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Effect and Nursing Analysis of Prone Mechanical Ventilation in Patients with Severe Pneumonia Complicated with Acute Respiratory Distress Syndrome

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Abstract: *Objective:* To explore the application value of prone position mechanical ventilation combined with special nursing intervention in patients with severe pneumonia complicated by acute respiratory distress syndrome. *Methods:* Thirty patients with severe pneumonia complicated with acute respiratory distress syndrome admitted to our hospital from January 2023 to June 2025 were selected and divided into a control group and an observation group by the random number table method, with 15 cases in each group. The control group received routine mechanical ventilation and basic nursing care, while the observation group received prone position mechanical ventilation combined with targeted specialist nursing care. *Results:* After the intervention, the oxygenation index and blood oxygen-related indicators of the observation group were better than those of the control group, the amount of sputum drainage was more than that of the control group, and the ventilation time and hospitalization time were shorter than those of the control group. There were significant differences in the data between the groups ($P<0.05$). *Conclusion:* Prone position mechanical ventilation combined with specialized nursing intervention can effectively improve the oxygenation status of patients with severe pneumonia complicated with acute respiratory distress syndrome, improve the efficiency of sputum drainage, and shorten the patient's mechanical ventilation and hospitalization recovery period.

Keywords: Mechanical ventilation in prone position; Severe pneumonia; Acute respiratory distress syndrome; Nursing effect; Oxygenation index

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1. Introduction

Severe pneumonia is a common critical respiratory disease in clinical intensive care units. The patient's condition progresses rapidly. Most patients will be accompanied by pathological changes such as alveolar

damage and interstitial edema, which can easily induce acute respiratory distress syndrome. Acute respiratory distress syndrome will directly cause a significant decrease in the patient's pulmonary ventilation function and the occurrence of refractory hypoxemia. It is also a core risk factor for death in patients with severe pneumonia [1]. The core clinical treatment goals for this type of patients are to correct hypoxemia, improve pulmonary ventilation function, and control the progression of pulmonary infection. Mechanical ventilation is currently the main means to correct patients with respiratory failure. Although conventional supine mechanical ventilation can provide patients with basic ventilatory support, it cannot effectively improve problems such as dorsal collapse of the lungs and secretion accumulation. The overall oxygenation improvement effect has certain limitations [2]. Mechanical ventilation in the prone position is a new ventilatory intervention method that can adjust the proportion of ventilation and blood flow in the lungs by changing the patient's position, promote recruitment of collapsed alveoli, and assist in the discharge of airway secretions [3]. Supporting specialist nursing intervention can avoid various risks during postural ventilation and ensure the safety and effectiveness of ventilation treatment. The purpose of this study is to explore the practical application effect of prone position mechanical ventilation combined with special nursing intervention in this type of patients.

2. Materials and methods

2.1. General information

Thirty patients with severe pneumonia combined with acute respiratory distress syndrome admitted to our hospital from January 2023 to June 2025 were selected and divided into two groups using the random number table method, with 15 cases in each group. There were 8 males and 7 females in the control group, aged from 60 to 85 years old, with an average age of (75.53 ± 6.38) years. There were 9 males and 6 females in the observation group, aged from 61 to 86 years old, with an average age of (75.73 ± 6.58) years. The two groups were comparable ($p > 0.05$). Inclusion criteria: (1) Meet the clinical diagnostic criteria for severe pneumonia and acute respiratory distress syndrome; (2) Receive mechanical ventilation for the first time; (3) Complete clinical data and family members sign informed consent. Exclusion criteria: (1) Those with thoracic deformity and history of lung surgery; (2) Those with multiple organ failure and severe coagulation dysfunction; (3) Those with contraindications to prone position ventilation and unable to cooperate with treatment.

2.2. Method

Patients in the control group received conventional supine mechanical ventilation treatment and basic intensive care. Mechanical ventilation parameters were dynamically adjusted according to the patient's blood gas analysis results, and the patients were assisted to complete bed rest. Vital signs, blood oxygen saturation, and blood gas indicators were regularly monitored. Oral care and airway humidification care were performed on a regular basis. Patients were regularly assisted to turn over, and airway secretions were simply cleared. Symptomatic treatments such as anti-infection, asthma, and nutritional support were strictly followed according to the doctor's instructions. Changes in the patient's condition and treatment-related data were recorded at the same time, and basic discomfort symptoms that occurred during the treatment were promptly dealt with.

The observation group implemented prone position mechanical ventilation combined with special nursing intervention on the basis of the treatment and care of the control group. (1) Prone position ventilation operation and nursing: three medical staff cooperated to complete the position conversion. First, the patient's bedside was lowered and all kinds of tube restraints at the bedside were removed. One person was responsible for fixing the patient's head and ventilator tubes, and the other two lifted the patient's trunk and lower limbs respectively. Smoothly transfer the patient to the prone position to avoid stretching, twisting, and falling off of the tubes. After the position change, adjust the position of the head and face to keep the head, neck and spine on the same axis to avoid local compression. The duration of ventilation in the prone position should be controlled to about 12 hours each time. The duration of ventilation should be adjusted according to the patient's tolerance every day, and the patient's postural status and vital signs should be assessed every 4 hours. (2) Refined care of the airway: Strengthen airway humidification management in the prone position, adjust the drop rate of humidification liquid according to the viscosity of the patient's sputum, and regularly clean airway secretions through a negative pressure suction device. The suction operation strictly follows the principle of asepsis, and the movement is gentle to avoid damage to the airway mucosa. Focus on cleaning up the sputum accumulated on the dorsal side of the lungs to ensure smooth airway. (3) Skin pressure care: During prone position ventilation, patients are prone to pressure injuries on their cheeks, forehead, chest, knee joints and other parts. Place special pressure-reducing cushions on the pressured parts in advance, fine-tune the patient's limb position every 2 hours, observe changes in local skin color and temperature, clean the patient's oral, nasal secretions and sweat in a timely manner, keep the skin dry and clean, and prevent the occurrence of pressure ulcers. (4) Pipe safety care: Comprehensively fix all types of pipes such as ventilator pipes, infusion pipes, gastric tubes, etc., and sort out the direction of the pipes to avoid folding, compression, and prolapse of the pipes caused by changes in body position. Regularly check the smoothness and firmness of the pipes, and record the indwelling status of the pipes. (5) Dynamic disease monitoring and care: During ventilation, the patient's heart rate, blood pressure, blood oxygen saturation and other vital signs are continuously monitored, arterial blood gas samples are collected every 6 hours, and changes in oxygenation index, blood oxygen partial pressure and other indicators are analyzed, and the patient is observed for abnormalities such as dyspnea, skin cyanosis, agitation, etc., and if problems are found, cooperate with the doctor as soon as possible. At the same time, daily sputum drainage volume, ventilation duration and other relevant data are recorded. (6) Nutritional and psychological care: Develop an enteral nutrition support plan based on the patient's physical condition to ensure the body's nutritional supply and improve the body's resistance. At the same time, pay attention to the patient's emotional state during treatment, explain the purpose and effectiveness of the treatment through simple communication, alleviate the anxiety and panic caused by severe bedridden patients, and improve the patient's cooperation with treatment.

2.3. Observation indicators

2.3.1. Oxygenation-related indicators

Compare the oxygenation index and arterial blood oxygen partial pressure levels of the two groups of patients before and after intervention, and obtain relevant values through arterial blood gas analysis to evaluate the improvement of the patients' pulmonary oxygenation function.

2.3.2. Sputum drainage volume

The average daily sputum drainage volume of the two groups of patients within 72 hours of intervention was calculated.

2.3.3. Rehabilitation-related indicators

Record and compare the duration of mechanical ventilation and the total duration of severe hospitalization between the two groups of patients to evaluate the patient's recovery efficiency.

2.4. Statistical methods

Data were analyzed using SPSS22.0. Measurement data are presented as mean plus or minus standard deviation, and *t* test is performed. $p < 0.05$ represents significant difference.

3. Results

3.1. Comparison of oxygenation indicators between the two groups of patients before and after intervention

Each value of the observation group was higher than that of the control group ($p < 0.05$). See **Table 1** for details.

Table 1. Comparison of oxygenation status between the two groups ($\bar{x} \pm s$, mmHg)

Group	n	Oxygenation index before intervention (mmHg)	Post-intervention oxygenation index (mmHg)	Arterial partial pressure of oxygen before intervention (mmHg)	Post-intervention arterial blood oxygen partial pressure (mmHg)
Control group	15	128.36 ± 10.25	186.52 ± 12.36	52.18 ± 6.32	72.35 ± 7.16
Observation group	15	127.95 ± 10.18	225.36 ± 13.52	51.96 ± 6.28	85.62 ± 7.85
t value	-	0.110	8.212	0.096	4.837
p value	-	0.913	< 0.001	0.924	< 0.001

3.2. Comparison of the average daily sputum drainage volume between the two groups of patients

The average daily sputum drainage volume of the patients in the observation group after intervention was significantly greater than that of the control group ($p < 0.05$). See **Table 2** for details.

Table 2. Comparison of the average daily sputum drainage volume between the two groups ($\bar{x} \pm s$, mL)

Group	n	Average daily sputum drainage volume
Control group	15	28.65 ± 5.32
Observation group	15	45.28 ± 6.15
t value	-	7.921
p value	-	< 0.001

3.3. Comparison of ventilation and hospitalization time between the two groups of patients

The mechanical ventilation time and hospitalization time of the patients in the observation group were shorter than those in the control group ($p < 0.05$). See **Table 3** for details.

Table 3. Comparison of ventilation and hospitalization time between the two groups ($\bar{x} \pm s$,d)

Group	n	Mechanical ventilation time	Length of stay
Control group	15	11.36 ± 2.15	18.52 ± 3.26
Observation group	15	7.25 ± 1.86	12.36 ± 2.85
t value	-	5.600	5.510
p value	-	< 0.001	< 0.001

4. Discussion

Patients with severe pneumonia combined with acute respiratory distress syndrome have severe pathological lung damage, severe disturbances in pulmonary ventilation and ventilation functions, and the body is in a state of persistent hypoxemia. Insufficient oxygen supply to multiple organs throughout the body will further aggravate the progression of the disease and increase the patient's risk of death. Mechanical ventilation is the core clinical intervention method to correct respiratory failure in this type of patients. Under the conventional supine ventilation mode, the alveoli on the dorsal side of the patient's lungs will collapse due to gravity, resulting in uneven distribution of pulmonary ventilation. Sputum secretions in the deep airways are easy to accumulate on the dorsal side of the pulmonary lobes and cannot be discharged smoothly. The continued accumulation of secretions will aggravate the pulmonary inflammatory response and alveolar edema, making it difficult to effectively improve the patient's oxygenation function, ultimately prolonging the ventilation treatment cycle and slowing down the patient's overall recovery. Prone position mechanical ventilation is a relatively mature ventilation intervention method in the field of severe respiratory diseases. Combined with targeted specialist nursing intervention, it can give full play to the therapeutic advantages of postural ventilation and avoid various shortcomings of conventional ventilation treatment. This is also the core basis why the indicators of the observation group in this study are better than those of the control group [4,5].

Data from this study show that after corresponding intervention, the oxygenation index of the patients in the observation group who implemented prone position mechanical ventilation combined with specialist nursing was much higher than that in the control group with conventional intervention. This result can reflect the improvement effect of prone position ventilation mode on patients' pulmonary oxygenation function. When the human body is lying on its back, the blood flow in the dorsal side of the lungs is large but the ventilation volume is insufficient. The imbalance of ventilation and blood flow ratio is more prominent. Ventilation in the prone position can completely change the gravity distribution of the patient's lungs, making the ventilation areas on the ventral and dorsal sides of the lungs more uniform. The originally collapsed dorsal alveoli can be effectively recruited, and the alveolar ventilation area is significantly increased. At the same time, during the specialized nursing intervention process, medical staff will dynamically adjust ventilation parameters and posture angles according to the patient's status to continuously ensure that the alveoli are in a good recruitment state. Refined airway care can reduce the occurrence of airway mucosal damage, airway spasm and other adverse conditions, allowing pulmonary gas exchange to proceed stably,

thereby gradually increasing the arterial oxygen partial pressure and oxygenation index, effectively correcting the patient's refractory hypoxemia, and improving the body's systemic hypoxic state. Conventional supine ventilation cannot solve the core problems of alveolar collapse and uneven ventilation, so the improvement in patients' oxygenation function is relatively limited [6].

The effectiveness of sputum drainage is a key factor affecting the recovery of patients with severe pneumonia. Sputum accumulated in the lungs will breed a large number of pathogenic bacteria and continue to aggravate lung infection. At the same time, blocking the airway will further hinder lung ventilation. In this study, the average daily sputum drainage volume of patients in the observation group was significantly greater than that of the control group. This data can prove that prone position ventilation combined with specialized care can significantly improve the clearance efficiency of airway secretions. The prone position can use gravity to promote the sputum accumulated in the deep and dorsal lung lobes to flow to the large airways, which changes the disadvantage of the supine position that the accumulated secretions cannot be discharged. At the same time, the observation group implemented refined airway care. Targeted airway humidification can dilute viscous sputum and reduce the strength of sputum adhering to the airway mucosa. Together with standardized negative pressure suction operations, secretions in the airway can be cleared to the maximum extent. Coupled with the regular fine-tuning of the posture and airway status assessment by the nursing staff, the airway patency can be continuously maintained, allowing sputum drainage throughout the entire ventilation treatment process. However, under the conventional nursing mode, turning over and suctioning sputum are more extensive and cannot effectively remove deep sputum. The sputum drainage effect is poor, which is not conducive to the rapid control of lung inflammation [7].

This study also found that the mechanical ventilation time and hospitalization time of patients in the observation group were significantly shorter than those in the control group, fully demonstrating that the intervention model of prone position ventilation combined with specialist nursing can effectively speed up the recovery process of patients and shorten the treatment period for severe cases. The effective improvement of the patient's oxygenation function can quickly correct the systemic hypoxic state, reduce the damage of hypoxia to important organs such as the heart, lungs, liver and kidneys, and reduce the probability of multiple organ function damage. Efficient sputum drainage can quickly reduce the inflammation load in the lungs, control the progression of the infection, and allow the patient's lung function to gradually return to normal. At the same time, the comprehensive interventions such as pipeline care, skin care, nutritional care, and psychological care carried out by the observation team can comprehensively avoid the risks of various complications during ventilation treatment, ensure that ventilation treatment can be carried out continuously, safely, and efficiently, and reduce the problem of prolonged treatment cycles caused by complications and recurrence of illness. Adequate nutritional support can improve the patient's immunity and provide sufficient energy and nutritional foundation for lung tissue repair. Positive psychological intervention can improve the patient's treatment compliance and avoid heart rate fluctuations, breathing disorders and other problems caused by emotional agitation. Multiple factors work together to shorten the patient's mechanical ventilation duration and hospitalization recovery time. The conventional intervention model can only provide patients with basic ventilation support and basic care, and cannot specifically solve the core problems in ventilation treatment for this type of patients, and the recovery speed of the disease is relatively slow [8]. The sample size of this study is small and it is a single-center study. In the future, the sample size needs to be expanded to further verify the long-term efficacy and safety of this protocol.

5. Conclusion

In summary, prone mechanical ventilation combined with specialized nursing intervention can effectively improve the pulmonary oxygenation status of patients with severe pneumonia and acute respiratory distress syndrome, improve sputum drainage efficiency, shorten the duration of mechanical ventilation and hospitalization, and effectively promote the recovery of patients.

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Disclosure statement

The author declares no conflict of interest.

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