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Clinical Efficacy of Immunoglobulin in Infants with Bronchopulmonary Dysplasia Complicated by Respiratory Syncytial Virus Infection

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Abstract: *Objective*: To investigate the clinical efficacy of immunoglobulin in infants with bronchopulmonary dysplasia (BPD) complicated by respiratory syncytial virus (RSV) infection. *Methods*: 104 infants with BPD complicated by RSV infection admitted to our hospital from May 2023 to November 2025 were enrolled. They were divided into observation group (n = 56, treated with immunoglobulin) and control group (n = 48, not treated with immunoglobulin), which accorded to whether they received immunoglobulin therapy. The therapeutic effects of the two groups were compared, and the levels of pulmonary function, arterial blood gas and inflammatory factors were recorded. *Results*: The overall therapeutic effect of the observation group was better than that of the control group ($p < 0.05$).The length of hospital stay and the time to disappearance of pulmonary rales were both significantly shorter in the observation group than in the control group ($p < 0.05$). After treatment, the PaO_2 and oxygenation index in the observation group were higher than those in the control group, while the $PaCO_2$ was lower than that in the control group ($p < 0.05$).After treatment, the serum levels of CRP and WBC in the observation group were lower than those in the control group ($p < 0.05$). *Conclusion*: The immunoglobulin has a significant therapeutic effect in infants with BPD complicated by RSV infection, it can help to alleviate inflammatory response, improves pulmonary function, and possesses high clinical application value.

Keywords: Immunoglobulin; Infants; Bronchopulmonary dysplasia; Respiratory syncytial virus infection; Curative effect observation

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1. Introduction

Bronchopulmonary dysplasia (BPD) is a common condition in infants and young children, often triggered by immature lung development and abnormal pulmonary vasculature. It can lead to persistent respiratory distress, hypoxia, coughing, wheezing, and other symptoms, and may even cause lung function impairment [1]. Infants and young children with BPD have weakened airway defense functions, compromised immune systems,

and a lack of specific antibodies, making them unable to effectively resist invasion by respiratory syncytial virus (RSV). This renders BPD patients a high-risk group for concurrent RSV infection [2]. Infants and young children with BPD complicated by RSV are more prone to lung function impairment, which affects their growth and development. In the past, symptomatic and supportive treatments such as oxygen therapy, mechanical ventilation, and anti-infection measures have been commonly employed, but specific therapeutic approaches are lacking, and the condition is prone to recurrence [3]. Therefore, optimizing treatment has garnered significant attention. Immunoglobulin is an artificially prepared antibody preparation that can neutralize antibodies, directly bind to viruses, prevent viral invasion of host cells, accelerate viral clearance, inhibit RSV replication, regulate the body's immune function, and alleviate inflammatory responses to achieve therapeutic goals [4]. However, reports on the application of immunoglobulin in infants and young children with BPD complicated by RSV infection are relatively rare. This study conducted a retrospective comparative study to explore the clinical value of immunoglobulin in infants and young children with BPD complicated by RSV, providing evidence for clinical practice. The report is as follows.

2. Materials and methods

2.1. Clinical data

PASS software was used to estimate the sample size. Clinical data from 104 infants and young children with BPD complicated by RSV infection who were treated in our hospital from July 2021 to November 2025 were collected for a retrospective comparative study.

2.1.1. Inclusion criteria

(1) All patients met the diagnostic criteria for BPD outlined in the "Expert Consensus on the Management of Bronchopulmonary Dysplasia in Childhood" [5]. RSV infection met the relevant criteria in the "Chinese Expert Consensus on the Clinical Diagnosis and Treatment of Respiratory Syncytial Virus Infection in Children" [6].
(2) All patients received standardized treatment.

2.1.2. Exclusion criteria

(1) Patients with concurrent congenital heart disease, immunodeficiency disorders, pneumothorax, or cardiac dysfunction;
(2) Patients with concurrent aplastic anemia, hemophilia, or neonatal hemolytic disease;
(3) Patients with concurrent malignancies;
(4) Patients who did not complete treatment as required or had missing clinical data.

2.1.3. Study group

Patients were divided into two groups based on whether they received immunoglobulin treatment: the observation group (56 cases) received immunoglobulin treatment, while the control group (48 cases) did not. There were no statistically significant differences in baseline data parameters such as gender, age, mode of delivery, and preterm birth status between the two groups ($p > 0.05$), as shown in **Table 1**, indicating comparability. This study was approved by the hospital's ethics committee.

Table 1. Baseline characteristics parameters of the two groups

Group	Number of cases	Gender		Age (years)	Delivery mode		Preterm birth
		Male	Female		Vaginal delivery	Cesarean section	
Observation group	56	32 (57.14)	24 (42.86)	1.91 ± 0.77	35 (62.50)	21 (37.50)	24 (42.86)
Control group	48	22 (45.83)	26 (54.17)	1.93 ± 0.76	27 (56.25)	21 (43.75)	18 (37.50)
t/χ^2 value		1.324		-0.178	0.419		0.308
p value		0.250		0.859	0.517		0.579

2.2. Treatment methods

Both groups of children received intervention with pulmonary surfactant (Poractant Alfa Injection, produced by Chiesi Farmaceutici S.p.A., Italy, Drug Registration Certificate No. 3 mL : 0.24 g H20140848, specification: 240 mg). The children were positioned with their upper bodies elevated by 30°, and the surfactant was administered via tracheal instillation at a dose of 100 mg/kg. Both groups were also treated with recombinant human interferon α-1b (produced by Shenzhen Kexing Biopharm Co., Ltd., National Medical Products Administration Approval No. S10960058, specification: 40 μg/vial) using a nebulizer (produced by Jiangsu Fulin Medical Equipment Co., Ltd., Jiangsu Medical Device Registration No. 20182080314, model: WP01-B) at a dose of 2–4 μg / (kg dose), twice daily. The intervention was continued for 3 consecutive days. In addition, children in the observation group received intervention with immunoglobulin (produced by Boya Bio-Pharmaceutical Group Co., Ltd., National Medical Products Administration Approval No. S19993012, specification: 2.5 g 50 mL) at a dose of 400 mg/(kg*day) via intravenous drip, once daily, for 3 consecutive days.

2.3. Observation indicators

(1) Efficacy evaluation

The efficacy was evaluated after 3 days of treatment [6]. Markedly effective: The symptoms of cough, wheezing, and shortness of breath disappeared in the children, along with the disappearance of pulmonary rales and wheezing sounds, normal respiratory rate, absence of three-concave sign, and disappearance of pulmonary shadows on chest X-ray. Effective: The symptoms of cough, wheezing, shortness of breath, and dyspnea were alleviated in the children, along with a reduction in pulmonary rales and wheezing sounds, and a decrease in pulmonary shadows. Ineffective: No improvement in clinical symptoms or signs, or even aggravation.

(2) The hospitalization duration and the time for pulmonary rales to disappear were recorded for both groups of children.

(3) Arterial blood gas parameters were measured using a blood gas analyzer (produced by Wuhan Mingde Biotechnology Co., Ltd., Hubei Medical Device Registration No. 20192222694, model: PT1000) before and after the intervention to record the arterial partial pressure of oxygen (PaO_2) and arterial partial pressure of carbon dioxide ($PaCO_2$) in the children, and the oxygenation index was calculated.

(4) Inflammatory factor detection

Blood samples (3.0 mL) were collected from the median cubital vein before and after treatment, centrifuged (2500 r/min for 15 minutes) using conventional methods, and the supernatant was retained for testing. The serum C-reactive protein (CRP) level was measured using an automatic biochemical

analyzer (produced by Shenzhen Shengxinkang Technology Co., Ltd., Guangdong Medical Device Registration No. 20182221055, model: SK6300). The white blood cell count (WBC) level in whole blood was measured using an automatic blood cell analyzer (produced by Qingdao Hantang Biotechnology Co., Ltd., Shandong Medical Device Registration No. 20202220789, model: HT-5010). The reagent kits were provided by Shanghai Bohu Biotechnology Co., Ltd., and the operations were strictly performed according to the reagent kit instructions.

2.4. Statistical methods

The SPSS 28.0 software package was selected for statistical analysis of the clinical medical data. Measurement data conforming to a normal distribution were described using ($\overline{x} \pm s$), and independent sample *t*-tests were performed for comparisons between two groups. Paired sample t-tests were performed for comparisons at different time points within the same group. Categorical data were described using [n (%)], and chi-square tests were performed for comparisons between groups. Rank sum tests were performed for ordinal data. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of efficacy between the two groups

Compared with the control group, the overall efficacy in the observation group was significantly improved ($p < 0.05$), as shown in Table 2.

Table 2. Comparison of overall efficacy between the two groups [n (%)]

Group	Number of cases	Markedly effective	Effective	Ineffective
Observation group	56	30 (53.57)	24 (42.86)	2 (3.57)
Control group	48	16 (33.33)	26 (54.17)	6 (12.50)
Z value			-2.315	
p value			0.021	

3.2. Comparison of hospitalization duration and disappearance time of pulmonary rales between the two groups

The hospitalization duration and the disappearance time of pulmonary rales in the observation group were significantly shorter than those in the control group ($p < 0.05$), as shown in **Table 3**.

Table 3. Comparison of pulmonary function parameter level between the two groups of children (d, $\overline{x} \pm s$)

Group	Number of cases	Length of hospital stay	Disappearance time of pulmonary rales
Observation group	56	10.64 ± 2.46	4.96 ± 1.35
Control group	48	12.19 ± 3.11	7.60 ± 1.57
t value		-2.825	-9.235
p value		0.006	<0.001

Note: Compared with the same group before treatment, *$p < 0.05$.

3.3. Comparison of arterial blood gas parameters between the two groups

Before treatment, there were no statistically significant differences in PaO_2, $PaCO_2$, and oxygenation index levels between the two groups of children ($p > 0.05$). Compared with before treatment, both PaO_2 and oxygenation index significantly increased, while $PaCO_2$ significantly decreased in both groups after treatment. Moreover, the observation group exhibited higher levels of PaO_2 and oxygenation index and a lower level of $PaCO_2$ after treatment, with all differences being statistically significant ($p < 0.05$), as shown in **Table 4**.

Table 4. Comparison of arterial blood gas parameters between the two groups (mm Hg, $\overline{x} \pm s$)

Group	Number of cases	PaO_2		$PaCO_2$		Oxygenation index	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation group	56	55.14 ± 3.64	79.11 ± 3.92*	52.75 ± 10.97	37.86 ± 3.62*	180.73 ± 12.28	216.82 ± 23.54*
Control group	48	55.88 ± 3.94	71.94 ± 5.72*	58.74 ± 32.42	42.96 ± 2.86*	183.19 ± 17.31	205.54 ± 14.51*
t-value		0.984	7.542	-1.298	-7.880	-0.843	2.883
p-value		0.327	< 0.001	0.197	< 0.001	0.401	0.005

Note: Compared with the same group before treatment, *$p < 0.05$.

3.4. Comparison of serum factors between the two groups

Before treatment, there were no statistically significant differences in serum CRP and WBC levels between the two groups of children ($p > 0.05$). Compared with before treatment, serum CRP and WBC levels significantly decreased in both groups after treatment, and the levels of each parameter indicator were lower in the observation group after treatment ($p < 0.05$), as shown in **Table 5**.

Table 5. Comparison of serum factor levels between the two groups ($\overline{x} \pm s$)

Group	Number of cases	Serum CRP (mg/L)		WBC (× 10^9/L)	
		Before Treatment	After Treatment	Before Treatment	After Treatment
Observation group	56	18.11 ± 3.14	5.19 ± 1.83*	7.43 ± 1.48	4.83 ± 1.18*
Control group	48	17.17 ± 2.82	6.58 ± 1.30*	7.05 ± 1.18	5.97 ± 1.26*
t value		1.597	-4.377	1.437	-4.734
p value		0.113	< 0.001	0.154	< 0.001

Note: Compared with the same group before treatment, *$p < 0.05$.

4. Discussion

Infants with BPD often exhibit airway remodeling, immature lung development, and chronic inflammatory responses. These infants have reduced immune function and are prone to concurrent RSV infection. The condition of infants with BPD complicated by RSV infection is more likely to deteriorate, progressing to severe pneumonia and even leading to respiratory failure, thereby increasing the risk of adverse outcomes [7]. Immunoglobulin contains high titers of RSV-specific neutralizing antibodies that can directly block the replication, adsorption, and invasion of the RSV virus, and exert a synergistic effect when combine with antiviral drugs such as

interferon to achieve antiviral treatment goals [8]. Additionally, infants with BPD complicated by RSV infection have immune dysfunction. Immunoglobulin can regulate the levels of T lymphocyte subsets, promote the proliferation and differentiation of B lymphocytes, enhance the body's ability to produce its own antibodies, correct the state of immune dysfunction, and delay airway remodeling [9]. The results of this study also found that the overall therapeutic effect in the observation group significantly improved after treatment, suggesting that immunoglobulin as an adjunctive therapy for infants with BPD complicated by RSV infection helps improve therapeutic efficacy. Dong Huiru et al. also reported that immunoglobulin can reduce airway mucosal edema, decrease inflammatory secretions, improve ventilation function, thereby alleviating symptoms such as wheezing and shortness of breath, and consolidating therapeutic effects, supporting the findings of this study [10].

Infants with BPD complicated by RSV infection have prolonged illness, reduced lung compliance, an imbalance in the ventilation/perfusion ratio, alveolar dysplasia, and progressive lung function damage [11]. Immunoglobulin can promote the proliferation and differentiation of type II alveolar epithelial cells, accelerate the synthesis and secretion of pulmonary surfactant, improve alveolar expansion capacity, increase lung compliance, improve lung function, and promote early recovery in infants, thereby shortening the duration of pulmonary rales and hospital stay. Some studies also suggest that immunoglobulin can inhibit excessive fibroblast proliferation by regulating the synthesis and degradation of extracellular matrix (ECM) in lung tissue cells, reduce the formation of pulmonary fibrosis, delay the process of airway remodeling, and protect residual lung function [12–14]. Additionally, this study found that after treatment, the PaO_2 in the observation group was higher than that in the control group, while $PaCO_2$ was lower. This may be because immunoglobulin can inhibit alveolar epithelial cell apoptosis, maintain the integrity of alveolar structure, increase the area for gas exchange, and thereby improve pulmonary gas exchange function [15]. Furthermore, immunoglobulin can regulate pulmonary vascular tone, improve the distribution of pulmonary circulation blood flow, enhance alveolar gas exchange efficiency, correct hypoxemia, and improve the oxygenation index [16].

CRP is a commonly used pro-inflammatory factor in RSV infection that can increase vascular permeability, induce and exacerbate airway edema, while WBC can aggravate airway inflammation, trigger an inflammatory storm, and worsen lung injury [17,18]. The results of this study found that after treatment, serum CRP and WBC levels in the observation group were lower than those in the control group. Immunoglobulin can inhibit the release of inflammatory mediators, reduce the damage caused by inflammatory factors to the airways and lung parenchyma, alleviate airway mucosal edema, decrease secretions, and improve airway ventilation function [19]. After binding to Fc receptors on the surface of immune cells, immunoglobulin can activate downstream signaling molecules, inhibit the phosphorylation of NF-κB, thereby suppressing the transcription and expression of related genes, and reducing the synthesis and secretion of pro-inflammatory factors such as serum CRP and WBC [20]. This may also be an important mechanism by which immunoglobulin alleviates the condition of infants with BPD complicated by RSV infection.

5. Conclusion

In summary, the use of immunoglobulin in infants with BPD complicated by RSV infection has significant effects, helping to reduce inflammation and improve lung function.

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Disclosure statement

The authors declare no conflict of interest.

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