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Conventional Chest Physiotherapy Accelerates Recovery and Attenuates Inflammatory Response in Hospitalized Children with Acute Pneumonia

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ABSTRACT

Background: Conventional physical therapy, specifically chest physiotherapy, can positively impact inflammatory markers and quality of life in children with acute pneumonia. It helps clear airway secretions, reduce airway resistance, and improve breathing, which can lead to a reduction in inflammatory markers like C-reactive protein (CRP) and an improvement in chest expansion.

Aim: to examine the impact of conventional chest physiotherapy on inflammatory biomarkers (Il-6, CRP, ESR) and hospital stay compared with traditional medical care in children hospitalized having acute pneumonia. Methods: This single blinded randomized controlled trial study included 50 children diagnosed with acute pneumonia, aged 5-12 years. Patients were randomized into two groups (25 patients each); Group (A) received pharmacological treatment for 2 weeks and Group (B) received conventional chest physiotherapy for seven sessions per week for 2 weeks plus their pharmacological treatments.

Results: IL-6, CRP, ESR significantly reduced in both groups post-treatment (p=0.001), as well as reduction of hospital stay duration and oxygen saturation (sPO2) increased post treatments (p=0.001). Both groups revealed significant changes, more pronounced in group (B) than in control group (A).

Conclusion: intervention conventional physiotherapy program to medical treatment in Children with acute pneumonia can effectively improve the inflammatory biomarker profile, oxygen saturation, and decrease length of hospital stay.

KEYWORDS: Conventional Chest physical therapy, hospital stay, inflammatory markers, IL-6.

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INTRODUCTION

Although pneumonia affects children all across the world, countries with low incomes have much greater rates of both incidence and mortality. Marangu D (1). Streptococcus pneumonia as well as Hemophilus influenza Frigati L are the two most prevalent pneumonia-causing organisms in countries with low incomes (2)

When fluid collects in the alveoli of the lungs, a condition known as pneumonia develops. Pneumonia typically presents with a dry cough, fever, headache, myalgia, along with sore throat. There may also be abnormal imaging findings (chest X-RAY) and high levels of inflammatory markers in laboratory testing Yadav KK (3).

Ebeledike C (4). Pneumonia develops after a fever in children whose infections persist for more than ten days, and the C-reactive protein level can rise by tens to fifty times as a result of the acute phase stimulation caused by the infection.

Bourbeau J (5). Chest physiotherapy has many advantages, such as easing airway obstruction by clearing inflammatory exudates as well as tracheobronchial secretions, decreasing airway resistance, improving gas exchange, and decreasing the work required to breathe .

Airway clearance therapy may or may not be effective for children with Acute pneumonia. In recent years, there has been a lack of randomized controlled trials (RCTs) with clear conclusions. There were no significant differences in the outcome measures among the intervention group as well as the control group in the study by Paludo C. and Lukrafka J. (6) and (7). This is alarming because the majority of the children suffering from pneumonia were younger than 5 years old, and respiratory rate is a key indicator for diagnosing pneumonia; thus, a decrease in respiratory rate could be an endpoint.

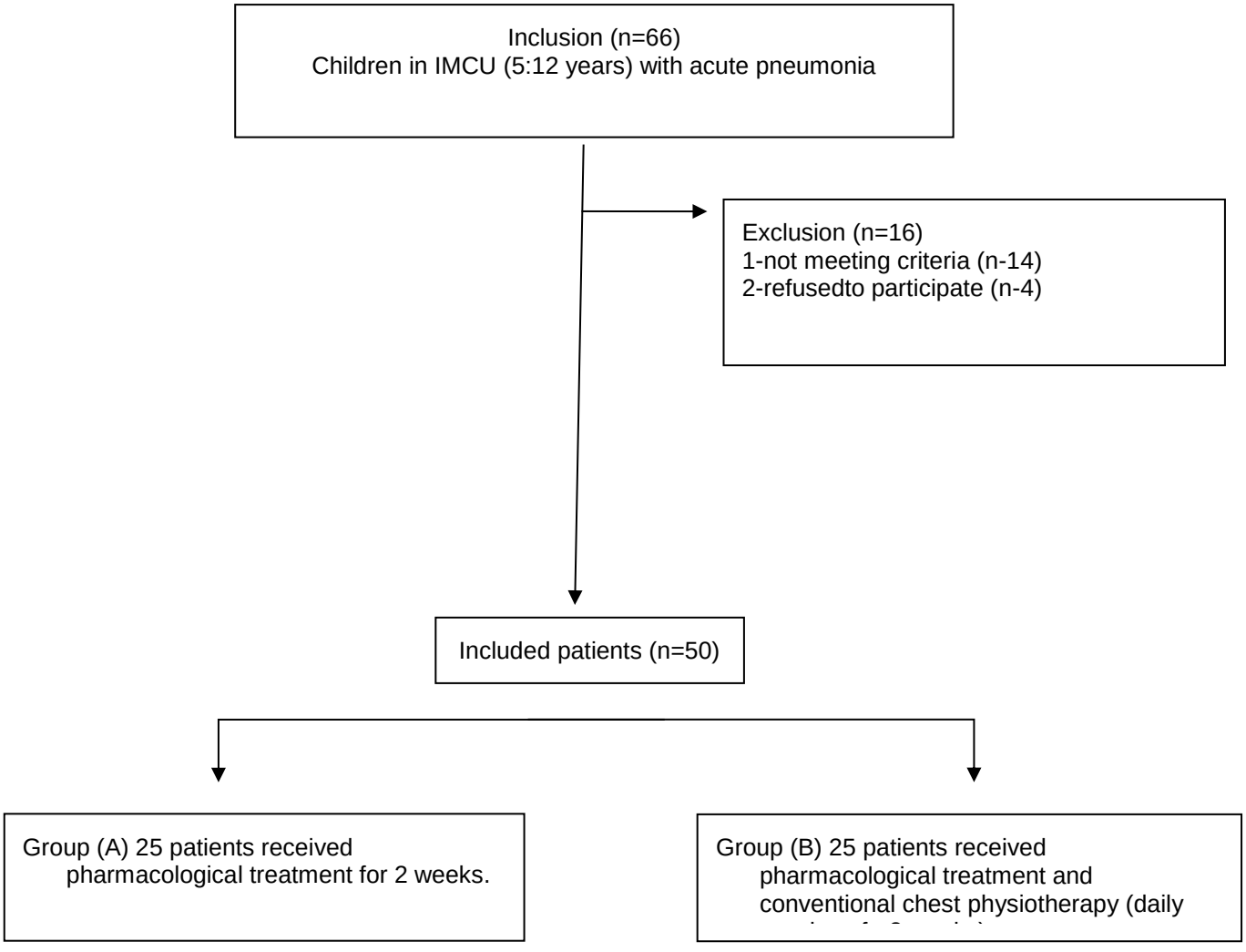
Consequently, it is not apparent that a single airway clearance approach could be helpful in treating children with Acute

pneumonia. This study was designed to compare the effectiveness of conventional chest physiotherapy with that of traditional medical care in reducing inflammatory markers (Il-6, CRP, ESR) and length of hospital stay in children admitted with acute pneumonia.

SUBJECTS AND PROCEDURES

Study Design: A single blinded randomized controlled trial study was done on children diagnosed with acute pneumonia at El Fayoum Fever hospital IMCU (Intermediate Medical Care Unit) from December 2024 to March 2025.

Participants: 50 children with acute pneumonia, ranging in age from 5 to 12 years, were evaluated for intervention eligibility in this study. Clinical severity was classified according to the criteria set by the WHO (2013). They had a body mass index (BMI) between 19 and 23 kg/m2, no history of neurological impairment, and were coughing and tachypnea (respiratory rate greater than 40 breaths per minute in those aged 1 to 5 years or 30 breaths per minute in those aged 5 and older). On the chest radiograph, they may have consolidations and/or infiltrates that are indicative of pneumonia. WHO (8).
Children who had a history of immunodeficiency, a mixture of infections, respiratory distress syndrome, a major underlying condition or its complications, altered consciousness, required mechanical ventilation, and intellectual impairment, were excluded from this study.



Clinical assessment procedures:
Medical history (recent medications, previous hospital admission, allergies, vaccination), vital signs (temperature, O2 saturation, R.R, H.R), and BMI (kg/m2) of each patient was completed out on data sheet upon admission to the hospital. oxygen saturation was measured for Children at baseline of the study and a day after discharge using a commercial pulse oximeter, placed securely on a fingertip of index finger. Respiratory rate is measured by observing the number of breaths for 60 seconds to determine breaths per minute (bpm) and record any abnormal respiratory patterns. The physical examination was conducted to confirm eligibility for study inclusion. The date of hospital admission and discharge date was written on the data sheet, to estimate the length of hospital stay.

IL-6, ESR and CRP Analysis:
Peripheral venous samples were collected from all included children on the day of admission and the day of discharge for both study groups to assess inflammatory biomarkers. 5 mL of venous samples collected were centrifuged, and serum stored at –80°C until analysis. Serum interleukin-6 (IL-6) levels were evaluated using a commercially available ELISA kit (JER-04, Anhui Joyee Biotechnics Co., Ltd.), with a reference range of 0–5.186 pg/mL. C-reactive protein (CRP) concentrations were measured via enzyme-linked immunosorbent assay using kits from Shanghai Enzyme-linked Biotechnology Co., Ltd.; the normal reference range for CRP was 0.02–14.4 mg/L. Erythrocyte sedimentation rate (ESR) also assessed by collecting a blood sample from the patient into Westergren tube and left undisturbed for a specific period, usually one hour. The red blood cells gradually settle to the bottom of the tube due to gravity. The distance the red blood cells fall in one hour is measured, the normal values ranging from 10 to 20 mm/hour Gong W (9)

Treatment Procedures:
Each child in the two groups received pharmacological therapy for two weeks

For all Children included in Group (B):
Chest Physical therapy: An essential technique for removing mucus from the lungs involves physical techniques such as chest percussion, vibration, and postural drainage to aid in clearing airway secretions. This approach is frequently used to reduce pulmonary complications and enhance respiratory health it was performed once daily for 15–20 minutes each session,
The purpose of the inductive inquiry was to collect information about the children's interests as well as hobbies prior to training. Then, based on their interests, we validated the interaction's substance.
1- Diaphragmatic breathing, or belly breathing, we ask the child to take deep abdominal inhalations followed by slow exhalations, which help stimulate the parasympathetic nervous system and promote relaxation. With children in the sessions these breathing exercises can be made more fun and we using interactive tools such as a musical pillow.
2- Pursed-lip breathing is a technique that we ask the child to slow exhale the air through O-shape lips to regulate and reduce the respiratory rate. To facilitate this technique for children we using colored balloons or blow bubbles as a visual and interactive aid during exhalation.
3-Aerobic activities that raise the heart rate and improve cardiovascular fitness, such as gait training through the hospital corridor with simple racing, and as well as we do some chest expanding exercises as moving arms and legs away during inspiration and vice versa with counting, with great cards rewards depending on their interesting.
4- Postural drainage: We select positions indicated by the chest radiograph to enhance the drainage of secretions from the most severely impacted regions in these positions we applied percussion over the ribs on the affected lobe with a cupped hand and using mechanical vibration to facilitate the clearance of mucus Fatima T. (10)

The daily training of the children was conducted by physiotherapists with assistance by nursing staff. It was essential to ensure that children did not experience fatigue, and they could receive a card for successfully completing a training session.

Chaves, Roqué (11; 12) The training was conducted continuously over a two-week period, supplemented by antibiotic therapy, herbal drinks, and oxygen therapy as required. The pediatrician was blinded to the group assignments.

For children Group (A) received only medical treatment prescribed by the pediatrician without intervening chest physiotherapy.

Statistical analysis:
A sample size was estimated to about 50 Children with acute pneumonia to achieve a power of more than 80 (1-βeta = 0.80), type I error (alpha = 0.05), and the Effect size d = 1.0698573 for the main variable outcome based on t-tests, utilizing the G power program version 3.1.9, Heinrich-Heine-University, Düsseldorf, Germany.

When comparing the groups based on participant characteristics and length of hospital stays, an independent t-test was used. A chi-squared test was performed to compare the sex distribution across groups. The Shapiro-Wilk test was employed to assess the normal distribution of the data. Levene's test for homogeneity of variances was performed to assess the homogenity of variances among groups. Mixed MANOVA was employed to examine the impact of treatment over time on CRP, ESR, IL-6, and SpO2. Subsequent multiple comparisons were analyzed using post-hoc tests. A significant level of $p < 0.05$ was applied in all analyses. Statistical analysis was conducted utilizing The Statistical Package for Social Sciences (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA).

RESULTS
The study involved fifty children with acute pneumonia. Table (1) illustrates shows the demographic and growth parameters of both group A and B. No significant difference was detected among the two groups in all measured parameters at start of the study ($p > 0.05$).

Table 1. Demographic data and growth parameters among groups A and B patients:

	Group A	Group B			
	Mean ±SD	Mean ±SD	MD	t-value	p-value

Age (years)	6.24 ± 1.94	6.60 ± 2.10	-0.36	-0.63	0.53
Sex, N (%) Females Males	 14 (56%) 11 (44%)	 13 (52%) 12 (48%)	 (χ^2 = 0.08)	 	 0.78
Weight (kg)	20.38 ± 5.31	20.84 ± 5.08	-0.46	-0.31	0.76
Height (cm)	114.16 ± 10.11	116.64 ± 11.62	-2.48	-0.81	0.43
BMI (kg/m²)	15.38 ± 1.03	15.08 ± 0.80	0.3	1.14	0.26
RR (breath/min)	36.80 ± 3.35	35.88 ± 3.54	0.92	0.94	0.35

SD, Standard deviation; MD, Mean difference, χ2, Chi squared value; p value, Probability value

Effect of Treatment on CRP, ESR, IL-6, SpO2:

A significant decline in CRP, ESR, as well as IL-6 and a significant improvement in oxygen saturation (SpO2) in both groups post treatment compared to pretreatment ($p < 0.001$). (Table 2-3).

No significant differences were noticed among patients' groups at baseline ($p > 0.05$). But, post-treatment group B, showed significant reductions in CRP, ESR, and IL-6 ($p = 0.001$), along with a significant improvement in SpO_2 level compared to group A ($p < 0.001$). (Table 2-3).

Table 2. Mean CRP, ESR, and IL-6 pre and post treatment among group A and B patients

	Pretreatment	**Post treatment**			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
CRP (mg/L)					
Group A	58.07 ± 4.05	42.06 ± 3.36	16.01	27.57	0.001
Group B	59.40 ± 3.66	35.36 ± 2.22	24.04	40.47	0.001
Mean difference MD	-1.33 ***(p = 0.23)***	6.70 (***p = 0.001)***			
ESR (mm/hr)					
Group A	23.80 ± 3.14	19.08 ± 2.56	4.72	19.83	0.001
Group B	23.36 ± 2.18	16.44 ± 1.89	6.92	29.62	0.001
MD	0.44 (***p = 0.57)***	2.64 (***p = 0.001)***			
IL-6 (pg/ml)					
Group A	13.03 ± 1.66	7.80 ± 1.41	5.23	40.14	0.001
Group B	13.68 ± 1.59	5.83 ± 1.30	7.85	57.38	0.001
MD	-0.65	1.97			
	p = 0.16	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p value, Probability value.

Table 3. Mean SpO2 pre and post treatment of group A and B:

	Pretreatment	**Post treatment**			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
SPO2 (%)					
Group A	95.20 ± 0.76	96.88 ± 0.67	-1.68	1.76	0.001

Group B	95.04 ± 0.93	97.76 ± 0.66	-2.72	2.86	0.001
MD	0.16	-0.88			
	p = 0.51	***p = 0.001***			

SD, Standard deviation; MD, Mean difference; p value, Probability value

Treatment and time interacted significantly, according to mixed MANOVA (F = 72.81, p = 0.001, Partial Eta Squared = 0.89). Longitudinal analysis revealed a statistically significant main effect of time (F = 590.51, p = 0.001, P = 0.99). F = 22.78, p = 0.001, Partial Eta Squared = 0.72), indicating a significant main impact of treatment.

The mean duration of hospital stays of group A was 8.76 ± 1.30 days, while that of group B was 5.04 ± 1.06 days. The mean difference in length of hospital stay between the groups was 3.72 days.

DISCUSSION

Pneumonia is an infectious disease that often affects children and can be very serious. In children, hypoxia and acidosis are symptoms of severe pneumonia, which can develop if treatment is delayed. Symptoms like sepsis and multiple organ failure are common side effects. Marcin A (13)

The continual release of inflammatory mediators in response to acute pneumonia can trigger a cytokine storm. There is a greater risk of adverse effects, immunosuppression, and reduced immune function due to this, in addition to T-cell death. Lee YC. 14. Evaluating the severity and prognosis of pediatric pneumonia relies heavily on the dynamic monitoring of inflammatory as well as immunological markers. Raju V (15).

The aim of traditional physical therapy is to assist patients breathe easier and accelerate their recovery by instructing them in proper coughing and breathing techniques and in cases when patients have lung disorders that cause less airway resistance, by employing manual chest wall vibrations to increase airway clearance. Early mobilization is generally encouraged by evidence-based practice, even though manual chest clearance approaches are applied differently. Abdelbasset W (16).

According to data analysis in the current study, the results revealed that CRP levels decreased in post-treatment group B (p = 0.001) with a percent of change 40.47%, while in post-treatment group A, CRP decreased (p = 0.001) with a percent change of 27.6%, favoring the addition of conventional physical therapy program in pneumonia patients. This current study also showed a significant post-treatment reduction in ESR in both groups: 19.83% in group A and 29.62% in group B (p =0.001, respectively). Additionally, posttreatment group B showed significant decrease in ESR compared with group A post-treatment (p = 0.001)
Medical treatment of pneumonia, including antibiotics and reduces inflammation and improves outcomes. Adjunct chest physiotherapy aids secretion clearance, thereby decreasing infection-related inflammation and lowering inflammatory biomarker profiles.

Consistent with our study findings, Chaves (11) reported that conventional physical therapy, including techniques like postural drainage, chest percussion, and breathing exercises, is often used as an adjunct treatment for pneumonia. While it is thought to help clear secretions and improve breathing, the direct impact of these therapies on inflammatory biomarkers in pneumonia patients is not definitively proved. They suggested that exercise, in general, can modulate inflammatory pathways.

Roqué, et al, (12) demonstrated that chest physiotherapy has several advantages, such as easing gas exchange, decreasing the work required to breathe, clearing airways of obstructions, and eliminating inflammatory exudates as well as tracheobronchial secretions.

Both medical treatment and chest physiotherapy can decrease the ESR level in children with pneumonia Hwang H (17) but conventional chest physiotherapy via the clearing of airway secretions and enhancing oxygenation and ventilation can certainly affect ESR and CRP levels as it may help resolve the underlying infection, in turn reducing the inflammatory response and the physiological stress linked with pneumonia.

Both groups had elevated levels of the pro-inflammatory cytokine IL-6 upon admission, demonstrating the significance of this cytokine in the inflammatory response of the lungs irrespective of the severity of the disease. Dein MSE (18).

The adaptive immune system, characterized by its specificity and immunological memory, is essential for the recognition and elimination of pathogenic organisms through antigen-specific responses. Innate immune cells have pattern recognition receptors (PRRs) that activate this system when they recognize pathogen-associated molecular patterns (PAMPs). This recognition triggers a cascade of immune responses, including the release of chemotactic mediators by infected and activated endothelial cells, which facilitate the recruitment of phagocytic cells as macrophages and neutrophils to the site of infection. When these innate immune cells become active, they release specific cytokines that promote inflammation, including IL-1, IL-6, and TNF-α. These effector molecules act together to amplify the local inflammatory response, enhance leukocyte trafficking, and potentiate the antimicrobial effector functions necessary for pathogen clearance Mathi A (19).

Physical therapy modalities have been shown to reduce inflammatory biomarker levels in patients with acute pneumonia through indirect mechanisms, which contribute to decreased inflammatory responses and potentially could lower IL-6 levels.

Similarly, medical treatment received by patients, such as anti-inflammatory and antimicrobial medications directly target infection and inflammation may also help reduce IL-6 levels.

In a study done by Wardika IK (20) on COVID-19 patients treated with upper arm along with breathing exercises revealed a significant enhancement in IL-6 levels which happened in severe COVID-19 patients.

In order to train the primary muscles of breathing, improve chest expansion, strengthen the muscles that support the chest wall or cavity, and control rhythm, a set of exercises involving the upper arms and breathing is recommended. Also, the inflammation in your airways and lungs can be reduced with this exercise. Tarigan .(21)

In addition, our results are in line with those of Hwang H. (17), who in a trial of 15 children with pneumonia (aged 6 to 12) used both traditional chest physiotherapy as well as pneumatic compression, whereas a control group received just traditional chest physiotherapy. they observed that following treatment, the study group had greater reductions in inflammation markers CRP along with WBC compared with the control group.

Gökçek O (22) reported that physiotherapy applications can reduce the inflammation markers in asthma patients that usually cause an escalation of asthma symptoms and the frequency of attacks and may play a critical or vital role in reducing adipose tissue which contribute to chronic systemic inflammation and lung tissue damage. Therefore, in both current and future clinical research as well as clinical practice, it is critical to incorporate physiotherapy applications into patient care.

According to the current study analysis, a significant improvement was noticed in oxygen saturation (SpO2) of group B post treatment with a percent change of 2.76%, this indicates that sPO2 of both groups improved after treatment with a better result toward group B on adding conventional physical therapy program to medical treatment.

As medical treatments short term goals were to facilitate patient remission by eliminating various agents causing pneumonia through antibiotics and supportive treatments used that would help reduce mucus formation and decrease the airway resistance during respiration process, this would improve oxygenation and sPo2 levels. In a similar way, adding conventional physical therapy modalities (postural drainage, breathing, and percussion and vibration) loosens bronchial airway secretions that ease the work of breathing and improve oxygenation in children with pneumonia.

The alveoli open, increasing the volume of air moving through the lungs, which promotes good exchange of carbon dioxide and oxygen, leading to an enhancement of acid-base balance and PO2 and sPO2 levels when airways are clear of secretions. Results from the current study corroborate those from Wang T (23)

Furthermore, Andrian's (24) research demonstrated that pursed lip breathing therapy can enhance alveolar pressure, which in turn promotes lung expansion, and pushes secretions during expiration. Additionally, this non-pharmacological method of treating dyspnea can lower respiratory rate and increase oxygen saturation.

Results showed that patients on mechanical ventilation had their arterial blood gas levels improved with a chest physiotherapy regimen that included manual hyperinflation, vibration, percussion, suctioning, exercises for both the upper and lower limbs, as well as an ending position. Abdeen HA (25).

Our results showed a significant decrease in ICU duration and mean hospital stays of group B compared with that of control group A ($p = 0.001$) probably because all complications of pneumonia were diminished by conventional physical therapy with improvement of ventilation and patient airway status

It has been reported that chest physiotherapy has the potential to reduce the need for mechanical ventilation, fever, and length of time stayed in the intensive care unit (ICU) (26). Results showed that patients on mechanical ventilation had higher PaO2 and SpO2 levels, shorter ICU stays, fewer psychological conditions connected to ICU stays, and lower healthcare expenditures when chest physiotherapy was added to their treatment. Maged AM (27).

In a study done as they indicated that the intervention group receiving conventional chest physiotherapy techniques showed faster clinical resolution, lesser respiratory rate, and greater discharge oxygen saturation compared to controls without physiotherapy Raju V (15)

In a study by Paludo C (6), children hospitalized having acute pneumonia ranging in age from 29 days to 12 years were divided into two groups: one group received standard treatment for pneumonia alone, while the other group received chest physical therapy in addition. They came to the conclusion that using chest physical therapy techniques alongside conventional treatment does not speed up the resolution of symptoms and might even make coughing last longer. These contradict with our study findings as the age group was different and some techniques as early mobilization and aerobics exercises in the form of walking, huffing and coughing techniques could not apply in their study.

Overall, our study highlighted the beneficial impact of conventional chest physiotherapy in pediatrics hospitalized with pneumonia. This study has some limitations. The study was from a single center, which increases the risk of selection bias, thus calls for further studies generalizing data on a multi-center study. In addition, the younger age groups have difficulty adhering to study protocols as instructions regimens or completing questionnaires.

CONCLUSION:

In conclusion, adding conventional physiotherapy program to medical treatment can effectively improve the biomarker inflammatory profile, oxygen saturation, and decrease the IMCU duration and quality of life in children with acute pneumonia.

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Conflict of interest:
There are no conflicts of interest declared by the authors.

Ethical approval:
The study was conducted according to the principles of Declaration of Helsinki (Code of Ethics of the World Medical Association). At the beginning of study, all patients and caregivers were informed about the objectives of study and their rights. Participation was authorized by a written informed consent signed with Legal guardian's acceptance for participation before starting the study procedures. The study protocol was approved by the Ethical Committee of the Faculty of Physical Therapy, October 6 University Egypt with the registration number2024 (No.P.T.REC/024/003003). All authors had access to the study and have reviewed and approved the final manuscript.

Patient consent:
All parents have signed written consent forms at the beginning of the study.

Author contribution:
Authors contributed equally to the study writing manuscript, proof reading, reviewing and revising the manuscript.

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