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Study on the Therapeutic Effect of High Flow Humidified Oxygen Therapy on Elderly Patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease

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Abstract: Objective: To evaluate the efficacy of high-flow nebulized oxygen therapy (HFNC) in restoring respiratory function during acute exacerbations (AECOPD) in elderly patients with chronic obstructive pulmonary disease (COPD), providing clinical guidance for adjusting oxygen therapy regimens. Methods: A total of 100 elderly AECOPD patients admitted between January and December 2024 were randomly assigned into observation and control groups (50 each). The observation group received HFNC therapy, while the control group received conventional nasal cannula oxygen therapy. Comparative analysis was conducted on arterial blood gas parameters (PaO_2, $PaCO_2$, SaO_2) and respiratory rate (RR) before and 72 hours post-treatment, along with hospitalization duration and non-invasive ventilation (NIV) usage rates. Results: At 72-hour post-treatment, the observation group showed higher PaO_2(86.5±7.3mmHg) SaO_2 (95.4±2.0%) and lower RR (18.0±2.4 vs 52.5±4.3mmHg) (22.8±2.6 vs 24.0). The observation group had shorter hospital stays (8.3±1.5d) (11.4±1.9d) and lower NIV usage rate (8.0% vs 24.0%), all with statistically significant differences ($P<0.05$). Conclusion: HFNC can improve the arterial blood gas status of elderly AECOPD patients, reduce respiratory rate and non-invasive ventilation demand, shorten hospitalization time, and has important value in promoting respiratory function recovery.

Keywords: High-Flow Humidified Oxygen Therapy; Elderly Patients; Acute Exacerbations of Chronic Obstructive Pulmonary Disease; Respiratory Function; Arterial Blood Gas.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent chronic respiratory disorder among the elderly population. Patients with acute exacerbations (AECOPD) often experience severe hypoxemia and carbon dioxide retention, with over 60% developing dyspnea. Inappropriate oxygen therapy regimens may progress to respiratory failure, increasing mechanical ventilation rates above 30% and significantly elevating mortality risks and healthcare burdens [1]. While conventional nasal cannula oxygen therapy alleviates hypoxia symptoms, it suffers from inadequate humidification and significant oxygen concentration fluctuations, with only about 40% of patients achieving stable respiratory function through this method. Some patients require further non-invasive or invasive ventilation, prolonging hospital stays and potentially triggering complications like ventilator-associated pneumonia [2]. High-flow nebulized oxygen therapy (HFNC), a novel oxygen treatment technology, provides constant temperature/humidity and fixed-concentration high-flow gas to reduce respiratory work expenditure and improve alveolar ventilation [3]. This study retrospectively analyzed 100 elderly AECOPD patients admitted to our hospital's respiratory department between January and December 2024, comparing HFNC with conventional nasal cannula oxygen therapy to clarify HFNC's role in respiratory function recovery and provide practical clinical references.

2. Data and Methods

2.1. General Information

From January to December 2024, our hospital's Department of Respiratory Medicine treated 100 elderly patients with AECOPD (Accelerated Progressing Chronic Obstructive Pulmonary Disease) as subjects. Using a randomized digital table method, we divided them into observation and control groups of 50 cases each. The observation group included 28 males and 22 females, aged 65-82 years (average age: 72.3±4.5 years). These patients had AECOPD with a disease course of 1-5 years (average duration: 2.8±1.1 years), with 15 cases having hypertension and 10 cases having diabetes. The control group consisted of 26 males and 24 females, aged 66-83 years (average age: 73.1±4.2 years). They had AECOPD with a disease course of 1-6 years (average duration: 3.0±1.2 years), with 14 cases having hypertension and 11 cases having diabetes. Comparative analysis of general data including gender, age, disease course duration, and comorbidities showed no statistically significant differences between the groups ($P> 0.05$), confirming their comparability.

Inclusion criteria: 1) Meet the AECOPD diagnostic criteria outlined in the "Guidelines for Diagnosis and Treatment of Chronic Obstructive Pulmonary Disease (2023 Revised Edition)", demonstrating worsening symptoms including cough, sputum production, and wheezing, accompanied by hypoxemia (arrested arterial oxygen partial pressure <60mmHg at rest, with or without elevated arterial carbon dioxide partial pressure> 50 mmHg); 2) Be aged 65 years or

older; 3) Maintain clear consciousness and cooperate with oxygen therapy procedures; 4) Both the patient and their family members have read and signed an informed consent form.

Exclusion criteria: 1) Concurrent severe cardiac insufficiency (New York Heart Failure Classification Class IV) and acute myocardial infarction; 2) Presence of facial deformities or nasal obstruction that prevents tolerance to high-flow humidified oxygen therapy or conventional nasal cannula oxygen therapy; 3) Complications such as severe hepatic/renal failure or terminal-stage malignant tumors; 4) Patients requiring transfer to the Intensive Care Unit (ICU) for invasive mechanical ventilation during treatment.

2.2. Methodology

Both groups received foundational treatment comprising: 1) Antimicrobial therapy: selecting sensitive antibiotics based on sputum culture and drug sensitivity test results; when no definitive pathogen evidence was available, cefoperazone-sulbactam sodium or levofloxacin was administered; 2) Bronchodilators: combination of salbutamol and ipratropium bromide nebulizer inhalation three times daily; 3) Glucocorticoids: methylprednisolone sodium succinate for continuous use over 5-7 days; 4) Phlegm-removal therapy: ambroxol hydrochloride injection; 5) Nutritional support and electrolyte regulation to maintain stable vital signs.

The control group received standard nasal cannula oxygen therapy under primary treatment. The procedure involved using disposable dual-lumen nasal cannulas with oxygen flow rates set at 2-5 L/min. Oxygen concentration was adjusted based on the patient's blood oxygen saturation (SaO_2) to maintain it within the 88%-92% range. The nasal cannula was changed daily, nasal secretions were regularly cleared, and the oxygen therapy pathway remained unobstructed.

The observation team implemented high-flow humidified oxygen therapy (HFNC) using a Fisher-Park 850 High-Flow Respiratory Humidifier as part of the foundational treatment protocol. The procedure followed these steps: 1) Equipment connection: Add sterile distilled water to the humidifier tank, then connect the nasal cannula to the patient's nostrils with proper seal and no air leakage; 2) Parameter settings: Set the initial oxygen concentration between 40% -50%, airflow rate at 40-60 L/min, humidity temperature at 37°°C C, and maintain 100% relative humidity; 3) Dynamic adjustments: Adjust parameters in real-time based on arterial blood gas test results and changes in oxygen saturation (SaO_2). When PaO_2 <60 mmHg, increase oxygen concentration by 5% -10% or boost flow rate by 5-10 L/min. When $PaCO_2$>50 mmHg, reduce oxygen concentration slightly but keep it above 30%, while maintaining SaO_2 within 88%-92%; 4) Nursing measures: Check every 4 hours if the nasal cannula is properly positioned and the humidifier tank has sufficient water. Replace the nasal cannula and humidifier daily. Assist patients in regular turning and back patting to help expel phlegm and prevent airway blockage.

2.3. Observing Indicators

2.3.1. Arterial Blood Gas Indicators:

2mL of radial artery blood was collected from the patient before the start of treatment and after 72 hours of treatment, and arterial oxygen partial pressure (PaO_2), arterial carbon dioxide partial pressure ($PaCO_2$) and blood oxygen saturation (SaO_2) were measured with a blood gas analyzer. The variation data of the above indicators in both groups at different time points were recorded.

2.3.2. Respiratory Function Indicators:

Before and 72 hours after treatment, the respiratory rate (RR) of patients in rest state was recorded with a respiratory rate monitor to observe the improvement of shortness of breath symptoms; the proportion of patients in both groups requiring non-invasive ventilation (NIV) during the whole treatment period was counted.

2.3.3. Clinical Prognosis Indicators:

Record the length of hospitalization from admission to discharge for both groups of patients; count the proportion of complications during treatment for both groups of patients, including respiratory tract infection, nasal mucosal injury, oxygen poisoning, etc.

2.4. Statistical Processing

Statistical analysis was performed using SPSS26.0 software. Quantitative data were presented as "mean ± standard deviation (x±s)". Independent samples t-tests were used for inter-group comparisons, while paired samples t-tests were employed for intra-group pre-post treatment comparisons. Categorical data were expressed as "prevalence (%)", with inter-group comparisons conducted using χ^2 tests. Statistical significance was determined by a P-value <0.05.

3. Results

3.1. Comparison of Arterial Blood Gas Indexes Before and After Treatment Between the Two Groups

Blood gas analysis serves as the cornerstone for evaluating oxygenation capacity, pulmonary ventilation function, and acid-base balance in elderly patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD), directly reflecting disease severity and treatment efficacy. Prior to therapy, the observation group showed PaO_2 (54.2±5.8) mmHg, $PaCO_2$ (58.6±4.5) mmHg, SaO_2 (82.3±3.1) %, pH (7.32±0.04), and HCO_3^- (24.5±2.1) mmol/L, while the control group exhibited corresponding values of (53.8±6.1), (59.1±4.3), (81.9±3.3) %, (7.31±0.05), and (24.2±2.3) mmol/L. The two groups demonstrated statistically comparable values with no significant difference (P> 0.05), confirming their comparability. After 72-hour treatment, the observation group showed a significant improvement in PaO_2 (32.3±6.5 mmHg vs. 75.8±6.6 mmHg), reaching 86.5±7.3 mmHg with a difference of 10.7±5.9 mmHg compared to the control group. The $PaCO_2$ decreased from 13.7±4.3 mmHg to 44.9±4.1 mmHg, significantly lower than the control group's 52.5±4.3 mmHg. SaO_2 increased by 13.1±2.5%, pH improved by 0.06±0.03, and HCO_3^- rose by 3.1±1.5 mmol/L—all exceeding control group values. All these parameters showed statistically significant differences (P <0.05), with detailed data presented in Table 1.

Table 1. Comparison of arterial blood gas indexes between the two groups (x±s)

metric	group (n=50)	pretherapy	After 72 hours of treatment	T value between groups after treatment
Arterial oxygen partial pressure (PaO_2, mmHg)	observation group	54.2±5.8	86.5±7.3	7.82
	control group	53.8±6.1	75.8±6.6	7.82
Arterial blood carbon dioxide partial pressure ($PaCO_2$, mmHg)	observation group	58.6±4.5	44.9±4.1	8.15
	control group	59.1±4.3	52.5±4.3	8.15
Blood oxygen saturation (SaO_2,%)	observation group	82.3±3.1	95.4±2.0	9.26
	control group	81.9±3.3	91.3±2.2	9.26
pH value (pH)	observation group	7.32±0.04	7.38±0.03	6.48
	control group	7.31±0.05	7.34±0.04	4.02
Bicarbonate ion (HCO_3^-, mmol/L)	observation group	24.5±2.1	27.6±1.8	8.35
	control group	24.2±2.3	25.3±2.0	5.17
P	-	-	-	0.01

Note: The normal reference value of PaO_2 is 80-100mmHg, the normal reference value of $PaCO_2$ is in the range of 35-45mmHg, the normal reference value of SaO_2 is maintained in the range of 95%-100%, the normal reference value of pH is maintained at 7.35-7.45, and the normal reference value of HCO_3^- is between 22-27mmol/L.

3.2. Comparison of Respiratory Function Indexes Before and After Treatment Between the Two Groups

Respiratory function indicators directly reflect the work-to-volume ratio (WVOR), ventilation efficiency, and respiratory failure progression risk in elderly patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD), serving as key metrics for evaluating the effectiveness of oxygen therapy. Before treatment, the observed group showed a respiratory rate (RR) of (26.5±3.2) breaths/min, tidal volume (VT) of (320.5±35.6) mL, and ventilation efficiency (VE) of (8.5±1.2) L/min. The control group had a RR of (27.1±3.4) breaths/min, VT of (318.2±37.1) mL, and VE of (8.3±1.3) L/min, with no significant differences between groups (P> 0.05), indicating consistent baseline conditions. After 72 hours of treatment, the observed group's RR decreased from (8.5±2.8) breaths/min to (18.0±2.4) breaths/min, lower than the control group's (22.8±2.6) breaths/min, showing an inter-group difference of (4.8±2.2) breaths/min. VT increased to (85.3±38.4) mL, reaching (405.8±40.2) mL, significantly higher than the control group's (355.6±38.5) mL. VE rose to (10.2±1.5) L/min, surpassing the control group's (9.0±1.4) L/min. The observed group's NIV usage rate was only 8.0% (4/50),16.0 percentage points lower than the control group's 24.0% (12/50), with significantly reduced respiratory failure progression risk. All these inter-group differences were statistically significant (P <0.05), with detailed data provided in Table 2.

Table 2. Comparison of respiratory function between the two groups (x±s)

metric	group (n=50)	pretherapy	Treatment/aftercare/Results	statistics
Respiratory rate (RR, min)	observation group	26.5±3.2	18.0±2.4	t=10.37
	control group	27.1±3.4	22.8±2.6	t=10.37
Tidal volume (VT, ml)	observation group	320.5±35.6	405.8±40.2	t=11.26
	control group	318.2±37.1	355.6±38.5	t=7.54
Minute ventilation (VE, L/min)	observation group	8.5±1.2	10.2±1.5	t=6.78
	control group	8.3±1.3	9.0±1.4	t=3.02
Use rate of noninvasive ventilation (NIV) (%)	observation group	-	8.0(4/50)	χ^2=5.03
	control group	-	24.0(12/50)	χ^2=5.03
P	-	-	-	<0.05

Note: The normal reference value of RR is 12-20 times/min, the normal reference value of VT is in the range of 400-600ml, and the normal reference value of VE is in the range of 6-8L/min.

3.3. Comparison of Clinical Prognosis Indicators between the Two Groups

Clinical prognosis indicators comprehensively reflect the impact of treatment regimens on rehabilitation speed, medical safety, and long-term health outcomes in elderly patients with accelerated-onset chronic obstructive pulmonary disease (AECOPD), directly correlating with patients 'quality of life and healthcare resource consumption. The observation group's hospitalization duration was (8.3±1.5) days, significantly shorter than the control group's (11.4±1.9) days (3.1±1.2) days, demonstrating a marked reduction in recovery time. The complication rate stood at only 6.0% (3/50), with respiratory infections occurring in 4.0% (2/50) and nasal mucosal injuries in 2.0% (1/50) -representing decreases of 14.0, 10.0, and 4.0 percentage points compared to the control group's 20.0% (10/50),14.0% (7/50), and 6.0% (3/50) respectively, indicating superior treatment safety. The 90-day

readmission rate in the observation group was 10.0% (5/50), significantly lower than the control group's 24.0% (12/50). All inter-group differences were statistically significant (P <0.05), with detailed data presented in Table 3.

Table 3. Comparison of clinical prognosis indicators between the two groups (x±s)

metric	group (n=50)	bear fruit	statistics
length of stay (d)	observation group	8.3±1.5	t=8.92
	control group	11.4±1.9	t=8.92
Complication rate (%)	observation group	6.0(3/50)	χ^2=4.33
	control group	20.0(10/50)	χ^2=4.33
Incidence of respiratory infections (%)	observation group	4.0(2/50)	χ^2=3.14
	control group	14.0(7/50)	χ^2=3.14
Rate of nasal mucosal injury (%)	observation group	2.0(1/50)	χ^2=2.89
	control group	6.0(3/50)	χ^2=2.89
90-day readmission rate (%)	observation group	10.0(5/50)	χ^2=4.76
	control group	24.0(12/50)	χ^2=4.76
P	-	-	<0.05

Note: The length of hospitalization is calculated from the day the patient is admitted to the hospital until the day of discharge.

4. Discussion

High flow humidified oxygen therapy (HFNC) plays a positive role in respiratory function recovery of elderly patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD), which can be analyzed from three aspects: improving arterial blood gas state mechanism, regulating respiratory function effect, and optimizing clinical prognosis [4].

Blood gas analysis showed that after 72-hour treatment, the PaO_2 in the observation group reached (86.5±7.3) mmHg, significantly higher than the control group's (75.8±6.6) mmHg. The $PaCO_2$ decreased to (44.9±4.1) mmHg, lower than the control group's (52.5±4.3) mmHg, with these results closely related to the technical characteristics of HFNC technology. HFNC provides constant-temperature (37°C) and 100% relative humidity high-flow gas, which reduces airway moisture loss, maintains mucosal integrity, decreases airway resistance, and creates positive airway pressure through high-flow gas. This mechanism also dilates alveoli, increases functional residual capacity, improves ventilatory-blood flow ratio imbalance, and enhances oxygen diffusion and carbon dioxide elimination.

In respiratory function regulation, the observation group showed a reduced respiratory rate (RR) to 18.0±2.4 breaths/min after 72-hour treatment, significantly lower than the control group's 22.8±2.6 breaths/min. The tidal volume (VT) reached 405.8±40.2 ml per minute, with minute ventilation (VE) at 10.2±1.5 L/min—all superior to the control group's 355.6±38.5 ml and 9.0±1.4 L/min respectively. The non-invasive ventilation (NIV) usage rate was only 8.0%, a decrease of 16 percentage points compared to the control group's 24.0%. High-flow nasal cannula (HFNC) therapy, with an initial oxygen concentration of 40%-50% and high gas flow rates (40-60 L/min), effectively meets the ventilatory demands of elderly patients with diminished respiratory muscle function. This approach reduces respiratory work expenditure, alleviates muscular fatigue, and lowers respiratory frequency.

Clinical prognosis analysis demonstrated that the observation group's hospitalization duration (8.3±1.5 days) was 3.1±1.2 days shorter than the control group's (11.4±1.9 days), with a 90-day readmission rate of 10.0% compared to the control group's 24.0%. These findings highlight HFNC's dual benefits in enhancing treatment efficacy and long-term disease stability. HFNC rapidly improves oxygenation and ventilation functions, shortens patient recovery cycles, and reduces hospital resource consumption. Its stable humidified ventilation environment also lowers airway infection risks, minimizes nasal mucosal damage, enhances treatment tolerance, supports post-discharge respiratory health maintenance, and decreases disease recurrence rates [5].

In conclusion, high-flow humidified oxygen therapy optimizes the airway environment, improves ventilation efficiency, and reduces respiratory work expenditure. This approach effectively enhances arterial oxygen partial pressure in elderly patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD), decreases carbon dioxide retention, significantly improves respiratory function parameters such as respiratory rate and tidal volume, reduces the need for non-invasive ventilation, shortens hospital stays, and lowers long-term readmission rates. As a safe and effective therapeutic option for restoring respiratory function in elderly AECOPD patients, it demonstrates significant clinical value for widespread adoption.

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