ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

Effect of Pulmonary Rehabilitation Training Combined with Non-invasive Ventilator on Elderly Patients with Acute Exacerbation of COPD Complicated with Respiratory Failure

Junting Ma[1,a], Xiaorong Xu[1,b,*], Yan Gao[1,c], Jingjing Niu[1,d]

[1]Department of Respiratory, Gansu Second People's Hospital, Lanzhou, China
[a]m13919043701@163.com, [b]17318778703@163.com, [c]15117265675@163.com, [d]niujjgssey@163.com
[*]Corresponding author

Abstract: *To investigate the effect of pulmonary rehabilitation training combined with non-invasive ventilator in elderly patients with acute exacerbation of COPD complicated with respiratory failure. 80 elderly patients with acute exacerbation of COPD combined with respiratory failure (January 2023 to December 2023) were selected and grouped by random number table method. Control group (40 cases) received conventional treatment plus noninvasive ventilator treatment. The study group (40 cases) carried out pulmonary rehabilitation training on the basis of the control group. The therapeutic effect, lung function, blood gas index, cardiopulmonary oxygenation index, inflammatory factors, respiratory rate and heart rate were compared. The effective rate of study group was higher than that of control group ($P < 0.05$). After treatment, the proportion of forced vital capacity, first second expiratory volume and first second expiratory volume in forced vital capacity in the study group was higher than that in the control group ($P < 0.05$). After treatment, the partial pressure of arterial blood oxygen and saturation of blood oxygen in the study group were higher than those in the control group, and the fraction of arterial blood carbon dioxide was lower than that in the control group ($P < 0.05$). After treatment, the maximal oxygen uptake and consumption metabolic equivalent of the study group were higher than those of the control group ($P < 0.05$). The levels of C-reactive protein and procalcitonin in the study group after treatment were lower than those in the control group ($P < 0.05$). After treatment, the respiratory rate and heart rate of the study group were lower than those of the control group ($P < 0.05$). The combination of pulmonary rehabilitation training and non-invasive ventilator in the clinical treatment of acute COPD exacerbation with respiratory failure in the elderly has good therapeutic effect, and can improve lung function, blood gas index, cardiopulmonary oxygenation index, inflammatory factors, respiratory rate and heart rate.*

Keywords: *Copd; Respiratory failure; Pulmonary rehabilitation training; A non-invasive ventilator*

1. Introduction

Copd, mainly manifested by shortness of breath and dyspnea during activity, is a common chronic respiratory disease with a long course of disease and difficult treatment, resulting in decreased activity endurance of patients, which greatly affects daily life[1]. The exact etiology of this disease is unclear, and the pathological basis is limited airflow and airway obstruction[2]. Heredity, age, lung growth and development are related to the occurrence and development of COPD. Smoking, infection, chronic bronchitis, air pollution, and occupational dust are risk factors for COPD[3]. When the patient's disease is aggravated, the symptoms of cough and sputum are severe, accompanied by shortness of breath and dyspnea, and respiratory failure may occur in severe cases, which is life-threatening[4]. Timely and effective treatment is the key to stabilizing the condition and alleviating symptoms, and scientific treatment plans should be formulated according to the actual situation[5]. In clinical treatment, patients should be given respiratory support, and non-invasive ventilators are commonly used to improve the symptoms of dyspnea and strengthen gas exchange[6]. At the same time, symptomatic treatment such as relieving cough, relieving asthma and reducing phlegm should be implemented for patients. In addition, pulmonary rehabilitation training during treatment can promote the recovery of patients' lung function and improve oxygenation and respiratory function[7]. In order to improve the therapeutic effect, it is very important to study and analyze the practical application and effect of clinical therapeutic methods,

ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

which can provide reference for the formulation and implementation of therapeutic programs. This study explored the effect of combined pulmonary rehabilitation training and non-invasive ventilator in the treatment of acute COPD exacerbation with respiratory failure in the elderly.

2. Data and methods

2.1 General information

Using random number table method, 80 elderly patients with acute exacerbation of COPD complicated with respiratory failure were divided into groups. The control group (n=40) included 24 males and 16 females. Age 66-86 (75.54±5.15) years old. Copd has a course of 2-8 (5.54±1.05) years. Bmi 19.7-24.6 (22.54±1.05) kg/m^2. There were 24 cases of hypertension and 16 cases of diabetes. The study group (n=40) included 23 males and 17 females. Age 65-88 (75.52±5.16) years old. Copd has a course of 2-8 (5.50±1.08) years. Bmi 19.6-24.8 (22.52±1.08) kg/㎡. There were 23 cases of hypertension and 17 cases of diabetes.

2.2 Inclusion and exclusion criteria

Inclusion criteria: (1) met the diagnostic criteria for COPD and had respiratory failure; (2) The patient has good cognition and normal mental state; (3) Patients who are aware of the study; (4) Age > 60 years old; (5) Complete medical records. Exclusion criteria: (1) patients with mental illness; (2) Those who do not cooperate with treatment; (3) Language, hearing impairment, unable to communicate normally; (4) Patients with malignant tumors; (5) People with metabolic diseases.

2.3 Method

(1) Control Group

Symptomatic treatment was given to the patient, including cough, asthma and expectorant drugs. At the same time, the patient received non-invasive ventilator treatment. Biphasic positive airway pressure was applied to the patients and oxygen flow was controlled by 3-5L/min. Set inspiratory pressure to 8-15cmH_2O and expiratory pressure to 4-6cmH_2O. Treatment was performed twice a day for 3-4h each time. The duration of treatment was 7 days.

(2) Research Group

On the basis of control group, the patients received pulmonary rehabilitation training. The doctor instructs the patient to take a seated position with one hand on the chest and the other on the abdomen and breathe from the abdomen. The doctor asks the patient to inhale through the nose and puff out the abdomen while keeping the chest still. Exhale slowly through your mouth, pulling in your stomach and not moving your chest. 10 minutes, 3 times a day. The doctor instructs the patient to breathe in a whistling position, inhaling through the nose and exhaling through the mouth. The lips are partially closed as you exhale. 10min 3 times a day. The patient exercises the strength of the respiratory muscle: in the supine position, the head is appropriately raised, and the patient is guided to inhale through the diaphragm. The doctor places 1-2kg of sandbags on the patient's upper abdomen and then performs inhalation and exhalation exercises. 5 minutes, 3 times a day. The duration of treatment was 7 days.

2.4 Observation index

(1) Treatment effect: After 7 days of treatment, the symptoms of shortness of breath, wheezing and dyspnea disappeared, and the lung function and respiratory function recovered, indicating obvious effect. The symptoms are alleviated, lung function and respiratory function are improved, which is effective. Failure to meet the above requirements shall be invalid. Treatment effective rate = (obvious + effective)/cases ×100%.

(2) Lung function: The patient's forced vital capacity and expiratory volume in the first second were measured by the pulmonary function instrument before treatment and 7 days after treatment. The proportion of expiratory volume in forced vital capacity in the first second was calculated. The doctor took an average for comparison.

(3) Blood gas index: The patient's arterial blood was extracted before treatment and after 7 days of treatment, and the arterial partial pressure of oxygen, arterial partial pressure of carbon dioxide and

ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

blood oxygen saturation were measured by blood gas analyzer. The doctor took an average for comparison.

(4) Cardiopulmonary oxygenation index: Before treatment and after 7 days of treatment, maximum oxygen uptake and consumption metabolic equivalent were measured by gas analyzer.

(5) Inflammatory factors: Blood tests (venous pressure) were taken before treatment and 7 days after treatment to determine C-reactive protein and procalcitonin.

(6) Respiratory rate and heart rate: Doctors closely monitored vital signs and compared changes in breathing rate and heart rate before and 7 days after treatment.

2.5 Statistical Processing

SPSS25.0 software handles statistics of data differences. Measurement data ($\bar{x}\pm s$) t test. Statistical data (n, %) χ^2 test. P<0.05, the data difference was significant.

3. Result

3.1 Therapeutic effect

The effective rate of the study group was higher than that of the control group (P < 0.05). See Table 1.

Table 1: Therapeutic effect [n (%)]

Group	Remarkable	Effective	Invalid	Effective rate
Research group(n=40)	35(87.50)	4(10.00)	1(2.50)	39(97.50)
Control group(n=40)	27(67.50)	6(15.00)	7(17.50)	33(82.50)
χ^2-value	/	/	/	5.000
P-value	/	/	/	0.025

3.2 Lung function

After treatment, the proportion of forced vital capacity, first second expiratory volume and first second expiratory volume in forced vital capacity in study group was higher than that in control group (P < 0.05). See Table 2.

Table 2: Lung function($\bar{x}\pm s$)

	Build lung capacity(L)		First second expiratory volume(L)		The proportion of expiratory volume in forced vital capacity in the first second (%)	
Group	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Research group(n=40)	1.68±0.11	2.78±0.35[a]	1.25±0.08	2.51±0.11[a]	65.24±2.45	84.05±3.65[a]
Control group(n=40)	1.66±0.09	2.35±0.24[a]	1.24±0.08	2.21±0.08[a]	66.04±2.35	80.24±2.78[a]
t-value	0.890	6.408	0.559	13.950	1.490	5.252
P-value	0.376	<0.001	0.578	<0.001	0.140	<0.001

Note: Before and after treatment, [a]P < 0.05, the difference was statistically significant.

3.3 Blood gas index

After treatment, the partial pressure of arterial blood oxygen and saturation of blood oxygen in the study group were higher than those in the control group, and the fraction of arterial blood carbon dioxide was lower than that in the control group (P < 0.05). See Table 3.

ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

Table 3: Blood gas index($\bar{x}\pm s$)

	Arterial partial oxygen pressure(mmHg)		Arterial partial pressure of carbon dioxide(mmHg)		Blood oxygen saturation (%)	
Group	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Research group(n=40)	58.65±3.15	85.35±4.68[a]	70.54±2.45	40.05±1.05[a]	75.54±2.45	93.24±3.45[a]
Control group(n=40)	58.66±3.13	80.24±3.78[a]	70.49±2.51	46.35±2.04[a]	75.55±2.46	90.15±2.47[a]
t-value	0.014	5.372	0.090	17.366	0.018	4.606
P-value	0.989	<0.001	0.928	<0.001	0.986	<0.001

Note: Before and after treatment, [a]$P < 0.05$, the difference was statistically significant.

3.4 Cardiopulmonary oxygenation indicators

After treatment, the maximal oxygen uptake and consumption metabolic equivalent of the study group were higher than those of the control group ($P < 0.05$). See Table 4.

Table 4: Cardiopulmonary oxygenation index($\bar{x}\pm s$)

	Maximal oxygen uptake(mL/min)		Consumption metabolic equivalent	
Group	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Research group(n=40)	1.45±0.44	2.99±0.74[a]	5.01±0.48	7.65±1.01[a]
Control group(n=40)	1.46±0.43	2.59±0.46[a]	4.98±0.51	6.35±0.54[a]
t-value	0.103	2.903	0.271	7.179
P-value	0.918	0.005	0.787	<0.001

Note: Before and after treatment, [a]$P < 0.05$, the difference was statistically significant.

3.5 Inflammatory factor

After treatment, the levels of C-reactive protein and procalcitonin in the study group were lower than those in the control group ($P < 0.05$). See Table 5.

Table 5: Inflammatory factors($\bar{x}\pm s$)

	C-reactive protein(mg/L)		Procalcitonin(ng/L)	
Group	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Research group(n=40)	64.54±5.45	10.15±1.05[a]	52.35±4.15	8.24±1.08[a]
Control group(n=40)	64.55±5.51	18.35±1.65[a]	52.31±4.16	13.65±2.78[a]
t-value	0.008	26.517	0.043	11.473
P-value	0.994	<0.001	0.966	<0.001

Note: Before and after treatment, [a]$P < 0.05$, the difference was statistically significant.

3.6 Respiratory rate and heart rate

The respiratory rate and heart rate of the study group were lower than those of the control group after treatment ($P < 0.05$). See Table 6.

Table 6: Respiratory rate and heart rate($\bar{x}\pm s$)

	Respiratory rate(Times /min)		Heart rate(Times /min)	
Group	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Research group(n=40)	26.78±2.45	19.15±1.05[a]	118.54±8.54	82.54±5.15[a]
Control group(n=40)	27.01±2.34	23.54±1.11[a]	118.49±8.61	92.35±6.74[a]
t-value	0.429	18.171	0.026	7.314
P-value	0.669	<0.001	0.979	<0.001

Note: Before and after treatment, [a]$P < 0.05$, the difference was statistically significant.

4. Discuss

The clinical incidence of COPD is high, mostly in the middle and old age. The incidence increases with age, showing an obvious age trend, which has a great impact on the daily life of patients with

ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

decreased activity endurance and cardiopulmonary function[8]. Because elderly patients suffer from a variety of basic diseases, the function of various tissues and organs of the body declines, and the symptoms can be aggravated with the development of the disease, and the disease is harmful. Patients with acute attacks have severe cough, shortness of breath, chest tightness, dyspnea, and respiratory failure in severe cases[9]. In addition to symptomatic treatment for patients, respiratory support treatment is also needed, and non-invasive ventilators are commonly used. The treatment goals of COPD acute exacerbation combined with respiratory failure are to restore spontaneous breathing, alleviate symptoms, and improve lung function[10]. Clinical pulmonary rehabilitation training can promote the recovery of lung function and improve dyspnea.

5. Conclusions

In this study, the treatment efficiency of the study group was higher than that of the control group. Analysis of the reasons: symptomatic treatment can effectively control the symptoms of patients, relieve cough and promote sputum discharge, thereby reducing airway blockage and improving airflow restriction[11]. Non-invasive ventilators can assist patients in breathing, correct hypoxia, and maintain normal oxygen supply[12]. Pulmonary rehabilitation training can promote the recovery of patients' diaphragm to normal position and function, reduce respiratory work, and improve the working efficiency of respiratory muscle[13]. The combination of pulmonary rehabilitation training and non-invasive ventilator can help patients recover lung function, improve breathing, and enhance therapeutic effect in different ways[14]. In this study, the lung function of the study group was better than that of the control group after treatment. Analysis of reasons: symptomatic treatment can reduce disease symptoms, maintain normal vital signs, and reduce patients' pain[15]. Non-invasive ventilator therapy can correct hypoxia and maintain normal oxygen supply, which has a certain effect on lung function recovery, but the effect is slow and limited. Lung rehabilitation training can enhance the strength of expiratory muscle and inspiratory muscle, exercise the function of autonomous breathing, so as to leave the non-invasive ventilator as soon as possible, and gradually restore lung function. In this study, the blood gas index of the two groups after treatment was compared, and the study group was better than the control group. Analysis of the reasons: During the onset of the disease, the elasticity of the lung tissue and bronchus decreased, and the lumen collapsed and blocked, making the gas trapped in the alveoli and unable to be discharged, reducing the exhaled volume. The patient has complex and severe symptoms, respiratory failure, inability to breathe on his own, and insufficient oxygen supply, resulting in abnormal blood gas indicators. Non-invasive ventilator treatment provides respiratory assistance to patients, ensuring adequate oxygen supply to the human body, maintaining the normal work of various tissues and organs, and stabilizing vital signs. Symptomatic treatment alleviates cough, alleviates shortness of breath, and promotes sputum discharge, thereby improving airway obstruction. Pulmonary rehabilitation training exercises the respiratory muscle, enhances the strength of the respiratory muscle, improves the fatigue of the respiratory muscle, and promotes the coordination between the diaphragm and the abdominal muscle[16]. Abdominal breathing allows patients to consciously change their breathing patterns, increase abdominal movement, increase tidal volume, and reduce respiratory rate. Lip contraction breathing can help to reduce the patient's expiratory airflow pressure, increase the airway pressure to promote the discharge of residual gas in the lung, accelerate the recovery of lung function, improve breathing, and then improve blood gas index. In this study, the cardiopulmonary oxygenation index of the study group after treatment was better than that of the control group. Analysis of the reason: non-invasive ventilator treatment helps patients inhale enough oxygen to maintain body function and keep vital signs stable. Patients receive positive pressure ventilation when receiving treatment, which can reduce airway resistance and improve the level of air exchange, thereby accelerating the removal of carbon dioxide from the body, and thereby improving cardiopulmonary oxygenation indicators. Lung rehabilitation training and non-invasive ventilator combined treatment, using different principles to promote the improvement of patients' lung function, reduce respiratory muscle fatigue, enhance respiratory muscle strength, enhance patients' respiratory muscle endurance, contribute to gas exchange, improve cardiopulmonary oxygenation ability. In this study, the respiratory rate and heart rate of the study group after treatment were lower than that of the control group. Analysis of the reasons: Pulmonary rehabilitation training can help patients better control the respiratory rate, master the correct breathing mode, so as to reduce gas trapping, improve respiratory function, correct hypoxia, and maintain the stable vital signs of patients. Combined with a non-invasive ventilator can promote gas exchange, reduce airway resistance, thereby reducing respiratory failure, dyspnea, and stabilize respiratory rate and heart rate[17].

In summary, the combined use of pulmonary rehabilitation training and non-invasive ventilator in

ISSN 2616-5791 Vol.5, Issue 10: 33-38, DOI: 10.25236/AJMHS.2024.051006

the treatment of acute COPD exacerbation with respiratory failure in the elderly has a significant effect.

Acknowledgements

This work was financially supported by Natural Science Foundation of Gansu Province: 2023 Natural Science Foundation of Gansu Province (23JRRA1256) and Gansu Provincial Health Commission Nursing plan (GSWSHI2024-034).

References

[1] Ma Zhanshan, Liu Xiaoping, Wang Xin, et al. Effect of external diaphragm pacemaker combined with non-invasive ventilator in the treatment of patients with acute exacerbation of moderate to severe chronic obstructive pulmonary disease [J]. The Great Doctor, 2024, 9(14):35-38.
[2] Yang Chuanliang, Zhang Guxiang, Liu Hanchen. Effect of doxofylline assisted non-invasive ventilator in the treatment of acute exacerbation of chronic obstructive pulmonary disease complicated with respiratory failure [J]. Chinese Journal of Medicine, 2019, 59(07):737-740.
[3] Zhou Chunqing, Zou Wen, Yang Zhe. Effects of BiPAP noninvasive ventilator combined with tiotropium bromide on respiratory intensity and lung function in patients with AECOPD and respiratory failure [J]. Chinese Journal of Medical Innovation, 2019, 21(12):26-30.
[4] Yang Xuxu, Jiang Yuanyuan, Li Wangbin. Effect and clinical analysis of noninvasive ventilator in treatment of acute respiratory failure in elderly patients with chronic obstructive pulmonary disease [J]. Guizhou Medicine, 2019, 48(02):264-266.
[5] Cong Meijiao. Effect of BiPAP noninvasive ventilator on patients with acute exacerbation of chronic obstructive pulmonary disease complicated with respiratory failure [J]. Chinese Journal of Medical Sciences, 2019, 35(21):30-32+36.
[6] Sun Jinyong, Shi Guanglin. Effect of combined noninvasive ventilator therapy on acute exacerbation of chronic obstructive pulmonary disease [J]. Jilin Medical Science, 2023, 44(10): 2814-2816.
[7] Chen Zhihai. Comparative study of nasal high flow oxygen inhalation and non-invasive ventilator-assisted ventilation in patients with acute exacerbation of chronic obstructive pulmonary disease [J]. Journal of Systems Medicine, 2019, 8(19):74-77.
[8] Jiang Zhihua, Luo Lihua, Xu Huiqing. Application of early pulmonary rehabilitation training in patients with acute exacerbation of chronic obstructive pulmonary disease [J]. Chinese and Foreign Medical Journal, 2019, 42(28):162-166.
[9] Zhao X L. Research progress on diagnosis and treatment of chronic obstructive pulmonary disease complicated with respiratory failure [J]. Youjiang Medical Journal, 2019, 51(09):840-843.
[10] Zhang Weirong. Clinical effect of noninvasive ventilator on patients with type II respiratory failure in acute exacerbation of chronic obstructive pulmonary disease [J]. Chinese Community Physician, 2019, 39(24):38-40.
[11] Hu Dongdong, Liu Ruifang, Wang Congmei, et al. Effect of nasal high flow oxygen therapy and non-invasive mechanical ventilation in acute exacerbation of chronic obstructive pulmonary disease [J]. Journal of Clinical Medicine, 2019, 43(07):50-52.
[12] Ma Yilong. Effect of non-invasive positive pressure ventilation on respiratory failure in acute exacerbation of chronic obstructive pulmonary disease [J]. Primary Medicine Forum, 2019, 27(16): 70-72.
[13] Jin Wenjing, Guo Xiaoxia, Zhou Chao. Study on timing and frequency of pulmonary rehabilitation in acute exacerbation of chronic obstructive pulmonary disease [J]. Journal of Clinical Internal Medicine, 2002, 39(10):684-687.
[14] Xie Qihua. Clinical effect of pulmonary rehabilitation training combined with noninvasive ventilator in the treatment of acute exacerbation of chronic obstructive pulmonary disease complicated with respiratory failure [J]. Current Medicine, 2022, 28(18):164-167.
[15] Liu Shaoyan, Wang Lin, Lu Jiayi, et al. Effect of early pulmonary rehabilitation training on patients receiving non-invasive mechanical ventilation during acute exacerbation of chronic obstructive pulmonary disease [J]. Journal of Qilu Nursing, 2021, 27(15):91-94.
[16] Liu Peiling. Effect of early pulmonary rehabilitation training on patients with acute exacerbation of chronic obstructive pulmonary disease [D]. Hebei Medical University, 2021.
[17] Varatharajah Y, Chen H, Trotter A, & Iyer R. K. A Dynamic Human-in-the-loop Recommender System for Evidence-based Clinical Staging of COVID-19. In HealthRecSys@ RecSys, 2020, 21-22.