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ORIGINAL RESEARCH

Effects of western medicine and Huangqi Taizishen Chenpi decoction on the treatment of severe pneumonia in children

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Abstract

To investigate the effects of Western medicine and Huangqi Taizishen Chenpi decoction on treating severe pneumonia in children. This study involved 100 children diagnosed with severe pneumonia and treated at our hospital from January 2021 to September 2023. They were randomly assigned into two groups: an experimental group (n = 50; received Huangqi Taizishen Chenpi decoction, a traditional Chinese medicine formulation) and a control group (n = 50; received conventional Western medical treatment). Then, the clinical outcomes between these two treatment modalities were compared. Among the 100 patients, 71 (71%) were infected by a single pathogen, with respiratory syncytial virus, rhinovirus and Pseudomonas aeruginosa being the most common pathogens identified. The experimental group exhibited a significantly higher overall effective treatment rate (98%) compared to the control group (84%) ($p < 0.05$). Additionally, the experimental group had significantly shorter hospital stays (11.30 $\pm$ 1.59 days), quicker resolution of lung rales (5.60 $\pm$ 1.70 days), and faster symptom improvement times (8.50 $\pm$ 1.91 days) than the control group (14.60 $\pm$ 2.08 days, 7.80 $\pm$ 2.33 days, 10.70 $\pm$ 2.13 days respectively) ($p < 0.05$). Post-treatment lung function tests, including Forced Vital Capacity (FVC) (2.76 $\pm$ 0.50 L), Maximum Mid-Expiratory Flow (MMF) (1.83 $\pm$ 0.56 L/s), and Forced Expiratory Volume in 1 second (FEV1) (2.25 $\pm$ 0.46 L), were significantly improved in the experimental group compared to the control group (2.41 $\pm$ 0.40 L, 1.43 $\pm$ 0.43 L/s, 1.87 $\pm$ 0.35 L respectively) ($p < 0.05$). The rate of adverse reactions in the experimental group was significantly lower (6%) compared to the control group (16%) ($p < 0.05$). Huangqi Taizishen Chenpi decoction significantly improves treatment outcomes in children with severe pneumonia, reduces the recovery period, and enhances the restoration of bodily functions with fewer adverse reactions, thereby demonstrating promising clinical significance.

Keywords

Western medicine; Huangqi Taizishen Chenpi decoction; Severe pneumonia in children

1. Introduction

Pneumonia remains a significant respiratory infection among children, predominantly occurring in the autumn and winter months. This condition arises from pathogenic infections of the lungs, manifesting with symptoms such as fever, cough and difficulty breathing [1, 2]. Children's respiratory systems, which are still in development, combined with reduced mucosal resistance, make them particularly vulnerable to pneumonia. If not promptly addressed, the infection can escalate into a severe state, leading to critical complications like hypoxemia, organ failure, and respiratory system dysfunction, significantly endangering pediatric health [3]. In developing countries, severe pediatric pneumonia has a mortality rate of 7%–13% [4]. Antibiotics are commonly prescribed to manage inflammation in severe childhood pneumonia cases [5]. However, their extended use can foster the emergence of drug-resistant bacterial strains and disturb the intestinal flora, thereby complicating the recovery process from severe pneumonia due to adverse effects [6]. Traditional Chinese Medicine (TCM) has been progressively incorporated into the treatment of various diseases. Studies suggest that TCM components can offer substantial therapeutic benefits [7]. The Huangqi Taizishen Chenpi decoction, primarily composed of Huangqi and Taizishen, is recognized for its ability to clear heat, detoxify, strengthen the spleen and stomach, and dispel dampness while resolving phlegm. Given its minimal side effects, this decoction is often applied in the treatment of respiratory ailments. Nevertheless, there is a lack of research directly comparing the effectiveness of TCM and Western

medicine in the management of severe pneumonia in children. Herein, we designed this study to evaluate the impact of Western medicine and Huangqi Taizishen Chenpi decoction on severe pneumonia in pediatric patients.

2. Materials and methods

2.1 General information

The study selected 100 children diagnosed with severe pneumonia who were admitted to Ruian Maternity and Child Care Hospital (January 2021–September 2023). They were allocated to either an experimental group or a control group, each comprising 50 cases (Table 1). The baseline characteristics of the two groups were statistically similar ($p > 0.05$), indicating good comparability. The pediatric patient's vaccination status is following (Table 2).

TABLE 1. Comparison of General Information between the two groups ($\bar{x} \pm s$).

Group	n	Gender (male/female)	Age (yr)	Course of disease (d)
Experimental group	50	26/24	7.20 ± 3.46	7.30 ± 2.62
Control group	50	27/23	7.10 ± 3.41	7.10 ± 2.43
χ^2/t	-	0.040	0.146	0.396
p	-	0.841	0.885	0.693

TABLE 2. Vaccination status of two groups of patients.

Group/Age (Vaccination)	1–3	3 ≤ X < 6	≥6
Experimental group	4 (2)	15 (13)	31 (30)
Control group	6 (4)	18 (15)	26 (24)

Note: 4 (2) indicates that there are four people aged 1–3, and two children are vaccinated.

Western medicine diagnostic criteria for pneumonia include several clinical manifestations: fever, cough and X-ray examination with shadows in the lungs, as well as the presence of pleural effusion, wet rales during auscultation and positive Immunoglobulin M (IgM) antibodies in serum in some patients. The TCM diagnostic criteria for pneumonia are characterized by clinical features such as fever, restlessness, cough with wheezing, flushed face accompanied by thirst, a yellowish tongue coating, and a wiry and smooth pulse.

The study inclusion criteria comprised: (1) Meeting both Western and TCM diagnostic standards; (2) Aged between 1 and 14 years old; (3) No allergies to the prescribed medications; (4) Signed informed consent form provided by the parents or guardians of the children. The exclusion criteria were: (1) Patients with other respiratory system diseases; (2) Children with immune dysfunction, cardiac or renal dysfunction; (3) Inability to take oral Chinese herbal medicine; (4) Patients with concurrent bronchitis, asthma, or other related diseases; (5) Patients with lobar pneumonia; (6) Patients who have deteriorated during the treatment period; and (7) Allergic reactions to treatment drugs.

2.2 Treatments

In the control group, patients with bacterial infections were treated with targeted antibiotic therapy as follows: Acinetobacter baumannii infections were treated with levofloxacin, administered orally at a dose of half a tablet every 12 hours (equivalent to 1 tablet/day). For Pseudomonas aeruginosa, treatment involved piperacillin sodium, administered *via* intravenous infusion at doses ranging from 100 to 200 mg/kg/day for children under 12 years. Staphylococcus aureus infections were treated with a daily intravenous dose of 50–100 mg/kg, administered over 4–6 hours.

Patients with parainfluenza virus infection received oseltamivir capsules, dosed according to weight: 30 mg twice daily for children over 1-year-old weighing <15 kg; 45 mg twice daily for those weighing 15–23 kg; and 60 mg twice daily for children weighing >23 kg, with the treatment continuing for 5 days.

For pneumonia caused by respiratory syncytial virus and rhinovirus, ribavirin was administered intravenously at 10–15 mg/kg, divided into two infusions, each lasting over 20 minutes, for 3 to 7 days. Cytomegalovirus infections were treated with acyclovir at a dosage of 10 mg/kg *via* intravenous (IV) infusion every 8 hours. Concurrently, the patients received ibuprofen oral liquid for antipyretic purposes along with treatments aimed at liver and myocardial protection, among other supportive measures.

The experimental group was treated with Huangqi Taizishen Chenpi decoction, which contained equal parts Taizishen (Radix Pseudostellariae) and Huangqi (Astragalus) at 25 g each, Chenpi (Tangerine Peel), Banxia (Pinellia Rhizome) and Chao Baizhu (Atractylodes Macrocephala) at 12 g each, Ziwan (Violet Herb), Yunfuling (Poria Cocos), and Baiqian (Rhizoma Cynanchi Paniculati) at 15 g each, Jinyinhua (Honeysuckle Flower) at 10 g, and Zhigancao (Licorice Root) at 6 g. The decoction was prepared in water, with two bags taken orally each morning and evening, totaling 200 mL per bag. The same supportive treatments as the control group were provided for 14 days, after which potential TCM side effects on the liver, kidneys, heart, lungs and blood vessels were monitored.

Both groups were monitored for any signs of deterioration throughout the treatment period, with arrangements for transfer to the pediatric intensive care unit if necessary.

2.3 Observation indicators

(1) Pathogen detection: Nasopharyngeal swabs were routinely collected within one day of admission for all children, and bronchoalveolar lavage fluid or endotracheal sputum samples were obtained for those with ineffective conventional treatment and low immune function. These samples were assessed using polymerase chain reaction capillary electrophoresis fragment assay kits for various pathogens, including influenza strains, novel influenza A H3N2 (H3N2), coat plasma, Mycoplasma pneumoniae, Boca virus, coronavirus, respiratory syncytial virus, adenovirus, H1N1, rhinovirus and parain-

fluenza virus. Identification of specific pathogens was conducted using the VITEK 2-Compact and VITEK MS automated microbial mass spectrometry systems. Additionally, sputum samples from the experimental group were collected three days post-treatment to evaluate the antibacterial effect of the traditional Chinese medicine formulation, comparing the presence and types of pneumonia pathogens before and after treatment.

(2) Treatment efficacy assessment: Efficacy was categorized into "Cure", indicating the absence of hypoxia symptoms, complete clearance of phlegm and lung rales, normalization of clinical signs (*e.g.*, cough, sputum production, shortness of breath, and difficulty breathing), and complete resolution of inflammatory lesions on chest Computer tomography (CT) scans. "Effective" cases showed significant symptom improvement, reduction in lung rales, improvement in clinical signs, and reduced lesion size on chest CT scans. Cases that did not meet these criteria were deemed "Ineffective". The overall effectiveness rate was calculated as the sum of cured and effective cases divided by the total number of cases multiplied by 100%.

(3) Clinical symptom improvement: This included the duration of hospitalization, time to resolution of lung rales, and symptom improvement (*i.e.*, fever, cough, wheezing).

(4) Lung function indicators in pediatric patients before and after treatment: Changes in lung function were assessed by measuring their forced vital capacity (FVC), maximum mid-expiratory flow rate (MMF), and forced expiratory volume in one second (FEV1).

(5) Adverse reaction monitoring: The incidence of adverse reactions during treatment was recorded to detect potential side effects impacting the liver, kidney, heart, or blood vessels.

(6) Inflammatory and immune response evaluation: Changes in white blood cells (WBC), neutrophils (NEU), and the neutrophil to lymphocyte ratio (NLR) were compared before and after treatment to assess the inflammatory and immune response.

2.4 Statistical methods

Data analysis was performed using SPSS 18.0 statistical software (IBM, Armonk, NY, USA). Quantitative data were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$). Comparisons between groups were conducted using the *t*-test for continuous variables. Count data were expressed as percentages (%) and analyzed using the chi-square (χ^2) test. A *p*-value of less than 0.05 was considered to indicate statistically significant differences.

3. Results

3.1 Pathogen detection

Among the patients, 71 cases (71%) were infected with a single pathogen. The most common pathogens, in descending order, were respiratory syncytial virus, rhinovirus, and Pseudomonas aeruginosa (Table 3). Mixed infections, involving two or more pathogens, were observed in 29 cases (29%), with virus-bacterial co-infections constituting 15% (15/100) of the total.

TABLE 3. Pathogen type (n (%)).

Pathogen type	Proportion
Respiratory syncytial virus	42 (42%)
Rhinovirus	34 (34%)
Pseudomonas aeruginosa	17 (17%)
Acinetobacter baumannii	14 (14%)
Staphylococcus aureus	14 (14%)
Parainfluenza virus	13 (13%)

3.2 Comparison of treatment efficacy

The total efficacy rate in the experimental group was significantly higher (98%) compared to the control group (84%) ($p < 0.05$; Table 4). In the experimental group, only one patient showed a suboptimal clinical outcome, necessitating prolonged hospitalization. In contrast, the efficacy of Western medicine in the control group varied with age, with significant differences observed in total efficacy rates among different age groups ($p < 0.05$; Table 5). Of the entire cohort, only two patients developed airway stenosis, leading to an increased treatment duration of 3 to 5 days.

3.3 Comparison of clinical indicators

The duration of hospital stay in the experimental group was significantly shorter (11.30 $\pm$ 1.59 days) compared to the control group (14.60 $\pm$ 2.08 days). Similarly, the time for lung rales to disappear (5.60 $\pm$ 1.70 days) and the overall symptom improvement time (8.50 $\pm$ 1.91 days, 9.10 $\pm$ 2.94 days, 10.20 $\pm$ 2.39 days) in the experimental group were shorter than those observed in the control group (7.80 $\pm$ 2.33 days, 10.70 $\pm$ 2.13 days, 11.60 $\pm$ 2.51 days, 12.30 $\pm$ 2.72 days), with the differences being statistically significant ($p < 0.05$; Table 6).

3.4 Changes in pulmonary ventilation indicators

After treatment, the experimental group exhibited superior lung function indicators compared to the control group, with FVC at 2.76 $\pm$ 0.50 L, MMF at 1.83 $\pm$ 0.56 L/s, and FEV1 at 2.25 $\pm$ 0.46 L. In contrast, the control group had an FVC of 2.41 $\pm$ 0.40 L, MMF of 1.43 $\pm$ 0.43 L/s, and FEV1 of 1.87 $\pm$ 0.35 L. These differences were statistically significant ($p < 0.05$), as detailed in Table 7.

3.5 Comparisons of adverse reactions

Adverse reactions were significantly less frequent in the experimental group compared to the control group ($p < 0.05$; Table 8). In the experimental group, a single case of transient liver function abnormality was documented, which normalized after discontinuing the herbal medication for one week. No additional complications related to kidney, heart or blood vessels were reported.

3.6 Blood sample testing

After treatment, the experimental group exhibited lower WBC, NEU and NLR compared to the control group ($p < 0.05$; Tables 9,10).

TABLE 4. Comparison of treatment efficacy between two groups of patients (n (%)).

Group	n	Cure	Effective therapy	Ineffective therapy	Total effective rate
Experimental group	50	3 (60.00)	19 (38.00)	1 (2.00)	49 (98.00)
Control group	50	24 (48.00)	18 (36.00)	8 (16.00)	42 (84.00)
χ^2					39.093
p					<0.001

TABLE 5. Efficacy comparisons of patients in the control group (n (%)).

Age	1–3	3 ≤ X < 6	≥6	Total
Number of people	6	18	26	50
Total effective rate	3 (50.00)	15 (83.33)	24 (92.31)	42 (84.00)
χ^2		6.502		-
p		<0.05		-

TABLE 6. Clinical indicators for the two groups of pediatric patients ($\bar{x} \pm s$, time/d).

Group	n	The disappearance time of lung rales	Symptom improvement time			Hospital stay
			Fever	Cough	Wheezing	
experimental group	50	5.60 ± 1.70	8.50 ± 1.91	9.10 ± 2.94	10.20 ± 2.39	11.30 ± 1.59
control group	50	7.80 ± 2.33	10.70 ± 2.13	11.60 ± 2.51	12.30 ± 2.72	14.60 ± 2.08
t	-	5.372	5.438	4.573	4.101	8.913
p	-	<0.001	<0.001	<0.001	<0.001	<0.001

TABLE 7. Comparison of pulmonary ventilation indicators of two groups ($\bar{x} \pm s$).

Group	n	FVC (L)		MMF (L/s)		FEV1 (L)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental	50	2.15 ± 0.28	2.76 ± 0.50*	1.02 ± 0.27	1.83 ± 0.56*	1.19 ± 0.20	2.25 ± 0.46*
Control	50	2.21 ± 0.31	2.41 ± 0.40*	1.11 ± 0.29	1.43 ± 0.43*	1.21 ± 0.18	1.87 ± 0.35*
t	-	1.016	3.865	1.606	4.006	0.526	4.649
p	-	0.312	<0.001	0.112	<0.001	0.600	<0.001

*Note: Compared with before treatment in this group, *p < 0.05.*
FVC: Forced Vital Capacity; MMF: Maximum Mid-Expiratory Flow; FEV1: Forced Expiratory Volume in 1 second.

TABLE 8. Adverse reactions (n (%)).

Group	n	Nausea and vomiting	Rash	Diarrhea	Headache	Abnormal liver function	Adverse Reaction rate
Experimental	50	1 (2.00)	1 (2.00)	0	0	1 (2.00)	3 (6.00)
Control	50	1 (2.00)	2 (4.00)	2 (4.00)	3 (6.00)	0	8 (16.00)
χ^2							27.655
p							<0.001

TABLE 9. Blood samples of patients in the two groups tested for ($\bar{x} \pm s$).

Group	n	WBC ($\times 10^9$/L)		NEU ($\times 10^9$/L)	
		Before treatment	After treatment	Before treatment	After treatment
Experimental	50	12.94 ± 1.67	7.45 ± 1.32	8.34 ± 2.31	3.60 ± 1.34
Control	50	13.64 ± 2.34	8.60 ± 1.61	7.97 ± 2.19	4.68 ± 2.06
t	-	1.722	3.906	0.822	3.108
p	-	0.088	<0.001	0.413	0.003

WBC: white blood cells; NEU: neutrophils.

TABLE 10. Comparison of neutrophil to lymphocyte ratio between two groups ($\bar{x} \pm s$).

Group	n	NLR	
		Before treatment	After treatment
Experimental	50	1.83 ± 0.97	1.32 ± 0.54
Control	50	1.81 ± 0.95	1.63 ± 0.89
t	-	0.104	2.106
p	-	0.917	0.038

NLR: neutrophil to lymphocyte ratio.

4. Discussion

Severe pneumonia, marked by respiratory failure or dysfunction of other organs, is a common condition in pediatric clinical settings. The primary pathogens associated with this disease are respiratory syncytial virus, Streptococcus pneumoniae, and Mycoplasma pneumoniae [8, 9]. Due to the immaturity of children's respiratory mucosa and underdeveloped immune function, there is a heightened susceptibility to bacterial infections that can lead to severe pneumonia [10]. The progression of this condition may result in respiratory or cardiac failure, significantly affecting lung function and adversely affecting prognosis. The widespread use of antibiotics, immunomodulators, and hormones has led to increased bacterial resistance, which complicates treatment strategies and presents challenges in managing the disease [11]. Therefore, timely and effective treatment approaches are essential to alleviate symptoms, enhance recovery, and decrease mortality rates in cases of pediatric pneumonia. TCM attributes pneumonia as a consequence of weakened Zheng Qi (vital energy), the invasion by pathogenic wind and heat toxins, and the conflict between pathogenic and healthy factors [12]. This conflict leads to obstructions in the airways due to phlegm and compromised pulmonary function. Treatment strategies in TCM focus on clearing the lungs, eliminating phlegm, fortifying the spleen, alleviating cough, and removing internal heat.

In the management of pneumonia, the application of anti-infective or immunosuppressive medications is common, showing initial effectiveness. However, their recurrent or extended use can prompt the production of antibodies, resulting in side effects such as bacterial mutation and secondary infections. Sole reliance on antibiotics for severe pneumonia treatment has proven ineffective, as prolonged medication use can weaken immune system functionality, hinder physiological recuperation, and prolong the recovery period [13]. In this study, in regard to pathogen detection, it was found that 71 cases (71%) were infected by a single pathogen, predominantly respiratory syncytial virus, rhinovirus, and Pseudomonas aeruginosa. Additionally, 29 cases (29%) had co-infections with two or more pathogens, with virus-bacterial mixed infections constituting 15% of these cases. The frequent occurrence of respiratory syncytial virus, rhinovirus, and Pseudomonas aeruginosa underscores their significant role in pediatric pneumonia, highlighting the vulnerability of children to these specific agents, primarily through bacterial or viral infections.

Studies have shown that TCM formulations aimed at dispelling dampness are highly effective in treating viral pneumonia, significantly enhancing treatment efficacy. Clinical evaluations of TCM have reported minimal adverse reactions, highlighting its safety [14]. Compared to Western medicine, TCM typically presents fewer side effects and allows for treatments to be customized to each patient's unique condition. Notably, prolonged use of TCM does not lead to a decrease in its effectiveness or patient tolerance [15]. TCM has been shown to substantially alleviate the clinical symptoms associated with severe pneumonia, reduce the duration of the illness, and improve patient outcomes. This study observed that the overall effectiveness rate in the experimental group, which received TCM treatment, was higher than in the control group. Additionally, the experimental group experienced shorter hospital stays, quicker resolution of lung rales, and faster improvement of symptoms. These outcomes suggest the effectiveness of the Huangqi Taizishen Chenpi decoction in managing severe pneumonia in children. This decoction, primarily composed of Huangqi and Taizishen, is known for its properties of fortifying qi, nourishing yin, moistening the lungs, and strengthening the spleen. The combination of Huangqi and Taizishen enhances lung and spleen qi, while other components of the decoction offer complementary benefits: Yunfuling soothes the mind, strengthens the spleen and stomach, and enhances joint function; Baizhu tones the digestive system, dries dampness, stops sweat, and stabilizes the spleen; Banxia reverses qi flow, arrests vomiting, dries dampness, and tranquilizes the mind; Chenpi stimulates the spleen, regulates qi, dispels dryness and heat, and transforms phlegm; Ziwan alleviates coughs and phlegm, moisturizes the lungs, and eases asthma; Baiqian offers heat clearance, blood cooling, detoxification, and treats sores; Jinyinhua provides heat clearance and detoxification, effective against wind-heat; and Gancao facilitates the patency of channels, tonifies qi and activates blood circulation. The holistic integration of these herbs in the treatment regimen

promotes circulation within channels, lungs and spleen, clears heat, neutralizes toxins, and expels wind, making it highly effective against pneumonia caused by external wind-heat factors. This approach not only regulates the respiratory system and enhances pulmonary function but also addresses symptoms like fever, coughing, and wheezing, demonstrating its comprehensive efficacy in treating severe pneumonia [16, 17]. The findings of Zhenxu Lan demonstrated a 90% efficacy rate of TCM in treating pneumonia [18], while a Xuedong reported a clinical cure rate of 94.74% using a specific TCM decoction [19]. To optimize recovery rates and minimize the duration of treatment for severe pneumonia, TCM is frequently combined with ibuprofen oral solution to manage fever and support crucial therapies, such as myocardial protection, thereby reducing the risk of complications. The bioactive components in Chinese medicine tackle both the symptoms and the root cause of the illness, preventing systemic physiological impacts and facilitating quicker management of the condition [20]. This integrative approach significantly enhances patient health and prognosis, yielding superior results compared to the use of antibiotics alone [21]. TCM is characterized by its ability to act on multiple targets, modulate the immune system non-specifically, and exhibit strong antiviral properties [22]. Chinese herbal medicine has been extensively studied and shown to alleviate clinical symptoms, reduce the incidence of severe cases, and play a crucial role in prevention [23]. Following treatment, the experimental group exhibited significantly higher levels of FVC, MMF and FEV1 compared to the control group, indicating notable improvements in pulmonary function with Huangqi Taizishen Chenpi decoction compared to Western medicine. The combination of TCM ingredients, where Ziyin and Chenpi alleviate coughs, and phlegm, Baiqian and Jinyinhua perform heat clearance and detoxification, and Gancao enhances meridian and blood circulation, synergistically addresses respiratory issues. Taizishen further promotes lung hydration and spleen vigor. This strategic combination first targets cough and phlegm, followed by lung hydration and, subsequently, heat removal and detoxification, effectively treating inflammation and other pneumonia-related symptoms with minimal side effects. Research by Qianru Zhao demonstrated that certain constituents of Chinese herbal medicine possess anti-inflammatory properties, inhibiting neutrophils and macrophages, downregulating macrophage-induced inflammation, and reducing macrophage-induced inflammation activation, thereby substantially mitigating lung damage in patients [24]. Licorice, in particular, is known for its therapeutic actions in relieving cough and phlegm, detoxification, and harmonizing effects within formulations. Together, these components promote lung health, resolution of dampness, heat clearance, and detoxification, leading to significant improvements in pulmonary function indices post-treatment. Findings from Yingli X's study align with those of the present study, revealing that TCM markedly enhances pulmonary function and reduces lung lesions [25]. We also observed that the experimental group had fewer adverse reactions than the control group, suggesting a high safety profile for TCM in treating severe pneumonia. Moreover, Huangqi Taizishen Chenpi decoction appeared to rapidly alleviate clinical symptoms and facilitate physical recovery in children with severe pneumonia, attaining the anticipated clinical outcomes. However, due to the limited sample size of this study, the results could be subject to bias. Thus, future investigations involving a larger sample size and multicenter trials are needed to confirm our findings.

5. Conclusions

In conclusion, the Huangqi Taizishen Chenpi decoction has shown considerable effectiveness in the management of severe pediatric pneumonia. It significantly ameliorates clinical manifestations, enhances lung function, and improves overall physical health, delivering promising therapeutic outcomes and supporting its potential clinical application.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

XLY—designed the study and carried them out; XLY, JX and LLJ—supervised the data collection, analyzed the data, interpreted the data; XLY, WMJ—prepared the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Ruian People's Hospital (Approval no. LZM2021043). Signed informed consent form was provided by the parents or guardians of the children.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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