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High-Flow Nasal Cannula (HFNC) Combined with Acapella Pep: Impact on Pulmonary Function, Blood Gas Analysis, and Serum Inflammatory Factors in Elderly Community-Acquired Pneumonia Patients

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Pneumonia; HFNC; Acapella PEP; mMRC; curative effect

1. Abstract

1.1. Purpose: To investigate the effects of high-flow nasal cannula oxygen therapy (HFNC) combined with Acapella PEP treatment on pulmonary function, blood gas analysis, mMRC, and serum inflammatory factor levels in elderly community-acquired pneumonia (CAP) patients and to assess the clinical therapeutic effect of this method.

1.2. Methods: This study included 100 elderly CAP patients treated at our hospital from November 2022 to November 2023, randomly divided into control and observation groups, with 50 patients in each group. The control group received routine anti-infective, antitussive, expectorant treatment and HFNC therapy after admission. The observation group received Acapella PEP treatment in addition to the treatment provided to the control group. Both groups underwent a 7-day treatment. The therapeutic effects of the two groups were assessed, including blood gas analysis, mMRC score, pulmonary function, infection indicators, and inflammatory factors such as WBC, PCT, CRP, IL-6, IFN-γ, and TNF-α.

1.3. Results: After treatment, compared with the control group, patients in the observation group showed an increase in the oxygenation index PaO_2/FiO_2 ratio, an elevated mMRC score for respiratory distress ($P<0.05$), and a significant decrease in $PaCO_2$ levels ($P<0.05$). The observation group also demonstrated improvement in pulmonary function indicators, including FVC, FEV1, and PEF, compared with the control group ($P<0.05$). Compared with the control group, the observation group exhibited a significant decrease in infection indicators WBC, PCT, and CRP, as well as inflammatory factor levels of IL-6, IFN-γ, and TNF-α ($P<0.05$).

1.4. Conclusion: HFNC combined with Acapella PEP treatment effectively alleviates respiratory distress, improves pulmonary function and oxygenation index, reduces infection indicators, and lowers levels of inflammatory factors in elderly CAP patients, resulting in better clinical therapeutic outcomes.

2. Introduction

Community-acquired pneumonia CAP is one of the serious infectious diseases affecting the health of the elderly population [1]. This disease is often characterized by clinical symptoms such as cough, sputum production, and respiratory distress. Despite the widespread use of various antitussive and expectorant medications, excluding deep bronchial sputum remains a clinical challenge for most elderly patients, especially when deep-seated sputum cannot be promptly cleared, directly impacting the effectiveness of anti-infective treatment. Therefore, effectively promoting sputum clearance becomes a crucial clinical issue in treating elderly CAP patients. High-flow nasal cannula HFNC oxygen therapy is an innovative respiratory support treatment technique that delivers high-concentration humidified oxygen, effectively improving

ventilation efficiency and respiratory patterns. HFNC can partially replace the function of non-invasive ventilators while enhancing ciliary function, demonstrating high tolerance, ease of use, and adaptability, and has been widely applied in clinical practice in recent years. Its main features include improving oxygenation and facilitating sputum clearance [2, 3]. The Acapella PEP vibratory positive expiratory pressure (PEP) therapy system, abbreviated as Acapella PEP, operates on the principle of loosening mucus through airflow vibrations. Expiratory resistance generates positive pressure in the lungs, thereby expanding the airways and promoting sputum clearance through airway vibration [4]. This device is simple to use, and patients can self-administer the treatment without assistance. Previous studies have indicated that HFNC-assisted therapy can improve the clinical outcomes of elderly CAP. However, there are no reports on whether the combined application of Acapella PEP based on HFNC can achieve better treatment results. Therefore, this study aims to explore this scientific question, and the clinical research results are reported below.

3. Research Methods

3.1. General Information: The study focused on elderly patients with Community-Acquired Pneumonia CAP, admitted for treatment from November 2022 to November 2023 at Tinglin Hospital in Jinshan District, Shanghai. According to the research design, a total of 100 patients were included in the study, evenly divided into two groups: the study group and the control group, each comprising 50 patients. The study group consisted of 28 males and 22 females, with an average age of 65.58±9.86 years, while the control group included 30 males and 20 females, with an average age of 65.48±10.12 years. The clinical diagnosis of CAP strictly followed the definition reported by Modi AR et al [5]. This includes clinical symptoms such as fever (temperature>38°C), purulent respiratory secretions, and peripheral blood leukocyte count >10×10^9/L or <4×10^9/L. Chest X-ray or CT should show new or progressing infiltrates, consolidation, and ground-glass opacities, with or without cavities and pleural effusion. All enrolled patients needed to meet any two of the criteria in the first condition and the requirements of the second condition. Exclusion criteria included pulmonary embolism, atelectasis, pulmonary edema, drug-induced lung injury, underlying diseases affecting the lungs, and ARDS.

3.2. Treatment Methods: Patients received routine anti-infective and antitussive expectorant treatments upon admission. The control group received High-Flow Nasal Cannula HFNC therapy (MaiSi, HUMID-BM) with an oxygen concentration of 30%-50%, a 30-40 L/min flow rate, and a temperature of 31-37°C. Parameters were adjusted based on the patient's condition, with HFNC administered twice daily for 5 hours each time. In addition to HFNC treatment, the observation group received Acapella PEP therapy with the same HFNC parameters as the control group. The steps for using Acapella PEP were as follows: a. Clean hands and set the resistance level according to the medical order. b. Take a deep breath and hold for 2-3 seconds. c. Close the mouth tightly, completely enclose the mouthpiece, and exhale continuously for 3-4 seconds, completing one breath. d. Hold the mouthpiece between the teeth, take another deep breath for 1 second, and exhale for 3-4 seconds, completing the second breath. e. Every 20 breaths constitute one set, taking approximately 3-5 minutes. After completion, the patient can remove the breathing device and perform 2-3 forceful exhalations, coughing, and sputum clearance. Complete 4-5 sets of breathing training daily in the morning, afternoon, and evening.

3.3. Observational Indicators: (a) Comparison of Blood Gas Analysis: Arterial blood samples (3 mL) were collected from fasting patients before and after treatment in the morning. After centrifugation (radius 15 cm, speed 3000 r/min, 10 min), the serum was stored at -20°C. A fully automatic blood gas analyzer was used to measure PaO_2, SaO_2, and $PaCO_2$ levels. (b) Comparison of Pulmonary Function Indicators: A portable pulmonary function detector (Saike, X2 model) was used before and after treatment to record forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow (PEF). (c) Comparison of respiratory distress severity: The Modified Medical Research Council Dyspnea Scale (mMRC) was used before and after treatment to compare and analyze the severity of respiratory distress in patients. (d) Comparison of Infection Indicators and Inflammatory Factors: Fasting venous blood samples (5 mL) were collected from patients before and after treatment. Infection indicators, including White Blood Cell (WBC), procalcitonin (PCT), and C-reactive protein (CRP), were tested. Additionally, fasting venous blood samples (5 mL) were centrifuged (radius 15 cm, speed 3000 r/min, 10 min), obtaining upper-layer serum stored at -20°C. ELISA was used to measure IL-6, IFN-γ, and TNF-α levels.

3.4. Statistical Analysis: Data analysis was performed using SPSS 24 statistical software. The count and measurement data were compared using t-test, with $P<0.05$ considered a statistically significant level.

4. Results

Comparison of Blood Gas Analysis and mMRC Scores between Two Groups After treatment, patients in both groups showed significant improvement in blood gas analysis, mMRC scores, and infection indicators. Compared to the control group, patients in the observation group exhibited more significant progress in multiple aspects. Specifically, patients in the observation group had a significant increase in PaO_2/FiO_2ratio, a significant decrease in $PaCO_2$ levels, and a significant reduction in mMRC scores, as detailed in (Table 1). The results suggest that PEP treatment can more effectively alleviate respiratory distress and improve oxygenation index.

Table 1: Comparison of blood gas analysis and mMRC between the two groups (x ± s)

		PaO_2/FiO_2		$PaCO_2$ (mmHg)		mMRC score	
Group	n	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation Control group	50	341.85±29.44	295.72±30.84 *	42.76±7.14	42.76±7.14	3.41±0.25	2.24±0.44 *
	50	345.35±30.28	236.72±32.54*	41.87±6.65	42.31±8.45	-3.46±0.19	1.94±0.56 *
t		0.208	11.314	0.884	12.894	1.037	7.513
P		0.912	0.013	0.698	0.015	0.882	0.024

Note：Being compared with before treatment，*P<0.05.

4.1. Comparison of Lung Function Indicators between Two Groups: After treatment, patients in the observation group showed significant improvement in lung function indicators. Compared to the control group, FVC, FEV1, and PEF were significantly increased (P<0.05), as shown in (Table 2). These results indicate that HFNC combined with Acapella PEP treatment can more effectively improve patients' ventilation function through airway clearance and promote respiratory recovery.

4.2. Comparison of Infection Indicators between Two Groups: After treatment, both groups of patients showed significant improvement in infection indicators. Compared to the control group, WBC, PCT, and CRP levels in the observation group significantly decreased, as detailed in (Table 3 and 4). These results suggest that HFNC combined with Acapella PEP treatment can enhance the effectiveness of anti-infective treatment.

Table 2: Comparison of lung function between the two group (x ± s)

		FEV1（L）		FVC（L）		PEF（L）	
Group	n	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation Control	50	1.66±0.24	2.21±0.53 *	2.32±0.16	3.23±0.38 *	4.31±0.42	7.35±1.14 *
	50	1.51±0.21	1.82±0.34 *	2.13±0.15	2.85±0.35 *	4.15±0.39	6.24±1.12 *
t		0.089	15.254	0.176	16.124	1.672	9.247
P		0.142	<0.01	0.453	<0.01	0.327	<0.01

Note：Being compared with before treatment，*P<0.05.

Table 3: Levels of infection indicators between the two groups (x ± s)

		WBC(10^9/L)		PCT(ng/L)		CRP(mg/L)	
Group	n	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation Control	50	16.84±3.11	8.65±2.76 *	2.25±1.13	0.37±0.15 *	117.49±32.17	24.27±11.54 *
	50	15.78±3.29	9.34±2.29 *	2.72±1.28	0.43±0.16 *	115.45±29.28	32.64±14.28 *
t		0.239	10.556	0.302	10.733	1.145	12.107
P		0.692	0.008	0.296	0.001	0.252	0.002

Note：Being compared with before treatment，*P<0.05.

Table 4: Levels of inflammatory factors between the two groups (x ± s)

		IL-6（pg/ml）		INF-γ（ng/L）		TNF-α（pg/ml）	
Group	n	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation control	50	85.32±11.45	35.48±8.22 *	145.55±11.24	71.44±18.37 *	3.56±1.54	1.37±0.29 *
	50	84.67±12.13	53.42±9.26 *	148.75±10.95	98.25±17.37 *	3.67±1.48	1.79±0.55 *
t		0.089	15.254	0.176	16.124	1.672	9.247
P		0.803	0.011	0.785	0.013	0.134	0.012

Note：Being compared with before treatment，*P<0.05.

4.3. Comparison of Inflammatory Factors between Two Groups: Compared to before treatment, levels of IL-6, IFN-γ, and TNF-α in both groups significantly decreased after treatment, with the observation group showing a more significant decrease, and the differences were statistically significant ($P<0.05$). Refer to Figure 1) for details.

5. Discussion

The continuous increase in the elderly population is a significant trend in current society, and the health issues of the elderly have become a major societal concern. Community-Acquired Pneumonia CAP is a common infectious disease, and elderly CAP patients face numerous unfavorable factors during treatment that may impact treatment outcomes and respiratory recovery. Elderly CAP patients often exhibit poor nutritional status, reduced immune function, respiratory muscle fatigue, thickened sputum, weakened cough, and impaired airway clearance, making it challenging to resolve pulmonary infections [6]. Since sputum serves as a culture medium for bacteria, the inability to promptly clear sputum can limit the effectiveness of anti-infective medications. Therefore, effectively promoting sputum clearance is a crucial issue to address when treating elderly CAP patients [7]. Airway humidification therapy is a method that assists in diluting sputum and promoting its clearance, helping to maintain airway patency and facilitate inflammation absorption. The normal movement of airway cilia is influenced by factors such as temperature and humidity, and the temperature and humidity within the airways directly affect ciliary movement [8]. Therefore, maintaining a specific temperature and humidity in the airways helps with the normal movement of cilia, aiding in the clearance of airway secretions. Mechanical vibration sputum clearance is a common physically assisted sputum clearance method, but elderly CAP patients often have multiple concurrent illnesses, and osteoporosis is prevalent, limiting its use and potentially leading to complications such as fractures. High-flow nasal cannula oxygen therapy (HFNC) is an innovative respiratory support treatment technique. It delivers a high-flow gas mixture with a controlled and relatively constant oxygen concentration (21-100%), temperature (31-37°C), and humidity (8-80 L/min) directly through nasal prongs to patients [9]. As a form of non-invasive respiratory support, HFNC effectively improves oxygenation, washes lung tissue, reduces physiological and anatomical dead space, lowers airway resistance, and enhances ventilation. By appropriately humidifying and heating the air, HFNC can maintain the normal temperature and humidity of the airways, facilitating the normal function of cilia and promoting sputum clearance [10]. HFNC has been widely used in the adjunctive treatment of severe pneumonia, chronic obstructive pulmonary disease, bronchiectasis, acute hypoxic respiratory failure, and other diseases. Acapella PEP is a vibratory positive expiratory pressure (PEP) therapy system that uses airflow vibrations to loosen mucus and generate positive pressure, facilitating sputum clearance. It can improve respiratory muscle endurance, enhance lung function, alleviate respiratory distress, and contribute to preventing and treating lung collapse [4, 11]. This treatment is suitable for the rehabilitation of chronic obstructive pulmonary diseases, bronchiectasis, asthma, and other chronic respiratory diseases, as well as for patients experiencing difficulty in sputum clearance, lung collapse, impaired ventilator function, prolonged smoking, and bed rest. The results of this study indicate that HFNC combined with Acapella PEP treatment significantly improves the therapeutic outcomes of elderly CAP patients. Firstly, this approach is superior to using HFNC alone in improving oxygenation and relieving respiratory distress. The study confirmed that, compared to the control group, patients in the observation group showed a significant increase in the PaO_2/FiO_2 ratio, a significant decrease in $PaCO_2$ levels, and a significant reduction in the mMRC score. Secondly, this method effectively improves patients' lung function. The research results confirmed that, compared to the control group, patients in the observation group showed significant improvements in pulmonary function indicators, including FVC, FEV1, and PEF. Finally, this method effectively reduces patients' infection indicators and inflammatory factor levels. The results confirmed that, compared to the control group, patients in the observation group exhibited significant decreases in infection indicators (WBC, PCT, CRP) and inflammatory factors (IL-6, IFN-γ, TNF-α). Therefore, HFNC combined with Acapella PEP treatment is a safe and effective method. In addition to diluting sputum and promoting its clearance, it offers advantages such as improving oxygenation, enhancing lung function, and reducing inflammatory reactions. This provides a new avenue for the rehabilitation of elderly CAP patients.

In conclusion, this study provides robust support for improving treatment regimens and respiratory rehabilitation for elderly CAP patients. Future research can further explore the long-term effects of this treatment method and its applicability in different cases. This method is expected to enhance the quality of life for elderly CAP patients, reduce the burden on healthcare systems, and promote the development of high-quality medical and health services.

6. Conflict of Interest

The authors declared no potential conflicts of interest to this article's research, authorship, and publication.

7. Author Contributions

Yanting Yan and Bao Qian designed the project, Yin Yao, Yanan Li and Wulin Yi performed the experiments, Zhanjun Chen conceived this study, supported and revised the manuscript. All authors read and approved the manuscript and the submission.

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References

1. Zhao Z, Wang W, Jin J, Liu X. Diagnosis for readmission of senile patients hospitalized with acute decompensated heart failure in different departments: a retrospective cross-sectional study. J Thorac Dis. 2022; 14(5): 1556-1562.
2. Xia J, Gu S, Lei W. High-flow nasal cannula versus conventional oxygen therapy in acute COPD exacerbation with mild hypercapnia: a multicenter randomized controlled trial. Crit Care. 2022; 26(1): 109.
3. Crimi C, Pierucci P, Renda T, Pisani L, Carlucci A. High-Flow Nasal Cannula and COVID-19: A Clinical Review. Respir Care. 2022; 67(2): 227-240.
4. Demchuk AM, Chatburn RL. Performance Characteristics of Positive Expiratory Pressure Devices. Respir Care. 2021; 66(3): 482-493.
5. Modi AR, Kovacs CS. Community-acquired pneumonia: Strategies for triage and treatment. Cleve Clin J Med. 2020; 87(3): 145-151.
6. Beloborodov VA, Stepanov IA, Scherbatykh AV, et al. [Risk factors of adverse clinical outcomes in the elderly and senile patients with stroke-associated pneumonia.]. Adv Gerontol. 2021; 34(4): 586-591.
7. Wang Y, Zhang M, Yu Y, Han T, Zhou J, Bi L. Sputum characteristics and airway clearance methods in patients with severe COVID-19. Medicine (Baltimore). 2020; 99(46): e23257.
8. Lavoie-Bérard CA, Lefebvre JC, Bouchard PA, Simon M, Lellouche F. Impact of Airway Humidification Strategy in Mechanically Ventilated COVID-19 Patients. Respir Care. 2022; 67(2): 157-166.
9. Nishimura M. High-Flow Nasal Cannula Oxygen Therapy Devices. Respir Care. 2019; 64(6): 735-742.
10. Nishimura M. High-Flow Nasal Cannula Oxygen Therapy in Adults: Physiological Benefits, Indication, Clinical Benefits, and Adverse Effects. Respir Care. 2016; 61(4): 529-41.
11. Sun J, Chen J, Wang L, Lu A. The effect of vibrating positive expiratory pressure therapy on refractory Mycoplasma pneumoniae pneumonia prognosis in children.Transl Pediatr 2021; 10(2): 315-322.