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Efficacy Of High Flow Nasal Cannula Oxygenation In Acute Respiratory Failure Patients And Comparing With Noninvasive Positive Pressure Ventilation

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Abstract:

The goal of this study is to assess HFNC oxygenation and compare the efficacy of high-flow nasal cannula (HFNC) to noninvasive ventilation (NIV) on oxygenation in patients with acute hypoxemic respiratory failure. The patients were randomly grouped into two groups, 20 in each group. Group 1: treated by high-flow nasal cannula (HFNC) and group 2: treated by non-invasive ventilation. There was a statistically significant difference regarding P_aO_2/FiO_2 at baseline and at the end **(**P-value < 0.001) in both groups indicating improvement of oxygenation in both groups. There was a statistically significant difference between the two groups regarding the P_aO_2 and P_aO_2/FiO_2 ratio (P-value < 0.05) at the end of the trial however the degree of oxygenation improvement was significantly higher with NIV group. The conclusion of our study: the use of high flow nasal cannula is effective in improving oxygenation but NIV was superior to HFNC.

Keywords: High flow nasal cannula; noninvasive ventilation; acute hypoxemic respiratory failure.

1. Introduction:

Acute respiratory failure is a very serious clinical condition and the hypoxemic type is a common form of respiratory failure [1]**.** Oxygen therapy is the main line of management that can be administrated by several methods. The selection of a specific method depends on the device efficacy and the clinical picture and scenario such as the hypoxia severity, the mechanisms, and the tolerance of the patient [2,3]**.**

Mechanical ventilation is commonly used as a supportive tool in intensive care units and is significant as a life saving device to any sort of respiratory failure. This intervention is used in critically ill patients with serious conditions but invasive ventilation is an expensive procedure associated with many adverse events and high mortality [4].

Over the last years, noninvasive ventilation has been utilized increasingly as an alternative strategy to avoid intubation and the complications of invasive ventilation and indeed was associated with reduction in the need of endotracheal intubation relatively, the

associated complications and subsequently in hospital mortality [5,6]. However, NIV failure has been reported in a number of studies to occur in up to 40% in ARF patients [7].

Recently, high flow nasal cannula (HFNC) is being used increasingly and tried as an alternative and a promising strategy in treatment of acute respiratory failure as an attempt to reduce mortality and adverse events associated with mechanical ventilation either noninvasive or invasive. The beneficial physiological effects and advantages of HFNC are delivery of high oxygen concentration, expiratory positive airway pressure (PEEP) effect, dead space washout effect, better tolerance, proper humidification and maintenance of mucociliary function [8].

2. Aim of the study:

Evaluation of High Flow Nasal Cannula (HFNC) oxygenation and compare its efficacy to noninvasive ventilation (NIV) in patients with acute hypoxemic respiratory failure.

3. Patients and Methods:

This was a clinical randomized observational study conducted at Beni-Suef university hospital from August 2018 till November 2019 involving 40 patients diagnosed as having acute hypoxemic respiratory failure.

3.1 Inclusion criteria: All the patients fulfilling the following criteria of acute hypoxemic respiratory failure:

- PaO_2/FiO_2 ratio < 300 mmHg.
- Respiratory rate > 30/min.
- The required FiO_2 > 50 % to obtain at least 90 % oxygen saturation.

3.2 Exclusion Criteria:

- Age < 18 years.
- History of chronic obstructive pulmonary disease.
- Glasgow coma score <12.
- Hemodynamic instability.
- Indication for urgent endotracheal intubation.
- Nasopharyngeal obstruction.
- Epistaxis.

3.3 All patients included in the study were subjected to the following:

1. History taking: Full history was taken from the patients' close relatives including personal data and a detailed medical history.

2. Full clinical assessment: All patients were subjected to full clinical examination including general and chest examination.

3. Investigations:

3.a. Laboratory:

- Routine laboratory investigations including : (CBC, Na, K, Mg, PO4, Urea, Creatinine, AST, ALT, Albumin, INR …).
- ABG: on admission, after intervention, daily and as required for follow up.

3.b. Radiological:

- Chest X-ray on admission & as required for follow up.
- Additional imaging according to clinical judgment as (CT chest...etc.)

2.4. Intervention:

Group A: High-flow–oxygen group

High flow nasal cannula was applied through medium/large nasal prongs fitting the nares size with a flow rate of 40 liters per minute, Temperature was set to 37°C and FiO2 of ~100% at initiation. The fraction of oxygen was subsequently adjusted targeting SpO_2 of 92% or more. High-flow oxygen was used for at least 2 days and readjusted according to the patient response represented by the patient comfortability, arterial blood gases and respiratory parameters, with close monitoring; till weaning or intubation.

Group B: Noninvasive-ventilation group

Noninvasive ventilation was applied through a mouth/nose mask connected to an ICU ventilator. The pressure support level was adjusted with the aim of a tidal volume of 5 to 8 ml/kg of predicted body weight, with an initial positive end expiratory pressure 8 cm of water. The FiO_2 and PEEP level were adjusted to maintain SpO_2 of 92% or more. The settings were re-adjusted based on the results of continuous pulse oximetry, measurements of arterial blood gases, respiratory parameters and the comfort of patient till weaning or intubation.

Statistical methodology

• Analysis of data was done by IBM computer using SPSS (statistical program for social science) as follows;

- Description of quantitative variables as mean, SD and range.

- Description of qualitative variables as number and percentage.

- Unpaired t-test was used to compare quantitative variables, in parametric data (SD < 50 % mean)

• P value > 0.05 insignificant

• P < 0.05 significant

• P < 0.01 highly significant.

4. Results:

The current study was conducted at Beni-Suef university hospital from August 2018 till November 2019. A total of 40 patients diagnosed as having acute hypoxemic respiratory failure, were randomly grouped into two groups, 20 in each group. Group 1: treated by high-flow nasal cannula (HFNC) and group 2: treated by non-invasive ventilation.

As summarized in Table (1), the baseline characteristics, such as age, gender, co-morbidities and risk factors, Causes of AHRF, APACHE II score, hemodynamic parameters and ABG were not significantly different between both groups (all P > 0.05).

[Table (1)]

Characteristics		Groups		P-value
		Group A (no.%)	Group B (no.%)	
Age (Mean± SD)		62.9±11.7	59.5±19.8	0.518
Gender Female Male		14(70%) 6(30%)	10(50%) 10(50%)	0.197
APACHE II score		15.7±4.3	18.2±5.5	0.117
Risk factors	Smoking	3(15%)	5(25%)	0.429
	DM	12(60.0%)	9(45.0%)	0.342
	HTN	10(50.0%	13(65.0%	0.337

		)	)	
	IHD	3(15.0%)	2(10.0%)	0.633
	AF	0(0.0%)	3(15.0%)	0.072
	Stroke	3(15.0%)	2(10.0%)	0.633
	ESRD	3(15.0%)	6(30.0%)	0.256
	AKI	6(30.0%)	2(10.0%)	0.114
	HCV	3(15.0%)	3(15.0%)	---
RR: (/minutes)		34±3	35±3	0.205
HR: (beat/min)		108±11	110±10	0.551
MAP		81±7.5	83±6.5	0.373
Cause of ARF: Pneumonia		20(100%)	20(100%)	---
ABG	**PH:**	7.37±0.2	7.35±0.4	0.842
	P_aCo_2	32.2±4	32.8±3.8	0.629
	HCo_3	21.3±4.5	20.8±4.1	0.715
	P_aO_2	77.5±3.8	75±4.2	0.055

As shown in table (2) there was no statistically significant difference between the two groups regarding the baseline P_aO_2, S_aO_2, P_aO2 / FiO2 ratio (P-value>0.05).

Table (2)

Parameter	Group A	Group B	P-value
PaO2	77.5±3.8	75±4.2	0.055
S_aO_2	85±5	84±6	0.570
PaO_2/FiO_2	154.3±13.7	152.8±14.5	0.738

As shown in table (3) there was a statistically significant difference between the two groups regarding the PaO2 and PaO2/FiO2 ratio (P-value

< 0.05) at the end of the trial in favor of NIV.

Table (3)

Parameter	Group A	Group B	P-value
PaO2	99.8±18.3	115±26.5	0.041
S_aO_2	94±2	93±2	0.122
PaO_2 / FiO_2	262.4±69.2	313±75	0.026

There was a statistically significant difference between both groups after initiation of therapy regarding the PaO_2/FiO_2 ratio (P-value < 0.05). The degree of oxygenation improvement was significantly higher with NIV group. Figure (1)

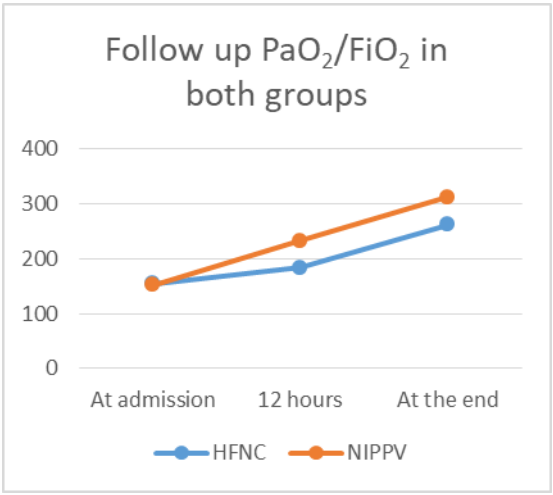

Figure (1) PaO_2/FiO_2 trend in both groups

4. Discussion

The purpose of the study was to determine the efficacy of HFNC oxygenation and compare with noninvasive ventilation (NIV) in patients with acute hypoxemic respiratory failure. The study included 40 patients in a random order.

Our study showed that using HFNC in adult patients with ARF had improved oxygenation as the PaO_2/FIO_2 increased significantly from (154.3±13.7) to (262.4±69.2) (P-value

<0.001), but a significantly greater improvement in PaO_2 /FIO_2 (from 152.8±14.5 to 313±75) with NIV than HFNC (P-value<0.05) was demonstrated.

In concordance with our study, Vargas et al. (2015) conducted a prospective observational study on 12 patients with hypoxemic respiratory failure to assess physiologic effects of high-flow nasal cannula oxygen showed a significant improvement in PaO_2/FIO_2 with HFNC but was significantly more with CPAP (*P* < .01). [9]

Matching with our study, Schwabbauer et al. (2014) conducted a prospective observational study on fourteen patients with hypoxemic respiratory failure using nasal high–flow oxygen therapy to assess effect on functional and subjective respiratory parameters compared to conventional oxygen therapy and non-invasive ventilation and showed oxygenation improvement with HFNC but was better with NIV as PaO_2 was higher under NIV (129 ± 38 mmHg) compared to HFNC (101 ± 34 mmHg, p <0.01 vs. NIV). [10]

In agreement with our study, Stephan et al. 2015 conducted a multicentre, randomized, non-inferiority trial on 830 patients who were hypoxemic after cardiothoracic surgery (BiPOP Study) found higher Pao_2/Fio_2 with BiPAP than HFNC (*P* < .001). [11]

In the same context, Liesching et al. J (2017) conducted a meta-analysis to compare the physiological and clinical outcomes of high-flow nasal cannula with standard oxygen or conventional noninvasive ventilation in intensive care units found that When comparing HFNC to NIV, the following oxygenation parameters were significantly lower: Pao_2 (106.9 vs 134.2 mm Hg, *P* = .02), Pao_2/Fio_2 (178.4 vs 220.0 mm Hg, *P* = .02). [12]

Also, these agreed with Frat et al. (2015) who performed a prospective observational study on twenty-eight subjects with AHRF to evaluate the clinical efficacy of humidified oxygen via high-flow nasal cannula (HFNC) alternating with noninvasive ventilation (NIV) in acute hypoxemic respiratory failure (AHRF) reported that the P_{aO2} was significantly increased from 83 (68–97) mm Hg to 108 (83–140) mm Hg using HFNC and to 125 (97–200) mm Hg using NIV (*P* < .01). [13]

Also Simon et al. (2014) conducted a Prospective trial randomizing 40 critically ill patients with hypoxemic respiratory failure to receive either NIV or HFNC during bronchoscopy in the intensive care unit and found a significant increase in PaO_2/FiO_2 after 15 minutes on NIV compared to baseline (*P* = 0.04) was observed in the NIV group, while there was no significant change in PaO_2/FiO_2 in the HFNC group (*P* = 0.96). Comparing the two groups after 15 minutes on NIV or HFNC, PaO_2/FiO_2 was significantly better in the NIV group (*P* = 0.002). [14]

5. Conclusion and Recommendations:

The use of high flow nasal cannula is effective in improving oxygenation.

NIV was superior to HFNC regarding oxygenation.

Further studies are needed to assess effectiveness of HFNC considering various physiological and clinical outcomes to get the best benefits in the appropriate patients

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