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Observation on the Efficacy of Non-Invasive Positive Pressure Ventilation in Respiratory Support Treatment for Severe Pneumonia

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Abstract: *Objective*: To evaluate the efficacy of noninvasive positive pressure ventilation (NIPPV) in respiratory support for severe pneumonia. *Methods*: Data were analyzed from 74 patients with severe pneumonia undergoing respiratory support at our hospital between May 2024 and April 2025. Patients were randomly assigned using a random number table to two groups (n = 37 each): the experimental group received NIPPV, while the control group underwent conventional invasive mechanical ventilation. Intergroup differences were compared. *Results*: Compared with the control group, the experimental group demonstrated significantly higher PaO_2 and oxygenation index, significantly lower $PaCO_2$, significantly reduced levels of WBC, CRP, and PCT, significantly higher overall efficacy rate, and significantly lower incidence of adverse reactions after treatment ($p < 0.05$). Pre-treatment PaO_2, oxygenation index, $PaCO_2$, WBC, CRP, and PCT levels showed no significant differences between groups ($p > 0.05$). *Conclusion*: Non-invasive positive pressure ventilation demonstrates favorable outcomes in respiratory support for severe pneumonia.

Keywords: Non-invasive positive pressure ventilation; Severe pneumonia; Respiratory support therapy; Application efficacy

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1. Introduction

Severe pneumonia is commonly encountered in clinical practice, characterized by rapid onset and progression, accompanied by significant respiratory dysfunction. Without timely initiation of respiratory support therapy, patients are prone to developing respiratory failure, posing a life-threatening risk. Invasive mechanical ventilation is the traditional respiratory support method, which can improve ventilation function [1]. However, it is associated with high invasiveness, multiple complications, and difficulties in weaning. In recent years, novel respiratory support technologies, such as non-invasive positive pressure ventilation (NIPPV), have been proposed for clinical use. The advantages of NIPPV include low invasiveness, simple operation, and fewer complications [2]. Clinicians can attempt to apply it in the treatment of patients with severe pneumonia. This study enrolled 74 patients to

evaluate the efficacy of NIPPV in respiratory support for severe pneumonia.

2. Materials and methods

2.1. Materials

Data analysis was conducted on 74 patients undergoing respiratory support therapy for severe pneumonia at our hospital from May 2024 to April 2025. Patients were randomly assigned using a random number table, with 37 patients in each group. The experimental group comprised 20 males and 17 females, aged 45–78 years (mean 62.39 ± 8.25 years). The control group included 21 males and 16 females, aged 44–77 years (mean 62.31 ± 8.24 years). Comparison of the two groups yielded $p > 0.05$.

2.1.1. Inclusion criteria

(1) Meets diagnostic criteria for the disease, confirmed through examinations such as chest CT, complete blood count, and blood gas analysis;
(2) Respiratory dysfunction requiring respiratory support therapy;
(3) Alert and able to cooperate with treatment;
(4) Informed consent obtained.

2.1.2. Exclusion criteria

(1) Contraindications to treatment, such as severe facial deformities, airway obstruction, or sleep apnea syndrome;
(2) Severe organ failure involving vital organs like the heart, liver, or kidneys;
(3) Complications including coagulation disorders or gastrointestinal bleeding;
(4) Withdrawal from the study or loss of follow-up.

2.2. Methods

The control group received conventional invasive mechanical ventilation. Tracheal intubation was performed via the mouth or nose, followed by connection to a ventilator. Assist/control ventilation (A/C) was selected with a tidal volume set at 6–8 mL/kg. respiratory rate set at 12–16 breaths/min. Inhaled oxygen concentration was adjusted based on patient oxygen saturation, maintaining 90–95% SpO_2. Positive end-expiratory pressure (PEEP) was controlled at 5–10 cmH_2O. Once patient condition stabilized, ventilator settings were gradually reduced to initiate weaning training.

The experimental group received non-invasive positive pressure ventilation therapy in a sitting or semi-recumbent position using a non-invasive ventilator. A properly fitted mask was applied, oral and nasal secretions were cleared, the humidifier and ventilator tubing were connected, the oxygen source was attached, the power supply was activated, and the ventilator was turned on.

The S/T mode was selected, Set inspiratory positive airway pressure (IPAP) to 9–20 cmH_2O and expiratory positive airway pressure (EPAP) to 4–6 cmH_2O, with a respiratory rate of 12 breaths per minute.

2.3. Observation indicators

(1) Compare PaO_2, oxygenation index, and $PaCO_2$ between the two groups.

(2) Compare WBC, CRP, and PCT levels between the two groups.
(3) Compare the overall response rate between the two groups. After 7 days of treatment: Marked improvement with stable respiration and successful weaning: marked response, improvement with stable respiratory and heart rates compared to baseline but not meeting weaning criteria: effective response, other cases: ineffective response Overall response rate = 100% - non-response rate.
(4) Compare the incidence of adverse reactions between the two groups.

2.4. Statistical analysis

Data were analyzed using SPSS 28.0 software. Quantitative data were described as mean ± SD and analyzed using *t*-tests. Qualitative data were described as rates (%) and analyzed using chi-square tests. $p < 0.05$ was considered statistically significant.

3. Results

Compared with the control group, the experimental group showed significantly higher PaO_2 and oxygenation index, significantly lower $PaCO_2$, significantly lower levels of WBC, CRP, and PCT, significantly higher overall efficacy rate, and significantly lower incidence of adverse reactions after treatment ($p < 0.05$). However, there were no significant differences between the two groups in pre-treatment levels of PaO_2, oxygenation index, $PaCO_2$, WBC, CRP, and PCT ($p > 0.05$). See **Table 1**–**4**.

Table 1. Comparison of PaO_2, oxygenation index, and $PaCO_2$ (mmHg) between two groups

Group	$PaCO_2$		Oxygenation index		$PaCO_2$	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group (n = 37)	52.34 ± 6.88	89.61 ± 10.34	58.61 ± 7.44	42.36 ± 5.11	225.36 ± 38.61	325.46 ± 45.61
Control group (n = 37)	51.88 ± 6.75	78.52 ± 9.88	59.16 ± 7.61	51.67 ± 6.33	223.67 ± 37.84	268.36 ± 42.17
t	0.2903	4.7169	0.3144	6.9612	0.1902	5.5914
p	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05

Table 2. Comparison of WBC, CRP, and PCT levels between the two groups

Group	WBC ($\times 10^9$/L)		CRP (mg/L)		PCT (ng/mL)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group (n = 37)	16.84 ± 3.26	9.26 ± 2.12	89.61 ± 15.34	35.61 ± 8.75	2.36 ± 0.67	0.57 ± 0.22
Control group (n = 37)	17.11 ± 3.37	12.67 ± 2.56	91.24 ± 16.02	58.36 ± 10.25	2.41 ± 0.71	1.24 ± 0.33
t	0.3503	6.2404	0.4470	10.2682	0.3115	10.2757
p	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05

Table 3. Comparison of overall response rates (%) between the two groups

Group	Markedly effective	Effective	Ineffective	Overall efficacy rate
Experimental group (n = 37)	22 (59.46)	12 (32.43)	3 (8.11)	91.89
Control group (n = 37)	14 (37.84)	12 (32.43)	11 (29.73)	70.27
χ^2	-	-	-	5.6381
p	-	-	-	< 0.05

Table 4. Comparison of adverse reaction incidence rates (%) between the two groups

Group	Ventilator-associated pneumonia	Airway injury	Gastrointestinal distension	Facial pressure ulcer	Total
Experimental group (n = 37)	0	0	2 (5.41)	1 (2.70)	3 (8.11)
Control group (n = 37)	4 (10.81)	3 (8.11)	2 (5.41)	1 (2.70)	10 (27.03)
χ^2	-	-	-	-	4.5725
p	-	-	-	-	< 0.05

4. Discussion

The core pathophysiological feature of severe pneumonia is the rapid, diffuse, and uncontrolled progression of pulmonary inflammation. Patients are prone to developing multiple organ dysfunction due to hypoxemia and hypercapnia, necessitating respiratory support therapy to rapidly correct respiratory dysfunction. This creates conditions for controlling pulmonary inflammation, clearing infection, and restoring organ function [3]. Analysis indicates that traditional invasive mechanical ventilation in severe pneumonia patients is an invasive procedure prone to complications, with complex weaning processes and prolonged durations that adversely affect treatment outcomes and prognosis. Clinical research on non-invasive positive pressure ventilation (NIPPV) utilizes face masks or nasal masks to provide positive pressure ventilation support. This non-invasive approach ensures adequate ventilation efficacy while significantly reducing patient trauma [4].

Analysis based on improvements in blood gas parameters revealed that post-treatment PaO_2 and oxygenation index in the experimental group were significantly higher than those in the control group, while $PaCO_2$ was significantly lower. The reasons for these findings are as follows: Non-invasive positive pressure ventilation using the S/T mode establishes appropriate inspiratory and expiratory airway positive pressures, creating an intra-airway pressure gradient. The inspiratory airway positive pressure overcomes airway resistance in patients [5]. This increases alveolar ventilation, promoting oxygen diffusion into the alveoli and elevating blood oxygen saturation. Positive end-expiratory pressure maintains alveolar opening at the end of exhalation, increasing functional residual capacity and improving alveolar ventilation efficiency [6]. This facilitates carbon dioxide elimination and reduces $PaCO_2$ levels. Additionally, patients in the experimental group were ventilated in a sitting or semi-recumbent position. This gravity-assisted approach promotes drainage of pulmonary secretions, reduces congestion in the lung bases, and further optimizes alveolar ventilation and gas exchange. Furthermore, the use of humidification chambers in NIPV thoroughly humidifies the airway, reducing bronchospasm and mucus viscosity. This enhances ventilation stability, resulting in more pronounced improvements in blood gas parameters among the experimental group.

Analysis of inflammatory markers revealed that post-treatment levels of WBC, CRP, and PCT in the

experimental group were significantly lower than those in the control group. The rationale for these findings is as follows: During the pathological process of severe pneumonia, pulmonary infection triggers uncontrolled inflammatory responses [7]. As the disease progresses, bacterial or viral infections induce the release of inflammatory cytokines, precipitating systemic inflammatory response syndrome (SIRS). Sensitive indicators reflecting the body's inflammatory state, including WBC, CRP, and PCT exhibit changes closely correlated with inflammation severity. The use of non-invasive positive pressure ventilation (NIPPV) rapidly improves patient oxygenation, corrects tissue hypoxia, and effectively suppresses hypoxia-induced inflammatory pathways [8]. Tissue hypoxia is a key driver of amplified inflammatory responses. Hypoxic environments activate hypoxia-inducible factor-1α (HIF-1α), promoting the synthesis and release of inflammatory mediators such as tumor necrosis factor-α and interleukins. NIPV provides efficient oxygenation support to alleviate tissue hypoxia, thereby inhibiting HIF-1α activation [9]. This interrupts the inflammatory cascade amplification, leading to reduced inflammatory marker levels. Additionally, patients in the experimental group demonstrated higher treatment tolerance, enabling earlier initiation of spontaneous activities and coughing to clear sputum. This facilitated the elimination of pulmonary infection foci, reducing persistent pathogen stimulation that triggers inflammatory responses. Consequently, inflammatory markers showed a marked decrease.

The overall response rate in the experimental group was 91.89%, significantly higher than that in the control group. Analysis revealed that treatment efficacy was directly correlated with symptom improvement, respiratory function recovery, and weaning outcomes. Providing noninvasive positive pressure ventilation rapidly corrected hypoxia and carbon dioxide retention, markedly alleviated symptoms such as dyspnea, chest tightness, and shortness of breath, and facilitated stabilization of respiratory rate and heart rate. Clinical research indicates that reduced inflammatory markers suggest effective control of pulmonary infection and gradual restoration of lung function, facilitating successful weaning. Additionally, NIV's non-invasive nature reduces complications, ensures continuous and effective treatment, and better preserves and trains patients' spontaneous breathing function during weaning, resulting in a higher weaning success rate.

In terms of safety, the incidence of adverse reactions in the experimental group (8.11%) was significantly lower than that in the control group. Analysis revealed that invasive mechanical ventilation is prone to complications such as ventilator-associated pneumonia and airway injury, which are closely associated with the invasive procedure of tracheal intubation. Tracheal intubation disrupts the normal barrier function of the patient's airway mucosa, inducing ventilator-associated pneumonia. Additionally, mechanical friction during the intubation process, combined with prolonged catheter pressure, increases the risk of complications such as airway mucosal damage and bleeding. Furthermore, invasive mechanical ventilation frequently causes gastrointestinal distension and facial pressure ulcers. The use of noninvasive positive pressure ventilation (NIPPV) offers significant benefits. In this study, the experimental group experienced only minor gastrointestinal distension and facial pressure ulcers, with mild symptoms. These can be alleviated through adjustments to mask fit, position changes, and reduced ventilation pressure. Analysis of these outcomes indicates that During treatment, NIPV protects facial skin through appropriate mask selection and humidifier use, significantly reducing adverse reactions. Humidifiers maintain airway moisture, minimizing dry gas irritation to mucosal membranes and markedly lowering risks of airway spasm and viscous secretions.

This study is a single-center investigation with a relatively limited sample size and short follow-up period, which did not assess long-term patient outcomes and may affect the generalizability of the findings. Future studies should conduct multicenter, large-sample, long-term follow-up research to further validate the long-term efficacy and prognostic impact of noninvasive positive pressure ventilation in patients with severe pneumonia, thereby providing reference for its clinical application.

5. Conclusion

In summary, the application of NIPV in respiratory support for severe pneumonia yields favorable outcomes. Post-treatment measurements demonstrate significantly higher PaO_2 and oxygenation index, significantly lower $PaCO_2$, markedly reduced levels of WBC, CRP, and PCT, and a notably lower incidence of adverse reactions. These findings support its clinical promotion and adoption.

Disclosure statement

The author declares no conflict of interest.

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