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Original Article

Outcomes of high-flow nasal cannula versus non-invasive positive pressure ventilation for patients with acute exacerbations of chronic obstructive pulmonary disease

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Abstract: Non-invasive positive pressure ventilation (NIPPV) is currently the gold standard for respiratory support for patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD). Although oxygen delivery via high flow nasal cannula (HFNC) is increasingly used, comparable evidence of its efficacy and safety with NIPPV is rather scarce. This study aimed to compare the nursing outcome of HFNC with NIPPV in AECOPD patients. 168 patients with AECOPD were randomly divided into HFNC and NIPPV groups each having 84 patients. The two groups were given the same nursing methods. Arterial blood gases, respiratory support time, hospitalization days, complications, comfort and nursing satisfaction were compared. After treatments, the arterial blood gas parameters in the two groups were better than before the treatment ($P < 0.05$); the complications in the HFNC group were significantly lower than in the NIPPV group, and the comfort and nursing satisfaction were higher in HFNC than in NIPPV group ($P < 0.05$). The two methods are both effective for AECOPD patients; NIPPV has better outcomes with lower complications and improved comfort and nursing satisfaction.

Keywords: High-flow nasal cannula therapy, non-invasive positive pressure ventilation, acute exacerbations of chronic obstructive pulmonary disease, nursing satisfaction

Introduction

Chronic obstructive pulmonary disease (COPD) is a type of obstructive lung disease characterized by long-term breathing problems and poor airflow [1]. It is particularly prevalent in the elderly population [2]. As is a common and frequently-occurring disease, it has high morbidity and mortality. The World Health Organization has identified COPD as the seventh-leading cause of disability and the fourth-leading cause of death internationally [3]. The quality of life of COPD patients is seriously affected due to declined pulmonary function [4]. Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is caused by viral or bacterial infections [5], as well as environmental factors (air pollution and meteorological effect) [6]. The symptoms include aggravated cough and sputum, acute respiratory failure and pulmonary heart disease. Depending on the severity, the acute management of AECOPD involves use of bronchodilators, steroids, antibiotics, oxygen and noninvasive ventilation. At present, non-invasive positive pressure ventilation (NIPPV) is widely used in the treatment of respiratory failure patients and is very effective. However, patients' comfort and compliance are relatively compromised with this method [7]. High flow nasal cannula (HFNC) is a recently developed therapy for oxygen intake, in which high-flow oxygen is delivered to the nostrils to improve patient ventilation [8]. To confirm the effectiveness of this new method, we compared its therapeutic effect and nursing outcomes with NIPPV in AECOPD patients. The outcomes would help improve nursing interventions for AECOPD patients.

Subjects and methods

Study design

This was a prospective, randomized, controlled, single-blind study conducted at the Respiratory Department of Weihai Central Hospital, Shan-

Table 1. Baseline demographics and clinical characteristics of patients included in study (n=168)

	NIPPV (n=84)	HFNC (n=84)	p
Gender			
Male (n, %)	50 (59.5)	48 (57.1)	0.56
Female (n, %)	34 (40.5%)	36 (42.9)	0.59
Age (y)	67.88±8.38	66.91±7.38	0.76
COPD (y)	6.06±2.22	6.99±2.45	0.36
AECOPD (d)	5.11±1.26	5.04±1.33	0.42
PaO_2 (mmHg)	54.08±15.33	53.10±16.22	0.32
$PaCO_2$ (mmHg)	72.91±16.41	72.11±16.31	0.85
Serum pH	7.27±0.09	7.25±0.08	0.63
SpO_2 (%)	77.51±14.10	77.55±14.11	0.72
FEV1/FVC	0.54±0.10	0.53±0.12	0.48
FEV1 (%)	68.98±13.23	68.66±13.53	0.49

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; FEV1, forced expiratory volume in 1 second; FEV1/FVC, percentage of the vital capacity which is expired in the 1st second of maximal expiration; $PaCO_2$, partial pressure of carbon dioxide; PaO_2, partial pressure of oxygen.

dong, China. The study was carried out in accordance with Good Clinical Practice guidelines and conformed to the Declaration of Helsinki 1964, as currently amended. The protocol was approved by the local ethics committee, and all patients gave written informed consent to participate in the study.

Subjects

168 patients with AECOPD were admitted into our Hospital between January 2015 and December 2017 were randomly divided into NIPPV and HFNC groups, each having 84 patients. The patients were aged 40 to 76 years with an average of 67.51±7.13 years and the duration of COPD was 2 to 18 years (6.10±2.23 years). Patients were included if they were diagnosed with AECOPD according the national guidelines [9], admitted to ICU due to severe illness and were give ventilation therapy. Patients were excluded if their hemodynamics were unstable and they were unable to complete the therapy. Patients with pneumonia, acute heart failure, bronchiectasis, asthma (as the primary diagnosis), acute respiratory acidosis needing noninvasive ventilation, lung cancer and other complications were also excluded. Patient's clinical data are listed in **Table 1**.

Methods

Patients were treated according to the AECOPD Guidelines. Antibiotics were given based on the results of sputum culture. Bronchodilator and glucocorticoid were also used when necessary [10]. Patients with heart failure were treated according to the guidelines for heart failure. Patients were randomized to receive either NIPPV or HFNC treatment. For NIPPV, patients were ventilated by mouth and nose using ventilator Hamilton G5 (Hamilton Medical AG; Bonaduz, Switzerland), and the inspiratory positive airway pressure (IPAP) was set at 10 cm H_2O and expiration pressure was set at 5 cm H_2O at beginning, and gradually increased after the patient adapted. Patients' symptoms and signs were monitored and FiO_2 was adjusted to ensure oxygen saturation. For HFNC therapy, patients were ventilated using OH-60C High-flow non-invasive breathing therapeutic apparatus (Micomme, Hunan, China) as described (8). The air temperature was set at 37°C at a flow rate of 30-35 L/min.

Nursing care

The patients were given comprehensive nursing care, including timely and frequent communication with patients and their family members using plain language, expression and body language. Efforts were made to deliver nursing care in a respectful, careful, humanistic and comfortable way to ensure full compliance of high standard medical service.

Outcome measures

The primary endpoint was blood gases as a measure of systemic inflammation during AECOPD and was measured before, 12 h and 5 days after treatments. The arterial blood gases were measured using GB303 blood gas analyzer (Shenbo Pharmaceutic Instrument, Shanghai, China).

Secondary clinical endpoints included ventilation support time, hospitalization days and complications, comfort and nursing satisfaction. Comfort and nursing satisfaction were investigated using hospital-designed questionnaires.

Statistical analysis

The measurement data was expressed as means ± sd (standard deviation). Statistical com-

Table 2. Blood gas parameters of patients receiving NIPPV and HFNC treatments

Time	PaO_2 (mmHg)		$PaCO_2$ (mmHg)		pH		SpO_2 (%)	
	NIPPV	HFNC	NIPPV	HFNC	NIPPV	HFNC	NIPPV	HFNC
Before therapy	54.11±16.15	53.87±15.17	72.16±16.96	72.16±16.42	7.32±0.09	7.26±0.08	77.93±14.07	77.53±14.17
12 h after therapy	71.99±17.49*	72.16±17.53*	63.06±15.97*	63.17±15.92*	7.36±0.06*	7.34±0.09*	88.65±7.15*	87.83±8.16*
5 days after therapy	82.22±15.64*	81.87±15.27*	59.95±13.56*	58.87±14.42*	7.36±0.07*	7.35±0.08*	92.75±4.07*	91.93±4.35*

*$P < 0.05$ vs before treatment in the same groups.

Table 3. Respiratory support time, hospitalization day and complications of patients receiving NIPPV and HFNC treatments

Treatment	No. cases	Respiratory support time (d)	Hospitalization stay (d)	Complications N (%)
NIPPV	84	9.55±4.78	18.31±7.01	56 (66.7%)
HFNC	84	10.02±5.11	18.04±6.15	33 (39.3%)
p		0.77	0.83	0.018

Table 4. Comfort and satisfaction of patients receiving NIPPV and HFNC treatments

Treatment	No. cases	Comfort N (%)	Satisfaction N (%)
NIPPV	84	57 (67.9)	71 (84.5)
HFNC	84	75 (88.2)	79 (94.0)
p		0.008	0.007

parisons between experimental and control groups were assessed by using the Student's *t*-test. χ^2 test was used to compare the difference in percentages between groups. $P < 0.05$ was considered statistically significant.

Results

A total of 168 hospitalized patients were eligible for inclusion in the study. Overall, 84 patients received NIPPV or HFNC treatment in addition to standard therapy for AECOPD. Demographic and clinical characteristics of patients in the two groups (gender, age, severity of COPD and AECOPD, arterial blood gases) were similar at baseline (**Table 1**).

The blood gases of the two groups before and after treatment are summarized in **Table 2**. The results showed that PaO_2, pH and SpO_2 were significantly increased and $PaCO_2$ was significantly decreased after NIPPV and HFNC treatments ($p < 0.05$). On other hand, these parameters were not significantly different between NIPPV and HFNC treatment ($p > 0.05$).

We then compared the respiratory support time, hospitalization days and complications and the data are shown in **Table 3**. Compared with NIPPV, HFNC treatment had fewer incidence of complications while the respiratory support time and hospitalization days were similar between the two groups.

Patient's comfort and satisfaction were surveyed for the two groups. As shown in **Table 4**, the HFNC group had a significantly higher number of patients feeling comfort and satisfaction as compared with NIPPV.

Discussion

Respiratory support is a major option of remission for patients with AECOPD who suffer from hypoxia and hypercapnia. At present, it is generally agreed that that NPPV is effective to relieve the disease. Under inspiratory positive airway pressure (IPAP) conditions, lung ventilation could be improved, while inspiration work and oxygen consumption are reduced, thereby attenuating hypercapnia effectively and avoiding tracheal intubation and tracheotomy [11]. However, NPPV has a number of contraindications and cannot be applied to patients with cardiopulmonary arrest and instable hemodynamics, nor patients who need airway protection, have severe encephalopathy and obstructed upper airway. Furthermore, the oxygen concentration in NPPV is not adjustable and may lead to hypoxia and CO_2 retention, particularly when the patient's compliance is poor. Since the ventilation parameters such as tidal volume and ventilation per minute cannot be monitored accurately in NPPV, skin damage, eye damage, dry respiratory tract, and abdominal distention may occur and deep sputum is difficult to remove and sedatives are restricted for uncompliant patients. These reduce the comfort, tolerance and subsequently compliance.

In HFNC, positive pressure is maintained in airways and invalid ventilation cavity in the nasopharynx is eliminated, which facilitates the exhaust of CO_2 and improves alveolar ventilation. Since the airflow in HFNC is heated and humidified, it results in increased airway conductivity and reduced metabolic consumption, reducing respiratory tract resistance [12, 13]. The results of the present study show that both NIPPV and HFNC are effective in improving blood gas parameters in AECOPD patients and have similar respiratory support time and length of hospital stay. However, the incidence of complications is significantly lower and patient comfort and satisfaction are significantly higher after HFNC treatment than after NIPPV treatment. The results are consistent with previous studies. For example, Stephan et al, showed that the two methods have similar treatment failure and mortality, but NIPPV has significantly higher skin breakdown after 24 hours in hypoxemic patients after cardiothoracic surgery [14]. For patients with acute, hypoxemic respiratory failure, HFNC and NPPV are found to be similar in terms of mortality, pH, $PaCO_2$, and rates of intubation or cardio-respiratory arrest, but patient tolerarance is different [15]. In Frat et al's study, HFNC was found to have a significantly higher number of ventilator-free days, at 28 days than for NIPPV patients with acute hypoxemic respiratory failure [12].

In conclusion, our study shows that the clinical efficacy of NIPPV and HFNC in the treatment of AECOPD patients is similar. However, HFNC can significantly reduce the incidence of complications and improve patient comfort and nursing satisfaction.

Disclosure of conflict of interest

None.

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