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The Effect of Chest Physiotherapy on Airway Clearance in Toddlers with Pneumonia: A Quasi-Experimental Study

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ABSTRACT

Pneumonia remains a leading cause of morbidity among children under five, particularly in developing countries. Excessive mucus accumulation often leads to ineffective airway clearance, worsening respiratory distress. Evidence on the effectiveness of chest physiotherapy using structured clinical assessment is still limited. This study aimed to examine the effect of chest physiotherapy on airway clearance in toddlers with pneumonia. This study used a quasi-experimental design with a one group pretest–posttest design was conducted in the Melati B Inpatient Ward of RSUD Kota Cilegon in 2024. A total of 36 toddlers were recruited using purposive sampling. Airway clearance was assessed using a structured respiratory checklist, including respiratory rate, breath sounds, sputum production, and use of accessory muscles, with acceptable reliability (Cronbach's alpha > 0.70). The intervention consisted of postural drainage, percussion, and vibration administered twice daily for three days. Data were analyzed using paired t-test ($p < 0.05$). Results show that the mean airway clearance score increased significantly from 3.28 ± 0.659 to 5.81 ± 0.525 after the intervention ($p = 0.001$). Chest physiotherapy significantly improves airway clearance in toddlers with pneumonia and can be recommended as an evidence based pediatric nursing intervention.

INTRODUCTION

Pneumonia remains one of the leading causes of morbidity and mortality among children under five years of age worldwide. According to the World Health Organization, pneumonia accounts for approximately 14% of all deaths in children under five, with more than 700,000 deaths reported annually, particularly in low and middle income countries [1]. Recent global estimates also indicate that pneumonia continues to contribute significantly to under five mortality, especially among children under two years of age due to anatomical and immunological immaturity [2]. In Indonesia, pneumonia remains one of the most common causes of pediatric hospitalization, reflecting persistent public health challenges in early detection and optimal management [3].

Pathophysiologically, pneumonia is characterized by inflammation of the lung parenchyma resulting in alveolar filling with inflammatory exudate, impaired gas exchange, and increased mucus production [2][4]. In toddlers, excessive secretion accumulation often leads to ineffective airway clearance, a common nursing diagnosis in pediatric respiratory care [5]. Narrower airway diameter, immature respiratory muscles, and limited cough reflex effectiveness make young children particularly

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susceptible to mucus retention and airway obstruction [6]. If not properly managed, retained secretions may worsen ventilation–perfusion mismatch, prolong hospitalization, and increase the risk of complications such as atelectasis and secondary infection [4][7].

Standard pneumonia management primarily focuses on pharmacological therapy, including antibiotics, bronchodilators, and oxygen supplementation [1]. However, non-pharmacological interventions are increasingly recognized as essential components of comprehensive respiratory care. Chest physiotherapy, which includes techniques such as percussion, vibration, and postural drainage, is widely used to facilitate secretion mobilization and improve airway patency [8][9]. Evidence suggests that airway clearance techniques may enhance mucus transport, reduce respiratory distress, and improve oxygenation in pediatric patients with lower respiratory tract infections [7][9]. Several recent clinical studies have demonstrated improvements in respiratory rate, breath sounds, and oxygen saturation following structured chest physiotherapy interventions in children with pneumonia [8][10].

Despite its clinical relevance, the implementation of chest physiotherapy in pediatric wards remains inconsistent and often depends on institutional protocols or practitioner preference. In many clinical settings, nebulization therapy is prioritized, while manual airway clearance techniques are less frequently standardized. Furthermore, several recent studies have demonstrated the effectiveness of chest physiotherapy in improving respiratory parameters such as oxygen saturation, respiratory rate, and breath sounds [8] However, most of these studies have focused on general pediatric populations, with limited evidence specifically addressing toddlers, who have distinct physiological vulnerabilities. Additionally, empirical data from local hospital settings in Indonesia remain limited, highlighting the need for context-specific research to support evidence-based nursing practice.

Based on these considerations, this study aimed to analyze the effect of chest physiotherapy on airway clearance among toddlers diagnosed with pneumonia in the Melati B Inpatient Ward of RSUD Kota Cilegon. The findings are expected to contribute to the development of standardized nursing interventions that improve respiratory outcomes and enhance the quality of pediatric care.

METHOD

This study employed a quantitative approach using a quasi-experimental design with a pretest–posttest without control group framework to examine changes in airway clearance following the implementation of chest physiotherapy among toddlers diagnosed with pneumonia. The research was conducted in the Melati B Inpatient Ward of RSUD Kota Cilegon in 2024, a setting selected due to the high incidence of pediatric pneumonia admissions and the frequent identification of ineffective airway clearance as a primary nursing concern.

The study population consisted of 67 toddlers diagnosed with pneumonia during the data collection period. The sample size was determined using a paired mean difference formula for pretest–posttest design, with a confidence level of 95% and power of 80%, resulting in a minimum required sample of 32 participants. To account for potential dropouts, a total of 36 respondents were included using purposive sampling based on predetermined inclusion and exclusion criteria. Inclusion criteria comprised toddlers aged 0–5 years with a confirmed medical diagnosis of pneumonia, exhibiting clinical signs of ineffective airway clearance, hemodynamically stable, and receiving standard medical therapy. Exclusion criteria included children with congenital respiratory abnormalities, severe complications requiring intensive care, or contraindications to chest physiotherapy.

Airway clearance status was measured using a structured observation sheet developed based on established clinical indicators, including respiratory rate, presence of additional breath sounds (rhonchi), cough effectiveness, and characteristics of respiratory secretions. Each indicator was scored using a standardized scale, with higher scores indicating better airway clearance. The instrument underwent content validity testing by three pediatric nursing experts and demonstrated acceptable reliability (Cronbach's alpha = 0.78), indicating good internal consistency.

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Data collection was conducted through direct clinical observation and respiratory assessment. Baseline measurements (pretest) were performed prior to the intervention. Participants then received chest physiotherapy consisting of postural drainage, percussion (clapping), and vibration. Each session lasted approximately 15–20 minutes and was administered twice daily (morning and evening) for three consecutive days. The intervention was performed by trained pediatric nurses under the supervision of the researcher to ensure procedural consistency. Following completion of the intervention period, posttest measurements were conducted using the same assessment instrument.

Data analysis was conducted in two stages. Univariate analysis was used to describe respondent characteristics and calculate the mean and standard deviation of airway clearance scores before and after the intervention. Prior to hypothesis testing, data normality was assessed using the Kolmogorov–Smirnov test. Since the data were normally distributed, bivariate analysis was performed using a paired t-test to determine the significance of differences between pretest and posttest scores. The data were analyzed using paired t-test with a significance level of $p < 0.05$.

This study received ethical approval from the Health Research Ethics Committee under Ethical Clearance Number 247/KEPK-UF/XI/2024. Institutional permission was obtained prior to data collection. Written informed consent was obtained from parents or legal guardians after providing a detailed explanation of the study objectives, procedures, and potential benefits. Participant confidentiality was maintained by assigning identification codes and excluding personal identifiers from all research records.

RESULT AND DISCUSSION

A total of 36 toddlers diagnosed with pneumonia were included in this study. The univariate and bivariate analyses are presented below.

Characteristics of Respondents

Table 1. Characteristics of respondents (n = 36)

Characteristics	n	%
Age		
0–1 year	17	47.2
2–3 years	15	41.7
4–5 years	4	11.1
Sex		
Male	19	52.8
Female	17	47.2
Health History		
Acute	21	58.3
Chronic	15	41.7
Previous Hospitalization		
Ever hospitalized	21	58.3
Never hospitalized	15	41.7

Based on Table 1, this study found that the highest proportion of pneumonia cases occurred in infants aged 0–1 year (47.2%), followed by children aged 2–3 years (41.7%) and 4–5 years (11.1%). This finding indicates that younger children, particularly infants, are the most vulnerable group to pneumonia. This vulnerability is primarily associated with the anatomical and physiological immaturity of the respiratory system and immune defenses. Infants have smaller airways, reduced lung compliance, and an underdeveloped mucociliary clearance mechanism, which increase their susceptibility to airway

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obstruction and infection. Furthermore, their adaptive immune response is not fully mature, making them less capable of effectively combating respiratory pathogens. Previous large-scale epidemiological studies have consistently shown that pneumonia incidence and severity are significantly higher in children under two years of age [11]

In terms of sex distribution, this study showed that pneumonia was slightly more common in males (52.8%) than females (47.2%). This finding is consistent with previous research suggesting that male children have a higher risk of respiratory infections. Biological differences, including narrower airways relative to lung volume and differences in immune response regulation, may contribute to this increased susceptibility. Additionally, hormonal and genetic factors are believed to influence immune modulation between sexes, potentially making males more prone to severe respiratory infections during early childhood [12] [13].

Regarding health history, most respondents had an acute health history (58.3%), while 41.7% had chronic conditions. Pneumonia in children is commonly an acute infectious disease caused by bacterial or viral pathogens, leading to inflammation of the lung parenchyma and impaired gas exchange. Acute infections may rapidly worsen due to excessive mucus production and ineffective airway clearance, particularly in young children. However, the presence of chronic illness also increases vulnerability due to compromised immunity and impaired pulmonary function. Previous studies have demonstrated that underlying health conditions significantly increase the risk of severe pneumonia and hospitalization in children [14][15].

Furthermore, this study found that 58.3% of respondents had a history of previous hospitalization. Previous hospitalization may indicate recurrent infections, underlying health vulnerabilities, or environmental risk factors such as poor air quality, inadequate nutrition, and crowded living conditions. Children with prior hospitalization are more likely to experience recurrent respiratory infections due to weakened immune defenses and increased exposure to pathogens. Similar findings were reported by Jackson et al, who identified prior hospitalization as a significant risk factor for recurrent pneumonia in children [16] .

Overall, the majority of cases were found in younger children, males, those with acute conditions, and those with a history of previous hospitalization. These findings describe the distribution of respondent characteristics in this study. However, no inferential analysis was conducted to determine the association between these variables and pneumonia outcomes. Therefore, the results should be interpreted descriptively. Preventive strategies, including improving nutritional status, immunization coverage, environmental hygiene, and early clinical management, remain important to reduce pneumonia morbidity and mortality among children.

Airway Clearance Before and After Chest Physiotherapy

Table 2. Airway clearance before and after chest physiotherapy

Variable	n	Mean	SD	Min–Max
Pretest	36	3.28	0.659	3–5
Posttest	36	5.81	0.525	4–6

Based on Table 2, the results showed that the mean airway clearance score before chest physiotherapy (pretest) was 3.28 (SD = 0.659), with a range of 3–5, indicating that most toddlers experienced moderate airway clearance impairment prior to the intervention. After chest physiotherapy (posttest), the mean score increased to 5.81 (SD = 0.525), with a range of 4–6. This finding demonstrates a substantial improvement in airway clearance following chest physiotherapy. The increase in the mean score and the decrease in standard deviation indicate not only clinical improvement but also more consistent airway clearance status among respondents after the intervention.

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The lower pretest score reflects the presence of airway obstruction caused by excessive mucus production, inflammation, and ineffective cough, which are common pathophysiological features of pneumonia in young children. Toddlers are particularly vulnerable due to their anatomically narrower airways and immature respiratory muscle function, which limit their ability to clear secretions effectively. This condition leads to mucus retention, airway obstruction, and impaired ventilation. According to World Health Organization, mucus accumulation and airway inflammation are primary causes of respiratory distress and reduced oxygen exchange in pediatric pneumonia [1].

Following chest physiotherapy, the increase in airway clearance scores indicates that this intervention was effective in mobilizing and removing secretions from the respiratory tract. Chest physiotherapy works through techniques such as percussion, vibration, and postural drainage, which help loosen mucus from the bronchial walls, making it easier to expel through coughing or suction. This process improves airway patency, enhances ventilation, and reduces respiratory effort. A systematic review by American Thoracic Society reported that airway clearance techniques significantly improve mucus removal, lung function, and respiratory status in pediatric patients with respiratory infections [17].

The relatively higher posttest mean score and narrower standard deviation also suggest that chest physiotherapy provided consistent therapeutic benefits across most respondents. This improvement is clinically important because effective airway clearance is essential for restoring normal breathing, improving oxygenation, and preventing complications such as respiratory failure. Similar findings were reported by Lestari et al, who found that chest physiotherapy significantly improved airway clearance and reduced respiratory distress in children with pneumonia [8].

These findings are also supported by a study conducted by McCool and Rosen, which demonstrated that chest physiotherapy is an effective non-pharmacological intervention for improving airway clearance by enhancing mucus mobilization and reducing airway resistance. Improved airway clearance contributes to better ventilation and accelerates the recovery process in pediatric pneumonia patients [18].

Overall, the results of this study confirm that chest physiotherapy is an effective intervention for improving airway clearance in toddlers with pneumonia. The significant increase in airway clearance scores after the intervention highlights the importance of incorporating chest physiotherapy into routine nursing care to optimize respiratory function and improve clinical outcomes in pediatric pneumonia patients.

Comparison of Airway Clearance Scores Before and After Chest Physiotherapy

The results of the normality test showed that the pretest data had a p-value of 0.084 and the posttest data had a p-value of 0.173. Since both values are greater than the conventional significance threshold of 0.05, the null hypothesis of normal distribution cannot be rejected. This indicates that both datasets follow a normal distribution pattern, satisfying one of the primary assumptions required for parametric statistical analysis.

Table 3. Comparison of airway clearance scores before and after chest physiotherapy

Variable	n	Mean	SD	p-value	Effect Size (Cohen's d)	Interpretation
Before Intervention	36	3.28	0.659	0.001	4.24	Very Large Effect
After Intervention	36	5.81	0.525			

Based on Table 3, a total of 36 toddlers were included in the analysis. The mean airway clearance score increased from 3.28 ± 0.659 before the intervention to 5.81 ± 0.525 after chest physiotherapy, with a mean difference of 2.53 points. The paired t-test showed a statistically significant difference ($p = 0.001$), indicating that airway clearance improved significantly following the intervention.

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In addition to statistical significance, the calculated effect size (Cohen's d = 4.24) indicates an extremely large magnitude of effect. This suggests that the observed improvement is not only statistically meaningful but also clinically relevant. Furthermore, the reduction in standard deviation after the intervention reflects a more consistent response among participants, suggesting that the intervention effect was relatively uniform within this study population.

From a clinical perspective, improved airway clearance in toddlers with pneumonia is highly significant. Pneumonia in children is characterized by alveolar inflammation and excessive mucus production, which can lead to airway obstruction, ventilation–perfusion mismatch, and increased work of breathing. According to the World Health Organization, pneumonia remains one of the leading causes of mortality among children under five years of age worldwide, largely due to respiratory complications associated with impaired secretion clearance [19]. Therefore, interventions that facilitate mucus mobilization and removal are of substantial therapeutic importance.

These findings are consistent with previous studies demonstrating the beneficial effects of chest physiotherapy on respiratory parameters in pediatric patients. Lubis et al [20] reported improvements in respiratory effectiveness, including reduced respiratory rate and increased oxygen saturation following chest physiotherapy. Similarly, Arifin et al. [21] found significant improvements in airway clearance among pneumonia patients in intensive care settings. The consistency across studies supports the role of chest physiotherapy as an effective supportive intervention in managing respiratory compromise.

However, the magnitude of improvement observed in this study appears larger than that reported in several previous studies. This discrepancy may be explained by differences in study design, patient characteristics, and outcome measures. The current study employed a one-group pretest–posttest design without a control group, which is more susceptible to overestimation of effect size due to factors such as natural clinical recovery, concurrent pharmacological therapy, and regression to the mean. In contrast, studies using more rigorous designs, such as randomized controlled trials, often report more moderate effect sizes due to better control of confounding variables.

Another important consideration is that most previous studies evaluated multiple respiratory outcomes (e.g., oxygen saturation, respiratory rate), whereas this study focused specifically on airway clearance scores derived from a structured clinical assessment. Differences in measurement approaches may also contribute to variability in reported outcomes and effect sizes across studies.

While the results indicate a strong positive effect, the interpretation should remain cautious. The absence of a comparison group limits causal inference, making it difficult to isolate the independent effect of chest physiotherapy from other ongoing treatments such as antibiotics, bronchodilators, and oxygen therapy. Additionally, the short duration of observation may capture immediate improvements but does not provide evidence regarding long-term clinical outcomes, such as length of hospital stay or recurrence rates.

From a clinical perspective, the findings support the integration of chest physiotherapy as part of comprehensive pediatric respiratory care, particularly for patients presenting with ineffective airway clearance. However, its application should be guided by standardized protocols and tailored to patient condition, as inappropriate or excessive use may not yield additional benefit.

Overall, this study contributes to existing evidence by demonstrating a substantial improvement in airway clearance following chest physiotherapy in toddlers with pneumonia. Nevertheless, further research using randomized controlled designs and comparative interventions is required to establish stronger causal relationships and to determine the relative effectiveness of chest physiotherapy compared to other airway clearance techniques.

CONCLUSIONS

Chest physiotherapy has a significant effect on improving airway clearance in toddlers with pneumonia. This study showed that the mean airway clearance score increased from 3.28 before the

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intervention to 5.81 after the intervention, with a p-value of 0.001 ($p < 0.05$). This finding indicates a statistically and clinically significant improvement in airway clearance following chest physiotherapy.

The improvement in airway clearance demonstrates that chest physiotherapy is effective in mobilizing and removing airway secretions, improving airway patency, and enhancing respiratory function. In addition, the decrease in standard deviation after the intervention indicates that the improvement occurred consistently among respondents.

Therefore, chest physiotherapy can be concluded to be an effective nursing intervention for improving airway clearance in toddlers with pneumonia. This intervention is recommended as part of routine nursing care to support respiratory recovery, accelerate the healing process, and prevent complications in pediatric pneumonia patients.

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