

Effect of Thoracic Block Technique on Atelectasis in Children on Mechanical Ventilation

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ABSTRACT

Background: Atelectasis is described as lung collapse that affects one or more regions of the lung. It is characterized by reducing lung volumes, altering the ventilation/perfusion ratio, and being one of the causes of delaying the weaning from mechanical ventilation. The aim of the present study was to investigate the effect of thoracic block technique on atelectasis in children on mechanical ventilation. **Patients and methods:** A total of 44 children with unilateral atelectasis on mechanical ventilation, from both gender and their ages ranged from 6 months to 4 years, were recruited from intensive care unit (ICU), Abo-Elreesh Hospital, Cairo University. Patients were randomly assigned into two groups; *Group A* included 22 children who received a designed chest physical therapy program, and *Group B* included 22 children who received a designed chest physical therapy program and thoracic block technique.

Results: A significant increase in the percentage of totally improved lobes of lung in chest X-ray in both groups; the increase was significantly higher in patients who received a designed chest physical therapy program and thoracic block technique than patients who only received a designed chest physical therapy program ($P=0.04$). There was no significant difference in oxygen saturation index between groups post treatment ($P=0.38$).

Conclusion: Applying thoracic block technique on mechanically ventilated children with atelectasis can produce a significant increase in the percentage of totally improved lobes of lung.

Keywords: Atelectasis, Chest X-ray, Mechanical Ventilation, Thoracic block technique.

INTRODUCTION

Atelectasis is a common pulmonary change that occurs in intensive care units and post-operative recovery areas. It can indicate that a child's symptoms are getting worse and that they may need more ventilatory support, including oxygen support, invasive mechanical ventilation (MV), and/or non-invasive ventilation ⁽¹⁾.

The majority of pediatric atelectasis cases are complications of underlying respiratory diseases like asthma, pneumonia, sickle cell disease, respiratory muscle weakness, acute respiratory distress syndrome (ARDS), and congenital lung disease ⁽²⁾.

Chest x ray examination is an objective method can be used to document the presence, extent and distribution of the atelectasis, Atelectasis is associated with loss of volume of lung, mediastinum shift toward the involved lung, compensatory emphysema and unilateral elevated diaphragm ⁽³⁾.

Oxygen saturation index (OSI) is noninvasive methods of oxygenation assessment, utilizing pulse oximetry as a substitute for PaO₂, can be calculated and used as a surrogate for the diagnosis of acute lung injury (ALI) and ARDS in children ⁽⁴⁾.

Chest physical therapy is a form of respiratory care that drains the lungs using an airway clearance technique (ACT). It entails positioning, postural drainage, percussion (clapping), vibration, deep breathing, and regular huffing or coughing by physiotherapists to remove secretions, thereby enhancing respiratory function and preventing lung collapse ⁽⁵⁾.

Thoracic block technique or technique of insufflatory exercise in atelectasis (TILA) is an intervention that involves manually compressing all of

the healthy lung tissue during expiration, leaving only the area with atelectasis free, in conjunction with the use of invasive or noninvasive mechanical ventilation, lung re-expansion can help to improve pulmonary perfusion by preventing or reversing ventilatory inequality situations by varying intra thoracic pressures or by using the right positioning ⁽¹⁾.

The goal of the thoracic block technique with invasive or non-invasive mechanical ventilation is to achieve collapsed alveoli aeration by changing the flow and acting on the airway driving without reaching the lung paranchyma ⁽⁶⁾.

The current study aimed to study the effect of thoracic block technique on atelectasis in mechanically ventilated children.

PATIENTS AND METHODS

A total of 44 children, with age range between 6 months and 4 years of both sexes, diagnosed with unilateral atelectasis and mechanically ventilated from more than 24 hours were recruited from intensive care unit (ICU), Abo-Elreesh Hospital, Cairo University. The research was carried out between November 2021 and June 2022.

Patients who met the following criteria were chosen to participate in this study:

Patients were diagnosed with pneumonia, have unilateral mild to moderate atelectasis according to medical referral, required mechanical ventilation from more than 24 hours, their age range from 6 months to 4 years, and they were vitally stable during the session.

The patient was ruled out of the study if met one of the following exclusion criteria:

Medically unstable (examples: tachycardia, tachypnea and bradycardia) uncontrolled convulsion, irritable or moderate to severe pain, rib fracture pneumothorax.

The participants were randomly assigned into two equal groups:

Group A included twenty two children who received a designed chest physical therapy program. Designed chest physical therapy program was performed as the following: (1) Modified postural drainage, put child in supine position (anterior basal lobe collapse) or side lying (lateral basal lobe collapse and medial basal lobe collapse) or side lying to prone (posterior basal lobe collapse); not head down (i.e. Trendelenburg position) at same side of lung collapse, (2) Percussion: applied with a "cupped-hand position" on the chest wall on anterior and middle and basal lobes of the lung ^(7,8), (3) Vibration: mechanical vibrator was used. It was placed on the chest wall (anterior, lateral and posterior) ⁽⁹⁾, total time for each session 30 minutes, one session daily for ten days.

Group B received designed chest physical therapy technique in addition to thoracic block technique.

Thoracic block technique was performed as the following: (1) Putting the child in supine position with head elevated to 30 degrees, therapist, (2) Putting one hand on anterior part of the chest and the other hand on the posterior part of the chest, (3) Applying compression to exhalation position, leaving only atelectasis area free maintain for 20 seconds with a pause lasting for 20 seconds, (4) The maneuver can be performed several times in a row, depending on the patient's response, depending on pulmonary(y auscultation and thoracic expansion, (5) Use of invasive or non-invasive mechanical ventilation, use PEEP 5-8 cm H₂O it takes 20 minutes fractionated in 4 series of 5 minutes each, (6) Child took one sessions daily for 10 days ⁽³⁾. Chest x ray was taken before the treatment and at the end of last session and oxygen saturation index was measured before and after the study.

Oxygen saturation index was measured through equation: (OSI= MAP X FIO₂ X 100/ spO₂) Where MAP (mean airway pressure) and FIO₂ (fraction of inspired oxygen) measured from ventilator display and spO₂ measured from monitor display by Continuous SpO₂ monitoring was done using pulse oximeter (SAT-2200 oxypal mini, Nihon Kohden Corporation) a sensor is placed over a digit ⁽¹⁰⁾.

Ethical considerations:

The work was approved by the Academic and Ethical Committees at Faculty of Physical Therapy, Cairo University. For guardians of the children, the potential dangers and advantages were completely explained, and they signed a consent document. The confidentiality of the information was guaranteed. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for the Social Sciences) version 25 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Quantitative data were expressed as mean and standard deviation (SD). Qualitative data were described using number and percent. Quantitative data were described using mean and standard deviation (SD) for parametric data after testing normality using Kolmogrov-Smirnov test. Chi-Square test or Fischer's exact test was used for comparison of qualitative data of 2 or more groups. Student's t-test or Mann-Whitney test was used for comparison of quantitative data of 2 independent groups. Paired t test or Wilcoxon Signed Ranks test was conducted for comparison between pre and post treatment in each group. P value ≤0.05 was considered significant.

RESULTS

There were no significant differences in age or sex between both groups (Table 1).

Table (1): Age and gender characteristics of participants in both groups.

Age	N	Mean	SD	Minimum	Maximum	
Group A	22	15.91	11.73	4	42	
Group B	22	15	11.03	6	48	
Qualitative Variable			Gender		Total	
			Male	Female		
Group	A	Count	12	10	22	
		Percentage %	54.5 %	45.5 %	100.0%	
	B	Count	11	11	22	
		Percentage %	50%	50%	100.0%	
Total			Count	23	21	44
			Percentage %	52.3 %	47.7%	100.0%

The level of significance for all statistical tests was set at p ≤0.05.

There was a significant decrease in OSI post treatment in both groups compared with that pre-treatment (Table 2).

Table (2): Comparative analysis between Pre and Post OSI in every group.

Groups		Mean	SD
Pre OSI	A	5.56	1.33
	B	5.65	1.34
Post OSI	A	4.01	0.95
	B	3.64	0.76
Difference between Groups		Mean difference	T
Pre OSI/ Post OSI		0.09	0.22
		0.37	0.87
		P (2-tailed)	
		0.82	
		0.38	

There was no significant difference between pre and post treatment in both groups as regard OSI (Table 3).

Table (3): Paired sample t-test to compare pre and post treatment OSI.

Group	Mean difference	% change	Paired t test	P (2-tailed)
Group A	1.55	27.88	4.75	0.001
Group B	2.01	35.58	6.52	0.001

Chest X-Ray:

There was no significant difference between groups in chest X-ray pre-treatment, however there was a significant difference in post treatment chest x ray between the 2 groups (Table 4).

Table (4): Descriptive statistic and Mann-Whitney U test for chest X-ray:

Groups		Count	%
Pre chest x ray collapsed	A total collapsed	14	63.6 %
	A partial collapsed	8	36.4 %
B	B Total collapsed	11	50%
	B Total collapsed	11	50%
Post chest X-ray improved	A partial improved	7	31.8%
	A total improved	11	50%
A	A not improved	4	18.2%
	B partial improved	4	18.2%
B	B Total improved	18	81.8%
	B not improved	0	0
Mann-Whitney U test value		P value	
Pre chest X-ray	209	0.36	
Post chest X-ray	157	0.01	

In group B there was a significant difference in chest x ray between pre and post treatment more than group A (Table 5).

Table (5): Wilcoxon signed ranks test to compare pre and post chest x ray.

Groups	Z-Value	P-value
Group A	2.57	0.01
Group B	2.57	0.01

DISCUSSION

Ventilated neonatal and pediatric patients have risk factors for atelectasis include small, collapsible airways, a compliant chest wall, and the absence of intra-alveolar and bronchoalveolar pores. Additional risk factors for atelectasis, which may be present in critically ill patients, include disruption of the mucociliary escalator and ineffective cough. These changes may lead to difficulty with secretion clearance that may cause

airway obstruction and accumulation of secretions, potentially increasing the risk of ventilator-associated pneumonia (4,5). Inadequate secretion clearance can also create secondary areas of lung hyper-expansion. Untreated atelectasis and impaired mucociliary clearance may result in prolonged duration of mechanical ventilation and, ultimately, a prolonged pediatric ICU stay (11). The results of this study confirmed that in mechanically ventilated children,

applying thoracic block technique in addition to designed chest physical therapy program is more effective in reducing atelectasis than only using designed chest physical therapy program. The results also showed that, no significant change in oxygen saturation index between group A and B post treatment.

These results agreed with the result in a study by **Gomes et al.** ⁽¹²⁾ who studied the effect of selective insufflation to revert the atelectasis by applying manual chest compression on healthy side of lung, in their study they found that selective insufflation technique is effective in reversing atelectasis from the first session, unfortunately they didn't include OSI.

Also the finding of this study coincided with result in study by **Pereira et al.** ⁽⁶⁾ who studied the effect of thoracic block technique on atelectasis, in their study they applied this technique in form of two session daily each session last 20 minutes for ten days associated with using CPAP, they showed total reversion of atelectasis without showing desaturation or transient bradycardia.

In another study, **Guimarães et al.** ⁽¹³⁾ showed that applying TILA causes a success rate of 93.15% in the atelectasis resolution by radiological examination before and after technique, The high rate of success can be explained by the fact that the children were ventilated with positive pressure, an important factor to compensate for the mechanical distortion between the lung and the ribcage in infants.

In our study OSI value decreased after applying treatment because of direct relationship between OSI and FIO₂, MAP which decreased in case of improvement of respiratory status, which accepted with **DesPrez et al.** ⁽¹⁴⁾ who stated that oxygen saturation index correlate directly with mortality rate. According to **Vadi et al.** ⁽¹⁵⁾ the study demonstrated that OSI is a monitoring indicator used to assess the oxygenation status of mechanically ventilated patients.

The noninvasively measured SpO₂ is deemed clinically appropriate in the continuous monitoring of mechanically ventilated patients. The advantage of employing OSI is that it contains MAP measures, which highlight changes in lung compliance, aggressiveness of respiratory support, and oxygenation deficit, providing a better approximation of the severity of ALI.

This results agreed with the result in a study by **Schaan et al.** ⁽¹⁶⁾ who studied the effect of physical therapy technique on children with pneumonia in intensive care unit, In their study they applied manual chest compression/ decompression, suction, passive exercise, limb stretching, and functional positioning in bed and used oxygen saturation index as an indicator for lung disease before start of intervention, after fourteen days showed a clinical and hemodynamic improvement

and progressive ventilator improvement tolerating weaning from ventilation unfortunately they didn't use oxygen saturation index after the last session.

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