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ORIGINAL ARTICLE

Retrospective Study

Clinical study of NFNC in the treatment of acute exacerbation chronic obstructive pulmonary disease patients with respiratory failure

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Abstract

BACKGROUND

Most patients with acute exacerbation chronic obstructive pulmonary disease (AECOPD) have respiratory failure that necessitates active correction and the improvement of oxygenation is particularly important during treatment. High flow nasal cannula (HFNC) oxygen therapy is a non-invasive respiratory aid that is widely used in the clinic that improves oxygenation state, reduces dead space ventilation and breathing effort, protects the loss of cilia in the airways, and improves patient comfort.

AIM

To compare HFNC and non-invasive positive pressure ventilation in the treatment of patients with AECOPD.

METHODS

Eighty AECOPD patients were included in the study. The patients were in the intensive care department of our hospital from October 2019 to October 2021. The patients were divided into the control and treatment groups according to the different treatment methods with 40 patients in each group. Differences in patient comfort, blood gas analysis and infection indices were analyzed between the two groups.

RESULTS

After treatment, symptoms including nasal, throat and chest discomfort were significantly lower in the treatment group compared to the control group on the 3rd and 5th days ($P < 0.05$). Before treatment, the PaO_2, PaO_2/FiO_2, $PaCO_2$, and SaO_2 in the two groups of patients were not significantly different ($P > 0.05$). After treatment, the same indicators were significantly improved in both patient groups but had improved more in the treatment group compared to the control group ($P < 0.05$). After treatment, the white blood cell count, and the levels of C-reactive protein and calcitonin in patients in the treatment group were significantly higher compared to patients in the control group ($P < 0.05$).

CONCLUSION

HFNC treatment can improve the ventilation of AECOPD patients whilst also improving patient comfort, and reducing complications. HFNC is a clinically valuable technique for the treatment of AECOPD.

Key Words: Acute exacerbation chronic obstructive pulmonary disease; HFNC; Noninvasive positive pressure ventilation; Application value

Core Tip: Patients with acute exacerbation of obstructive pulmonary disease have respiratory failure, so improving oxygenation is the most important thing. The purpose of this study is to compare the efficacy of HFNC and noninvasive positive pressure ventilation in treating acute exacerbation chronic obstructive pulmonary disease (AECOPD) patients. By analyzing and comparing the differences of patients' comfort, blood gas analysis and infection index under different treatment methods. The results show that HFNC treatment can improve the ventilation function of patients with AECOPD, improve their comfort and reduce complications. This study shows that HFNC is a clinically valuable technique for the treatment of AECOPD.

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INTRODUCTION

Acute exacerbation chronic obstructive pulmonary disease (AECOPD) is a common disease characterized by persistent airflow limitation[1]. The progressive development of airflow limitation along with acute exacerbations and complications affects the severity of the disease and the prognosis of the individual. Oxygen therapy or mechanical ventilation is routinely used in the treatment of AECOPD that improves hypoxemia caused by respiratory failure and reduces hypoxia in the body extent[2,3]. The most common clinical oxygen delivery method is continuous low-flow oxygen delivery with a dual-cavity nasal catheter. This oxygen delivery method requires a low level of oxygen and can easily cause the airway mucosa to lose moisture that is not conducive to correcting the hypoxic state and patient discomfort[4]. High flow nasal cannula (HFNC) is a method that warms and humidifies oxygen to provide patients with oxygen at a constant concentration, temperature and humidity[5]. For patients with AECOPD, non-invasive positive pressure ventilation (NIPPV) is conventionally used, however, NPPV masks can cause facial compression that can affect patient communication, eating, sleeping and patient comfort[6].

HHFNC is a new type of non-invasive breathing assistance method that is used to provide oxygen at a precise concentration that is heated and humidified and meets the flow rate requirements of patients. HHFNC is advantageous as it improves ventilation and oxygenation levels and high comfortable. It is widely used in breathing patients who fail but do not meet the criteria for mechanical ventilation with tracheal intubation. In this study, we aimed to explore the clinical value of HFNC in the treatment of AECOPD.

MATERIALS AND METHODS

General information

80 AECOPD patients who were treated in our hospital from October, 2019 to October, 2021 were selected as the subjects of this study. The patients were divided into the control and treatment group with 40 cases in each group. The indications for invasive mechanical ventilation as follow: (1) Conditions that had significantly worsened with aggravated dyspnea and blood gas indicators that had not significantly improved; (2) new symptoms or complications such as pneumothorax,

aspiration, severe sputum retention and the elimination of obstacles; (3) severely ill patients; (4) hemodynamic instability; and (5) deterioration of consciousness. The patients were recruited under written informed consent. This study was approved by the Medical Ethics Committee of our hospital.

Inclusion and exclusion criteria

Inclusion criteria: (1) All patients in this study met the diagnostic criteria for AECOPD in the "AECOPD Diagnosis and Treatment Chinese Expert Consensus (Draft)"[7]. After 15 minutes, the state was stabilized and the arterial blood gas was measured; (2) the oxygenation index was ≤ 300 mmHg (oxygenation index = PaO_2/FiO_2, 1 mmHg = 0.133 kPa), and the bedside lung function test showed FEV1 ≥ 50% Pred; and (3) combined with hypercapnia ($PaCO_2$) ≥ 50 mmHg), respiratory rate ≥ 25 times/min.

Exclusion criteria: (1) Unconsciousness [Glasgow Coma Score (GCS) ≤ 12 points] who needed emergency tracheal intubation, and had previous chronic obstructive pulmonary disease, severe cardiac insufficiency, and sleep apnea; (2) patients with unstable hemodynamics and those who require vasoactive drugs; and (3) patients with > 1 severe organ dysfunction, severe non-cooperation, neuromuscular diseases, and severe mental illness.

Treatment methods

Both groups of patients were given conventional treatment including bronchodilators, low-dose glucocorticoids and antibacterial drugs. The vital signs, inflammatory response indicators, fluid balance and nutrition of the patients were monitored. The body positions were changed every two hours and chest physical therapy was performed. Patients in the control group were treated with NIPPV in which the ventilation mode was pressure support ventilation + positive end expiratory pressure. The initial inspiratory pressure was 5-8 cm H_2O. The positive end-expiratory pressure was set to 2-4 cm H_2O, and the oxygen concentration was 30%-35%. The parameters were adjusted according to the blood gas analysis results to final levels of $PaCO_2$ < 45 mmHg and PaO_2 > 60 mmHg.

Patients in the treatment group received HFNC. The initial temperature setting of the HFNC device (New Zealand) was 37 °C, the flow rate was 40L/min, and the oxygen concentration was 0.5%. The inspired oxygen concentration was adjusted to maintain a fingertip blood oxygen saturation > 92%. If the breathing cycle is stable, the flow rate was gradually lowered to 20 L/min and the oxygen concentration was lowered to 0.3. A nasal cannula was used to inhale oxygen. When the fingertip blood oxygen saturation was maintained at 92-96% for > 12 h the HFNC treatment was stopped.

In patients treated with HFNC, the clinician may decide to switch to NIPPV or establish an artificial airway for invasive mechanical ventilation. This may occur in cases of respiratory or cardiac arrest, when consciousness or anxiety is disturbed, in patients with pH ≤ 7.30 or rising $PaCO_2$ during treatment, when hypoxemia persists and cannot be corrected, when hemodynamics are unstable and require the use of vasoactive drugs, with increased airway secretions and during respiratory muscle fatigue or failure. During the treatment process, nurses assisted in expectoration and strengthened facial skin care to ensure patients could communicate.

Observational indicators

Comfort evaluation: A comfort questionnaire was used to evaluate patient comfort on the 3rd and 5th days after treatment [8]. The evaluation included headache and nasal, throat and chest discomfort. The severity of each symptom was scored using the Wong-Baker facial expression scale assessment (0 = no discomfort, 5 = severe discomfort). Both groups of patients had blood gas analysis before and after treatment and the results were compared to the partial pressure of oxygen (PaO_2), oxygenation index (PaO_2/FiO_2), partial pressure of carbon dioxide ($PaCO_2$), oxygen saturation (SaO_2), white blood cell count and levels of C-reactive protein and Calcitonin. The ventilator weaning standards were in line with the clinical application guidelines for comfort, that is, imaging examinations indicated that pneumonia was significantly or completely absorbed and routine bloods showed normal white cell count is normal and the body temperature was normal[8].

When the ventilator FiO_2 ≤ 0.4 and PEEP ≤ 5 cm H_2O, arterial blood gas analysis showed that PaO_2 ≥ 60 mmHg, PH > 7.3, and hemodynamics were stable. Before weaning, the ventilation mode adopted SIMV+PSV, and the support pressure was gradually reduced from the original parameter to 10 cm H_2O. Weaning was considered in patients who were stable for 30 min.

Statistical analysis

All data were recorded using Epidata and statistical analysis was performed using SPSS 25.0. The data were entered into a computer database by a second person to ensure completeness and accuracy. The count data was expressed as a *n* (%), using the χ^2 test. The measurement data was expressed as mean ± standard deviation (SD), using the *t*-test. A *P* value threshold of <0.05 was considered statistically significant.

RESULTS

General information comparison

80 patients with AECOPD participated in this study. The basic characteristics of patients are summarized in Table 1. The mean age of patients in the treatment and control groups were 54.78 ± 3.09 years and 54.62 ± 3.10 years, respectively. The mean body mass index (BMI) of patients in the treatment and control groups were 25.01 ± 3.67 kg/m^2 and 25.33 ± 3.65

Table 1 Comparison of the general information patients in the two groups

Group	Gender (Male/Female)	Age (yr)	BMI (kg/m^2)	Type of lung infection (*n*)			
				Germ	Fungus	Mix	Others
Therapy group (40)	26/14	54.78 ± 3.09	25.01 ± 3.67	18	13	7	2
Control group (40)	27/13	54.62 ± 3.10	25.33 ± 3.65	20	14	3	3
χ^2/t	0.056	0.231	0.391	0.201	0.056	1.829	0.213
P value	0.813	0.818	0.697	0.654	0.813	0.176	0.644

BMI: Body mass index.

kg/m^2, respectively. There were 26 males and 14 females in the treatment group and 27 males and 13 females in the control group. No significant differences were found between the two groups with regards to age, gender, and BMI (P = 0.818, P = 0.813, P = 0.697, respectively). With regard the type of lung infection, the treatment group had 18 germ, 13 fungus, seven mix, and two others, which the control group had 20 germ, 14 fungus, three mix, and three others.

Comfort situation

After treatment, the symptoms of nasal, throat and chest discomfort on the 3rd and 5th days in the treatment group were significantly lower when compared with patients in the control group (P < 0.05) (Table 2).

Blood gas analysis

Before treatment, PaO_2 (P = 0.980), PaO_2/FiO_2 (P = 0.991), $PaCO_2$ (P = 0.995), and SaO_2 (P = 0.989) were not significantly differences between the two groups. After treatment, PaO_2, PaO_2/FiO_2, $PaCO_2$, and SaO_2 were improved in both groups. Meanwhile, PaO_2 (P = 0.007), PaO_2/FiO_2 (P < 0.001), $PaCO_2$ (P = 0.012), and SaO_2 (P = 0.035) were significantly improved in the treatment group compared to the control group (Table 3).

Comparison of infection indicators

Before treatment, the levels of white blood cell count (P = 0.935), C-reactive protein (P = 0.965), and calcitonin (P = 0.799) were not significantly differences between the two groups. After treatment, the levels of white blood cell count (P = 0.017), C-reactive protein (P < 0.001), and calcitonin (P = 0.003) in the treatment group were significantly better compared to the control group (Table 4).

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is a common disease of the respiratory system. AECOPD refers to the rapid deterioration of respiratory symptoms and requires additional treatment[9]. The main clinical manifestations of AECOPD are often dyspnea, increased sputum volume and purulent sputum, which is an important factor in the death of COPD patients. Acute respiratory failure caused by AECOPD often requires respiratory support treatment[10]. NIPPV is the preferred treatment for AECOPD with mild-to-moderate respiratory failure (pH 7.25-7.35). NIPPV can improve symptoms, increase oxygenation, alleviate carbon dioxide retention, and effectively reduce intubation rate and mortality [11].

HFNC is a new type of oxygen therapy that has recently become more popular in the clinic. HFNC can provide accurate inhaled oxygen concentration, good airway humidification and can provide a high flow rate of 8-80 L/min[12]. HFNC involves oxygen therapy through nasal delivery that is comfortable and well tolerated. HFNC has been used in the treatment of pure hypoxic respiratory failure and can improve the 90-d survival rate of patients[13]. HHFNC uses high-velocity gas to flush the anatomical dead space in the nasopharynx, increase alveolar ventilation, and improve lung ventilation efficiency[14]. It also reduces upper airway resistance and the effort of breathing. The warming and humidification of gas can increase lung compliance, improve airway conductivity and defense function. Also, it reduces airflow resistance, promotes sputum discharge, and generates positive airway pressure to prevent atelectasis and promote lung recruitment[15]. The HHFNC system is advantageous as it required simple equipment and uses only three indicators (flow rate, oxygen concentration, temperature) that need to be adjusted. It can provide a stable concentration of oxygen close to body temperature, reduce the stimulation of the airways, and avoid airway spasm. It is also conformable for patients with less abdominal distension and does not affect communication, sputum and eating[16].

Analysis of comfort during the two treatment methods showed that the comfort score of HHFNC 3 and 5 d after treatment was significantly lower than that of the traditional oxygen therapy method. These data suggest that this method can reduce discomfort during the treatment[17,18]. After treatment, the main blood gas indices (PaO_2, PaO_2/FiO_2, $PaCO_2$, and SaO_2) of patients in the two groups of patients were significantly improved. Patients in the treatment group improved more compared to the control group indicating that HFNC treatment can improve ventilation in AECOPD patients. A number of studies have shown that NIPPV can reduce $PaCO_2$ in patients with AECOPD and relieve respiratory distress[19,20]. The results of blood gas analysis showed that HFNC has a similar effect to NTV in improving

Table 2 Summary of the levels of comfort in the two patient groups

Group		Nose discomfort	Pain	Chest discomfort	Throat discomfort
Control group (40)	Treatment 3 d difference	1.37 ± 0.38	0.56 ± 0.20	0.49 ± 0.15	1.24 ± 0.32
	Treatment 5 d difference	1.22 ± 0.34	0.41 ± 0.18	0.45 ± 0.12	1.01 ± 0.33
Therapy group (40)	Treatment 3 d difference	1.01 ± 0.22[a]	0.55 ± 0.19	0.30 ± 0.14[a]	0.68 ± 0.35[a]
	Treatment 5 d difference	0.89 ± 0.28[a]	0.37 ± 0.20	0.28 ± 0.15[a]	0.47 ± 0.25[a]

[a]$P < 0.05$.
Compared with control group.

Table 3 Comparison of blood gas analysis between the two groups of patients before and after treatment

Group	PaO_2 (mmHg)		PaO_2/FiO_2 (mmHg)		$PaCO_2$ (mmHg)		SaO_2 (%)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group (40)	67.44 ± 7.23	93.27 ± 8.14	172.34 ± 11.25	291.81 ± 7.82	52.23 ± 6.57	39.67 ± 2.24	94.76 ± 3.15	96.45 ± 0.15
Therapy group (40)	67.40 ± 7.22	98.37 ± 8.20	172.31 ± 11.64	322.27 ± 7.81	52.24 ± 6.53	37.23 ± 2.26	94.75 ± 3.26	97.57 ± 0.16
t	0.025	2.792	0.012	17.431	0.007	4.850	0.014	32.298
P value	0.980	0.007	0.991	< 0.001	0.995	0.012	0.989	0.035

Table 4 Analysis of infection indicators in the two groups of patients

Group	White blood cell count (10^9/L)		C-reactive protein (g/L)		Calcitonin (g/L)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group (40)	11.38 ± 1.10	10.41 ± 1.16	23.41 ± 2.27	8.71 ± 1.56	1.57 ± 0.33	3.41 ± 0.32
Therapy group (40)	11.40 ± 1.08	8.44 ± 1.65	23.43 ± 2.25	6.50 ± 1.82	1.55 ± 0.37	5.64 ± 1.15
t	0.082	6.177	0.040	5.831	0.255	11.815
P value	0.935	0.017	0.965	< 0.001	0.799	0.003

oxygenation and alleviating CO_2 retention[21]. The mechanism of HFNC in the treatment of AECOPD is mainly considered to be due to the scouring effect of the physiological dead space. The high-flow inhalation with adjustable flow rate provided by HFNC can wash out the anatomical ineffective cavities remaining in the nose, mouth and pharynx at the end of expiration. The retained CO_2 and repeated inhalation of CO_2 is significantly reduced[22,23]. HFNC adopts nasal congestion ventilation. The maximum positive airway pressure produced is 6-7 cm H_2O and so it does not cause abdominal distension due to excessive airway pressure. The patient can eat, expectorate, talk and communicate with others at any time.

Studies have confirmed that HFNC can improve the hypoxic state of patients with AECOPD and reduce the respiratory rate[24]. In theory, HFNC can produce the gas flushing effect on the physiological dead space of the nasopharyngeal area. In COPD patients, the scouring effect of HFNC is therapeutically significant[25]. For critically ill AECOPD patients treated with mechanical ventilation after extubation, HFNC and conventional mask oxygen therapy were used to monitor the diaphragm muscle potential of the two groups of patients to evaluate the respiratory muscle work intensity of the patients[21]. Our data showed that the respiratory muscle work of the HFNC group was significantly higher than that of the conventional oxygen therapy group indicating that HFNC is beneficial to the successful weaning of severe patients with AECOPD. The use of electrical impedance tomography technology confirmed that compared with nasal cannula oxygen inhalation, HFNC can reduce the respiratory frequency of long-term oxygen therapy in patients with AECOPD in the chronic phase. It can also increase the patient's tidal volume, and reduce the work of breathing[26]. Our results provide a reference for the use of HFNC in the treatment of AECOPD.

However, the current research also has some limitations. In this study, only the symptoms of nose, throat and chest discomfort were counted on the third and fifth days, but there was no measurement of discomfort symptoms under the long-term time measurement index. In addition, the index of measuring ventilation function under different treatments in this study is relatively simple. Therefore, this study should also increase the incidence of adverse reaction symptoms under long-term measurement, and increase the measurement index to measure the oxygenation state after treatment.

CONCLUSION

In summary, the application of HFNC treatment can improve the ventilation of AECOPD patients, improve patient comfort, and reduce the occurrence of complications. It has good clinical application value and is worthy of reference for clinical treatment of AECOPD.

ARTICLE HIGHLIGHTS

Research background

Improving oxygenation is very important in the clinical treatment of patients with chronic obstructive pulmonary disease. High-flow nasal intubation (HFNC) oxygen therapy is an effective clinical treatment method to improve oxygenation.

Research motivation

The treatment of acute exacerbation chronic obstructive pulmonary disease (AECOPD) is the key point in clinic at present. The purpose of this study is to explore the clinical effect of HFNC in improving oxygen and prognosis of AECOPD.

Research objectives

To compare the efficacy of HFNC with non-invasive positive pressure ventilation in patients with AECOPD.

Research methods

The oxygenation status and clinical efficacy of AECOPD patients treated with HFNC and noninvasive positive pressure ventilation were analyzed retrospectively.

Research results

The oxygenation state, white blood cell count, C-reactive protein and calcitonin levels in HFNC treatment group were significantly increased, and the complications were significantly reduced.

Research conclusions

HFNC treatment can improve the ventilation function of patients with AECOPD, improve the nursing comfort of patients, improve the prognosis of patients, and reduce the occurrence of complications.

Research perspectives

HFNC is an effective clinical nursing method to treat patients with AECOPD, which is of great significance to improve the quality and level of clinical nursing.

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FOOTNOTES

Co-first authors: Xiang Chen and Ling Dai.

Author contributions: Chen X, Dai L, Ma JZ, and Chu XX designed the research; Dai L, Liu JM, and Guo SW performed the research; Ru XW and Zhuang XS contributed new reagents/analytic tools; Zhuang XS analyzed the data; Chen X and Dai L wrote the paper; Chen X and Dai L contributed equally to this work as co-first authors equally to this work. The reasons for designating Chen X and Dai L as co-first authors are three-fold. First, the research was performed as a collaborative effort, and the designation of co-corresponding authorship accurately reflects the distribution of responsibilities and burdens associated with the time and effort required to complete the study and the resultant paper. This also ensures effective communication and management of post-submission matters, ultimately enhancing the paper's quality and reliability; Second, the overall research team encompassed authors with a variety of expertise and skills from different fields, and the designation of co-first authors best reflects this diversity. This also promotes the most comprehensive and in-depth examination of the research topic, ultimately enriching readers' understanding by offering various expert perspectives; Third, Chen X and Dai L contributed efforts of equal substance throughout the research process. The choice of these researchers as co-first authors acknowledges and respects this equal contribution, while recognizing the spirit of teamwork and collaboration of this study. In summary, we believe that designating Chen X and Dai L as co-first authors of is fitting for our manuscript as it accurately reflects our team's collaborative spirit, equal contributions, and diversity.

Institutional review board statement: This study protocol was approved by the The Sixth Hospital of Wuhan, Affiliated Hospital of

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Informed consent statement: Informed written consent was obtained from the patient for publication of this study.

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