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Analysis of the Effect of Extracorporeal Diaphragmatic Pacing Combined with Noninvasive Ventilator on the Respiratory Function and Prognosis of COPD Patients

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Abstract: *Objective:* To investigate the effect of extracorporeal diaphragmatic pacing combined with noninvasive ventilators on the respiratory function and prognosis of chronic obstructive pulmonary disease (COPD) patients. *Methods:* A total of 50 COPD patients were selected between January 2023 to December 2023 and randomly grouped into an observation group and a control group, with 25 cases. The observation group was given extracorporeal diaphragm pacing combined with a noninvasive ventilator, while the control group was given a conventional treatment mode. After the treatment, the results of each index in the two groups were compared. *Results:* Compared with the diaphragm function indexes of the two groups, the data of the observation group were more dominant ($P < 0.05$). The rehospitalization rate of the observation group was lower than that of the control group ($P < 0.05$). The COPD assessment test (CAT) and mMRC (Modified Medical Research Council) Dyspnoea scale scores after treatment between the two groups were significantly different ($P < 0.05$). Compared with the control group, the lung function indexes of the observation group were more dominant ($P < 0.05$). *Conclusion:* Extracorporeal diaphragmatic pacing combined with a noninvasive ventilator promoted the improvement of the patient's prognosis and improved their respiratory function.

Keywords: COPD; Extracorporeal diaphragmatic pacing; Noninvasive ventilator; Respiratory function; Prognosis

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1. Introduction

Currently, the mechanism of chronic obstructive pulmonary disease (COPD) is still unclear and it is believed that COPD is closely related to a variety of factors, such as abnormal inflammatory response caused by harmful gases and particles. It has a high clinical mortality rate, which is often accompanied by a series of adverse symptoms, such as chronic cough, shortness of breath, wheezing, chest tightness, and dyspnea [1]. Extracorporeal diaphragmatic pacing combined with a noninvasive ventilator as a new clinical treatment for chronic obstructive pulmonary disease can effectively improve the patient's lung function and reduce their stress response, to improve the prognosis of the disease [2]. This paper aims to investigate the efficacy of extracorporeal diaphragmatic pacing combined with a noninvasive ventilator on the respiratory function and prognosis of COPD patients.

2. Information and methods

2.1. Baseline information

Fifty COPD patients admitted to our hospital from January 2023 to December 2023 were selected and randomly divided into a control group and an observation group of 25 cases each. Inclusion criteria: (1) Patients who meet the diagnostic criteria of COPD [3]; (2) patients who are stable with no acute exacerbation during treatment; (3) consented. Exclusion criteria: (1) Patients who are receiving other rehabilitation treatments; (2) respiratory diseases; (3) presence of malignant lesions; (4) presence of mental abnormalities.

The observation group consisted of 14 and 11 cases of men and women respectively, aged 54–78 years old, with an average age of 66.32 ± 3.71 years. The disease duration ranged from 6–16 years, with an average of 11.32 ± 2.16 years. The control group consisted of 15 and 10 cases of men and women respectively, aged 55–78 years old, with an average of 66.85 ± 3.09 years. The disease duration ranged from 7–16 years, with an average of 11.96 ± 2.01 years. A comparison of the above indicators showed no significant difference ($P > 0.05$).

2.2. Methods

The control group received conventional treatment. Symptomatic treatment was carried out to improve the various examinations of the patients, including asthma, oxygen inhalation, expectoration, and anti-infection. During the treatment, the patients were instructed to carry out functional exercises, and nutritional support was also provided.

The observation group received extracorporeal diaphragm pacing combined with a non-invasive ventilator treatment based on the control group. The extracorporeal diaphragm pacing device of model HLO-GJ13A (produced by Guangzhou Xuelion Biotechnology Co., Ltd.) was chosen as the treatment equipment, and the patients were instructed to adopt a sitting position or recumbent position. Skin electrodes were placed on the third of the lower edge of the sternocleidomastoid muscles of the patient's bilateral muscle. The pulse frequency was set at 30–50 Hz. When combined with the patient's respiratory rate, the pacing was clearly defined at 8–15 times per minute. Subsequently, when combined with the patient's tolerance and sensation, the stimulation intensity was clearly defined, i.e., 12–30 units, where the stimulation intensity followed the principle of weak to strong. This treatment was performed once a day for half an hour, for 12 weeks. For the non-invasive ventilator treatment, the model of the ventilator was selected as V60, and the appropriate parameters of the ventilator were selected according to the individual differences of each patient. the ventilation mode was selected as S/T, the oxygen concentration was set between 0.35 and 0.45, the respiratory rate was set at 12–16 times/min, the inspiratory pressure was set at 10 cmH_2O, and the expiratory pressure was set at 4 cmH_2O. If the patient is tolerant to the parameters mentioned above, the parameters were appropriately increased. When the patient tolerates the above parameters, the pressure is appropriately increased. and The treatment was performed 1 to 3 times a day for 4 to 6 hours, over 2 weeks.

2.3. Observation indexes

The diaphragm function indexes, re-hospitalization rate, COPD assessment test (CTA), mMRC (Modified Medical Research Council) Dyspnea scores, and lung function indexes of the two groups after treatment were compared. The diaphragm function index was analyzed by the Doppler ultrasound system (minauderyM5) to determine diaphragm activity (DE). The patient's head of the bed was tilted 30° at the supine position, and the convex array probe was placed on the right side of the patient's midclavicular line, as well as the anterior axillary line and the lower edge of the costal arches of the intersection. The probe was directed to the posterior portion of the diaphragm, and upon the appearance of thick line-like hypoechoic bands, the M ultrasound system was used to record the longitudinal motion waveform of the diaphragm's top over 3 respiratory cycles. At the same time, the patient was instructed to maintain the expiratory state, and then forcefully inhale until the total lung capacity was reached。 The range of diaphragmatic motion of the patient was measured until it was smooth and the largest sample line perpendicular to the patient's diaphragm was selected and regarded as DE. The diaphragm thickening fraction (DTF) was measured using a line array probe (frequency of 7–13Hz) and placed in the patient's right anterior axillary line in the 7th or 8th intercostal space, and the diaphragm was scanned by M ultrasound. The movement of the diaphragm was scanned by M ultrasound, and the patient's diaphragm thickness at the end of inspiration (DTei), and the diaphragm thickness at the end of expiration (DTee) were recorded. The final results were averaged over 3 consecutive respiratory cycles, DTF = (DTei + DTee)/ DTee × 100%.

The patient's lung function was measured using the ratio between the first-second expiratory volume with exertion and lung volume exertion. It was measured by a lung function tester (model Master Screen, Germany). The modified version of the mMRC and the CAT were used to assess the respiratory function of the two groups of patients, and the scores were inversely proportional to the patients' dyspnea symptoms.

2.4. Statistical processing

The SPSS 20.0 software for statistical analysis and all the results conformed to the normal distribution. Measurement data were expressed as mean ± standard deviation and compared using the *t*-test. Count data were expressed as % and analyzed using the chi-squared (χ^2) test. Results were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of diaphragm function indexes between the two groups

As shown in **Table 1**, the diaphragm function indexes of the observation group were higher than that of the control group after treatment ($P < 0.05$).

Table 1. Comparison of diaphragm function indexes between the two groups

Group	DE (cm)		DTF (%)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Observation group (*n* = 25)	1.80 ± 0.22	3.88 ± 1.52*	23.22 ± 2.11	37.63 ± 2.41*
Control group (*n* = 25)	1.81 ± 0.23	2.32 ± 1.42*	23.23 ± 2.12	28.25 ± 2.11*
t	0.157	3.750	0.017	14.642
P	0.876	0.001	0.987	0.000

Note: *$P < 0.05$ compared with pre-treatment.

3.2. Comparison of the re-hospitalization rate between the two groups

As shown in **Table 2**, the re-hospitalization rate of the observation group was lower than that of the control group after treatment ($P < 0.05$).

Table 2. Comparison of the re-hospitalization rate between the two groups [*n* (%)]

Group	Case (*n*)	6 months after treatment	12 months after treatment
Observation group	25	0 (0.00)	1 (4.00)
Control group	25	1 (4.00)	6 (24.00)
χ^2	-	1.020	4.153
P	-	0.312	0.042

3.3. Comparison of CAT and mMRC scores between the two groups

As shown in **Table 3**, the CAT and mMRC scores of the observation group after treatment were lower than those of the control group ($P < 0.05$).

Table 3. Comparison of CAT and mMRC scores between the two groups (points)

Group	Case (*n*)	CAT		mMRC	
		Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Observation group	25	26.32 ± 2.11	20.36 ± 1.04*	2.98 ± 0.11	2.41 ± 0.02*
Control group	25	26.33 ± 2.12	26.85 ± 1.88*	2.99 ± 0.12	3.29 ± 1.77*
t	-	0.017	15.104	0.307	2.486
P	-	0.987	0.000	0.760	0.017

Note: **P* < 0.05 compared with pre-treatment.

3.4. Comparison of lung function indexes between the two groups

As shown in **Table 4**, the lung function indexes of the observation group were greater than that of the control group after the treatment ($P < 0.05$).

Table 4. Comparison of lung function indexes between the two groups (%)

Group	Case (*n*)	FEVI		FEVI/FVC	
		Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Observation group	25	42.25 ± 2.11	69.63 ± 3.78*	54.85 ± 2.96	66.52 ± 3.74*
Control group	25	42.26 ± 2.12	55.25 ± 2.01*	54.86 ± 2.97	59.63 ± 2.41*
t	-	0.017	16.794	0.012	7.743
P	-	0.987	0.000	0.991	0.000

Note: **P* < 0.05 compared to pre-treatment. Abbreviation: Forced expiratory volume in the first second, FEV1; forced vital capacity, FVC.

4. Discussion

As a common respiratory disease, COPD is characterized by reduced airflow and is incurable and highly recurrent, which seriously affects patients' daily lives. In China, the clinical treatment of COPD is often via drug treatment. However, for the acute stage cases, it is important to perform pulmonary rehabilitation training, which can effectively improve exercise endurance and lung function. This way, the conscious symptoms of the patients can be reduced [4].

In this study, the lung function of the observation group was better than that of the control group after the treatment, suggesting that the advantages of using extracorporeal diaphragmatic pacing combined with a noninvasive ventilator are significant, which promoted the improvement of the patient's lung function. Extracorporeal diaphragmatic pacing utilizes the role of body surface electrodes to electrically stimulate the phrenic nerves of the patient, which is functional, non-invasive, and can stimulate the diaphragm of patients to maintain a regular contraction state [5]. A non-invasive ventilator is commonly used in the treatment of COPD. It is easily operable and causes minimal damage to the patient's organs. It is also more consistent with the physiological needs of the patient, and the patient's degree of cooperation and acceptance are higher when using this device. The application of a non-invasive ventilator significantly increased the patient's lung capacity of patients and lung compliance. This procedure will not impact the patient's end-of-breath lung volume and expiratory flow, thus ensuring the uniform state of the gases, reducing the risk of respiratory failure, and greatly improving the treatment outcomes [6].

In this study, the diaphragm activity and diaphragm thickening scores of the observation group were higher than those of the control group after the treatment, which suggested that extracorporeal diaphragm pacing combined with noninvasive respiratory function effectively improved the diaphragm function of COPD patients. In addition, it significantly increased the amount of type I and II fibers in the diaphragm and improved its function [7].

The re-hospitalization rate of the observation group after the treatment was lower, indicating that the use of combined treatment methods promoted the improvement of the patient's prognosis and reduced the incidences of re-hospitalization. COPD patients are associated with gastrointestinal digestive and absorption dysfunction due to intestinal hemorrhage, hypoxemia, and respiratory acidosis. When the patients experience constipation, anorexia, and abdominal distension, these affect their respiratory dynamics, causing the diaphragm to move upward, thus affecting the gas exchange function of the lungs. Therefore, improving diaphragm function and correcting diaphragm fatigue should be emphasized in treatment to improve the respiratory function of the patients. This would increase their pulmonary ventilation and delay events of respiratory failure [8]. Extracorporeal diaphragmatic pacing has the advantages of simple operation, low cost, few complications, non-invasive, etc., and is now regarded as an effective means of treatment for COPD rehabilitation. It can increase the spontaneous electromyographic activity of the patient's diaphragm, increase the strength of respiratory muscles, and produce reflexive sputum expectoration. The increase in diaphragm mobility can prompt the patient to produce a larger thoracic cavity positive pressure when coughing, thereby improving the patient's breathing function. By increasing the mobility of the diaphragm, the patient can generate a greater positive pressure in the chest cavity when coughing, thus enhancing the patient's airway clearance and coughing ability. Non-invasive respiratory function can also promote an increase in lung volume, fight against airway resistance, and prevent patients from end-expiratory alveolar collapse. This eventually improves the function of pulmonary ventilation but also reduces the workload of the auxiliary respiratory muscle. Ultimately, respiratory muscle fatigue can be alleviated to reduce the patient's risk of re-hospitalization [9].

5. Conclusion

Extracorporeal diaphragmatic pacing combined with a noninvasive ventilator improved the patient's prognosis and respiratory function. Hence, it is worthy of further promotion.

Disclosure statement

The authors declare no conflict of interest.

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