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Effect of Combined Chest Mobilization with Conventional Chest Physical Therapy on Vital Signs and Respiratory Parameters in Critically-Ill Children

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ABSTRACT

Background: Respiratory issues such as atelectasis and bronchopneumonia are more common in patients in the intensive care unit (ICU).

Objective: The aim of the present study was to investigate the impact of chest mobilization exercises on vital signs and respiratory parameters in mechanically ventilated children.

Subject and methods: Fifty children who had pneumonia and received mechanical ventilation were enrolled in this study. Their mean ages were 3.8 ± 2 and 4.06 ± 1.9 years in the control and study groups respectively, and they required mechanical support. The children were divided randomly into two equal groups: conventional chest physical therapy group and combined chest mobilization with conventional chest physical therapy group. Heart rate, respiratory rate, tidal volume, minute ventilation and fraction of inspired oxygen were recorded before and after the study.

Results: There was a significant increase in tidal volume in favor of the combination group ($p < 0.05$) with no significant change in respiratory rate, heart rate, minute ventilation and fraction of inspired oxygen between both groups ($p>0.05$).

Conclusions: Combined chest mobilization exercises with conventional techniques of physical therapy were found to have a substantial impact on respiratory parameters in mechanically ventilated children and improve air entry into the lungs.

Keywords: Chest mobilization, Pneumonia, Atelectasis, Mechanical ventilation**,** Critical illness.

INTRODUCTION

Critically ill patients receive care in special units called intensive care units (ICUs). These units consume 15- 40% of total hospital expenses [1]**.** In pediatric intensive care units (PICU), mechanical ventilator is frequently used, with more than 20% of children requiring invasive ventilation. Although, there are many non-respiratory causes for mechanical ventilation, such as neurological and neuromuscular disease, hemodynamic shock, congenital heart disease, postoperative care and pain management, respiratory disease is a main indication for invasive mechanical support [2]**.**

Mechanical ventilation (MV) gives positive oxygen pressure and fulfills the partial oxygen (PO_2) and carbon dioxide (PCO_2) pressures. This property helps to decrease the respiratory system effort. Mechanical ventilation is generally used for critical patients with inadequate ventilation, compromised airway, and/or respiratory failure [3]**.** In intensive care, MV is a common treatment for patients of all ages. This supportive treatment, regardless of the underlying illness, is linked to numerous complications that may lengthen its duration, as pneumonia and ventilator-related lung injury [4]**.**

Pneumonia in children is more severe than in adults. Children's body temperature may not rise due to their immune system is not well developed. So, caution is required from parents. Furthermore, because children's mucociliary clearance is still developing, a dry cough appears first, and then cases of rapid transmission of infection to the lungs are observed [5]**.**

In 2019, pneumonia was responsible for the death of 740 180 children under the age of 5 years. In South Asia and sub-Saharan Africa, around 80% of deaths in children due to pneumonia occur [6]**.**

The risks of secretions retention, airway obstruction, atelectasis and infection might be increased by intubation and mechanical ventilator in the PICU [7]**.** The complications of mechanical ventilation in pediatrics have been reported between 40-150%, given that a single patient may have many complications [8]**.**

Atelectasis refers to incomplete expansion or collapse of part of the lung. It is the most common complication after mechanical ventilation in pediatrics [2]**.** Impaired gas exchange in critically ill patients is commonly caused by atelectasis. The incidence is probably higher if the patient is immobile, sedated, smoker, obese and elderly or has a history of lung illness. Its pathophysiology has many factors: non-obstructive, obstructive, or both. The majority of cases have multiple contributing factors, the most common ones being infection and prolonged immobility. A mucus plug and foreign body are common examples for obstructive atelectasis in both adult and children. Anesthesia can lead to collapse of 10–15% of lung tissue. The functional residual capacity (FRC) is reduced by loss of intercostal muscle function secondary to anesthesia, especially in children. Additionally, supine position decreases the FRC as the diaphragm is pushed cephalad by abdominal contents [9]**.** Physical therapy has the potential to dramatically lower the frequency of complications occurred with medical interventions, such as infections brought on by

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the intubation of mechanical ventilation [10]. Chest physiotherapy (CPT) aims to strengthen respiratory muscles, increase lung expansion, decrease secretion from the respiratory system, and enhance respiratory efficiency [11, 12]. Percussion and vibrations are CPT techniques, which are frequently used to remove secretions from the lungs. Both may be applied manually or mechanically [13]. Chest wall mobility changes in people with respiratory dysfunction may lead to abnormal chest biomechanics and chest wall stiffness [14].

Patients with conditions that limit their ability to move their chest wall, such as kyphosis, scoliosis, ankylosing spondylitis, multiple sclerosis, chronic lung disease, long time on mechanical ventilation, pneumonia and patients underwent lung surgery can all benefit from the chest mobilization exercises [15].

Since obstructive lung disease appears to decrease rib cage mobility, physiotherapy attempts to mobilize rib cage joints. In addition to enhancing chest wall mobility, chest wall mobilization increases tidal volume, enhances gas exchange, lowers respiratory rate, reduces dyspnea, decreases work of breath and promote relaxation. Chest wall flexibility and mobility improved by stretching the tissue surrounding the rib and keeping proper respiratory muscles and this results in improving ventilation [16, 17, 18].

Chest mobilization technique aims to increase chest expansion and allow better ventilation. Therefore, this technique should be used with patients with a limitation of chest movement to increase their chest expansion and improve ventilation [18, 19]. So we hypothesized that chest mobilization exercises would improve the respiratory parameters in critically ill children.

PATIENTS AND METHODS

Setting and participants:

All children were categorized randomly by flipping a coin into two groups. The research was designed as a prospective randomized parallel trial. Fifty children who had a pneumonia and receiving mechanical ventilation were enrolled in this study. The intervention group received chest mobilization exercises and conventional chest physical therapy, while the control group received only conventional chest physical therapy. They were enrolled from Pediatric Intensive Care Units, Abo El-Reesh Hospital, Cairo University Hospitals, Giza, Egypt.

Inclusion criteria: Children from both sexes aged 2–7 years on mechanical ventilator and diagnosed as pneumonia and their general condition was medically stable.

Exclusion criteria: Patients with uncontrolled convulsions, osteogenesis imperfect or rib fracture, Coagulation defects, unstable cardiac patients, patient with spinal fusion, pulmonary hemorrhage.

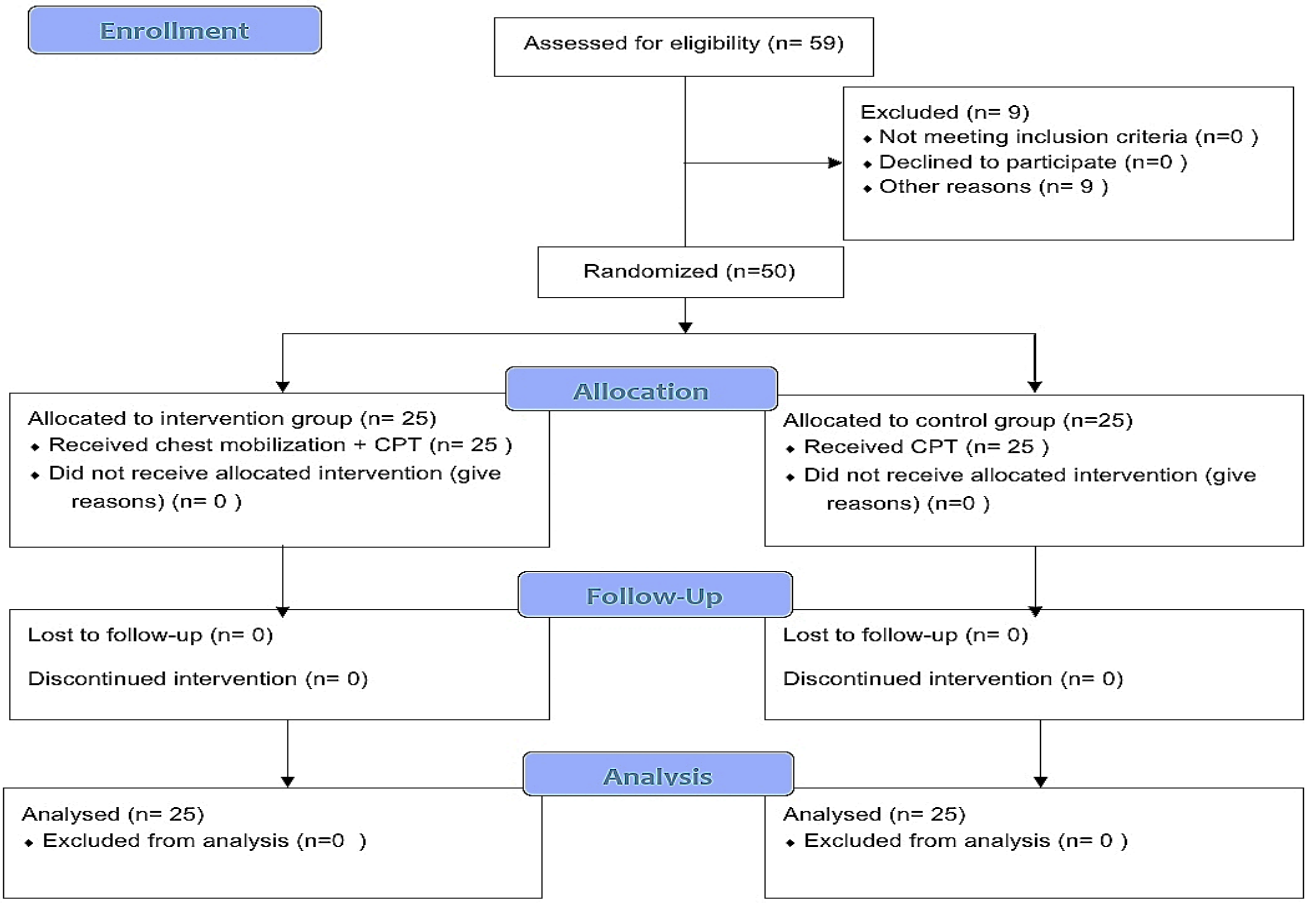

Figure (1): Study flow chart

Intervention: Chest physical therapy session started before child feeding or after feeding with 2 hours and post nebulizer session.

- **Control group** received conventional chest physical therapy only (percussion, vibration, postural drainage and positioning).
- **Intervention group** received conventional chest physical therapy in addition to chest mobilization technique that involved chest wall lateral flexion, rotation, extension, rib rotation and stretching pectoralis major muscle [20].

The technique was performed five times/set, three sets per session [15], one session per day from supine, sidelying or sitting positions, passively or actively according to patient's cooperation and awareness then chest clearance modalities (percussion and vibration) were applied from modified postural drainage positions mainly inverted sidelying and high supine. Percussion applied by cupped hand for 1-5 minutes on affected lobes then range of motion exercise and bed mobility according to the child abilities and finally proper positioning. Rest period was provided for secretions suction. The duration was between twenty and thirty minutes guided by child fatigue and discomfort.

Outcome measures: Respiratory rate (RR), heart rate (HR), tidal volume (TV), minute ventilation (MV) and fraction of inspired oxygen (FiO_2) were recorded from the monitor and mechanical ventilator before and after session for 2 weeks.

Ethical approval: Approval for the study was obtained from The Research Ethics Committee, Faculty of Physical Therapy, Cairo University, [No. of approval: P.T.REC/012/003311]. Each parent provided written informed consent before participating in the research. The Helsinki Declaration was followed throughout the research's conduct.

Statistical analysis

Version 20 of the statistical package for social studies (SPSS) for windows (IBM SPSS, Chicago, IL, USA) was employed for all statistical tests. Descriptive statistics was used to determine mean and SD of the participants. Descriptive statistics and unpaired t-test were carried out for assessment of the mean age (years), weight (Kg), of the two groups. Test of Chi square was performed for evaluation of allocation of sex among groups. In advance of analysis, test of Shapiro-Wilk was employed to check the data normality.

Variance's homogeneity test of Leaven was performed to evaluate among groups homogeneity, which revealed normally distributed data with variance homogeneity. Boxplot showed no data outliers. MANOVA of mixed 2 x 2 design was carried out to examine the impact of treatment (between groups), time (pre versus post) besides the interaction impact on mean values of RR, HR, TV, MV and FiO_2. The significance level for all statistical examinations appointed at $p \leq 0.05$.

RESULTS

A total of 50 children were assigned randomly into two groups equally (25 children/group). Table (1) showed that there was no significant difference between both groups in age, weight, or sex ($p > 0.05$).

Table (1): Demographic data of subjects of both groups

Demographic data	Control group	Study group	t-value	p-value
Age (years)	3.8 ± 2	4.06 ± 1.9	-0.48	0.632
Weight (kg)	14.78 ± 4.6	14.86 ± 4.7	-0.061	0.952
Sex	N (%)	N (%)		
Males	12 (48%)	15 (60%)	0.725	0.395
Females	13 (52%)	10 (40%)		

Data was expressed as mean ± standard deviation or number (percentage), χ^2: chi square, p- value: significance.

Effect of treatment within group comparison: The RR, HR and FiO_2 were significantly decreased post-treatment. Also, there was statistical significant increase in TV with no significant difference in MV between pre- and post-treatment.

Effect of treatment between groups comparison: The tidal volume increased significantly post-treatment ($p=0.041$) in favor to intervention group with no statistical significant difference in RR, HR, FiO_2 and MV between both groups, as shown in table (2).

Table (2): Comparison of RR, HR, TV, MV and FiO_2 variables pre- and post-treatment of both groups

Measured variable	Control group		Study group		f-value		P-value	
	Before	After	Before	After	Before	After	Before	After
Respiratory rate (breaths/min)	31.52 ± 7.49	28.48± 5.59	28.72 ± 4.64	25.68± 4.83	2.52	3.59	0.119	0.064
Heart rate (beats/min)	130.24 ± 13.76	123.48 ± 12.87	131.28± 16.11	117.48 ± 12.03	0.060	2.9	0.807	0.095
Tidal volume (ml)	98.56 ± 27	104.4 ± 23.5	97.6 ± 29.2	121.4± 32.9	0.015	4.41	0.905	0.041*
Minute ventilation (Liter/min)	3 ± 0.97	2.9 ± 0.95	2.78 ± 1.04	3.06 ± 1.01	0.623	0.319	0.434	0.575
FiO_2 (%)	50.68± 17.08	33.76 ±10.17	47.04 ± 15.13	30.56 ± 9.89	0.636	1.27	0.429	0.265

FiO2: Fraction of inspired Oxygen, *: Significance, Data was expressed as mean ± standard deviation.

DISCUSSION

We aimed to assess the impact of chest mobilization exercises combined with conventional chest physiotherapy on vital signs and respiratory parameters in children receiving mechanical ventilation. The findings suggest that the tidal volume was increased significantly in favor to chest mobilization group. There was significant decrease in RR, HR and FiO_2 within both groups with no significant change between them. Also, the minute ventilation didn't show significant difference post treatment in both groups.

The study of **Lee *et al.* [21],** found that combined chest mobilization with breathing exercise had a beneficial effect more than routine chest physiotherapy with breathing exercise on respiratory function after coronavirus in chronic stroke patients. According to **Wang *et al.* [22],** chest physical therapy, which includes rib cage compression, clearance of airway secretions, chest wall mobilization and early mobilization, can improve RSBI scores in mechanically ventilated patients and decrease the likelihood of extubation failure. Combined chest mobilization technique with postural drainage was more beneficial than mobilization techniques of chest wall alone according to **Sibtain *et al.* [23].** A study compared the chest mobilization exercises and core stabilization effects on chest wall expansion and lung function in patients had stroke, conducted by **Park *et al.* [24]** revealed that the chest expansion was significantly increased in the chest mobility group. **Park [25]** stated that adding mobilization of rib cage to training the inspiratory muscle improved chest expansion and inspiratory muscle activity more than training the inspiratory muscle alone. **Jung and Moon [26],** showed that self-thoracic area mobilization improved expansion of the whole chest area in patients with decreased chest mobility.

The current study supported the findings of **Zaman *et al.* [27]** who reported that chest physical therapy is very effective in acute lobar collapse intubated patients by minimizing secretion retention, maximizing oxygenation and reopening the atelectatic lung segments, thus preventing pulmonary complications. Our findings confirm with **Leelarungrayub *et al.* [18],** who stated that stretching exercise for chest wall causes improvement of expired tidal volume, and increase in expansion of chest. Chest mobilization exercises can enhance respiratory function as they improve respiratory muscle function according to **Jang *et al.* [28]. Younes *et al.* [29]** also reported that using chest physiotherapy techniques can improve oxygenation and decrease the risk for pneumonia.

Elbana *et al.* [30] conducted a study to explore the role of multimodality chest physical therapy on the clinical outcomes in patients with myasthenia gravis. They found that the respiratory rate was significantly lowered in the study group. **Abdelbasset and Elnegamy [31]** showed a more significant decrease in respiratory rate for the study group, which is considered as an improvement in a study, which examined the chest physiotherapy effects on children hospitalized with pneumonia. **Putt *et al.* [17]** revealed no significant difference in respiratory rate between the hold and relax approach to the pectoralis major and the sham approach, but revealed an improvement in vital capacity and upper limb range of motion in favor for the hold and relax approach.

However, the current study findings disagree with **Lukrafka *et al.* [32]** as they concluded that there is no sufficient data support the benefits of chest physiotherapy in children admitted with pneumonia. Our findings disagree with **Jiandani and Patel [33]** who investigated how chest physical therapy (CPT) affected the cardiorespiratory response in the intensive care unit. They discovered that there was no significant

difference in respiration rate in spontaneous breathing and ventilator support group at any time after CPT and when heart rate was examined, it was significantly raised immediately following CPT in both groups, which returned to the baseline after 30 minutes. At any time interval following chest physiotherapy, there was no any statistical difference in heart rate between both groups. **Zeng *et al.* [34]** showed that no significant change was observed in respiratory rate (RR) pre- and post-treatment in chest physical therapy group, indicating that CPT treatment did not cause differences in vital signs and respiratory function.

LIMITATIONS

The study limitations were mostly due to psychologically disturbed and uncooperative children, severe complications, which lead to withdrawal of the children from the study as high pulmonary hypertension and child arrest and death of 4 children. There was no much discussion and studies on effect of chest physical therapy in PICU.

CONCLUSION

It could be concluded that combined chest mobilization exercises with conventional chest physical therapy were found to have a substantial impact on respiratory parameters in children on mechanical ventilator, help to reopen the atelectatic lobes and overall improve air entry into the lungs. So it is better to add the chest mobilization exercises to chest physiotherapy program in PICU.

RECOMMENDATION

- In the future, more studies related to chest physical therapy in PICU needs to be conducted.
- Further research is important to examine the chest mobilization effects on non-ventilated children and spastic children with spinal deformities.
- Application of chest mobilization on cases as pleural effusion, pneumothorax and empyema.
- Further study is needed to apply the chest mobilization exercises as a part of the rehabilitation protocol for patients post-cardiac or abdominal surgeries.

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