Allergologia et immunopathologia
Sociedad Española de Inmunología Clínica, Alergología y Asma Pediátrica
www.all-imm.com

RESEARCH ARTICLE

OPEN ACCESS

Effect of electronic fibrobronchoscope alveolar lavage combined with local administration of budesonide on the efficacy of *Mycoplasma pneumoniae* pneumonia in children

Fengqin Xu*, Qi Zhang, Fuzhe Chen

Department of Pediatric Respiratory Medicine, Anhui Provincial Children's Hospital, Hefei, Anhui, China

Received 2 August 2024; Accepted 5 October 2024
Available online 1 November 2024

KEYWORDS
alveolar lavage;
budesonide;
electronic fibrobronchoscope;
Mycoplasma pneumoniae pneumonia

Abstract
This study investigates the effect of electronic fibrobronchoscope alveolar lavage combined with local administration of budesonide on the efficacy of treating *Mycoplasma pneumoniae* pneumonia (MPP) in children. A retrospective analysis was conducted on the clinical data of 100 children with MPP treated at our hospital from April 2022 to April 2024. The patients were divided into an experimental group (50 cases) and a control group (50 cases) based to the treatment method. Both groups received routine treatment, however, the control group was treated with electronic fibrobronchoscope alveolar lavage alone, while the experimental group received electronic fibrobronchoscope alveolar lavage combined with local administration of budesonide. The efficacy of the two treatments was compared. The experimental group showed a significantly higher overall effective rate than the control group ($p<0.05$). After treatment, the time for cough relief, lung rales resolution, fever reduction, and hospital stay were significantly shorter in the experimental group compared to the control group ($p<0.05$). One week after treatment, the levels of tidal volume, vital capacity, and peak expiratory flow in the experimental group were higher than those in the control group ($p<0.05$). Post-treatment levels of WBC and CRP were lower in the experimental group than in the control group ($p<0.05$). Additionally, the incidence of complications in the experimental group was lower than in the control group ($p<0.05$). Electronic fibrobronchoscope alveolar lavage combined with local administration of budesonide improves the efficacy of treatment for children with MPP, enhances clinical indicators, reduces inflammation levels, and has high safety, making it worthy of clinical promotion.

***Corresponding author:** Fengqin Xu, Department of Pediatric Respiratory Medicine, Anhui Provincial Children's Hospital, No. 39, Wangjiang East Road, Baohe District, Hefei City, Anhui Province, China. *Email address:* xfq_dr12@163.com

https://doi.org/10.15586/aei.v52i6.1184

Introduction

Mycoplasma pneumoniae pneumonia (MPP) is a respiratory disease caused by an infection with *Mycoplasma pneumoniae*. It predominantly affects children and adolescents, accounting for about one-fifth of childhood pneumonia cases.[1,2] Early symptoms include fever and a persistent dry cough, with some patients experiencing wheezing. Lung auscultation may reveal reduced breath sounds, as well as dry and wet rales. Severe cases can lead to respiratory distress and atelectasis and may also involve other organ systems, such as the heart, kidneys, liver, nervous system, and gastrointestinal tract. If not treated promptly, MPP can result in sequelae such as obliterative bronchitis, which poses a threat to the patient's life.[3] Currently, Western medicine primarily treats pediatric MPP through symptomatic and comprehensive interventions, including antibacterial agents, inhaled corticosteroids for their anti-inflammatory effects, and bronchodilators, which can significantly improve clinical symptoms. However, due to strong resistance in some strains of Mycoplasma, clinical efficacy is somewhat limited, and relapse is common.[4,5] With advances in medical technology, fiberoptic bronchoscopy is increasingly used to treat respiratory diseases by repeatedly irrigating areas of lung infection to reduce inflammatory responses and promote early lesion healing.[6] Budesonide, a corticosteroid, provides potent local anti-inflammatory effects, reduces airway irritation, improves pulmonary ventilation, and helps alleviate discomfort caused by inflammation. Following alveolar lavage using an electronic fibrobronchoscope, local administration of budesonide can directly target the lesions, offering robust pharmacological effects.[7] Previous studies on treating MPP in children have primarily focused on the efficacy of single treatments, with limited research on the combined use of bronchoalveolar lavage and local administration of budesonide.[8] Therefore, this study explores the efficacy of combining electronic fibrobronchoscopy with local budesonide administration in treating MPP.

Materials and Methods

General information

A retrospective inclusion of analysis was conducted using clinical data from 100 children with *Mycoplasma pneumoniae* pneumonia who were treated at our hospital between April 2022 and April 2024. The patients were divided into an experimental group (50 cases) and a control group (50 cases) based on the treatment methods. The general information of the two groups is shown in Table 1, with data being comparable ($p>0.05$).

Inclusion criteria includes the following: (1) A qualified sputum specimen must be collected for culture and *Mycoplasma* PCR testing on the day of admission. A chest CT examination must be completed within 48 hours of admission. Diagnosis of *Mycoplasma pneumoniae* pneumonia must be confirmed through pulmonary imaging and laboratory tests, meeting the diagnostic criteria for the condition. (2) Age must be <14 years. (3) Complete clinical data must be available. (4) Signed informed consent form regarding the condition must be obtained.

Exclusion criteria includes the following: (1) Presence of bronchial asthma, satellite lesions, or lymph node enlargement. (2) Combined heart, liver, or other organ dysfunction. (3) Children with immune deficiencies. (4) Children with other inflammation, infections, and so on, or allergic to the drugs used in this study.

Methods

Routine treatment: Both groups of children received targeted medication. Azithromycin was routinely administered at a dose of 10 mg/(kg·d) via intravenous infusion. For those with aggravated conditions, methylprednisolone was administered concurrently at a dose of 2 mg/(kg·d) via intravenous infusion. Cephalosporin antibiotics were given intravenously to those with bacterial infections.

1. **On the basis of routine treatment**
   The control group received lavage treatment with 0.9% NaCl injection. The procedure involved fasting for 4-6 hours beforehand. About 10 minutes before the operation, midazolam was administered intravenously at a dose of 0.2 mg/kg for sedation. During the procedure, the patients lay in a supine position and were connected to ECG monitoring, blood oxygen monitoring, and provided with oxygen inhalation. Surface anesthesia was applied, and a bronchoscope (manufactured by OLYMPUS, Japan) was inserted through the nasal cavity, with 2% lidocaine used for local anesthesia. Under the bronchoscope, 3 ml/kg of 0.9% sodium chloride injection was repeatedly lavaged 3–5 times into the infected lung segment bronchi. The lavage fluid was then aspirated with a negative pressure of 14-15 kPa and retained for examination.

2. **On the basis of routine treatment**
   The experimental group underwent bronchoscopy with lavage followed by the administration of budesonide. The procedure involved fasting for 4-6 hours beforehand. About 10 minutes before the operation, midazolam was administered intravenously at a dose of 0.2 mg/kg for sedation. During the procedure, the patients lay in a

Table 1 Comparison of general information between the two groups ($\bar{x} \pm s$).

Group	*n*	Age (yr)	Gender (male/female)	Course of disease (d)	BMI(kg/m^2)
Experimental group	50	6.40±1.15	27/23	5.20±0.85	16.53±1.23
Control group	50	6.35±1.30	29/21	5.13±0.78	16.38±1.06
t/x^2	-	0.171	0.162	0.429	0.688
p	-	0.865	0.687	0.669	0.493

supine position and were connected to ECG monitoring, blood oxygen monitoring, and provided with oxygen inhalation. Surface anesthesia was applied, and a bronchoscope was inserted through the nasal cavity, with 2% lidocaine used for local anesthesia. Under the bronchoscope, 3 ml/kg of 0.9% sodium chloride injection was repeatedly lavaged 3-5 times into the infected lung segment bronchi. The lavage fluid was then aspirated with a negative pressure of 14-15 kPa and retained for examination. Following lavage, a budesonide suspension (manufacturer: Chia Tai Tianqing Pharmaceutical Group Co. Ltd., China; batch number H20203063, specification 1 mg/2 ml) was prepared by mixing 1 mg of budesonide with 3 ml/kg of 0.9% NaCl injection to make a 5-10 ml solution. This mixture was injected into the lesion site and retained. Throughout the procedure, blood oxygen saturation was maintained at >95%, and any signs of discomfort in the children were closely monitored.

Observation indicators

(1) Overall clinical efficacy
Significant effect: Normalized body temperature, chest X-ray showing disappearance of inflammatory shadows, no atelectasis, and complete disappearance of lung rales and cough.
   a. Effective: Normalized body temperature, chest X-ray showing a reduction in the area of inflammatory shadows by ≥50% but not completely disappeared, no atelectasis, and disappearance or improvement of lung rales and cough.
   b. Ineffective: No significant improvement in clinical symptoms and signs, with the chest X-ray showing less than a 50% reduction or no change in the area of inflammatory shadows.[9]
   c. Overall efficacy rate (%) = Number of significant effect cases + Number of effective cases)/Total number of cases × 100%.

(2) Symptom relief time and hospital stay
Recorded Record the time required for relief of cough, lung rales, fever, and the duration of hospital stay for both groups.

(3) Pulmonary function indicators
Compare pulmonary function indicators between the two groups before treatment and one week after treatment. A pulmonary function tester (Shandong Boke Conservation Technology Co. Ltd., registration number Shandong Machinery Registration No. 20212071169) was used to measure tidal volume, vital capacity, and peak expiratory flow (PEF).

(4) Inflammatory indicators
Measure white blood cell count (WBC) and C-reactive protein (CRP) levels before and after treatment.

(5) Adverse reactions
Document adverse reactions, including nasal bleeding, paroxysmal cough, and cyanosis.

Statistical methods

Data were analyzed using SPSS 22.0 statistical software (IBM, Armonk, NY, USA). Measurement data are presented as x±s, and comparisons were made using the t-test. Count data are presented as percentages (%), and comparisons were made using the x^2 test, with $p < 0.05$ indicating statistically significant differences.

Results

Comparison of clinical efficacy

The overall efficacy rate in the experimental group was significantly higher than that in the control group ($p<0.05$) (Table 2).

Clinical indicators

After treatment, the times for cough relief, resolution of lung rales, fever reduction, and hospital stay were significantly shorter in the experimental group compared to the control group ($p<0.05$) (Table 3).

Table 2 Comparison of patient efficacy in the two groups (n%).

Group	*n*	Significant effect	Effective	Ineffective	Total effective rate
Experimental group	50	26(52.00)	23(46.00)	1(2.00)	49(98.00)
Control group	50	24(48.00)	17(34.00)	9(18.00)	41(82.00)
x^2	-	-	-	-	7.111
p	-	-	-	-	0.008

Table 3 Comparison of the clinical indicators ($\bar{x} \pm s$, d)

Group	*n*	Cough relief time	Time to lung rale relief	Fever relief time	Length of stay
Experimental group	50	7.20±1.43	9.16±1.40	6.35±1.17	7.60±1.10
Control group	50	8.10±1.95	11.34±1.62	7.23±1.67	9.35±0.65
t	-	2.652	7.172	3.052	9.709
p	-	0.009	< 0.001	0.003	< 0.001

Lung function indicators

One week after treatment, the levels of tidal volume, vital capacity, and peak expiratory flow (PEF) in the experimental group were significantly higher compared to those in the control group ($p<0.05$) (Table 4).

Inflammatory indicators

Post-treatment white blood cell count (WBC) and C-reactive protein (CRP) levels in the experimental group were lower than those in the control group ($p<0.05$) (Table 5).

Adverse reactions

The incidence of complications in the experimental group was lower than that in the control group ($p<0.05$) (Table 6).

Discussion

Mycoplasma pneumoniae pneumonia (MPP) is a common respiratory disease in children caused by an infection with *Mycoplasma pneumoniae*, which leads to poor prognosis and a high risk, posing a serious threat to children's health.[10] After invading the lungs, *Mycoplasma* destroys mucosal epithelial cells, affects bronchial ciliary movement, and induces an inflammatory response. Concurrently, tracheal congestion and edema, along with increased airway secretions, impair lung ventilation function and can cause extrapulmonary symptoms such as myocarditis.[11] Due to the lack of a cell wall in *Mycoplasma*, macrolide antibiotics are generally used for treatment. However, while antibiotics can kill the pathogens, their effectiveness in improving ventilation function and reducing inflammation is limited. Therefore, finding more effective treatment methods is crucial.[12]

Budesonide is a commonly used inhaled corticosteroid in clinical settings that can reduce airway and pulmonary inflammation and promote the recovery of ciliated epithelial cell function. Electronic fiberoptic bronchoscope alveolar lavage is a treatment method that uses sterile saline to wash the bronchoalveolar space to obtain and remove secretions. This procedure is safe and effective, making it widely applied in clinical practice.[13] Therefore, this study combined bronchoalveolar lavage with medication therapy to improve clinical efficacy and alleviate the condition in pediatric patients. The results showed that the total effective rate in the experimental group was significantly higher than that in the control group. This indicates that electronic fiberoptic bronchoscope alveolar lavage combined with budesonide can effectively improve tracheal ventilation and gas exchange functions in children with

Table 4 Comparison of the pulmonary function indicators ($\bar{x} \pm s$).

		Tidal volume (mL)		Vital capacity (L)		PEF (L/min)	
Group	*n*	Before treatment	1 week after treatment	Before treatment	1 week after treatment	Before treatment	1 week after treatment
Experimental group	50	238.72±30.20	426.30±30.47	1.08±0.24	1.98±0.30	104.62±15.30	207.18±20.47
Control group	50	237.96±30.05	409.25±30.62	1.06±0.26	1.59±0.31	104.32±15.23	195.12±20.56
t	-	0.125	2.792	0.400	6.345	0.096	2.939
p	-	0.901	0.006	0.690	< 0.001	0.924	0.004

Table 5 Comparison of the levels of inflammation indicators ($\bar{x} \pm s$).

		WBC($\times 10^9$/L)		CRP(mg/L)	
Group	*n*	Before treatment	After treatment	Before treatment	After treatment
Experimental group	50	12.40±1.22	7.14±1.45	30.25±2.25	6.15±0.54
Control group	50	12.88±1.35	8.30±1.85	29.88±2.64	6.94±0.68
t	-	1.828	3.499	0.774	6.423
p	-	0.071	< 0.001	0.441	< 0.001

Table 6 Comparison of the complications (*n*%).

Group	*n*	Nosebleed	Paroxysmal cough	Cyanosis	Total
Experimental group	50	1(2.00)	1(2.00)	0	2(4.00)
Control group	50	3(6.00)	5(10.00)	3(6.00)	11(22.00)
x^2	-	-	-	-	7.162
p	-	-	-	-	0.007

Mycoplasma pneumoniae pneumonia. The analysis suggests that electronic fiberoptic bronchoscope alveolar lavage, performed via endoscopy, effectively reaches the trachea, bronchi, and lungs. It clears respiratory secretions, relieves airway obstruction, and removes bronchial foreign bodies. The procedure involves performing bronchoalveolar lavage at the affected sites, recovering small airway and alveolar lavage fluids, and removing mucus plugs to facilitate airway patency and enhance pulmonary gas exchange functions. Additionally, budesonide, as a corticosteroid, possesses anti-inflammatory, anti-allergic, and bronchospasm-relieving properties. It can mitigate pulmonary mucosal inflammatory responses and alleviate discomfort caused by inflammation. Local administration of budesonide via electronic fiberoptic bronchoscope after alveolar lavage allows the drug to directly target tracheal and pulmonary lesions, exerting potent pharmacological effects. The combined use of both methods can produce synergistic effects, enhancing anti-inflammatory and anti-infective outcomes, improving pulmonary ventilation function, reducing airway oxidative stress and inflammatory responses, decreasing capillary permeability, and boosting immune function.[14,15] Therefore, the combined efficacy of electronic fiberoptic bronchoscope alveolar lavage and budesonide is superior to using bronchoalveolar lavage alone. The overall effective rate in the experimental group was higher than that in the control group. After treatment, the times for relief of symptoms such as cough, lung rales, and fever, as well as the duration of hospital stay, were significantly shorter in the experimental group compared to the control group. This indicates that electronic fiberoptic bronchoscope alveolar lavage combined with local administration of budesonide can alleviate clinical symptoms more rapidly and expedite recovery in pediatric patients. Alveolar lavage involves injecting lavage fluid into the alveolar space and repeatedly washing it out, thereby reducing the number of *Mycoplasma* adhered to the lungs and clearing accumulated inflammatory secretions, which improves symptoms and restores lung ventilation function.[16,17] Additionally, with the aid of the electronic fiberoptic bronchoscope, thorough and clear observation of the airway and lesions during the procedure significantly enhances the clearance of inflammatory secretions. Concurrently, the local administration of budesonide increases drug concentration at the lesion site, effectively and rapidly killing pathogens.[18] Furthermore, the high concentration of the drug at the lesion site exerts anti-inflammatory effects and relieves bronchospasm, thereby improving drug absorption in the affected tissue and enhancing therapeutic outcomes. This improves alveolar gas exchange efficiency, increases lung capacity, corrects hypoxia, and accelerates symptom relief.[19,20] In Li Ya's study, children with refractory *Mycoplasma pneumoniae* pneumonia (RMPP) in the control group received conventional symptomatic treatment and budesonide suspension aerosol inhalation. In contrast, children in the study group received budesonide suspension bronchoscopic lavage in addition to the treatment regimen of the control group. The results showed that the overall effective rate of treatment in the study group was higher than that in the control group. Additionally, the time to fever reduction, cough relief, disappearance of lung rales, and hospital stay were all shorter in the study group compared to the control group.[7] This demonstrated that budesonide suspension combined with bronchoscopic lavage can improve clinical symptoms, enhance ventilation function, and accelerate the recovery of children's health. Budesonide suspension is a glucocorticoid that enhances the stability of lysosomal membranes in endothelial and smooth muscle cells, inhibits immune responses, reduces antibody synthesis, and decreases enzymatic processes caused by antigen-antibody binding. It inhibits the synthesis and release of bronchoconstrictors, thereby reducing smooth muscle contraction reactions, minimizing capillary leakage, exerting strong local anti-inflammatory effects, and repairing damaged airways.[21,22] Using bronchoalveolar lavage can effectively remove inflammatory secretions from children's respiratory tracts. When combined with glucocorticoids, it can significantly reduce mucosal edema, promote sputum dissolution, enhance local anti-inflammatory effects, and thereby improve clinical symptoms. This is consistent with the results of the present study.

One week after treatment, the levels of tidal volume, vital capacity, and PEF in the experimental group were higher than those in the control group. This improvement is due to fiberoptic bronchoscopy lavage, which allows for clear observation of lesion sites under direct vision through the fiberoptic bronchoscope. By repeatedly lavaging with physiological saline and using negative pressure suction, inflammatory secretions in the airways can be cleared, enhancing alveolar gas exchange efficiency and increasing vital capacity. This corrects the body's hypoxic state and accelerates symptom relief. Simultaneously, instilling budesonide locally through fiberoptic bronchoscopy alveolar lavage increases the drug concentration at the lesion site, enabling effective and rapid antibacterial treatment. The high concentration of the drug at the lesion site can combat allergies, reduce inflammation, and alleviate bronchial spasms, thereby enhancing drug absorption in the affected tissue and improving clinical outcomes. As a result, the pulmonary indicators in the experimental group were better than those in the control group after treatment. Post-treatment levels of WBC and CRP were lower in the experimental group than in the control group, indicating that the combined approach can mitigate the inflammatory response. Controlling inflammation in Mycoplasma pneumonia primarily relies on removing inflammatory secretions, exudates, and pathogens from the patient's lungs. The electronic fiberoptic bronchoscope not only effectively clears these elements but also disrupts the proliferation base of pathogenic microorganisms, reduces inflammatory damage, and significantly improves ventilation and blood circulation in the infected area. This notably ameliorates hypoxic and ischemic conditions at the infection site and inhibits the secretion of various inflammatory factors.[23,24] Inhaled budesonide suspension targets multiple aspects of airway inflammation, reducing the levels of inflammatory cytokines and cellular infiltration. Therefore, the combination of electronic fiberoptic bronchoscope alveolar lavage and budesonide significantly reduces the levels of inflammatory factors in pneumonia patients.[25] The incidence of complications in the experimental group was lower, indicating that the combined use of bronchoscopy alveolar lavage and budesonide is relatively safe. However, this study has limitations, such as a small sample size and insufficient

consideration of patients' underlying conditions and general characteristics. Moreover, due to the young age of the study subjects, fewer pronounced adverse reactions were observed. More definitive conclusions require support from large-sample data. Future studies should increase the sample size and conduct multi-center research to enhance the accuracy of the results.

Conclusion

In summary, the combination of electronic fiberoptic bronchoscope alveolar lavage and local administration of budesonide in treating pediatric *Mycoplasma pneumoniae* pneumonia can improve efficacy, enhance clinical indicators, reduce inflammation, and ensure safety. This method is worthy of clinical promotion and application.

Conflict of interests

The authors declare no conflict of interest.

Ethics approval

Ethical approval was obtained from the Ethics Committee of Anhui Provincial Children's Hospital.

Consent to participate statement

Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Data availability

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

FX and QZ designed the study and carried them out, FX, QZ, FC supervised the data collection, FX, QZ analyzed the data, interpreted the data, FX and QZ prepare the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

References

1. Wang F, Cheng Q, Duo H, Wang J, Yang J, Jing S, et al. Childhood *Mycoplasma pneumoniae*: epidemiology and manifestation in Northeast and Inner Mongolia, China. Microbiol Spectr. 2024;e0009724–e0009724. https://doi.org/10.1128/spectrum.00097-24
2. Seda HD, Halil Ö, Şükriye Y, Gül A, Kübra KH, Ceren KZ, et al. Evaluation of the epidemiological, clinical and radiological features of pneumonia cases caused by *Mycoplasma pneumoniae* in childhood. Mikrobiyoloji Bult. 2023;57(1):14–29. https://doi.org/10.5578/mb.20239902
3. Bo L, Xu C, Ningsheng Y. Clinical analysis of the epidemiology and changes in inflammatory indexes of Mycoplasma pneumonia in acute and recovery stage pediatric patients. Transl Pediatr. 2022;11(10):1645–1655. https://doi.org/10.21037/tp-22-416
4. Peng L, Wei W, Xianhui Z, Jie P, Lina G. Observational retrospective clinical study on clinical features of macrolide-resistant *Mycoplasma pneumoniae* pneumonia in Chinese pediatric cases. Sci Rep. 2024;14(1):5632–5632. https://doi.org/10.1038/s41598-024-55311-2
5. Ying C, Yan Z, Ni TQ, Bo SH. Efficacy of doxycycline therapy for macrolide-resistant *Mycoplasma pneumoniae* pneumonia in children at different periods. Italian Journal of Pediatrics. 2024;50(1):38. https://doi.org/10.1186/s13052-024-01615-y
6. Le W, Sukun L, Yinghui G, Jianhua L, Peng W, Shuo Y. Comparative study of diagnostic efficacy of sputum and bronchoalveolar lavage fluid specimens in community-acquired pneumonia children treated with fiberoptic bronchoscopy. BMC Infect Dis. 2023;23(1):565. https://doi.org/10.1186/s12879-023-08522-3
7. Ya L, Wei Y, Xin W, Xiaohua G. Effect of bronchofiberscopic lavage with budesonide suspension on refractory *Mycoplasma pneumoniae* pneumonia. Pak J Med Sci. 2022;38(4Part-II):922–927. https://doi.org/10.12669/pjms.38.4.4835
8. Yanli W, Kai L, Chuangui C, Chengyun Z. Acetylcysteine and budesonide for the treatment of refractory *Mycoplasma pneumoniae* pneumonia in children: a clinical observation. Ital J Pediatr. 2023;49(1):80–80. https://doi.org/10.1186/s13052-023-01491-y
9. Chen J, Zhu Y, Zheng C, Zhao W, Liu Q. Clinical efficacy of budesonide combined with acetylcysteine in the treatment of *Mycoplasma pneumoniae* infection. Immunol Inflam Dis. 2023;11(11):e1068–e1068. https://doi.org/10.1002/iid3.1068
10. Xiang Wq, Xu Jl, Aliahmed F, Chen Yh, Li W. Epidemiological Characteristics of *Mycoplasma pneumoniae* in Hospitalized Children with Pneumonia in Hangzhou, China. Iran J Pediatr. 2020;30(2). https://doi.org/10.5812/ijp.99960
11. Xu M, Li Y, Shi Y, Liu H, Tong X, Ma L, et al. Molecular epidemiology of *Mycoplasma pneumoniae* pneumonia in children, Wuhan, 2020-2022. BMC Microbiol. 2024;24(1):23. https://doi.org/10.1186/s12866-024-03180-0
12. Leng M, Yang J, Liu X. Macrolide-resistant *mycoplasma pneumoniae* infection in children observed during a period of high incidence in Henan, China. Heliyon. 2024;10(13):e33697–e33697. https://doi.org/10.1016/j.heliyon.2024.e33697
13. Akira Y, Machiko A, Hiromasa T, Fumiaki T, Chikatoshi S, Hiromitsu S, et al. Impact of bronchoalveolar lavage lymphocytosis on the effects of anti-inflammatory therapy in idiopathic non-specific interstitial pneumonia, idiopathic pleuroparenchymal fibroelastosis, and unclassifiable idiopathic interstitial pneumonia. Respir Res. 2021;22(1):115. https://doi.org/10.1186/s12931-021-01726-8
14. Sa RN, Wang AQ, Gao YH, Li XA, Hugejiletu. Efficacy of bronchoalveolar lavage combined with prone positioning in children with *Mycoplasma pneumoniae* pneumonia and atelectasis: a prospective randomized controlled study. Chin J Contemp Pediatr. 2024;26(1):31–36.
15. Qian W, Wei Z. Clinical effect analysis of budesonide atomization inhalation in the treatment of neonatal pneumonia. MEDS Clin Med. 2023;4(7). https://doi.org/10.23977/medsc.2023.040715

16. Xiang W, Zuozhou X, Jinhong Z, Yi L. Analysis of clinical symptoms improvement in treatment of severe pneumonia caused by multi-drug resistant bacterial infection by bronchoscopy alveolar lavage. J Clin Nurs Res. 2021;5(4):180–184. https://doi.org/10.26689/jcnr.v5i4.2301
17. Hua XX, Feng FH, Ting ST, Yuan YD, Li H, hui JW, et al. Influence of the timing of bronchoscopic alveolar lavage on children with adenovirus pneumonia: a comparative study. BMC Pulm Med. 2021;21(1):363. https://doi.org/10.1186/s12890-021-01708-y
18. Huajun Z, Congling S, Zhongcui Y. Effect of azithromycin sequential therapy combined with budesonide nebulization on chest CT changes in children with *Mycoplasma pneumonia*. Minerva Gastroenterol. 2023;69(3):447–449. https://doi.org/10.23736/S2724-5985.23.03373-9
19. Yu Y, Chen C. Clinical observation of aerosol inhalation of azithromycin combined with budesonide suspension in the treatment of *Mycoplasma pneumoniae* pneumonia in children. Panminerva Med. 2021. https://doi.org/10.23736/S0031-0808.20.04260-3
20. Wang C, Feng G, Yang S, Zhang Y. The efficacy of budesonide nebulized inhalation combined with antibiotics in the treatment of pneumonia. Minerva Surg. 2024. https://doi.org/10.23736/S2724-5691.24.10224-9
21. Rokkas T, Niv Y, Malfertheiner P. A network meta-analysis of randomized controlled trials on the treatment of eosinophilic esophagitis in adults and children. J Clin Gastroenterol. 2021;55(5):400–410. https://doi.org/10.1097/MCG.0000000000001356
22. Vizarraga D, Torres-Puig S, Aparicio D, Pich OQ. The Sialoglycan Binding Adhesins of Mycoplasma genitalium and *Mycoplasma pneumoniae*. Trends Microbiol. 2021;29(6):477–481. https://doi.org/10.1016/j.tim.2021.01.011
23. Linjuan T, Yunping W, Dong W, Wei L, Yongding W, Zhihe Z, et al. Application of fiberoptic bronchoscopy assisted local injection of budesonide in improving the prognosis of severe pneumonia. Minerva Med. 2021;115(1):88–89. https://doi.org/23736/S0026-4806.21.07609-6.
24. Wang C, Ye S, Wang X, Zhao Y, Ma Q, Wang L. Clinical efficacy and safety of mechanical ventilation combined with fiberoptic bronchoalveolar lavage in patients with severe pulmonary infection. Med Sci Monit. 2019;25:5401. https://doi.org/10.12659/MSM.915507
25. Guoqing L, Ran M. Clinical efficacy of budesonide combined with ambroxol in the treatment of neonatal aspiration pneumonia. Basic Clin Pharmacol Toxicol. 2021;128161–161.