ORIGINAL RESEARCH ARTICLE

Effect of an airway clearance technique in the treatment of children with severe pneumonia

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Abstract

This was a research study, mainly explored the effect of an airway clearance technique (ACT) in treating children with severe pneumonia. One hundred children with severe pneumonia who accepted therapy in Shulan (Hangzhou) Hospital Affiliated to Zhejiang Shuren University Shulan International Medical College from January 2023 to January 2024 were selected and randomly divided into a control group and observation group. The control group accepted anti-inflammatory, cough, phlegm and asthma treatment, while the observation group accepted ACT therapy including anti-inflammatory, cough, phlegm, and asthma treatment. As compared to the control group, the observation group presented better total effective rate, shorter cough and sputum relief time, defervescence time, length of hospital stay, lung rale and disappeareance time, and lung shadow disappearance time. The observation group also had higher peak expiratory flow (PEF), forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) levels, higher cough reflex, secretion viscosity and secretion volume scores, higher arterial oxygen pressure (PaO_2) and arterial oxygen saturation (SaO_2) levels as well as lower levels of inflammatory markers. We conclude that, the clinical efficacy of ACT for treatment of children with severe pneumonia is remarkable, which can improve related symptoms, improve lung function and blood gas indices, repress inflammation, and promote airway recovery.. *(Afr J Reprod Health 2025; 29 [4]: 142-149).*

Keywords: severe pneumonia; airway clearance technique; children; lung function; blood gas indexes; inflammatory response

Résumé

Il s'agissait d'une étude de recherche, principalement axée sur l'étude de l'effet d'une technique de dégagement des voies aériennes (ACT) dans le traitement des enfants atteints de pneumonie sévère. Cent enfants atteints de pneumonie sévère ayant suivi un traitement à l'hôpital Shulan (Hangzhou) affilié au Collège médical international Shulan de l'université Shuren du Zhejiang de janvier 2023 à janvier 2024 ont été sélectionnés et répartis aléatoirement en un groupe témoin et un groupe d'observation. Le groupe témoin a suivi un traitement anti-inflammatoire, contre la toux, les mucosités et l'asthme, tandis que le groupe d'observation a suivi un traitement ACT comprenant un traitement anti-inflammatoire, contre la toux, les mucosités et l'asthme. Par rapport au groupe témoin, le groupe d'observation a présenté un meilleur taux d'efficacité total, un temps de soulagement de la toux et des expectorations plus court, un temps de défervescence, une durée d'hospitalisation, un râle pulmonaire et un temps de disparition, ainsi qu'un temps de disparition de l'ombre pulmonaire. Le groupe d'observation présentait également des débits expiratoires de pointe (DEP), des volumes expiratoires maximums (VEMS) et des capacités vitales forcées (CVF) plus élevés, des scores de réflexe de toux, de viscosité et de volume de sécrétion plus élevés, des pressions artérielles en oxygène (PaO2) et de saturation artérielle en oxygène (SaO2) plus élevées, ainsi que des taux plus faibles de marqueurs inflammatoires. Nous concluons que l'efficacité clinique de l'ACT dans le traitement des enfants atteints de pneumonie sévère est remarquable, car elle peut améliorer les symptômes associés, la fonction pulmonaire et les gaz du sang, réduire l'inflammation et favoriser la récupération des voies respiratoires.. *(Afr J Reprod Health 2025; 29 [4]: 142-149).*

Mots-clés: Espérance de vie; mortalité des moins de cinq ans, inégalité entre les sexes; travail indépendant.

Introduction

As a common infectious disease in children, severe pneumonia has a high incidence of 7%-13%[1]. Severe pneumonia in children is a syndrome with lung infection as the main manifestation[2].

Due to the relatively low body immunity, imperfect respiratory function, the lungs of children are easily invaded by bacteria or viruses, leading to inflammation and infection[3]. Severe pneumonia develops rapidly and progresses rapidly. It is characterized by multiple organ dysfunction, rapid

heart rate, irritability, pallor, cyanosis low and dull heart sound, liver enlargement and other systemic manifestations which can lead to respiratory failure and hypoxemia, and seriously threaten their life safety[4].

Under normal circumstances, the mucosal tissue of the respiratory tract itself secretes a certain amount of mucus to keep the respiratory tract in a humid environment[5]. When children are infected with severe pneumonia, the function of human cilia will be affected, resulting in blocked discharge of secretions, which may cause the secretion to remain in the airway, increasing the risk of infection, and then causing inflammation and damage to the soft tissue and airway[6]. It is even more harmful for newborns who can only breathe nasally, increasing the risk of respiratory distress[7]. Therefore, maintaining normal airway clearance is the fundamental treatment of severe pneumonia.

Airway clearance technique (ACT) refers to the methods and techniques that facilitate the removal of respiratory secretions to facilitate airway clearance[8]. ACT primarily promotes the discharge of airway secretions by physical or mechanical means to help improve ventilation and gas exchange[9]. There are some difficulties in the application of ACT in children[10]. Due to the difference between children's and adults' airways, careful operation should be carried out in accordance with the characteristics of children's airways, and many factors such as children's cooperation, parents' understanding and interaction should also be taken into account[11].

This study intended to explore the effects of ACT in treating children with severe pneumonia. Our study indicated that the clinical efficacy of ACT for children with severe pneumonia was remarkable, which could improve related symptoms, improve lung function and blood gas indexes, repress inflammation and promote airway recovery. Our study may provide a novel sight for the treatment of children with severe pneumonia.

Methods

One hundred children with severe pneumonia accepted therapy in Shulan (Hangzhou) Hospital Affiliated to Zhejiang Shuren University Shulan International Medical College from January 2023 to January 2024 were chosen. They were randomly divided into a control group (CG, n=50) and an observation group (OG, n=50) based on the different treatment methods. The OG consisted of 26 boys and 24 girls, aged 3 months-6 years, with a mean age of (2.8±0.6) years. The duration of the disease in the OG was 1-5 days, with an average of (2.7±0.6) days. The CG comprised 25 boys and 25 girls, aged 4 months-6 years, with a mean age of (2.9±0.6) years. The duration of the disease in the OG was 1-6 days, with an average of (2.7±0.6) days. No difference was seen in general information between the two groups (P>0.05).

The inclusion criteria were: (1) children who met the diagnostic criteria for severe pneumonia; confirmed by CT and laboratory examination; (2) those aged 3 months to 6 years; (4) patients met the criteria for ACT therapy.

The exclusion criteria were: (1) children with congenital pulmonary hypoplasia; (2) those with severe hepatic and renal insufficiency; (3) children with allergic constitution; (4) those with immune dysfunction; (5) those Combined with coagulation dysfunction and congenital heart disease; and (6) children experiencing extrapulmonary infection. The parents of the children understood the content of this study and signed the informed consent voluntarily.

Procedures

Children in the control group accepted anti-inflammatory, cough, phlegm and asthma treatment. Children in the observation group accepted ACT therapy based on anti-inflammatory, cough, phlegm, and asthma treatment. The children were seated, the appropriate size of the sputum discharge vest was used according to different age groups of the children, the shoulder pouch and front lock were adjusted, and the position of the vibrating air bag was wrapped upwards in the chest as far as possible, so that the vest could fit comfortably with the children, and the tightness should accommodate a palm to a fist, and then the machine was manually adjusted, and the frequency was divided into 0~6 months and 2~4 Hz according to age. The frequency was 3-6 Hz for 6 to 12 months, and 5-10 Hz for 1 to 3 years old, and the intensity was the highest level that did not cause discomfort to the child. The treatment time was 10 minutes, twice a day. Based on the patient's condition, the patients were considered to continue for 5-7 days.

Observed indicators

These were the following:
(1) The clinical efficacy in the two groups was compared. These were: Obvious effects the symptoms and signs of severe pneumonia such as respiratory failure, accelerated heart rate and increased lung rales were significantly improved, and X-ray films showing no obvious shadow in the lungs. Effective: The signs and symptoms of severe pneumonia were improved, and the X-ray displayed that the shadow area of the lung was reduced by >50%. Ineffective: The above criteria were not met. Total effective rate = (obvious effect + effective) number of cases/total number of cases ×100%.

(2) During the intervention period, the recovery time of various symptoms and signs of the children was observed, including time of relief of cough and sputum, defervescence, length of hospital stay and disappearance of lung rale and lung shadow.
(3) Lung function. Peak expiratory flow (PEF), forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) were detected using the BK-LFT-I lung function detector produced by Shandong Brocade Medical (https://www.biobase.cn/productDetail-1300.html?Id=1300). (4) The airway grading scale was used for assessing the condition of airway recovery, which consisted of three dimensions: cough reflex, secretion viscosity and secretion volume, with a score of 0 to 5 for each dimension. The higher score represented better airway recovery. (5) Levels of blood gas indices. 2 mL of radial artery blood was obtained from the children, and arterial oxygen pressure (PaO2) and arterial oxygen saturation (SaO2) were detected by fluorescence method using a blood gas analyzer (Meizhou Cornley High-Tech Co., Ltd., model: BG-800) (http://www.cornley.com/products-show-31.html).
(6) Levels of inflammatory factors were compared between 2 groups. Utilizing enzyme-linked immunosorbent assay, the levels of C-reactive protein (CRP), tumor necrosis factor-α (TNF-α), along with interleukin 6 (IL-6) were examined.

Statistical analysis

SPSS 24.0 statistical software was adopted for data analysis. Measurement data were exhibited as (x±s), followed by comparison using t-test. Count data were expressed as (n, %), followed by comparison using χ^2 test. $P<0.05$ meant statistical significance.

Ethical consideration

Our study was approved by the Ethics Committee of Shulan (Hangzhou) Hospital Affiliated to Zhejiang Shuren University Shulan International Medical College. The Ethical number was 2021L-0221, and Ethical date was February 2021.

Results

Clinical efficacy in the two groups

As shown in Table 1, when compared to the CG, the OG presented better total effectiveness rate ($P<0.05$).

Improvement time of symptom and sign of children in 2 groups

The results in Figure 1 show that relative to the CG, the OG had shorter cough and sputum relief time, defervescence time, length of hospital stay, lung rale and disappeared time and lung shadow disappeared time ($P<0.01$).

Lung function in the two groups

The results in Figure 2 indicate that there were no differences in PEF, FEV_1 and FVC levels between the two groups before therapy ($P>0.05$). After therapy, PEF, FEV_1 and FVC levels were elevated in two groups, but relative to the CG, the OG had higher PEF, FEV_1 and FVC levels ($P<0.05$).

Condition of airway recovery in the two groups

As shown in Figure 3, there were no differences in cough reflex, secretion viscosity and secretion volume scores between the two groups before therapy ($P>0.05$). After therapy, cough reflex, secretion viscosity and secretion volume scores increased in the two groups, but when compared to the CG, the OG had higher cough reflex, secretion viscosity and secretion volume scores ($P<0.05$).

Levels of blood gas indices in the two groups

The results in Figure 4 indicate that there were no differences in PaO_2 and SaO_2 levels between the two groups before therapy ($P>0.05$). After therapy, PaO_2 and SaO_2 levels were elevated in both groups, but relative to the CG, the OG had higher levels of blood gas indices ($P<0.05$).

Table 1: Clinical efficacy in the two groups

Groups	N	Obvious effect	Effective	Ineffective	Total effective rate
Control group	50	24 (48.0)	16 (32.0)	10 (20.0)	40 (80.0)
Observation group	50	30 (60.0)	28 (56.0)	2 (4.0)	48 (96.0)
χ^2					6.1
P					0.0

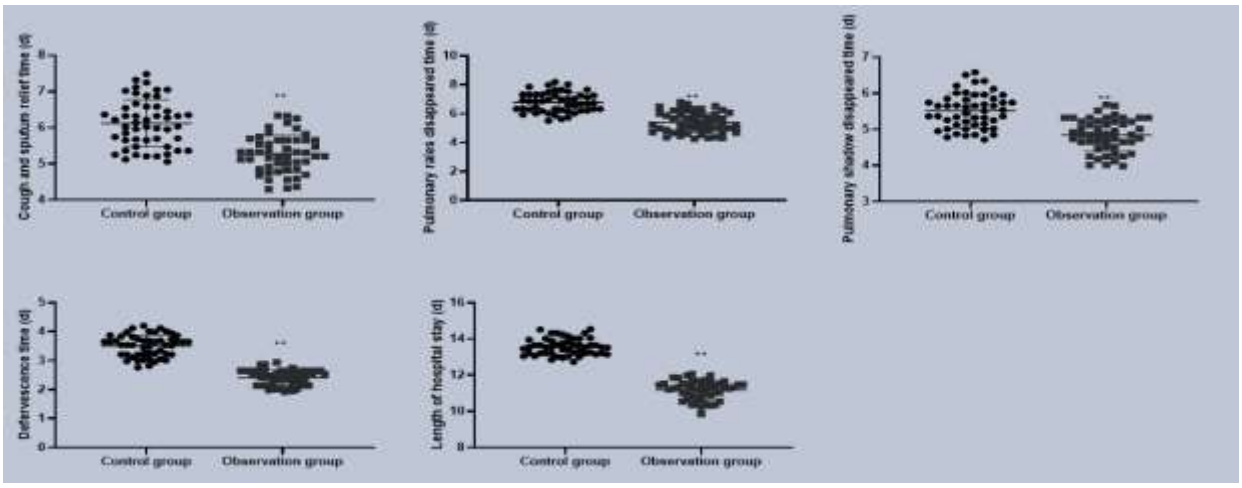

Figure 1: Improvement time of symptom and sign of children in 2 groups. **P<0.01.

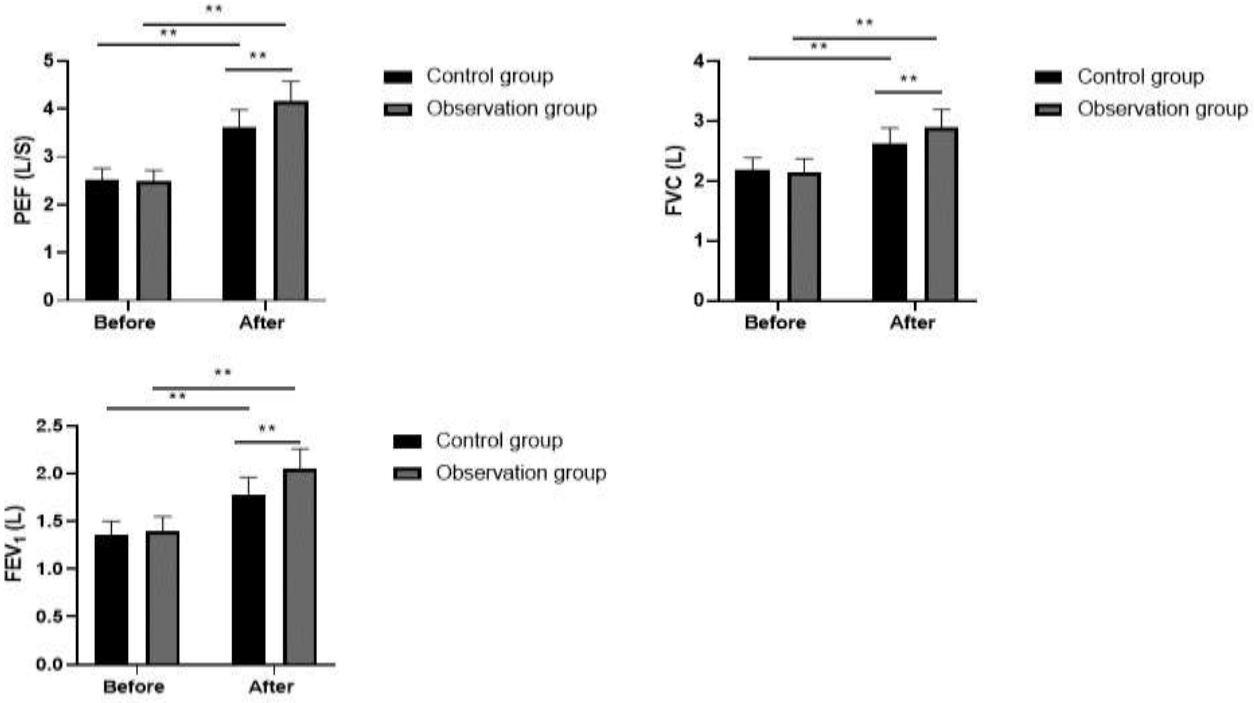

Figure 2: Lung function in 2 groups. **P<0.01.

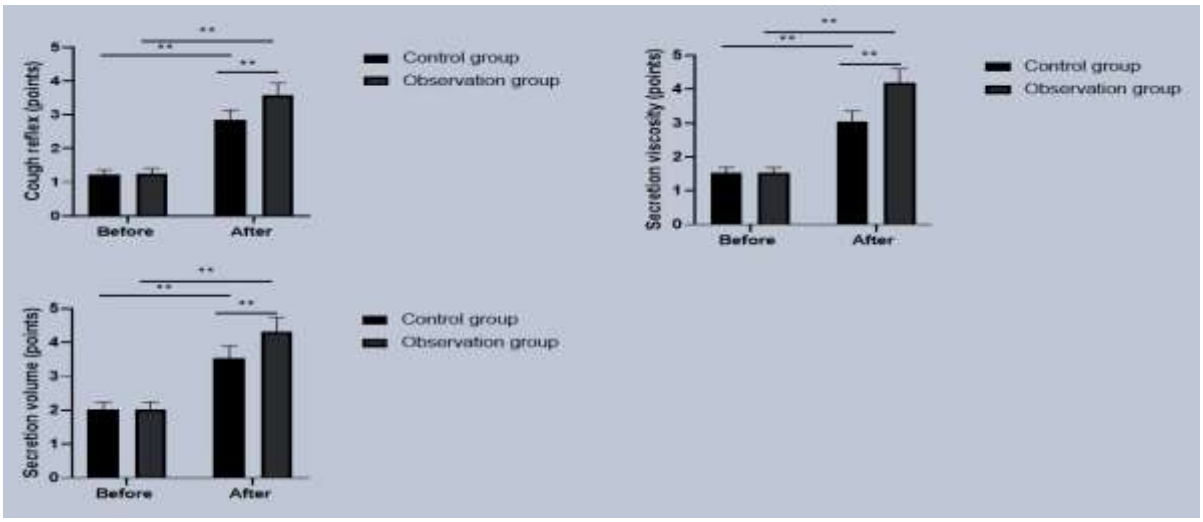

Figure 3: Condition of airway recovery in 2 groups. **P<0.01.

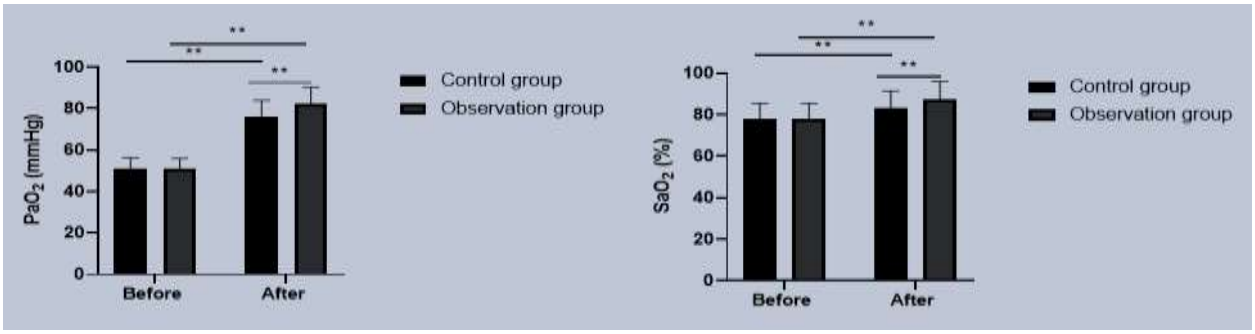

Figure 4: Levels of blood gas indexes in 2 groups. **P<0.01.

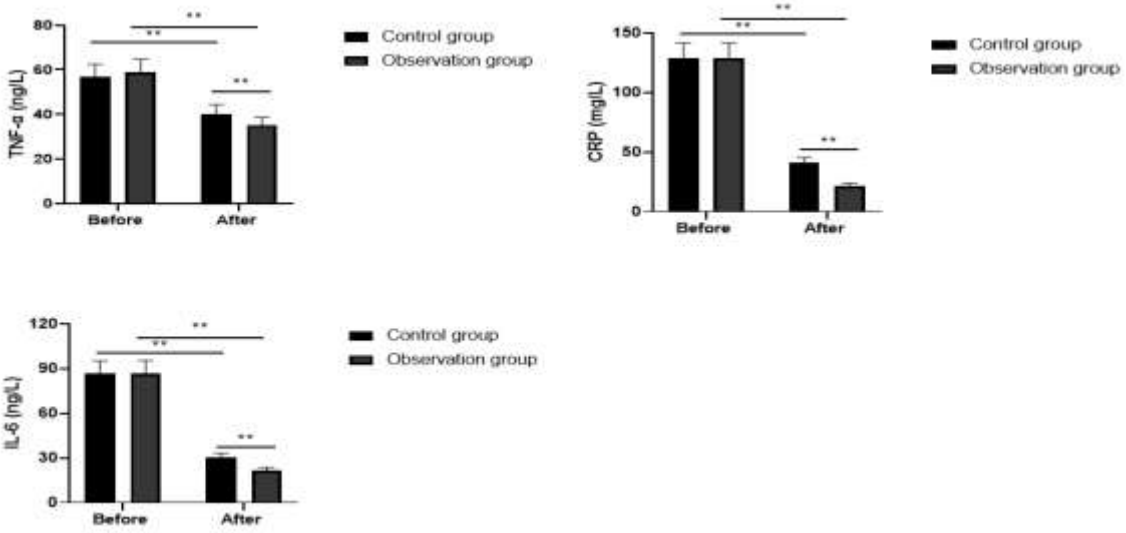

Figure 5: Levels of inflammatory factors in 2 groups. **P<0.01.

Levels of inflammatory factors in the two groups

As shown in Figure 5, there were no differences in the levels of inflammatory markers between the two groups before therapy (P>0.05). After therapy, CRP, TNF-α along with IL-6 levels were reduced in the two groups. However, relative to the CG, the OG had lower levels of inflammatory markers (P<0.05).

Discussion

Severe pneumonia is mostly caused by virus or bacterial infection, and results in the respiratory tract secreting a large amount of sputum under the stimulation of pathogenic bacteria[12]. As for children with severe pneumonia, the movement of bronchial cilia is reduced which makes it difficult for them to push sputum away from the lung This causes large amount of sputum to accumulate in the respiratory tract, which affects the breathing of children[13]. Therefore, timely and effective removal of sputum is essential to improve the respiration of children with severe pneumonia.

ACTs are divided into peripheral ACT and proximal ACT[14]. Peripheral ACT mainly promotes the ventilation of children to accelerate the loosening of secretions and promote the movement of loose secretions to the central airway[15]. In contrast, proximal ACT is used to assist inhalation, exhalation, or a combination of the two, ultimately to enhance the child's cough and discharge of secretions, especially for children with significantly reduced cough ability[16]. The treatment method of peripheral ACT is usually used because the patient has excessive sputum in the airway in the early stage, resulting in breathing difficulties and symptoms of hypoxia[17].

This study focused on four physiotherapy techniques: chest tapping and chest vibration, modified postural drainage, active circulation breathing, and positive expiratory pressure. The commonly used chest tapping methods include manual tapping on the back and tapping on the sputum dispenser, with a frequency of about 10 min, 2 times/d. The specific choice is also be based on the degree of cooperation of the child, the two methods have advantages and disadvantages, and can be utilized to the clinical common respiratory diseases of airway high secretion, but the acute phase of the disease and intolerance should be excluded[18]. Artificial back tapping can be used for home nursing of children, because it is not limited by location and equipment, and it is easy to operate[19]. The modified postural drainage uses gravity to drain secretions in order to prevent gastroesophageal reflux in children, and changes the head position to a high or horizontal position[20]. Active cycle of breathing technique (ACBT) is a method that combines abdominal breathing, chest expansion exercises, and forced exhalation exercises to remove respiratory secretions[21]. In this study, individual choices were made according to the basic condition, age and degree of cooperation of patients, which can be studied individually or applied jointly.

In our study, the results indicated that in comparison with the CG, the OG presented better total effective rate and shorter the cough and sputum relief time, defervescence time, length of hospital stay, lung rale and disappeared time and lung shadow disappeared time, suggesting that based on traditional treatment, ACT could improve the effective rate of children with severe pneumonia, shorten the hospital stay and improve the clinical effect. Consistently, Magalhães et al. have pointed that ACT is a potential physiotherapy intervention for children with COVID-19/SARS-CoV-2[22]. Besides, our study revealed that after therapy, as comparing with the CG, the OG presented higher PEF, FEV_1 and FVC levels, higher cough reflex, secretion viscosity and secretion volume scores, higher PaO_2 and SaO_2 levels, and lower CRP, TNF-α along with IL-6 levels. All these results suggested that ACT could improve lung function and blood gas indexes, repress inflammation and promote airway recovery in children with severe pneumonia. Likewise, Tambascio *et al.* have suggested that airway clearance device can reduce inflammation, bacteriology and improve mucus transport by coughing in bronchiectasis[23]. Zanni et al. have revealed that ACT can improve the pulmonary function in patients with cystic fibrosis[24].

Strengths and limitations

This was a well-designed, randomized trial with various measurement indicators. Limitations include being a single-center study and limited sample size. Our study reported the clinical efficacy of ACT for children with severe pneumonia, which may provide

a novel sight for the treatment of children with severe pneumonia.

Conclusion

Our study demonstrates that the clinical efficacy of ACT for children with severe pneumonia is remarkable, which can improve related symptoms, improve lung function and blood gas indexes, repress inflammation and promote airway recovery.

Authors contribution

Huang YL and Bo YL: conceived and designed the study, and collected and analysed the data. Huang YL and Bo YL: prepared the manuscript. All authors mentioned in the article approved the manuscript

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