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RESEARCH ARTICLE

Observations on the application of plateau prone ventilation combined with lung-protective ventilation care in mechanical ventilation for severe pneumonia in ICUs

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ABSTRACT

Objective To observe the application effect of plateau prone ventilation combined with lung-protective ventilation care in mechanical ventilation for ICU severe pneumonia.

Methods 50 patients admitted to our hospital from January 2023 to May 2024 for mechanical ventilation treatment of severe pneumonia in ICU in plateau area were selected and grouped into 25 cases each by bicolour method. The control group took prone position ventilation, and the study group combined lung protective ventilation care. Compare the application effect.

Results The blood gas indexes of the study group were better than those of the control group ($P < 0.05$); the lung function indexes of the study group were better than those of the control group ($P < 0.05$); the APACHE II scores of the study group were lower than those of the control group, and the time of ICU treatment and the time of mechanical ventilation were shorter than those of the control group ($P < 0.05$).

Conclusion For patients with severe pneumonia receiving mechanical ventilation in the ICU, the combined care of prone ventilation and lung-protective ventilation is more effective, and it has a certain promotion effect on the physical recovery of the patients.

Keywords: ICU severe pneumonia, mechanical ventilation, prone ventilation, lung protective ventilation care.

1. Introduction

Severe pneumonia is a critical condition caused by multiple etiologies, characterized by impaired pulmonary ventilation and gas exchange. It results in a compromised systemic oxygen supply and is often associated with varying degrees of carbon dioxide retention[1,2]. Severe pneumonia is commonly accompanied by respiratory failure, particularly in patients with compromised immune function, chronic comorbidities, or acute complications[3]. Early intervention and aggressive treatment are essential, typically involving mechanical ventilation support, anti-infection therapy, nutritional support, and symptomatic nursing measures.

In high-altitude areas, the unique environmental conditions—high altitude and low atmospheric pressure—pose additional challenges to patients' cardiopulmonary function[4]. Due to the lower oxygen concentration in the air, pulmonary artery pressure in patients is generally higher than that in individuals at sea level, leading to increased cardiovascular and pulmonary strain. As a result, individuals in high-altitude regions are more prone to respiratory infections, with a higher incidence of pneumonia that progresses more rapidly[5]. This makes early detection and intervention particularly critical[6]. Furthermore, the lower atmospheric pressure and reduced oxygen content in high-altitude regions exacerbate hypoxia and carbon dioxide retention in patients, which may reduce the efficacy of standard treatment protocols, necessitating individualized treatment strategies tailored to the specific physiological conditions of high-altitude environments.

Mechanical ventilation, especially prone positioning ventilation, has become a standard treatment method for severe pneumonia patients, particularly in the intensive care unit (ICU). Mechanical ventilation can effectively improve pulmonary oxygenation, reduce carbon dioxide retention, and support patients through the acute phase[7]. However, prolonged mechanical ventilation may lead to complications such as ventilator-associated pneumonia and airway injury[8-10].Consequently, lung-protective ventilation strategies have become an important area of development in critical care nursing[11]. Lung-protective ventilation care aims to minimize lung injury through optimized ventilator settings, reducing ventilatory pressures, and improving gas exchange, which ultimately enhances patient outcomes by reducing complications and improving the prognosis[12,13].

In this context, we have implemented a combined approach of prone positioning ventilation and lung-protective care during mechanical ventilation for patients with severe pneumonia in the ICU. This study aims to evaluate the clinical application and effects of these interventions, with the goal of providing more comprehensive treatment and nursing protocols for severe pneumonia patients, thereby improving treatment outcomes and quality of life. It is summarized as follows.

2. Materials and Methods

2.1. GENERAL INFORMATION

Fifty patients admitted to our hospital from January 2023 to May 2024 for mechanical ventilation treatment of severe pneumonia in ICUs in highland areas were selected and grouped into 25 cases each by bicolour method. In the study group, there were 13 males and 12 females, aged 48-74 years, with a mean of (60.25±4.51) years. In the control group, there were 14 males and 11 females, aged 48-75 years, with a mean of (61.33±1.37) years. There was no statistically significant difference between the two groups in terms of baseline data such as gender and age ($P > 0.05$).

Inclusion criteria:(1) those who met the indications for mechanical ventilation and were ventilated in the prone position for≥12h;(2)those who met the diagnosis of severe pneumonia;(3)those who were hemodynamically stable (mean arterial pressure >65mmHg); (4)those who did not have failure of important organs other than the lungs; (5)those who had complete clinical data; (6) those who had the consent of the patients and their families, who were aware of the consent, and who signed the informed consent form. Exclusion criteria: (1) those with elevated intra-abdominal pressure≥12mmHg; (2) those with non-mechanical ventilation and less than 8h of ventilation in prone position; (3) those with elevated intracranial pressure≥15mmHg.

2.2.METHODS

2.2.1 Prone position ventilation

The ventilators of both groups were set to BiLevel mode, the positive end-expiratory pressure was 5-15 cmH_2O, the pressure was 5-30 cmH_2O, and the ventilation parameter was 40%-50% FiO_2.Before treatment in the prone position, the patients were coated with gentamycin ophthalmic ointment to protect both eyes, and their heads were protected with soft cushions. The patient's hands were placed in the functional position, and soft pads were placed on the pressure areas to improve the patient's comfort. During the process of ventilation, we need to pay close attention to the changes of the patient's signs, and clean the secretions in the respiratory tract in a timely manner.

2.2.2 Lung protective ventilation care

Before ventilation, lung opening as well as low tidal volume is carried out, tidal volume is set at 5-8ml/kg, respiratory ratio is 1:2, ventilation frequency is kept at 12 times/min, positive end-expiratory pressure is adjusted to 8-20cmH_2O, and inspiratory pressure is adjusted to 12-25cmH_2O, and the parameters are adjusted dynamically according to the patient's condition. After 30 minutes of ventilation, 1 lung atelectasis control ventilation was required, the pressure of end-expiratory carbon dioxide was kept between 30-40 mmHg, and the pressure of airway plateau was adjusted between 10-25 cmH_2O.

2.3 OBSERVATION INDEXES

2.3.1 Primary Observation Indexes:

Lung function: the U.S. Medica automatic blood gas analyzer is used to determine the static compliance of the lungs and oxygenation index of the patients, and the higher the value is, the better[14].

Blood gas indexes: the same automatic blood gas analyzer is used to determine the indexes including pulse oximetry (SpO_2), arterial partial pressure of oxygen (PaO2), arterial partial pressure of carbon dioxide ($PaCO_2$) and other indexes.

2.3.2 Secondary Observation Indexes：

Acute and Chronic Health Status Scoring System Ⅱ (APACHE Ⅱ) [15]: including age, acute and chronic health status, etc., with a full score of 71 points, the higher the score, the worse the health status of the patient; statistics on the time of the patient's ICU treatment and the time of mechanical ventilation.

2.4 STATISTICAL ANALYSIS

SPSS 22.0 software was used to compare the data collected during the 30-day follow-up period. The measurement data were expressed as ($\bar{x}$ ± s), and the test value was tt; n (%) was the count mode, with the X^2 test used for comparison. $p < 0.05$ was considered statistically significant.

3. Results

3.1 COMPARISON OF LUNG FUNCTION INDEXES BETWEEN THE TWO GROUPS

The static lung compliance and oxygenation index of the study group were higher than those of the control group ($P < 0.05$). See Table 1.

Table 1. Comparison of lung function indices between the two groups （$\bar{x}$ ±s）

groups	Number of examples	static pulmonary compliance		Oxygenation index	
		pre-nursing	aftercare	pre-nursing	aftercare
Research group	25	44.26±5.17	78.24±7.69	139.49±16.33	189.96±21.24
Control group	25	44.78±5.63	69.41±6.62	141.65±17.12	173.22±19.78
t		0.340	4.351	0.456	2.884
P		0.735	0.000	0.650	0.006

3.2 COMPARISON OF BLOOD GAS INDEXES BETWEEN THE TWO GROUPS

SpO_2 and PaO_2 of the study group were significantly higher than that of the control group after nursing, and $PaCO_2$ was significantly lower than that of the control group ($P < 0.05$). See Table 2.

Table 2.Comparison of blood gas indices between the two groups($\bar{x}$ ±s)

groups	Number of examples	SpO_2 (%)		PaO_2 (mmHg)		$PaCO_2$ (mmHg)	
		pre-nursing	aftercare	pre-nursing	aftercare	pre-nursing	aftercare
Research group	25	91.76±3.16	97.49±5.78	73.69±3.78	86.21±6.87	43.36±5.66	31.25±3.44
Control group	25	92.02±3.21	94.11±4.41	73.84±3.82	81.34±5.52	42.19±5.58	35.69±4.14
t		0.289	2.325	0.140	2.763	0.736	4.124
P		0.774	0.024	0.890	0.008	0.465	0.000

3.3 COMPARISON OF APACHE II, ICU TREATMENT TIME AND MECHANICAL VENTILATION TIME BETWEEN THE TWO GROUPS

The APACHE II score of the study group was significantly lower than that of the control group, and the ICU hospitalisation and mechanical ventilation time were significantly shorter ($P < 0.05$). See Table 3.

Table 3.Comparison of APACHE II, ICU treatment time and mechanical ventilation time between the two groups ($\bar{x}$ ±s)

groups	Number of examples	APACHEII score		Duration of ICU treatment(d)	Duration of mechanical ventilation(d)
		pre-nursing	aftercare		
Research group	25	23.12±3.24	16.25±2.69	10.93±2.17	6.25±1.18
control group	25	22.98±3.17	20.21±2.84	13.58±2.54	8.31±1.44
t		0.154	5.062	3.966	5.533
P		0.878	0.000	0.000	0.000

4. Discussion

Severe pneumonia in plateau areas usually possesses the following characteristics: firstly, the incidence rate is analysed, which is significantly higher in plateau areas than in plains. Under the environment of hypoxia, cold and dryness, the infection is more likely to lead to an increase in the pressure of lung tissues, which makes the pulmonary artery pressure rise and the permeability of lung capillaries increase, leading to alveolar collapse and the interior is filled with exudate, which induces pulmonary oedema as well as pulmonary atelectasis, and it is an important reason for the development of severe pneumonia[16]. Severe pneumonia causes a large release of ADH in the blood due to hypoxia, leading to dilution of body fluids, decrease in blood osmotic pressure, interstitial exudation, and ventilation impairment. In addition, the incidence of induced toxic encephalopathy in patients with severe pneumonia at altitude is about 50 per cent and the mortality rate is much higher, with hypoxia being the main cause of induced metabolic abnormalities in brain tissue.As we can see from the above, patients with pneumonia in highland areas have high morbidity, rapid disease progression, many complications and high mortality rate, and the key to treatment is to improve hypoxia, and mechanical ventilation therapy mechanical ventilation therapy can help patients maintain normal blood oxygen levels by artificially delivering oxygen, reduce the burden on the lungs, and promote the improvement of the condition. Maintaining the prone position during ventilation can promote the expansion of the dorsal alveoli, which increases the ventilation flow, and also well reduces the pressure caused by the mediastinum to the lungs, making sputum better drainage[17].Traditional mechanical ventilation advocates the use of large tidal volumes, but large tidal volumes lead to an increase in short-term respiratory resistance in patients, resulting in increased damage to lung compliance and more pronounced atelectasis, thus reducing clinical efficacy. Lung protective ventilation helps atrophied lung tissue to reexpand through small tidal volume ventilation and appropriate positive end-expiratory pressure, avoids the damage to lung tissue caused by large tidal volume, and improves patient oxygenation[18].The current study group's lung function and blood gas indexes after ventilation were better than those of the control group, confirming the above view.

The APACHE II score of the study group was lower than that of the control group after care, and the treatment time was shorter than that of the control group. It is suggested that prone position ventilation combined with lung protection ventilation care can improve the patient's condition and accelerate recovery. The reason for this analysis is that prone position ventilation can reduce the dispersion of gas, strengthen the contraction capacity of the lungs, reduce the redistribution of gas exchange in the lungs, which is conducive to the formation of a cross-lung pressure between the chest cavity and the lungs, promote the respiratory capacity of the patients, and help the patients to better divert the secretions in the lungs, reduce the viscous resistance of the secretions to the lungs, improve the circulation of blood in the lungs, and reduce the lung injury[19-20].The use of lung protective ventilation avoids the exacerbation of lung damage and also reduces the inflammatory response, helping the patient's respiratory capacity to recover as soon as possible, as well as avoiding ventilator dependence due to prolonged mechanical ventilation, which in turn shortens the duration of the patient's mechanical ventilation[21].

In conclusion, prone position combined with lung-protective ventilation care can significantly shorten the recovery time of lung function in patients with severe pneumonia in plateau ICU, improve the ventilation effect, and improve the prognosis of patients.

Conflict of Interest:

The authors have no conflicts of interest to disclose.

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