Observation on the Effect of Non-Invasive Ventilator Combined with Conventional Therapy in the Treatment of Chronic Obstructive Pulmonary Disease Complicated with Respiratory Failure

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Abstract: *Objective:* To explore the clinical effect of a non-invasive ventilator combined with conventional therapy in the treatment of patients with chronic obstructive pulmonary disease (COPD) combined with respiratory failure. *Methods:* 68 patients with COPD combined with respiratory failure treated in our hospital from September 2021 to October 2023 were selected as the research subjects. Using the random number table method, they were divided into a control group and an experimental group of 34 cases each. The control group received conventional symptomatic treatment, and the experimental group received non-invasive ventilator treatment based on the control group. The clinical effects, blood gas indicators (partial pressure of carbon dioxide ($PaCO_2$), partial pressure of oxygen (PaO_2), arterial oxygen saturation (SaO_2)), lung function (forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), 6 min walking distance), complications, and inflammatory factor levels (c-reactive protein (CRP), interleukin-6 (IL-6), neutrophil-to-lymphocyte ratio (NLR)) of the two groups of patients were observed. *Results:* (1) The clinical efficacy of the patients in the experimental group (33/97.06%) was more significant as compared with the control group (25/73.53%) ($P < 0.05$); (2) After treatment, the clinical efficacy of the two groups of patients in terms of FEV_1, FEV_1/FVC, 6-minute walking distance, PaO_2 and SaO_2 all increased in the experimental group as compared to that of the control group ($P < 0.05$); (3) After treatment, the $PaCO_2$, CRP, IL-6, and NLR of the two groups of patients decreased, and the decrease in the experimental group was higher than that of the control group ($P < 0.05$); (4) The patients' complication rate in the experimental group (2/5.88%) was lower as compared to that of the control group (9/26.46%) ($P < 0.05$). *Conclusion:* Non-invasive ventilators combined with conventional therapy achieved good clinical results in treating patients with COPD and respiratory failure.

Keywords: Non-invasive ventilator; Conventional therapy; Chronic obstructive pulmonary disease; Respiratory failure; Clinical effect

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory respiratory disease characterized by persistent airway inflammation, airway obstruction, and emphysema. As the disease progresses, COPD patients may develop respiratory failure, which is one of the main causes of death in COPD patients [1–3]. Traditional conventional treatments include medication, oxygen therapy, and breathing exercises, but their therapeutic effects are limited. Recently, the widespread use of non-invasive ventilators combined with conventional therapy has gradually become an important means of treating COPD with respiratory failure. Therefore, this article aims to explore the effect of a non-invasive ventilator combined with conventional therapy in treating COPD complicated by respiratory failure to provide a reference for clinical treatment.

2. Materials and methods

2.1. General information

68 patients with COPD combined with respiratory failure treated in our hospital from September 2021 to October 2023 were selected as the research subjects and were divided into a control group and an experimental group of 34 cases each using the random number table method. The control group consisted of 22 males and 12 females with an average age of 62.15 ± 3.28 years. The experimental group consisted of 20 males and 14 females in the experimental group with an average age of 62.21 ± 3.18 years. The comparison of the baseline data between the two groups of patients showed no statistically significant difference ($P > 0.05$).

Inclusion criteria: (1) Patients diagnosed with COPD combined with respiratory failure; (2) patients with complete clinical data; (3) consented. Exclusion criteria: (1) Patients with severe heart, lung, liver, and kidney dysfunction, such as bronchial asthma, pulmonary edema, heart failure, etc.; (2) other serious neurological diseases such as stroke, epilepsy, etc.; (3) patients who have undergone surgical treatment such as lung transplantation or tracheotomy; (4) allergic or intolerant to the study drugs; (5) refuse to participate in the study.

2.2. Methods

The control group received conventional symptomatic treatment, including continuous oxygen inhalation, administration of bronchodilators, anti-inflammatory, anti-infection, and expectorant drugs to improve airflow restriction, reduce inflammation and infection reaction, and promote sputum, and breathing exercises. The experimental group received the non-invasive ventilator treatment based on the control group, where positive pressure ventilation with a non-invasive respiratory mask was used. The ventilator was connected to the patient through the mask, and the respiratory frequency was set to 12 to 18 times/min. The expiratory/inspiratory pressure was 4–6 cmH$_2$O/10–18 cmH$_2$O, blood oxygen saturation (SaO$_2$) was maintained above 90%, and ventilation time was less than 15 hours daily. After the symptoms were relieved, the ventilation time was reduced to less than 8 hours a day, and both groups continued the intervention for 7–10 days [4].

2.2.1. Observation indicators

The observation indicators are shown in **Table 1**.

2.3. Statistical methods

The SPSS 22.0 software was used for statistical analysis. Measurement data were expressed as mean ± standard deviation and compared using the *t*-test; count data were expressed as % and the chi-square (χ^2) test was used to compare data between groups. Results were considered statistically significant at $P < 0.05$.

Table 1. Observation indicators

Observation indicators	Specific indicators	Evaluation and methods
Clinical effects	1) Markedly effective: clinical symptoms such as dyspnea and shortness of breath have disappeared, and the respiratory condition is stable. 2) Effective: clinical symptoms such as dyspnea and shortness of breath have been alleviated, and the respiratory condition is stable. 3) Ineffective clinical symptoms such as dyspnea and shortness of breath are not relieved, and the breathing condition is unstable.	Total effective rate = (markedly effective + effective) / total number of cases × 100%
Blood index	1) Arterial blood carbon dioxide partial pressure ($PaCO_2$) 2) Arterial blood oxygen partial pressure (PaO_2) 3) Arterial oxygen saturation (SaO_2)	Method: 5 mL of the patient's arterial blood was taken and measured using a fully automatic biochemical an-alyzer.
Lung function	1) Forced expiratory volume in 1 second (FEV_1) 2) FEV_1 / forced vital capacity (FVC) 3) 6min walking distance	Method: A pulmonary function instrument was used to measure FEV_1.
Complication	1) Difficulty excreting phlegm 2) Pneumonia 3) Dry mouth and nose	Overall incidence = (number of cases with difficulty in excreting phlegm + number of pneumonia cases + number of dry mouth and nose cases) / total number of cases × 100%
Inflammatory factor levels	1) C-reactive protein (CRP) 2) Interleukin-6 (IL-6) 3) Neutrophils/Lymphocytes (NLR)	3 ml of venous blood was taken, centrifuged, and the supernatant was obtained to measure CRP and IL-6; 5 ml of fasting cubital venous blood was taken and a routine blood test to carried out to measure the neutrophil and lymphocyte count.

3. Results

3.1. Comparison of clinical effects between the two groups of patients

As shown in **Table 2**, the total clinical effectiveness of patients in the experimental group (33/97.06%) was significantly higher than that of the control group (25/73.53%) ($P = 0.019 < 0.05$).

3.2. Comparison of pulmonary function between the two groups of patients

As shown in **Table 3**, the FEV_1, FEV_1/FVC, and the 6-min walking distance of the two groups of patients all increased after treatment, and the increase in the experimental group was significantly higher than that of the control group ($P < 0.05$).

3.3. Comparison of blood gas indicators between the two groups of patients

As shown in **Table 4**, the PaO_2 and SaO_2 of both groups of patients increased after treatment, and the increase rate of the experimental group was higher than that of the control group ($P < 0.01$); after treatment, the $PaCO_2$ of both groups of patients decreased, and the decline rate of the experimental group was higher than that of the control group ($P < 0.01$).

3.4. Comparison of complications between the two groups of patients

As shown in **Table 5**, the incidence of complications in the experimental group (2/5.88%) was significantly lower than that of the control group (9/26.46%) ($P = 0.021 < 0.05$).

Table 2. Comparison of clinical effects between two groups of patients

Group	Markedly effective	Effective	Ineffective	Total effective rate
Control ($n = 34$)	14 (41.18%)	11 (32.35%)	9 (26.47%)	25 (73.53%)
Experimental group ($n = 34$)	18 (52.94%)	15 (44.12%)	1 (2.94%)	33 (97.06%)
χ^2				5.545
P				0.019

Table 3. Comparison of lung function between two groups of patients

Lung function indicators	Stage	Control group ($n = 34$)	Experimental group ($n = 34$)	t	P
FEV_1 (L)	Before treatment	1.66 ± 0.29	1.65 ± 0.31	0.137	0.891
	After treatment	1.71 ± 0.42	1.99 ± 0.51	2.471	0.016
FEV_1/FVC (%)	Before treatment	52.15 ± 3.87	52.32 ± 3.79	0.183	0.855
	After treatment	53.21 ± 4.10	65.25 ± 4.72	11.229	0.000
6-min walking distance (m)	Before treatment	245.39 ± 12.48	246.12 ± 11.99	0.246	0.867
	After treatment	295.78 ± 18.73	275.29 ± 15.36	4.932	0.000

Table 4. Comparison of blood gas indicators between the two groups of patients

Blood gas index	Stage	Control group ($n = 34$)	Experimental group ($n = 34$)	t	P
$PaCO_2$ (mmHg)	Before treatment	76.25 ± 10.11	76.12 ± 9.85	0.054	0.957
	After treatment	65.28 ± 8.15	56.29 ± 6.21	5.116	0.000
PaO_2 (mmHg)	Before treatment	56.15 ± 7.62	57.15 ± 8.02	0.527	0.600
	After treatment	70.11 ± 7.23	85.69 ± 7.67	8.619	0.000
SaO_2 (%)	Before treatment	83.21 ± 5.01	82.26 ± 5.19	0.768	0.445
	After treatment	90.03 ± 2.14	95.87 ± 2.57	10.182	0.000

Table 5. Comparison of complications between the two groups of patients

Group	Dry mouth and nose	Pneumonia	Difficulty with excreting phlegm	Overall incidence
Control ($n = 34$)	4 (11.76%)	1 (2.94%)	4 (11.76%)	9 (26.46%)
Experimental ($n = 34$)	1 (2.94%)	0 (0.00%)	1 (2.94%)	2 (5.88%)
χ^2				5.314
P				0.021

3.5. Comparison of inflammatory factor levels between the two groups of patients

As shown in **Table 6**, the CRP, IL-6, and NLR of the two patient groups decreased after treatment, and the experimental group had a greater decline rate than the control group ($P < 0.01$).

Table 6. Comparison of inflammatory factor levels between the two groups of patients

Inflammatory factors level	Stage	Control group ($n = 34$)	Experimental group ($n = 34$)	t	P
CRP (mg/mL)	Before treatment	81.21 ± 26.58	81.56 ± 27.23	0.054	0.957
	After treatment	50.01 ± 20.28	36.12 ± 16.87	3.070	0.003
IL-6 (pgm/L)	Before treatment	126.21 ± 33.37	126.98 ± 33.40	0.095	0.925
	After treatment	78.52 ± 15.97	47.29 ± 16.91	7.829	0.000
NLR	Before treatment	7.43 ± 1.53	7.46 ± 0.98	0.096	0.924
	After treatment	6.64 ± 1.34	3.17 ± 0.82	12.879	0.000

4. Discussion

In the course of COPD, respiratory failure is a common complication and one of the main causes of death in COPD patients [5]. The combination of non-invasive ventilator combined with conventional therapy is a new treatment modality and has demonstrated significant advantages in treating COPD and respiratory failure [6].

Non-invasive ventilators combined with conventional therapy enable better therapeutic effects by utilizing the full advantage of both methods. Firstly, non-invasive ventilators can provide continuous airway pressure and oxygen support through non-invasive methods such as masks to improve the patient's ventilation status [7,8]. Not only is this method easy to operate but also does not require invasive operations such as tracheal intubation, reducing patient pain and the risk of complications. Parameter adjustment based on the patient's condition can also achieve individualized treatment and improve treatment effects [9]. Secondly, measures such as drug treatment, oxygen therapy, and breathing exercises in conventional therapies can also positively impact patients with COPD and respiratory failure. Drug treatment can alleviate the inflammatory response and improve airway patency [10]; oxygen therapy can correct the patient's hypoxic state and protect the function of important organs such as the heart and brain [11]; breathing exercises can enhance the strength of the diaphragm and intercostal muscles, and improve the patient's ventilation. In addition, a non-invasive ventilator combined with conventional therapy is also relatively safe. The incidence of adverse reactions in patients using non-invasive ventilators is low, and most patients can tolerate them. At the same time, drug treatment, oxygen therapy, and other measures in conventional therapy can also effectively reduce complications and ensure the safety of the patient's lives [12].

This study has several limitations. The sample size of this study is relatively small and may not fully represent the situation of all COPD patients with respiratory failure. A larger sample size can provide more accurate results, so the sample size needs to be further expanded to enhance the generalizability and applicability of the study. On the other hand, this study mainly focused on the short-term (7–10 days) therapeutic effect of non-invasive ventilators combined with conventional therapy. It did not follow up on the long-term prognosis of the patients. COPD is a disease that requires long-term management, so further research on the impact of combination therapy on long-term patient prognosis is needed. In future research, these two problems should be addressed.

5. Conclusion

This study showed that compared with the control group, patients in the experimental group after treatment had better clinical efficacy, lower complication rates, higher levels of FEV_1, FEV_1/FVC, 6-min walking distance,

PaO_2, SaO_2, $PaCO_2$, and lower CRP, IL-6, and NLR levels. This confirmed that a non-invasive ventilator combined with conventional therapy could achieve good clinical results in the treatment of patients with COPD combined with respiratory failure. This is consistent with the research results of Qin [13], Pang [14], Ding [15], and others.

Disclosure statement

The author declares no conflict of interest.

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