Original Article

Clinical Research on Modified Postural Drainage for Secretion Clearance in Infants with Wheezing Bronchitis

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Abstract

Background: Wheezing bronchitis is common in infants and can lead to complications if not properly managed. Postural drainage is a standard technique for secretion clearance, but the optimal protocol remains debated. **Aims:** This study aims to assess the clinical efficacy and safety of a modified postural drainage nursing protocol for secretion clearance in infants with wheezing bronchitis. **Methods:** This prospective study included 104 infants (six months to three years) hospitalized with wheezing bronchitis between January 2023 and May 2024. Participants were randomly divided into two groups: observation (N = 52, modified protocol) and control (N = 52, conventional protocol). The modified protocol optimized drainage frequency, standardized position transitions, regulated rest periods, and included respiratory training. Key outcomes included the Modified Respiratory Sound Score (MRSS), symptom resolution, radiological improvements, and hospital stay duration. **Results:** On Day four, MRSSs were significantly lower in the observation group (2.2 ± 0.4) compared to the control group (3.5 ± 0.5, $P < 0.001$). Rhonchi, wheezing, and cough resolved more quickly in the observation group ($P < 0.001$ for all). Chest X-ray absorption rates were higher (88.5% vs. 80.8%, $P = 0.035$), and hospital stays were shorter (6.5 ± 1.2 vs. 8.5 ± 1.5 days, $P < 0.001$). Adverse event rates were similar (21.2% vs. 25.0%, $P = 0.641$). **Conclusion:** The modified protocol significantly improved secretion clearance, accelerated symptom resolution, and reduced hospital stays without compromising safety in infants with wheezing bronchitis.

Keywords: *Clinical efficacy, infants, modified postural drainage, nursing intervention, secretion clearance, wheezing bronchitis*

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Introduction

Wheezing bronchitis is one of the most common lower respiratory tract infections in infancy and early childhood, characterized by airway inflammation, secretion retention, and bronchial spasm, leading to symptoms such as respiratory distress, wheezing, and coughing.[1,2] A relevant study evaluating 377 children under the age of 2 found that wheezing was the primary cause of hospitalization in 69.2% of cases, with 12.5% having severe bronchiolitis.[3] Due to the anatomical and physiological characteristics of infant airways, including small airway diameter, abundant mucus secretion, and imperfect cough reflex, secretion clearance difficulty becomes a key factor affecting disease outcomes.[4,5]

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Postural drainage is an important non-pharmacological therapeutic approach for promoting secretion clearance, utilizing gravity and chest wall vibration to facilitate secretion movement from small bronchi to larger airways.[6] Although conventional postural drainage protocols have demonstrated moderate efficacy in clinical settings, significant challenges persist regarding procedural standardization, optimal intervention frequency determination, and patient adherence optimization.[7,8] Consequently, optimizing postural

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drainage protocols to improve therapeutic efficacy and safety has become a focus of current research. In recent years, with deeper understanding of infant respiratory physiology, postural drainage techniques have continued to evolve. Li *et al*.[9] found that precise control of drainage position angles significantly improved secretion clearance efficiency. Williams *et al*.[10] reported that appropriate rest period scheduling could improve treatment compliance. Additionally, studies have suggested potential synergistic effects from integrating respiratory training into postural drainage protocols.[11,12] However, there is currently a lack of standardized protocols systematically incorporating these optimization measures, and relevant randomized controlled studies are limited.

Clinical outcomes of respiratory diseases are closely related to airway clearance function.[13] Empirical evidence demonstrates that prompt and efficacious secretion clearance confers multiple therapeutic benefits, including enhanced ventilatory function, attenuated risk of secondary infections, and abbreviated hospitalization periods.[14] Chen *et al*.[15] studied barrier function changes in airway epithelial cells after injury. The study highlighted that epithelial barrier integrity is crucial for mucosal clearance effectiveness, and mechanical factors may help restore ciliary motion and clearance efficiency after injury. These findings provide a theoretical foundation for optimizing postural drainage protocols.

Study rationale

Although the therapeutic value of postural drainage in facilitating secretion clearance among infants with wheezing bronchitis is well-established, current protocols exhibit considerable limitations in standardization and effectiveness, with a lack of standardization in frequency, position transitions, and rest periods. Moreover, there are limited studies that systematically incorporate optimized techniques into a single protocol. This study aims to fill this knowledge gap by evaluating a modified postural drainage protocol designed to improve secretion clearance, symptom resolution, and reduce hospital stays.

Aims/Objectives

This study aims to establish an innovative modified postural drainage nursing protocol, systematically evaluating its clinical efficacy and safety in secretion clearance for infants with wheezing bronchitis through optimized drainage frequency, standardized position transitions, regulated rest periods, and integrated respiratory training.

Materials and Methods

Study population and design

This study was approved by the Lixin County Hospital's Medical Ethics Committee (Approval No.: TZRY-2022-153) and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients' guardians. A total of 104 pediatric patients hospitalized with wheezing bronchitis between January 2023 and May 2024 were enrolled and randomly assigned using a random number table to either the control group (n = 52) or observation group (n = 52). The control group comprised 31 males and 21 females, with a mean age of 17.60 ± 6.06 months (range: six months to three years).

Patients were eligible if they met the diagnostic criteria for wheezing bronchitis according to pediatric bronchitis treatment guidelines, including acute onset with fever and cough, wheezing and tachypnea, presence of wheezing and/or moist rales on lung auscultation, and increased lung markings with enlarged hilum on chest X-ray. Additional inclusion criteria were age between six months and three years, hospital admission within 48 h of onset, and guardians capable of understanding and following medical instructions.

Exclusion criteria included concurrent severe cardiac, hepatic, or renal dysfunction; history of chronic respiratory diseases; concurrent severe pneumonia, pleural effusion, or pneumothorax; contraindications to postural drainage (increased intracranial pressure, severe arrhythmia, massive hemoptysis, spontaneous pneumothorax); history of major surgery or trauma; antibiotic treatment exceeding 24 h prior to admission; use of glucocorticoids or immunosuppressants within two weeks; and poor compliance during the study period.

Treatment protocol

Both groups received standardized treatment according to the pediatric bronchitis treatment guidelines. The standard treatment protocol included continuous low-flow oxygen supplementation (flow rate 1–2 L/min, maintaining oxygen saturation ≥95%); nebulized budesonide suspension (0.5 mg/dose) combined with salbutamol (0.2 mg/kg/dose, maximum 5 mg) every 6 h; appropriate antibiotics based on sputum culture and sensitivity results; maintenance of fluid and electrolyte balance; and symptomatic treatment for fever and cough as needed.

The control group received conventional postural drainage nursing care. Upon admission, specialized nurses conducted assessments to exclude contraindications for postural drainage. Drainage procedures were implemented at 4 h intervals, with individual sessions extending for 20–30 min. Prophylactic bronchodilation was achieved through salbutamol nebulization administered 30 min prior to each procedure to optimize bronchial smooth

muscle relaxation. Modified Clark's drainage positions were employed sequentially for bilateral upper, middle, and lower lobes, maintaining each position for 5–8 min with standardized chest percussion (120 ± 5 beats/min) and vibration. The observation group received a modified postural drainage protocol with the following specifications:

Optimized Drainage Frequency: A complete drainage cycle was strictly implemented every 2 h, totaling 8–10 cycles daily. This frequency was established based on previous research and clinical experience to optimize secretion clearance while preventing fatigue.

Sequential Positioning Protocol: Each cycle consisted of four standardized positions executed in a fixed sequence. The first phase employed a 30° head-up position for precisely 10 min, focusing on upper lobe drainage. The second phase involved a left lateral position with 15° head elevation for 10 min, with the dependent arm flexed forward to facilitate left lung drainage. The third phase mirrored this position on the right side. The final phase utilized a 15° head-down position for 8 min, targeting bilateral lower lobe drainage. All positional angles were verified using electronic goniometers.

Standardized Rest Periods: Structured 8–10 min rest periods were implemented between position transitions. During these intervals, patients maintained a semi-recumbent position with 30° head elevation. Trained nursing staff performed standardized gentle back-patting (100–120 beats/min) while monitoring respiratory status and recovery.

Integrated Respiratory Training: Standardized diaphragmatic breathing exercises were incorporated during drainage positions. A unified breathing pattern was established: 3 s inspiration, 6 s expiration, maintaining a respiratory rate of 6–8 breaths/min. Nursing staff employed abdominal palpation to guide proper technique. For younger infants, toy balloons or specialized breathing training devices were utilized.

Vital Sign Monitoring: Continuous multiparameter monitoring included heart rate (documenting fluctuations within ± 20% of baseline), respiratory rate (maintained within age-appropriate reference ranges), peripheral oxygen saturation (maintained ≥95%), and temperature (measured every 2 h). Staff closely monitored skin color, consciousness, and work of breathing, with standardized alert thresholds triggering immediate intervention when necessary.

All participating nursing staff completed a two-week standardized training program covering theoretical foundations, operational procedures, complication prevention, and emergency management. Only those achieving competency scores ≥90% were permitted to participate. Unified assessment scales and electronic documentation systems were implemented to record detailed metrics for each drainage session. A quality control team conducted weekly random audits of procedural compliance to ensure research quality.

Outcome measures

The primary endpoint was secretion clearance effectiveness, evaluated using the Modified Respiratory Signs Score System (MRSS). This scoring system encompasses four dimensions: wheezing, extent of moist rales, auscultation intensity, and respiratory sound conduction. Each dimension is scored from 0 to 3, yielding a total score range of 0–12, with higher scores indicating more severe respiratory symptoms.

Secondary endpoints included clinical symptoms, pulmonary sign improvement time, radiological changes, and length of hospital stay. Clinical symptoms were monitored through respiratory rate (measured twice daily in morning and evening, averaged) and oxygen saturation (continuous pulse oximetry monitoring, recorded every 4 h). Pulmonary sign improvement was assessed by recording the time to resolution of rhonchi, wheezing, and cough symptoms. Radiological changes were evaluated using standardized chest X-ray examinations, categorized as complete absorption (complete disappearance of lesions), significant absorption (≥75% reduction in lesion area), partial absorption (50–74% reduction), mild absorption (25–49% reduction), and no significant improvement (<25% reduction).

Safety assessment followed a prospective adverse event monitoring protocol, including vital sign abnormalities, gastrointestinal reactions, and cardiovascular adverse events. All assessment data were recorded using a unified electronic documentation system with dedicated quality control personnel.

Statistical analysis

Data analysis was performed using SPSS 26.0 software (IBM Corporation, Armonk, NY, USA). The Shapiro-Wilk test was used to assess normality of continuous variables. Normally distributed data are presented as mean ± standard deviation ($\bar{x} \pm s$), with between-group comparisons conducted using independent samples *t*-tests and repeated measures ANOVA for longitudinal data. For multiple group comparisons, one-way ANOVA followed by Tukey's post-hoc test was used. Non-normally distributed data are presented as median (interquartile range) [M (Q1, Q3)], with between-group comparisons performed using

the Mann-Whitney U test. Categorical data are presented as frequencies (percentages), with between-group comparisons using Chi-square tests or Fisher's exact test as appropriate. Ordinal data were compared between groups using the Wilcoxon rank-sum test. Potential confounding factors affecting treatment efficacy were analyzed using multivariate logistic regression. All statistical tests were two-sided, with $P < 0.05$ considered statistically significant.

Results

Comparison of baseline characteristics

A total of 104 infants with wheezing bronchitis were enrolled in this study. The observation group (n = 52) included 28 males (53.9%) and 24 females (46.1%), with a mean age of 17.3 ± 6.4 months and mean weight of 11.1 ± 2.1 kg. The control group (n = 52) comprised 31 males (59.6%) and 21 females (40.4%), with a mean age of 17.6 ± 6.1 months and mean weight of 11.4 ± 2.2 kg. Disease severity distribution in the observation group was as follows: severe 26 (50.0%), moderate 19 (36.5%), and mild 7 (13.5%); in the control group, it was as follows: severe 27 (51.9%), moderate 21 (40.4%), and mild 4 (7.7%). On admission, mean temperature was 38.6 ± 0.6°C vs. 38.6 ± 0.8°C, respiratory rate was 47.2 ± 5.1 vs. 46.8 ± 5.3 breaths/min, and oxygen saturation was 93.2 ± 1.8% vs. 93.2 ± 2.0% in observation and control groups, respectively. No statistically significant differences were observed between groups in any baseline characteristics (all $P > 0.05$) [Table 1].

Comparison of respiratory system signs scores

Prior to treatment, no significant differences were observed in MRSS dimensional scores and total scores between groups ($P > 0.05$). During treatment, the observation group showed more significant improvement in respiratory system signs compared to the control group. On day two of treatment, the observation group showed significantly lower scores in rhonchi (1.8 ± 0.4 vs. 2.1 ± 0.4), wheezing (1.5 ± 0.4 vs. 1.7 ± 0.3), respiratory sound transmission (1.1 ± 0.3 vs.

Table 1: Comparison of general characteristics between groups [n (%)]/($\bar{x}$±s)

Characteristic	Observation group (n=52)	Control group (n=52)	t/χ^2	P
Gender			0.39	0.535
Male	28 (53.9)	31 (59.6)		
Female	24 (46.1)	21 (40.4)		
Age (months)	17.3±6.4	17.6±6.1	−0.24	0.814
Weight (kg)	11.1±2.1	11.4±2.2	−0.76	0.449
Disease severity			1.24	0.537
Severe	26 (50.0)	27 (51.9)		
Moderate	19 (36.5)	21 (40.4)		
Mild	7 (13.5)	4 (7.7)		
Admission temperature (°C)	38.6±0.6	38.6±0.8	0.13	0.899
Admission respiratory rate (breaths/min)	47.2±5.1	46.8±5.3	0.46	0.650
Admission oxygen saturation (%)	93.2±1.8	93.2±2.0	0.22	0.824

Table 2: Comparison of MRSS before and after treatment ($\bar{x}$±s, points)

Score item	Time point	Observation group (n=52)	Control group (n=52)	t	P
Rhonchi Score	Pre-treatment	2.7±0.3	2.8±0.3	−0.51	0.614
	Day 2	1.8±0.4	2.1±0.4	−4.84	<0.001
	Day 4	0.6±0.2	1.3±0.3	−12.26	<0.001
Wheezing Score	Pre-treatment	2.3±0.4	2.2±0.4	0.90	0.371
	Day 2	1.5±0.4	1.7±0.3	−3.58	<0.001
	Day 4	0.6±0.2	0.9±0.3	−4.98	<0.001
Moist Rales Range Score	Pre-treatment	2.1±0.4	2.1±0.4	0.61	0.545
	Day 2	1.5±0.4	1.5±0.3	−0.57	0.569
	Day 4	0.5±0.2	0.8±0.3	−5.49	<0.001
Respiratory Sound Transmission Score	Pre-treatment	1.6±0.4	1.7±0.4	−1.69	0.095
	Day 2	1.1±0.3	1.3±0.3	−3.16	0.002
	Day 4	0.4±0.2	0.7±0.2	−6.31	<0.001
Total MRSS	Pre-treatment	8.7±0.7	8.8±0.6	−0.31	0.760
	Day 2	5.8±0.8	6.6±0.6	−5.96	<0.001
	Day 4	2.2±0.4	3.5±0.5	−15.12	<0.001

1.3 ± 0.3), and total MRSS (5.8 ± 0.8 vs. 6.6 ± 0.6) compared to the control group (all $P < 0.001$). By day four, the observation group showed further reduction in all scores, with the total MRSS showing particularly notable improvement (2.2 ± 0.4) compared to the control group (3.5 ± 0.5) ($P < 0.001$) [Table 2 and Figure 1].

The plot demonstrates the distribution changes of MRSSs in both groups at baseline, day 2, and day 4. From baseline to day 4, the observation group (red) shows a leftward shift with greater concentration, indicating more significant and stable symptom improvement, while the control group (blue) shows improvement but with greater dispersion. The distribution difference is most prominent on day 4.

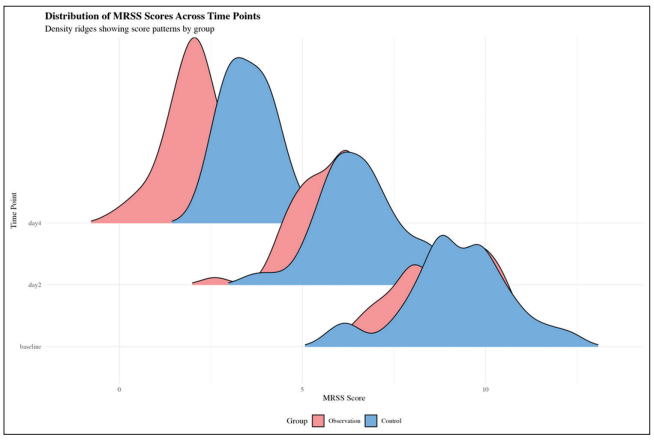

Figure 1: MRSS time trend density plot

Comparison of clinical symptom improvement

The observation group demonstrated more significant advantages in symptom improvement compared to the control group. Starting from day two of treatment, the observation group showed significantly lower respiratory rates (40.7 ± 5.0 vs. 44.0 ± 4.1 breaths/min, $P < 0.001$) and higher oxygen saturation levels (95.5 ± 1.5% vs. 94.9 ± 1.5%, $P = 0.045$) compared to the control group. Regarding symptom resolution time, the observation group showed significantly shorter durations for rhonchi disappearance (4.3 ± 0.9 vs. 5.8 ± 0.8 days), wheezing resolution (5.0 ± 1.2 vs. 6.0 ± 1.3 days), and cough improvement (3.8 ± 0.8 vs. 4.8 ± 1.1 days) compared to the control group (all $P < 0.001$) [Table 3 and Figure 2].

Figure 2A (top) shows the distribution of clinical indicators, including sputum, wheezing, moist rales, and respiratory sounds in both groups. Violin plots demonstrate superior performance in the observation group (red) compared to the control group (blue). Figure 2B (bottom) presents a scatter plot showing the

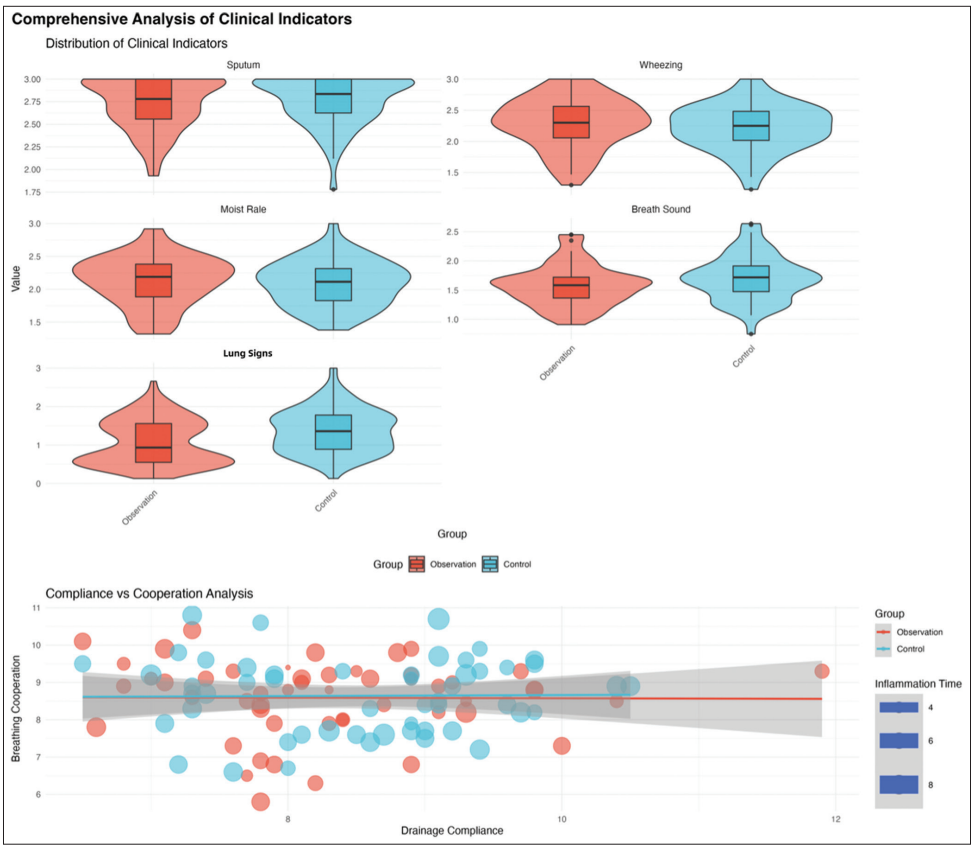

Figure 2: Comprehensive clinical indicators analysis

Table 3: Comparison of clinical symptoms and signs improvement (x̄±s)

Indicator	Time point	Observation group (*n*=52)	Control group (*n*=52)	*t*	*P*
Respiratory rate (breaths/min)	Pre-treatment	47.7±5.0	47.7±4.6	−0.02	0.984
	Day 2	40.7±5.0	44.0±4.1	−3.67	<0.001
	Day 4	38.8±4.1	42.8±4.8	−4.55	<0.001
Oxygen saturation (%)	Pre-treatment	92.8±2.0	93.3±1.7	−1.32	0.188
	Day 2	95.5±1.5	94.9±1.5	2.03	0.045
	Day 4	97.3±1.2	96.5±1.1	3.33	0.001
Temperature (°C)	Pre-treatment	38.6±0.8	38.7±0.7	−0.37	0.716
	Day 2	37.7±0.5	37.7±0.6	−0.07	0.942
	Day 4	36.9±0.4	37.1±0.4	−2.21	0.029
Rhonchi disappearance time (days)	–	4.3±0.9	5.8±0.8	−8.83	<0.001
Wheezing resolution time (days)	–	5.0±1.2	6.0±1.3	−4.14	<0.001
Cough improvement time (days)	–	3.8±0.8	4.8±1.1	−5.01	<0.001

Table 4: Comparison of radiological changes and hospitalization outcomes

Indicator	Observation group (*n*=52)	Control group (*n*=52)	χ^2/t	*P*
X-ray inflammation absorption [*n* (%)]			8.62	0.035
Complete absorption	34 (65.4)	34 (65.4)		
Significant absorption	12 (23.1)	8 (15.4)		
Partial absorption	6 (11.5)	9 (17.3)		
Mild absorption	0 (0.0)	1 (1.9)		
Time to complete absorption (days)	5.8±1.3	7.2±1.4	−5.37	<0.001
Mean hospital stay (days)	6.5±1.2	8.5±1.5	−7.58	<0.001
Clinical cure rate [*n* (%)]	47 (90.4)	38 (73.1)	5.22	0.022

Table 5: Comparison of adverse reactions between groups [*n* (%)]

Adverse reaction type	Observation group (*n*=52)	Control group (*n*=52)	χ^2	*P*
Vomiting	2 (3.9)	3 (5.8)	–	–
Crying and restlessness	4 (7.7)	5 (9.6)	–	–
Transient tachycardia	3 (5.8)	2 (3.9)	–	–
Temporary oxygen desaturation	2 (3.9)	3 (5.8)	–	–
Total incidence	11 (21.2)	13 (25.0)	0.22	0.641

Table 6: Correlation analysis of treatment-related factors and clinical outcomes (*r* value)

Related factor	MRSS improvement	Hospital stay duration	Inflammation absorption time	Clinical cure rate
Age	0.18	0.02	0.11	−0.09
Disease course	0.15	0.03	−0.04	0.07
Admission MRSS	0.01	0.04	−0.02	−0.03
Postural drainage compliance	−0.23*	0.10	0.01	0.04
Respiratory training cooperation	−0.09	−0.17	−0.04	−0.09
Daily drainage frequency	0.54**	−0.33**	−0.36**	−0.00

*P<0.05, **P<0.01

correlation between drainage compliance and respiratory training cooperation, indicating a slight positive correlation trend, with the observation group showing slightly higher overall compliance and cooperation.

Comparison of radiological changes and hospitalization outcomes

In the assessment of pulmonary X-ray inflammation absorption, the observation group showed a higher rate of complete and significant absorption (88.5%) compared to the control group (80.8%), with statistical significance (χ^2 =8.62, P = 0.035). The time to complete inflammation absorption was significantly shorter in the observation group (5.8 ± 1.3 days) compared to the control group (7.2 ± 1.4 days, P < 0.001). Additionally, the observation group showed significantly shorter mean hospital stay (6.5 ± 1.2 vs. 8.5 ± 1.5 days, P < 0.001) and higher clinical cure rate (90.4% vs. 73.1%, P = 0.022) [Table 4].

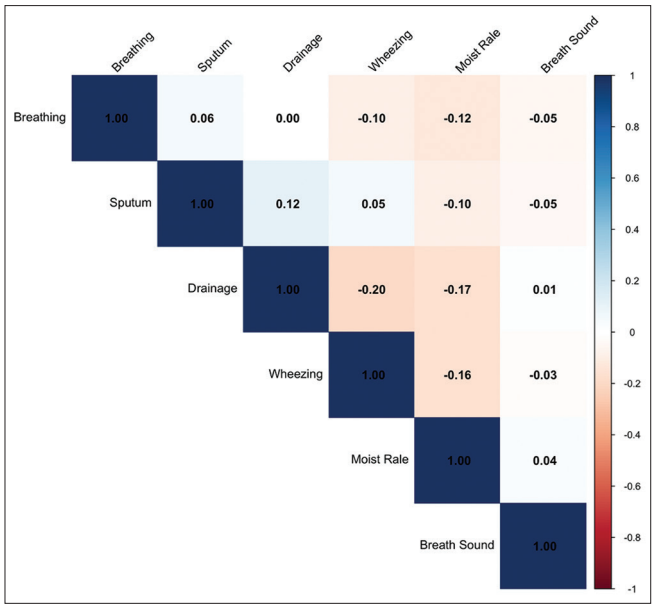

Figure 3: Clinical indicators correlation heat map

Safety assessment

No serious adverse reactions were observed in either group during treatment. The total incidence of adverse reactions was 21.2% in the observation group and 25.0% in the control group, showing no statistically significant difference ($\chi^2 = 0.22$, $P = 0.641$). The main adverse reactions included vomiting (3.9% vs. 5.8%), crying and restlessness (7.7% vs. 9.6%), transient tachycardia (5.8% vs. 3.9%), and temporary oxygen desaturation (3.9% vs. 5.8%), all of which were mild and self-limiting [Table 5].

Correlation analysis

Pearson correlation analysis showed a significant positive correlation between daily drainage frequency and MRSS improvement ($r = 0.54$, $P < 0.001$) and significant negative correlations with hospital stay duration ($r = -0.33$, $P < 0.001$) and inflammation absorption time ($r = -0.36$, $P < 0.001$). Postural drainage compliance showed a weak correlation with MRSS improvement ($r = -0.23$, $P = 0.021$). Age, disease course, admission MRSS, and respiratory training cooperation showed no significant correlations with clinical outcomes ($P > 0.05$) [Table 6 and Figure 3].

The heat map displays the correlation intensity between various clinical indicators, with darker colors indicating stronger correlations. Results show a weak correlation between breathing and sputum indicators and a negative correlation between drainage and wheezing

Discussion

This prospective randomized controlled trial evaluated the clinical value of a modified postural drainage nursing protocol for secretion clearance in infants with wheezing bronchitis. The protocol achieved significant clinical outcomes through optimized drainage frequency, standardized position transitions, regulated rest periods, and integrated respiratory training.

The study found that a drainage frequency of every 2 h enhanced secretion clearance efficiency. Airway secretion production and accumulation in infants follow distinct temporal kinetics. Research has shown that airway secretions in children with wheezing bronchitis reach critical accumulation levels within 90–150 min.[16] The 120 min interval precisely matches this physiological rhythm, enabling timely clearance before secretions reach obstructive levels. Kimura's research explored how airway resistance measurements can help determine ventilation mode changes. When airway resistance exceeds 400 cm H_2O/kg/L/s, it indicates the need to switch to a lower-frequency mechanical ventilation mode to maintain lower airway resistance and reduce alveolar pressure.[17]

The study revealed a significant positive correlation between drainage frequency and MRSS improvement ($r = 0.539$, $P < 0.01$), suggesting that appropriate increases in drainage frequency can improve clinical symptoms. Analysis indicates that frequent but moderate drainage not only enables timely secretion clearance but may also enhance mucosal self-cleaning ability through mechanical stimulation of ciliary movement.[18] This hypothesis is supported by molecular biological research; Luthra *et al.*[19] reported that moderate mechanical stimulation upregulates Cystic fibrosis transmembrane conductance regulator (CFTR) protein expression in airway epithelial cells, helping improve mucus clearance function. This mechanism has important implications for CFTR defects and pulmonary infections in cystic fibrosis (CF) patients.

The present study employed electronic goniometers to precisely control drainage position angles and established a fixed four-stage position sequence. Results showed that this standardized position transition significantly shortened the time to rhonchi disappearance ($P < 0.001$) and inflammation absorption ($P < 0.001$). The observed therapeutic advantages can be attributed to several mechanistic factors, primarily the precise maintenance of a 30° head-up position, which optimizes gravitational drainage dynamics in the upper pulmonary lobes. Previous studies often relied on empirical judgment of position angles, leading to substantial fluctuations in actual drainage effects.[20,21] The current study ensured positional precision through goniometer use, significantly improving drainage reproducibility. This improvement was particularly pronounced in severely ill children, with the observation group showing significantly shorter symptom improvement

times compared to the control group ($P < 0.01$). The design of alternating left and right lateral positions with a 15° head elevation effectively addressed the reflux problems common in traditional supine positions. This improvement is particularly suitable for infant anatomical characteristics, as their bronchial orientation tends to be more horizontal compared to adults.[22]

The research incorporated standardized 8–10 min rest periods between adjacent position transitions, an innovation that improved treatment compliance. Correlation analysis showed a significant association between postural drainage compliance and MRSS improvement ($P < 0.05$). The 30° semi-recumbent position during rest periods maintained certain drainage effects while reducing patient fatigue. Research indicates that intermittent position changes are more beneficial for maintaining cardiopulmonary function stability than continuous fixed positioning.[23] The data also showed that the observation group maintained more stable oxygen saturation levels during treatment ($P < 0.05$). Additionally, the standardized gentle back-patting (100–120 times/min) during rest periods may have additional therapeutic value. Studies suggest that regular chest wall vibration can activate vagal reflexes and improve bronchial smooth muscle tone.[24] The significantly shortened wheezing resolution time in the observation group ($P < 0.001$) may be related to this mechanism.

The integration of standardized abdominal breathing training into the postural drainage protocol yielded significant results. The 3 s inspiration: 6 s expiration breathing rhythm not only improved patients' ventilation function but may also promote secretion clearance through multiple mechanisms: prolonged expiration time can increase end-expiratory positive pressure, helping maintain small airway patency. The data showed more significant improvement in respiratory rate in the observation group ($P < 0.001$), possibly related to the optimized breathing pattern. Standardized abdominal breathing can enhance diaphragm function and improve cough efficiency.[25] The observation group showed notably shortened cough improvement time ($P < 0.001$), superior to traditional protocols using postural drainage alone. Respiratory training potentially facilitates inflammatory resolution through optimization of ventilation-perfusion matching, a mechanism corroborated by radiological findings, with the observation group showing higher rates of complete and significant absorption ($P = 0.035$).

The present study has several limitations that should be addressed in future research. First, the sample size ($n = 104$) is relatively limited, potentially affecting result generalizability. Larger-scale multicenter randomized controlled trials are recommended to further validate the protocol's effectiveness. The follow-up period was relatively short, precluding evaluation of long-term outcomes. Particularly for children prone to recurrent episodes, long-term follow-up studies are necessary to assess the protocol's impact on disease recurrence. Third, the study could not achieve double-blind design, potentially introducing bias. Future studies should consider assessor-blinding to improve research quality. Additionally, the lack of dynamic biomarker monitoring data limited in-depth investigation of treatment mechanisms. Future research should include monitoring of inflammatory factors, immunoglobulins, and other indicators to explore molecular mechanisms.

In conclusion, the modified postural drainage nursing protocol, through multidimensional innovative design, improved treatment outcomes for infant wheezing bronchitis. The protocol not only accelerated symptom improvement and reduced hospital stay but also demonstrated good safety and operability, providing new insights and methods for improving pediatric respiratory care quality.

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Author contributions

PL conceptualized and designed the study. PL was involved in data collection/acquisition and statistical analysis. All authors (PL) were involved in the writing and revising of the manuscript for intellectual content. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

Ethics approval

This study was approved by Lixin County Hospital's Medical Ethics Committee (Approval No.: TZRY-2022-153) and conducted in accordance with the Declaration of Helsinki.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Helsinki

The study was conducted according to the principles of Helsinki Declaration.

Availability of research data

Authors are available and ready to supply the data upon any requests through the corresponding author

Financial support and sponsorship

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Conflicts of interest

The authors declare that they have no financial or non-financial interests that are directly or indirectly related to the work submitted for publication. Authors have no conflict of interest to declare.

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