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Therapeutic Effect of Nasal Continuous Positive Airway Pressure Ventilation on Severe Pneumonia Complicated with Respiratory Failure in Children

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Abstract: *Objective:* To explore the clinical effect of nasal continuous positive airway pressure (nCPAP) in children with severe pneumonia complicated with respiratory failure. *Methods:* 80 children were randomly divided into a control group and an observation group, 40 cases in each group. The control group was given routine treatment, and the observation group was given nCPAP intervention. The changes of oxygenation index, ventilation efficiency, respiratory load and inflammatory index were compared between the two groups. *Results:* After treatment, A-ADO decreased significantly, PaO_2/FiO_2 and Cdyn increased, $PaCO_2$ decreased, pH increased, VE and VT improved, and f/VT decreased in the observation group. The ratio of CRP, PCT, WBC and neutrophil was significantly lower than that of the control group, with statistical significance ($P < 0.05$). *Conclusion:* nCPAP can effectively improve lung oxygenation, ventilation function and inflammatory state, reduce respiratory load, and promote recovery of children, and its clinical application value is significant.
Keywords: Transnasal; Continuous positive airway pressure ventilation; Severe pneumonia in children; Respiratory failure; Observation of curative effect

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1. Introduction

Severe pneumonia is a common acute respiratory disease in children. The course of the disease progresses rapidly, often accompanied by significant ventilation disorder, which easily leads to hypoxemia and carbon dioxide retention, leading to acute respiratory failure. Because of poor lung compliance and weak compensatory ability, respiratory load and unstable vital signs often appear in the clinic [1]. As a noninvasive and well-tolerated ventilation method, nasal continuous positive airway pressure (nCPAP) can effectively maintain alveolar opening and improve oxygenation function, and it is increasingly widely used in pediatric severe respiratory support [2]. How to accurately apply nCPAP in the acute phase and explore its mechanism, timing, and individual response law is the key direction of current research.

2. General information and methods

2.1. General information

Eighty children with severe pneumonia complicated with respiratory failure who were treated in our hospital from December 2023 to December 2024 were included. The children ranged in age from 6 months to 12 years old, with an average of (4.87–2.15) years old, including 45 male children and 35 female children. All of them were diagnosed as severe pneumonia by clinical diagnosis and imaging examination, and showed symptoms of respiratory failure to different degrees. According to the difference in treatment methods, the children were randomly divided into the control group and the observation group, with 40 cases in each group. The control group received conventional oxygen inhalation, anti-infection, and symptomatic support treatment, while the observation group received additional nasal continuous positive airway pressure treatment based on the control group. There was no statistical difference between the two groups in terms of gender, age and severity of illness ($P > 0.05$), which was comparable.

Inclusion criteria:

(1) Children between 6 months and 12 years old, regardless of sex.

(2) Severe pneumonia was diagnosed by clinical manifestations, chest imaging (X-ray or CT) and laboratory examination.

(3) Combined with type I or type II respiratory failure, which accords with the Diagnostic Criteria for Respiratory Failure in Children.

(4) The patient's condition is stable and his consciousness is clear, and he has the basic conditions to cooperate with nasal continuous positive airway pressure (nCPAP) treatment.

(5) Interventional treatment was started within 48 hours after admission, with complete clinical follow-up data.

Exclusion criteria:

(1) Congenital cardiopulmonary malformation, severe cardiac insufficiency or other serious basic diseases affect the curative effect evaluation.

(2) Patients with nCPAP contraindications such as pneumothorax, mediastinal emphysema, severe upper respiratory tract obstruction or active bleeding.

(3) Children who are in urgent need of invasive mechanical ventilation or have been treated with tracheal intubation.

(4) Nervous system diseases such as status epilepticus and disturbance of consciousness.

(5) Have a history of repeated lung infections or chronic lung diseases.

2.2. Methods

2.2.1. Control group

The children in the control group were treated with routine comprehensive treatment, including continuous low-flow nasal catheter oxygen inhalation to ensure the smooth breathing of the children; Anti-infection treatment can effectively resist the invasion of germs on children's bodies; Relieve fever and pain, and relieve the discomfort of children; Bronchial relaxation helps children's respiratory tract unobstructed; Sucking and expelling phlegm to keep the respiratory tract clean; A series of general symptomatic support measures such as water and electrolyte balance adjustment, ensuring the stability of children's internal environment, and nutritional support.

2.2.2. Observation group

Based on the basic treatment plan of the control group, the observation group was additionally treated with nasal continuous positive airway pressure (nCPAP), and its specific operation mode was as follows:

(1) Equipment preparation and interface selection: Use a special double-pipe nCPAP device for infants, and match the nasal plug to ensure good airtightness and prevent air leakage.

(2) Parameter setting and dynamic adjustment: the initial pressure is 4–6 cm H_20, and the maximum pressure does not exceed 8 cm H_2O; The oxygen concentration is set to 40% and dynamically adjusted to maintain 92–96%

according to SpO_2.

(3) Ventilation duration and monitoring frequency: ventilation should be no less than 6 hours per day, and intermittent ventilation should be decided according to the fatigue degree and blood gas condition. Vital signs (SpO_2, respiratory rate, heart rate) were recorded every 4 hours.

(4) Prevention of skin and complications: Strengthen nasal care to prevent pressure sores, and clean oral cavity to prevent common complications such as nosebleeds and bloating.

(5) Standard and transition of weaning: When the SpO_2 is stable ≥ 95%, the respiratory frequency is normal and there is no obvious respiratory distress, gradually decompress and switch to low-flow oxygen therapy.

(6) Efficacy evaluation: Blood gas, SpO_2 and respiratory rate were evaluated before treatment, 48 hours later and before weaning, and the hospitalization days and complications were recorded [3].

2.3. Observation indicators

2.3.1. Pulmonary oxygenation and ventilation efficiency index

(1) Alveolar-arterial oxygen pressure difference (A-ADO) to evaluate the improvement of oxygenation disorder and reflect alveolar gas diffusion efficiency.

(2) Partial arterial oxygen pressure (PAO) and its ratio (PaO_2/FiO_2).

(3) Dynamic lung compliance (Cdyn), combining with the pressure waveform to evaluate the ventilation elasticity of lung tissue, and to judge the effect of nCPAP on lung dilation mechanics.

2.3.2. Gas exchange and acid-base state adjustment index

(1) Arterial partial pressure of carbon dioxide ($PaCO_2$)

(2) Blood pH and bicarbonate concentration (HCO)

(3) Dynamic change trend of respiratory quotient (RQ).

2.3.3. respiratory system load response index

(1) Ventilatory volume per minute (VE) and tidal volume (VT)

(2) Respiratory frequency-tidal volume ratio (f/VT)

(3) Auxiliary respiratory index score.

2.3.4. Inflammatory state and systemic response index

(1) The changes of C-reactive protein (CRP) and procalcitonin (PCT) levels can be used to evaluate the control trend of pulmonary infection.

(2) White blood cell count and neutrophil ratio can reflect the differences in immune response between acute infection and recovery.

(3) Combine the actual temperature data to describe the inflammatory reaction cycle, and get the temperature change curve and thermal range length.

2.4. Statistical methods

The data were analyzed by SPSS 28.0. The measurement data were expressed by mean ± standard deviation (SD), the counting data by rate, and the difference was statistically significant if $P < 0.05$.

3. Results

3.1. Compare the lung oxygenation and ventilation efficiency between the two groups

From **Table 1**, it can be seen that the A-ADO of the observation group decreased obviously after 48 hours of treatment and before weaning, while the PaO_2/FiO_2 and Cdyn showed a great upward trend. These three indexes were better than those of the control group, and the difference between them was statistically significant ($P < 0.05$).

Table 1. Pulmonary oxygenation and ventilation efficiency in two groups of children

Index	Alveolar-arterial oxygen pressure difference (a-ado, mmHg)			PaO_2/FiO_2 ratio (mmHg)			Pulmonary dynamic compliance cdyn (mL/cm H_2O)		
Point of time	Before treatment	Treatment for 48 hours	Before aircraft withdrawal	Before treatment	Treatment for 48 hours	Before aircraft withdrawal	Before treatment	Treatment for 48 hours	Before aircraft withdrawal
Control group (mean ± SD)	62.14 ± 6.83	48.36 ± 6.25	40.74 ± 5.87	164.25 ± 18.41	215.83 ± 21.65	244.11 ± 23.08	0.82 ± 0.14	1.12 ± 0.16	1.21 ± 0.17
Observation group (mean ± SD)	62.39 ± 6.77	38.22 ± 5.91	32.83 ± 5.44	163.76 ± 17.93	278.34 ± 22.17	304.29 ± 20.94	0.84 ± 0.15	1.45 ± 0.18	1.58 ± 0.19
t value	1.248	12.476	11.139	1.357	13.938	14.273	1.118	10.774	11.835
P value	< 0.05								

3.2. Compare the gas exchange and acid-base state adjustment between the two groups

From **Table 2**, it can be found that after 48 hours of treatment, the $PaCO_2$ of the children in the observation group decreased, the pH value increased, and the HCO_3^- level became more stable. The improvement rate of ventilation and the compliance rate of internal environment regulation in the observation group were better than those in the control group. Nasal continuous positive airway pressure ventilation can effectively improve the ventilation function and internal environment stability ($P < 0.05$).

Table 2. Analysis of gas exchange and acid-base state adjustment in two groups of children

Index	Partial pressure of arterial blood carbon dioxide ($PaCO_2$, mmHg)	Blood pH value	Bicarbonate concentration (HCO, mmol/L)	Dynamic trend of Respiratory Quotient (RQ)	The number of cases with improved ventilation (SPO > 92%, RR close to normal)	Number of cases of internal environment adjustment reaching the standard ($PaCO_2$↓, pH normal range)
Control group (*n* = 40)	45.13 ± 4.76	7.29 ± 0.05	24.25 ± 2.08	0.77 ± 0.06	27 cases (67.50%)	25 cases (62.50%)
Observation group (*n* = 40)	38.92 ± 3.64	7.36 ± 0.03	22.51 ± 1.67	0.85 ± 0.05	36 cases (90.00%)	35 cases (87.50%)
t value	11.734	10.589	10.021	9.883	8.327	6.839
P value	< 0.05					

3.3. Compare the respiratory system load response index between the two groups

As can be seen from **Table 3**, after 48 hours of treatment, the ventilation volume and tidal volume of the observation group are significantly higher than those of the control group, and the f/VT ratio is lower, and the number of cases of assisted breathing signs is also more, with statistical significance, which means that nCPAP can effectively reduce the respiratory load and improve the ventilation function ($P < 0.05$).

Table 3. Responsive indexes of respiratory system load in two groups of children

Index	Ventilation per minute (VE, L/min)	Tidal volume (VT, mL)	Respiratory frequency-tidal volume ratio (f/VT)	Improvement rate of auxiliary respiratory signs (%)
Control group (*n* = 40)	6.82 ± 0.91	205.3 ± 25.6	0.338 ± 0.057	25 cases (62.50%)
Observation group (*n* = 40)	8.13 ± 0.86	243.8 ± 27.2	0.294 ± 0.042	35 cases (87.50%)
t value	11.327	9.863	10.237	6.472
P value	< 0.05			

3.4. Compare the inflammatory status and systemic response index between the two groups

Table 4 shows that the CRP, PCT, WBC and neutrophil ratio of children in the observation group are significantly lower than those in the control group, suggesting that nCPAP can effectively reduce the inflammatory reaction, control the infection process and promote the recovery of children ($P < 0.05$).

Table 4. Inflammatory status and systemic response indexes of two groups of children

Index	C-reactive protein (CRP, mg/L)	Procalcitonin (PCT, ng/mL)	White blood cell count (WBC, × 10/L)	Neutrophil ratio (%)
Control group (*n* = 40)	27.34 ± 5.63	1.26 ± 0.42	13.45 ± 2.13	76.13 ± 5.84
Observation group (*n* = 40)	18.96 ± 4.51	0.84 ± 0.35	10.72 ± 1.98	69.41 ± 4.92
t value	10.364	9.256	9.843	9.129
P value	< 0.05			

4. Discussion

As a non-invasive respiratory support method, nasal continuous positive airway pressure (nCPAP) shows multiple clinical advantages in the treatment of severe pneumonia complicated with respiratory failure in children [4]. It can maintain alveolar opening through continuous positive pressure, effectively improve alveolar diffusion disorder and oxygenation function, significantly improve PaO2/FiO2 and lung dynamic compliance, and optimize ventilation-blood flow matching. NCPAP can also reduce the compensatory burden of respiratory muscles, improve tidal volume and ventilation efficiency, reduce the f/VT value, improve children's spontaneous breathing ability and reduce the need for tracheal intubation. At the same time, the intervention is helpful to alleviate the pro-inflammatory reaction related to hypoxia, reduce the inflammatory indices such as CRP, PCT and WBC, shorten the thermal course and accelerate the recovery of the focus. The results of this study suggest that nCPAP can be optimized in many aspects, such as lung function, respiratory mechanics and inflammation control, and has a good acute intervention effect and early prevention and control potential [5].

As a non-invasive respiratory support method, nasal continuous positive airway pressure ventilation can comprehensively improve the pathological conditions of children from alveolar ventilation, gas exchange, respiratory mechanics, and inflammation control. This method has obvious advantages in improving lung oxygenation efficiency, stabilizing the acid-base environment, reducing respiratory muscle compensation load, and reducing inflammatory factors. In the future, we can study its synergistic approach with drug intervention and pathogen spectrum control based on larger samples, and provide a reference for the construction of more accurate and safe respiratory management strategies for critically ill children.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wang X, 2024, Study on the Value of Early Continuous Positive Airway Pressure Ventilation in the Treatment of Severe Pneumonia Complicated with Respiratory Failure in Children. China Disaster Rescue Medicine, November(9): 1052–1054 + 1078.

[2] Guo J, Zhang J, 2022, Observation on the Effect of High-Quality Nursing Mode in the Treatment of Severe Pneumonia Complicated with Respiratory Failure in Children by NCPAP. Guizhou Medicine, 46(11): 1834–1835.

[3] Lin Y, 2022, Therapeutic Value of Nasal Continuous Positive Airway Pressure Ventilation in Children with Severe Pneumonia Complicated with Respiratory Failure. China Modern Drug Application, 16(7): 28–30.

[4] Zhou W, Wei S, Zhang X, 2022, Influential Factors of Nasal Continuous Positive Airway Pressure Combined with Gamma Globulin in the Treatment of Severe Pneumonia Complicated with Respiratory Failure in Children. Chinese Journal of Woman and Child Health Research, 33(2): 76–80.

[5] Bai J, Que X, Feng X, 2021, Effect of Whole-Course Responsibility Nursing Mode on Neonates with Severe Pneumonia Complicated with Respiratory Failure Treated by Nasal Continuous Positive Airway Pressure. Henan Medical Research, 30(33): 6329–6332.