Original Article

Value of blood gas analysis and immunological indicators in early diagnosis and treatment monitoring of children with severe pneumonia and sepsis

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Received August 26, 2021; Accepted August 2, 2022; Epub October 15, 2022; Published October 30, 2022

Abstract: Objective: This study was designed to investigate the clinical value of blood gas analysis and related immunological indicators in the early diagnosis and treatment monitoring of children with severe pneumonia and sepsis. Methods: A retrospective study was conducted on children with pneumonia and sepsis and healthy children undergoing physical examination in the First People’s Hospital of Fuyang Hangzhou from January 2020 to December 2020. A total of 31 children with pneumonia and sepsis (observation group) and 31 healthy children (control group) were included. The levels of partial pressure of carbon dioxide (PaCO₂), partial pressure of oxygen (PaO₂), pH, immunoglobulin A (IgA), immunoglobulin M (IgM), immunoglobulin G (IgG), complement 3 (C3) and complement 4 (C4) were compared between the two groups. The changes of blood gas analysis indices and immune indices in the observation group before treatment (T0), as well as after 1 month (T1), 2 months (T2) and 3 months (T3) of treatment were dynamically analyzed. Results: Compared with the control group, the level of PaCO₂ was significantly increased, and the levels of PaO₂, pH, IgA, IgM, IgG, C3 and C4 were significantly decreased in the observation group, showing statistically significant differences (P < 0.05). With the progress of treatment, the levels of PaO₂, pH, IgA, IgM, IgG, C3 and C4 showed a slowly increasing trend, while PaCO₂ gradually decreased, and the differences between T3 and T0 were statistically significant (P < 0.05). ROC curve analysis showed that PaCO₂, PaO₂, pH, IgA, IgM, IgG, C3 and C4 had good diagnostic value for severe pneumonia combined with sepsis (P < 0.05). Conclusion: Blood gas analysis and immune indices exhibited high precision in early diagnosis and treatment monitoring of children with severe pneumonia and sepsis.

Keywords: Blood gas analysis, immune indices, severe pneumonia, diagnosis, treatment

Introduction

Pediatric pneumonia, as a common respiratory disease in clinic, may lead to serious complications without timely and appropriate treatment, and its morbidity and mortality account for a relative high proportion of childhood diseases [1-3]. The exacerbation of pneumonia in children can lead to impaired immune regulation, inducing malignant complications such as shock, sepsis, septicemia and multiple organ failure [4, 5], which causes great harm to the children and their families. Studies have shown that children with pneumonia and sepsis may have specific pathological changes. For instance, their immune system is in an unbalanced state, and the immune cells rapidly release large amounts of inflammatory factors, leading to inflammatory cytokine storm, as well as disturbance of the coagulation and fibrinogen system, thereby resulting in disseminated intravascular coagulation, shock, multiple organ failure, and acidosis caused by water-salt metabolic imbalance [6, 7], consequently increasing the risk of death in children.

Severe pneumonia is the critical stage of pneumonia, accounting for about 5-15% of all pneumonia in children. There is no unified standard for the diagnosis of severe pneumonia in children worldwide, but severe pneumonia in children is often complicated with multiple organ failure and shock, especially sepsis, which is an inflam-
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Inflammatory syndrome involving lungs and bile ducts, and patients with sepsis are often accompanied by serious complications such as shock. Blood gas analysis is one of the methods for the diagnosis of pneumonia, and can be used to evaluate pulmonary ventilation function and acid-base balance state by determining the pressure value of carbon dioxide and oxygen as well as the pH value in blood [11, 12]. Blood gas analysis plays a decisive guiding role in correcting acid-base imbalance in children with pneumonia. Clinically, the conditions of children with pneumonia can be comprehensively analyzed and evaluated based on blood gas indices. Therefore, blood gas analysis is an important means to improve the recovery and reduce the mortality.

The imbalance of immune response mechanisms and impaired immune function are mainly manifested as apoptosis of spleen cells and significant hypofunction of T lymphocytes (including T lymphocytes, helper T lymphocytes and immune response products) [13]. Helper T lymphocytes are an important subgroup of T lymphocytes that play a key role in the resistance to disease progression in patients with bacterial sepsis. Due to the invasion of infectious factors and inflammatory response, immunocompromise is the main cause of sepsis [14, 15]. The levels of immunoglobulin A (IgA), immunoglobulin M (IgM), immunoglobulin G (IgG), complement 3 (C3) and complement 4 (C4) can reflect the strength of the body's cellular immunity and assess the condition of sepsis.

This study was designed to investigate the value of blood gas analysis and immune indices in early diagnosis and treatment monitoring of children with pneumonia and sepsis, with the hope to provide scientific data and basis for improving the prognosis of children with pneumonia.

Materials and methods

General information

A retrospective study was conducted on children with pneumonia and sepsis and healthy children undergoing physical examination in the First People's Hospital of Fuyang Hangzhou from January 2020 to December 2020. The clinical data of 31 children with pneumonia and sepsis (observation group) and 31 healthy children (control group) were collected.

Inclusion criteria: children in the observation group met the diagnostic criteria for pneumonia combined with sepsis; children aged 1 month to 12 years. Exclusion criteria: children with primary major organ failure; children who had received anti-infective or symptomatic treatment drugs; children with incomplete case data.

All data analysis ensured the privacy of patient information. The basic clinical data such as age, sex and weight of all children were collected, analyzed and compared. There was no statistically significant difference in the basic data between the two groups (P>0.05), indicating comparability between the two groups. This study was approved by Ethics Committee of the First People's Hospital of Fuyang Hangzhou (approval number: NCT03268468).

Investigation methods

The name, sex, age, telephone number and other personal information of patients were recorded. Besides, body temperature, concomitant symptoms and signs, epidemiological history, blood gas analysis, including arterial partial pressure of carbon dioxide (PaCO$_2$), partial pressure of oxygen (PaO$_2$), pH and other clinical data were recorded. Results of blood tests, throat swabs, imaging or other laboratory tests were recorded. Immune indicators including levels of IgA, IgM, IgG, C3 and C4 were recorded. The blood gas analysis and immune indices were recorded before treatment (T0), as well as 1 month (T1), 2 months (T2) and 3 months (T3) after treatment.

Statistical analysis

SPSS22.0 statistical software was adopted to analyze the collected data. Measurement data were represented by mean ± standard deviation (mean ± SD). Normal distribution and homogeneity of variance tests were carried out. T-test was carried out for comparison between groups of data satisfying normal distribution or homogeneity of variance, and the approximate t-test was applied for data with heterogeneity of variance. Bonferroni post hoc test was adopted.
Results

Comparison of blood gas analysis indices between the two groups

The observation group exhibited significantly lower PaO₂ and pH levels and significantly higher PaCO₂ level than the control group, with statistically significant differences (P < 0.05) (Figures 1, 2).

Comparison of immune indices between the two groups

The observation group showed significantly lower levels of IgA, IgM, IgG, C3 and C4 compared with the control group (P < 0.05). This suggested that severe pneumonia combined with sepsis could lead to a remarkable decline in immune function and a reduction in immune system parameters in children (Figures 3, 4).

Dynamic observation of blood gas analysis indices of children in the observation group

Blood gas analysis indices showed that PaO₂ and pH levels in the observation group were significantly increased from T0 to T3, while PaCO₂ level in the observation group was significantly decreased from T0 to T3, and the intra-group comparison differences were statistically significant (P < 0.05), indicating that blood gas indices could reflect the treatment efficacy in children with severe pneumonia and sepsis, which could effectively guide the treatment and the evaluation of prognosis (Figures 5, 6).

Dynamic observation of immune indices of children in the observation group

Monitoring of immune indices revealed that the levels of IgA, IgM, IgG, C3 and C4 in the observation group were significantly increased from T0 to T3, and the differences were statistically
significant \( (P < 0.05) \), indicating that immune indices were a powerful tool for accessing the treatment progress of severe pneumonia with sepsis. So, monitoring immune indices could help physicians to effectively control the disease and avoid its deterioration and development \( (\text{Figures} \ 7, \ 8) \).

The ROC curves of \( \text{PaCO}_2 \), \( \text{PaO}_2 \), pH, IgA, IgM, IgG, C3 and C4 were plotted for the diagnosis of severe pneumonia combined with sepsis, and the calculation showed that the above indices had good diagnostic value for severe pneumonia combined with sepsis \( (P < 0.05) \) \( (\text{Table} \ 1; \ \text{Figure} \ 9) \).

**Discussion**

Pneumonia, as a common respiratory disease in China, is susceptible to all age groups and is the main cause of infectious disease-associated deaths. According to statistics, about 21 million children in China are infected with pneumonia each year, and pneumonia is listed as one of the four major diseases among children by the National Health and Family Planning Commission. Severe pneumonia is a severe form of pneumonia that
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depends on the degree of local inflammation of the pneumonia and systemic inflammatory response.

Severe pneumonia may be considered when patients develop severe hypoxemia, acute respiratory failure, shock, or other organ failure. Severe pneumonia combined with sepsis is an acute and critical clinical disease, which has the characteristics of rapid onset, rapid development, multiple complications, systemic involvement, poor prognosis and high mortality. Accurate diagnosis and early intervention are important prerequisites for improving the prognosis of these patients. This study analyzed the application value of blood gas analysis and immune indices in early diagnosis and treatment monitoring of children with severe pneumonia and sepsis by setting up two groups. The results showed that in terms of early diagnosis, the level of PaCO$_2$ in the observation group was significantly higher than that in the control group, while the levels of PaO$_2$, pH, IgA, IgM, IgG, C3 and C4 in the observation group were significantly lower than those in the control group. Although PaCO$_2$, PaO$_2$ and pH are crucial
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indicators for the diagnosis and treatment of children with severe pneumonia and sepsis, the differences of PaCO₂, PaO₂ and pH levels measured at different sites may be an issue. Therefore, it is particularly critical to optimize the selection of appropriate sites for the monitoring of these indicators, so as to effectively guarantee the safety during the treatment cycle and improve the prognosis of children [16, 17]. Therefore, future efforts may be placed on the combination of PaO₂, pH, IgA, IgM, IgG, C3 and C4, to develop appropriate diagnosis methods.

In terms of immune function, children in the observation group had significantly lower levels of IgA, IgM, IgG, C3 and C4 as compared with the control group. The results indicated that severe pneumonia combined with sepsis resulted in a dramatic decrease in immune function. The levels of IgA, IgM, IgG, C3 and C4 were significantly increased in the observation group from T0 to T3 (P < 0.05), suggesting that immune indices could be used to determine the efficacy of treatment, which can help physicians to effectively control the disease and avoid the deterioration. IgA, IgM and IgG are often used to assist the diagnosis of the severity of impaired immune function, since these substances can effectively indicate the activity of antibodies in the immune system. C3 and C4 are important immunomodulatory receptors with the ability to deliver antigens, enhance antigen-antibody responses and directly kill infected cells [18]. The expression levels of C3 and C4 can reflect the strength of cellular immunity. Our study indicated that levels of IgA, IgM, IgG, as well as C3 and C4 are lowly expressed in children with pneumonia and sepsis. Therefore, these indicators provided potential targets for future treatments.

At present, autoimmune diseases are usually characterized by Th1 drift, i.e., elevated Th1/Th2 ratio (elevated level of Th1 and decreased level of Th2), while Th2 drift, i.e., decreased Th1/Th2 ratio (decreased level of Th1 and elevated level of Th2), occurs in diseases such as tumors and bronchial asthma. In bacterial sepsis, Th2 drift can impair immune function of the organism.

However, the limitation of this study is that there is no clear definition of combination of serum factors. Besides, the inflammation levels were not detected, which means the targets in this study are not comprehensive. So, more combinations of serum factors should be explored in the future.

In conclusion, blood gas analysis and immune indices can be used for early diagnosis and treatment monitoring in children with pneumonia and sepsis.

Disclosure of conflict of interest

None.

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Table 1. Diagnostic value of blood gas analysis and immune indices in children with severe pneumonia and sepsis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Critical value</th>
<th>AUC</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaCO₂</td>
<td>20.21 mmHg</td>
<td>0.7075</td>
<td>0.5615-0.8535</td>
<td>0.0067</td>
</tr>
<tr>
<td>PaO₂</td>
<td>28.19 mmHg</td>
<td>0.6944</td>
<td>0.5393-0.8495</td>
<td>0.0184</td>
</tr>
<tr>
<td>pH</td>
<td>7.01</td>
<td>0.8409</td>
<td>0.7111-0.9708</td>
<td>0.0001</td>
</tr>
<tr>
<td>IgA</td>
<td>1.87 g/L</td>
<td>0.8475</td>
<td>0.7232-0.9718</td>
<td>0.0002</td>
</tr>
<tr>
<td>IgG</td>
<td>7.19 g/L</td>
<td>0.7004</td>
<td>0.5409-0.8599</td>
<td>0.0199</td>
</tr>
<tr>
<td>IgM</td>
<td>0.78 g/L</td>
<td>0.8488</td>
<td>0.7275-0.9701</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>C3</td>
<td>1.12 g/L</td>
<td>0.6730</td>
<td>0.5075-0.8384</td>
<td>0.0444</td>
</tr>
<tr>
<td>C4</td>
<td>0.89 g/L</td>
<td>0.8068</td>
<td>0.6734-0.9403</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

PaCO₂: partial pressure of carbon dioxide; PaO₂: partial pressure of oxygen; IgA: Immunoglobulin A; IgG: immunoglobulin G; IgM: immunoglobulin M; C3: complement 3; C4: complement 4.
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References


