhance the work of breathing, respiratory rate, and exercise tolerance.[5]

Therefore, the purpose of this study was to evaluate the efficacy of NIV versus HFNC oxygen therapy in the treatment of ARF.

2. Patients and methods

Patients were primarily excluded if they were: aged<18 years old, presented with ARF due to non-respiratory causes (e.g., CPE), fulfilled the criteria for immediate invasive MV (e.g., disturbed consciousness with respiratory distress, persistent or worsening hypoxemia and/or hypercapnia, clinically evident increased work of breathing unrelieved by other interventions or threatened upper airways).[6]

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Data collection

A thorough medical history was taken for each patient, along with a general examination, a local chest examination, and basic laboratory tests such as CBC, ESR, RBS, renal function test, hepatic profile, and serum electrolytes for every patient. Additionally, a plain chest X-ray was performed, showing the postero-anterior aspect, as well as a CT scan of the chest (optionally with or without IV contrast). After starting HFNC/NIV, arterial blood gases were applied in a serial fashion, recording FiO2 at baseline, 30, and 120 minutes later. Moreover, valuable data during management were recorded (i.e., need for intubation and invasive MV, days on invasive MV (if occurred), duration of ICU stay, complications, and outcome (survival or mortality).

High flow nasal cannula:

The Arab Organization for Industrialization, located in Cairo, Egypt, utilized the BioHF BB60101 system, which is part of the Biovent A series. The machine was configured as per the manufacturer's guidelines. 45 L/min was the initial flow rate. If the respiratory rate did not decrease or the oxygenation was still not correct, the flow rate was then gradually increased by 5 to 10 L/min, then decreased if it was not tolerated. The first step in raising SpO2 is typically to titrate the flow rate upward in order to raise FiO2.[7] However if SpO2 significantly drops below the desired level, FiO2 levels can rise SpO2 more quickly. Oxygen flow was maintained until target oxygenation was achieved, then FiO2 was gradually lowered to<0.5. Thereafter, the flow was gradually decreased as long as oxygenation was accepted. Once optimal oxygenation was reached with a flow <20L/min while FiO2<0.5, HFNC therapy was terminated, and switching to conventional oxygen therapy took place.[8] In the majority of cases, the goal SpO2 was≥92%; in patients with established COPD or hypercapnic respiratory failure, it was 88–92%.[9]

Noninvasive ventilation:

While the patient adopted a semi-recumbent position, NIV was delivered by means of an oronasal mask connected to a ventilator apparatus with a dedicated NIV mode. The ventilators used were Drager Evita 4 (Drager Medical GmbH, Lübeck, Germany).

Subjects were ventilated by an NIV device (either CPAP or BIPAP), aiming for a breathing frequency of less than thirty breaths per minute and an expired tidal volume of six to eight milliliters per kilogram. FiO2 was changed to keep above 92% while maintaining a PEEP of at least four cmH2O.[10]

Monitoring

Throughout both procedures, continuous monitoring of vital data, pulse oximetry, ECG, airway patency and equipment integrity was performed. Alongside with cautious assessment of signs of HFNC/NIV therapy failure and need for intubation and invasive MV, e.g., disturbed conscious level, persistent respiratory distress and thoracoabdominal asynchrony.

Ethical consideration:

At the beginning, all patients involved (or legal guardians) were asked for their informed consent. The Scientific Research Ethics Committee amended and approved the consent (Al-Azhar University). Confidentiality was preserved for all subjects and data were collected namelessly. Surely, the right to reject participating or to decide withdrawing was guaranteed with perfect pledge to the declaration of Helsinki.

Statistical analysis:

SPSS (Statistical Package for Social Science; IBM Corp., Armonk, NY, USA) version 25.0 was used to process the data that were fed into the computer. Number and percent were used to characterize qualitative data. Verify the normality of the distribution using the Shapiro-Wilk test. Interquartile range (IQR) and median were used to characterize quantitative data, along with mean±standard deviation. Significance was determined by P-values ~0.05. Analyzing categorical variables involved using the chi-square test. Instead, Fisher's Exact test was used in cases where more than 20% of cells had predicted counts of less than 5. The Student T-test and the Mann-Whitney U test were used to test for regularly distributed and abnormally distributed quantitative variables.

3. Results

In terms of sociodemographic information, the average age of patients in the HFNC group was 55.64±14.08 years, with 52% of them being male. In contrast, the NIV group had a mean age of 61.24±11.22 years and a male predominance of 64%. There were no statistically significant variations found in the sociodemographic information and comorbidities between the study groups (Table 1).

Table 1. Comorbidities and sociodemographic information in the research groups.

VARIABLES		HFNC GROUP (N=25)	NIV GROUP (N=25)	STATISTICAL TEST	P-VALUE
SEX					
MALE	n (%)	13 (52)	16 (64)	X^2=0.739	0.390
FEMALE	n (%)	12 (48)	9 (36)		
AGE	Median (IQR)	59 (49-65)	62 (53-70)	Z=1.464	0.144
SMOKING					
YES	n (%)	10 (40)	15 (60)	X^2=2.00	0.157
NO	n (%)	15 (60)	10 (40)		
COMORBIDITIES					
HYPERTENSION	n (%)	7 (28)	11 (44)	X^2=1.389	0.239
DM	n (%)	7 (28)	5 (20)	X^2=0.439	0.508
IHD	n (%)	1 (4)	3 (12)	X^2=1.087	0.290
CKD	n (%)	2 (8)	4 (16)	X^2=0.758	0.384
CLD	n (%)	3 (12)	2 (8)	X^2=0.222	0.638

DM: diabetes mellitus, IHD: ischemic heart disease, CKD: chronic kidney disease, CLD:

chronic liver disease, SD: standard deviation, IQR: interquartile range, X2: Chi-square test, Z: Mann-Whitney U test.

The mean pH values at baseline, 30 minutes, and 120 minutes were considerably higher in the HFNC group, as shown in Table 2. However, the HFNC group's mean PaCO2 and HCO3 values at baseline, 30 minutes, and 120 minutes were considerably lower. There were no statistically significant differences between the study groups at baseline or 120 minutes, while the HFNC group's mean PaO2 value at 30 minutes was significantly higher. Moreover, there were no appreciable differences in the mean PaO2/FiO2 ratios between the HFNC and NIV groups at baseline, 30 minutes, or 120 minutes.

Regarding chest X-ray follow-up, length of stay on HFNC/NIV, overall length of ICU stay, clinical progression, length of stay on invasive MV (for non-responsive cases), and outcome, no statistically significant differences were seen between the study groups. With the exception of mouth dryness, which was significantly more common in the NIV group while nasal irritation/dryness was significantly more common in the HFNC patients, the rate of procedure-related problems did not differ significantly between the two groups (Table 3).

Table 2. ABG parameters and PaO2/FiO2 at baseline and follow-up intervals in the study groups.

PARAMETERS	TIME		HFNC GROUP (N=25)	NIV GROUP (N=25)	T-TEST	P-VALUE
PH	Baseline	Mean±SD	7.35±0.08	7.31±0.06	2.423	0.019*
	At 30 min.	Mean±SD	7.37±0.08	7.32±0.06	2.562	0.014*
	At 120 min.	Mean±SD	7.39±0.07	7.34±0.08	2.491	0.016*
$PACO_2$	Baseline	Mean±SD	41.48±11.70	65.80±15.00	6.397	<0.001**
	At 30 min.	Mean±SD	43.04±11.10	64.56±15.50	5.651	<0.001**
	At 120 min.	Mean±SD	40.81±9.36	66.28±19.70	5.840	<0.001**
PAO_2	Baseline	Mean±SD	51.12±6.23	49.68±7.36	0.746	0.458
	At 30 min.	Mean±SD	56.96±7.28	52.64±7.49	2.068	0.044*
	At 120 min.	Mean±SD	65.68±12.20	60.56±7.52	1.788	0.080
HCO_3	Baseline	Mean±SD	21.92±5.13	31.20±5.68	6.063	<0.001**
	At 30 min.	Mean±SD	21.95±4.93	30.06±8.32	4.191	<0.001**
	At 120 min.	Mean±SD	24.38±6.56	33.20±5.33	4.191	<0.001**
PAO_2/FIO_2	Baseline	Mean±SD	99.52±14.40	102.24±12.20	0.705	0.483
	At 30 min.	Mean±SD	104.08±48.34	115.80±39.50	0.129	0.352
	At 120 min.	Mean±SD	115.52±53.03	134.40±42.50	1.390	0.171

PaCO2: partial pressure of carbon dioxide in arterial blood, PaO2: partial pressure of oxygen in arterial blood, HCO3: Bicarbonate, FiO2: fraction of inspired oxygen, SD: standard deviation, T: student T test, *: statistically significant, **: statistically highly significant.

Table 3. Radiological and clinical outcomes in the study groups.

VARIABLES		HFNC GROUP (N=25)	NIV GROUP (N=25)	STATISTICAL TEST	P-VALUE
CHEST X-RAY FOLLOW-UP					
IMPROVED	n (%)	6 (24)	5 (20)	X^2=43.00	0.074
STATIONARY	n (%)	10 (40)	16 (64)		
WORSENED	n (%)	9 (36)	4 (16)		
DURATION ON HFNC/NIV (DAYS)	Median (IQR)	2 (2-3)	3 (2-4)	Z=1.467	0.142
OVERALL ICU STAY (DAYS)	Mean±SD	9.72±5.81	8.12±3.0	T=1.223	0.229
CLINICAL PROGRESSION					
IMPROVED ON APPLIED MANAGEMENT	n (%)	12 (48)	18 (72)	X^2=3.00	0.0832
DETERIORATED WITH NEED FOR MV	n (%)	13 (52)	7 (28)		
DURATION ON MV (DAYS)	Mean±SD	5.30±2.01	6.71±1.27	T=1.588	0.064
OUTCOME					
SURVIVED	n (%)	15 (60)	18 (72)	X^2=0.802	0.37
DIED	n (%)	10 (40)	7 (28)		
COMPLICATIONS					
NO	n (%)	14 (56)	12 (48)	X^2=0.320	0.571
ABDOMINAL DISTENSION	n (%)	0 (0)	4 (16)	X^2=2.446	0.118
INTOLERANCE	n (%)	3 (12)	5 (20)	X^2=0.595	0.44
MOUTH DRYNESS	n (%)	0 (0)	6 (2)	X^2=4.735	0.03*
NASAL IRRITATION/DRYNESS	n (%)	6 (24)	0 (0)	X^2=4.735	0.03*

ICU: intensive care unit, MV: mechanical ventilation, SD: standard deviation, IQR: interquartile ratio, X2: Chi-square test, Z: Mann-Whitney U test, T: student T test, *: statistically significant.

4. Discussion

A high-flow nasal cannula (HFNC) can provide a sufficient level of positive end-expiratory pressure, resulting in a significant reduction in both pharyngeal dead space and nasopharyngeal resistance. Furthermore, a high-flow nasal cannula (HFNC) may offer enhanced comfort and reduced obtrusiveness compared to alternative methods of oxygen administration in patients with severe hypoxia.[11]

The socio-demographic data reveals that the average age of patients in the HFNC group was 55.64±14.08 years, with a majority of them (52%) being male. Conversely, the average age of patients in the NIV group was 61.24±11.22 years, with a 64% male majority. There were no statistically significant variations seen between the research groups in terms of age and sex, as

indicated by p-values of 0.144 and 0.39, respectively.

Our findings are corroborated by those of Papachatzakis et al.[12] In that study, The HFNC group had a mean age of 76.0±13.4 years, with an equal distribution of genders. The NIV group exhibited a mean age of 78.1±8.1 years, with a female participation rate of 55.0%. There were no statistically significant differences seen in relation to age and sex (p-value=0.544 and 0.752, respectively). Comparable outcomes were achieved by Wanget al. [13] and Lee et al. [14]

In relation to comorbidities, there were no statistically significant disparities seen across the study groups. In the work of Sun and his colleagues[15] the frequencies of hypertension, DM, IHD, CKD and CLD among the patients in HFNC and NIV groups were negligently different. Those conclusions are closely adherent to ours.

In the present investigation, the average PaCO2 measurements at the beginning, 30 minutes, and 120 minutes exhibited a statistically significant decrease in the HFNC group. In contrast, it was observed that the average PaO2 value at 30 minutes was notably elevated in the HFNC group. However, no statistically significant disparities were identified between the study groups at the beginning and after 120 minutes. Furthermore, the average PaO2/FiO2 ratios at the beginning, 30 minutes, and 120 minutes did not exhibit any significant differences between the HFNC and NIV groups.

Abo-Galala et al.[16] registered a significantly higher PaCO2value at 120 min. in NIV group compared to HFNC group, with analogous results to ours when comparing PaO2 values at 30 min. and 120 min. in both groups. In contrary, Cortegiani et al.[17] revealed that the mean PaCO2 values at baseline and 120 min. did not significantly vary in HFNC and NIV groups.

However, Simon et al.[18] After 15 minutes of starting oxygen therapy, the NIV group had a substantially higher mean PaO2/FiO2 than the HFNC group (p-value=0.002). This finding contradicts our initial results. However, this link became insignificant after 24 hours (p-value=0.29).

In our study, the mean days on either noninvasive ventilatory supportive method were 3.24±4.87 days in HFNC and 3.52±2.66 days in the NIV group; The study groups showed no statistically significant difference (p-value=0.142). Combining our findings, Lee et al.[14] revealed a non-significant variance between the study groups according to the median duration of HFNC/NIV (p-value=0.978). While conflicting with us, Sun et al.[15] reported a significantly longer mean duration on noninvasive devices in comparison to the HFNC group and the NIV group. Simon et al.[18] recorded a hassling conclusion (p-value=0.04).

When noninvasive options failed, the mean duration on invasive MV was 5.30±2.01 days in HFNC group, while its match in NIV group was 6.71±1.27 days, without any statistically significant disparity The p-value is 0.064.

This finding corresponds to that of Coudroy and co-workers[19] who showed an insignificant variation between HFNC group and the NIV group considering the median period of invasive MV in unresponsive cases (p-value=0.63). So, Cortegiani et al.[17] registered an alike result.

As appeared in the current study, 48% of HFNC group patients improved on applied management, while 52% required invasive MV. On the other hand, 72% of NIV group patients recovered, while 28% were impaired with the need for invasive MV. The study groups did not exhibit any statistically significant disparity in terms of clinical development (p-value=0.0832).

These observations harmonize with da Silva Costa et al.[20] who reported intubation rates of 69.6% and 57.1% in HFNC and NIV groups respectively (p-value=0.49). Alongside, an Asian-conducted study showed resembling findings. Adversely[21], Coudroy et al.[19] exposed a significantly higher intubation rate in NIV group (55%) compared to HFNC group (35%) (p-value=0.04).

In the HFNC group, the mean overall ICU stay was 9.72±5.81 days, while in the NIV group, was8.12±3.0 days; the study groups did not exhibit any statistically significant differences (p-value=0.229). The preceding observation exhibits an analogous relationship with Sun et al.[15] and Nair et al.[22] who reported identical results (p-value=0.207 and 0.36, respectively)

In this work, 60% and 72% were the survival rates in HFNC and NIV groups respectively, whereas 40% and 28% represented the mortality rate in both groups respectively, without any statistically significant disparity The p-value is 0.37.

Consistent with our study, Simon et al.[18] The mortality rates in the HFNC group and NIV group were reported to be 65% and 40% respectively (p-value=0.11). Conversely, Coudroy et al.[19] detected a significant higher 28-day mortality among NIV patients (40%) compared to HFNC patients (20%) (p-value=0.02).

The rate of procedure-related complications did not vary widely between the study groups, except for mouth dryness, which was significantly frequent in the NIV group, while nasal irritation/dryness was significantly abundant among HFNC patients (p-value=0.30).

Matching with our results, da Silva Costa et al.[20] stated that compared with NIPPV, HFNC treatment had approximately similar incidences

of complications. Nevertheless, Cong et al.[23] showed considerable better comfort and satisfaction within HFNC patients (p-value=0.008 and 0.007 respectively).

4. Conclusion

HFNC demonstrates comparable efficacy to NIV in the treatment of ARF, with concomitant clinical success, overall ICU stay and outcome. Moreover, HFNC bears a modest lesser spectrum of complications and better comfort and tolerability than NIV.

Disclosure

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