Journal of Medicine in Scientific Research

Volume 5 | Issue 2 Article 9

Subject Area: Pediatrics

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Recommended Citation

S. Hamed, Abeer E. and El Din Mohamed, Rabab Salah (2022) "The effectiveness of chest physiotherapy on mechanically ventilated neonates with respiratory distress syndrome: a randomized control trial," *Journal of Medicine in Scientific Research*: Vol. 5: Iss. 2, Article 9.
DOI: https://doi.org/10.4103/jmisr.jmisr_87_21

The effectiveness of chest physiotherapy on mechanically ventilated neonates with respiratory distress syndrome: a randomized control trial

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Abstract

This study aimed to investigate the effect of chest physiotherapy on mechanically ventilated neonates with respiratory distress syndrome. Thirty neonates were concluded in the study where their age ranged from 1 to 28 days. They were divided into two equal groups. Group A was the control group that received medical treatment and mechanical ventilation. Group B or the study group has received the same treatment and the chest physiotherapy program. The physiotherapy session was conducted daily until the child was weaned off the ventilator. The results showed significant differences in vital signs, blood gases, oxygen saturation, respiratory stay, and hospital stay. Therefore, chest physiotherapy should be introduced as a fixed-line treatment for mechanically ventilated neonates with respiratory distress syndrome.

Keywords: Chest physiotherapy, mechanical ventilation neonatal respiratory distress syndrome, neonatal respiratory distress syndrome mechanical ventilation

Introduction

Respiratory distress syndrome (RDS), or hyaline membrane disease, is a life-threatening condition caused in newborns where the lungs cannot provide the body's vital organs with enough oxygen. RDS is more severe with higher incidence related inversely to the neonate's gestational age [1].

The earlier a baby is born, the less the lungs develop and the higher the chance of developing neonatal RDS. Most cases appear in babies born before 28 weeks. It is very rare in neonates born full-term (at 40 weeks) [2].

Prematurity is not the only risk for neonatal RDS yet; many factors are involved, such as, a brother or sister with RDS, a mother with diabetes, cesarean delivery, a complicated birth that leads to acidosis in the newborn at birth, multiple pregnancies (twins or more), and rapid labor [2].

RDS results from a relative deficiency of surfactant, which leads to a decrease in lung compliance and residual functional capacity with increased dead space. The consequent massive perfusion mismatch and left-to-right shunting may comprise up to 80% of cardiac output [1].

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DOI:
10.4103/jmisr.jmisr_87_21

A premature neonate with RDS may have one or more of the following [2,3]:

(1) Very rapid breathing or periods of no breathing (apnea).
(2) Grunting sounds, especially when exhaling (breathing out).
(3) Retractions (the skin between and around the ribs pulls in during inhalation due to intercostal muscles contractions).
(4) The middle of the baby's chest may also sink down when breaths.
(5) Nasal flaring (the two nose openings become larger with breathing).
(6) Pale or blue-colored skin, lips, and nail beds.

Macroscopically, the lungs of neonates with RDS appear unventilated and gray consequently, and they need higher critical pressure to open and inflate. Under a microscope,

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Submitted: 17-Dec-2021 **Revised:** 25-Dec-2021 **Accepted:** 06-Jan-2022 **Published:** 09-Aug-2022

How to cite this article: Hamed AE, Mohamed RS. The effectiveness of chest physiotherapy on mechanically ventilated neonates with respiratory distress syndrome: a randomized control trial. J Med Sci Res 2022;5:129-41.

diffuse atelectasis of distal air spaces and the expansion of some distal airway and perilymphatic areas are observed. Damaging endothelial and epithelial cells lining the distal airways due to progressive atelectasis and barotrauma or volutrauma and oxygen toxicity results in an exudation of fibrinous matrix derived from blood [1].

Complications of neonatal RDS are related mainly to the clinical course of the disease and consequences in the long term. Despite that surfactant therapy has reduced the morbidity linked with RDS, many patients remain to have complications during and after the acute path of RDS [1]. Acute complications due to positive pressure ventilation or invasive mechanical ventilation include air-leak syndromes such as pneumothorax, pneumomediastinum, and pulmonary interstitial emphysema. There is also an increase in the incidence of intracranial hemorrhage and patent ductus arteriosus in very low birth weight infants with RDS, although independently linked to prematurity itself [4].

Recently, RDS outcome has improved with increased use of prenatal steroids to improve lung maturation, early postpartum installation for surface treatment, and gentle ventilation techniques to reduce injury to immature lungs. Because of these treatments, the survival of smaller and sicker premature newborns is increasing. Although reduced, the incidence and severity of RDS complications continue to present with significant morbidity [1].

Unfortunately, mechanical ventilation with endotracheal intubation is frequently associated with disruption and inflammation of the airways and increased secretions in the lung. These effects may lead to respiratory complications after mechanical ventilation and extubation cessation. Postextubation complications vary from an accumulation of viscous secretions causing discomfort, agitation, and malaise (necessitating repeated suctioning) to obstruction of the major airways with subsequent lung collapse [5].

Treatment of the RDS involved both medical and physical therapy modalities. The medical treatment involves; respiratory support (oxygen, endotracheal tube, and mechanical ventilation), venous lines (arterial line, intravenous, and peripheral or central), medicine (antibiotics, bronchodilators, diuretics, pain medicine, sedatives, steroids, and inotropes) [6]. The aim of management for neonates with RDS is to maintain a pH of 7.25–7.4 and arterial oxygen (PaO_2) of 50–70 mm Hg. The pressure of carbon dioxide (PCO_2) ranges from 40 to 65 mm Hg, depending on the clinical condition of the newborn [1]. Continuous positive airway pressure (CPAP) is indicated in children with RDS who have a PaO_2 consistently below 7 kPa (50–60 mm Hg) even though their inspired oxygen is increased to 50% or greater. The establishment of an artificial ventilator should be considered if a PaO_2 above 7 kPa is not maintained at an inspired oxygen concentration of more than 50% (mainly in infants less than 32 weeks of age); and/or $PaCO_2$ rises to levels around 7 kPa especially with a pH of less than 7.25. [1]

Chest physiotherapy (CPT) has been used to remove secretions and aid lung ventilation in newborns who require mechanical ventilation for respiratory problems [7]. The goals of CPT are to prevent debris buildup, improve mobilization of airway secretions, and improve the efficiency of several separate techniques, including postural drainage, percussion, vibration, oropharyngeal, and tracheal aspiration [7,8]. Observational studies in premature neonates undergoing ventilation have documented improved oxygenation, improved airway resistance, and fewer episodes of hypoxemia in neonates after active CPT [9].

Mechanical ventilation (machine-assisted breathing) surges the baby's lungs discharges and CPT is believed to clear the baby's lungs [10]. Although CPT for newborns with pulmonary dysfunction is a growing specialty of physiotherapy practice, CPT for newborns with RDS on mechanical ventilation is neglected in physiotherapy, especially in Egypt [11]. CPT has an optimistic effect on blood gases and respiratory functions. Although this positive effect did not reduce mortality, CPT is recommended as a standard treatment modality in critically ill patients. It helps with both lung function and blood gases, which may be beneficial in decreasing the need for ventilation assistance its problems [12,13].

The purpose of this study was to investigate the effects of applying for selected CPT programs on mechanically ventilated neonates with RDS.

The hypothesis

CPT in mechanically ventilated neonates is one of the standard treatment methods in the intensive care unit. Because intubated babies cannot cough effectively and can retain bronchial secretions, CPT modalities including postural drainage, percussion, vibration, and suction significantly affect the management of mechanically ventilated neonates with RDS.

Patients and methods

This randomized controlled trial was conducted on 30 preterm neonates of both sexes suffering from RDS who were selected from the Department of Neonatology of El-Galaa Teaching Hospital, Mabara Misr El Qadema Hospital, and Mabara Maadi Hospital from January 11, 2020 to February 28, 2021. The ethics committee approved this study at both Mabara Hospitals and El Galaa Teaching Hospital; according to the Helsinki Declaration, all patients' guardians concluded in this study were authorized to have written informed consent. Those patients were concluded according to the following criteria:

(1) Their ages ranged from birth to 28 days.
(2) Should be among the preterm neonates less than 36 weeks.
(3) They were characterized by the following signs and symptoms as examined by neonatologists:

(a) Tachypnea more than 60 breaths per minute or apnea (the normal value is 40–60 b/m).
(b) Heart rate (HR) was more than 160 beats per minute (tachycardia) (the normal value is 120–160 b/m).
(c) Diastolic blood pressure (DBP) was less than 60 mm Hg (hypotension) in complicated cases only (the normal value is >60 mm Hg).
(d) Decreased airway entry.
(e) Grunting sound.
(f) Retractions (intercostal, substernal, suprasternal).
(g) Nasal flaring.
(h) Pale or blue-colored skin, lips, and nail beds.
(i) X-ray findings showed white lungs, the fine reticular granularity of the parenchyma, and airway bronchograms.
(j) Blood gases were: arterial blood pH less than 7.20 (normal value 7.35–7.45), arterial blood PCO_2 of 60 mm Hg or higher (normal value 45–55 mm Hg), arterial blood PO_2 of 50 mm Hg or less at an oxygen saturation of 70–100% (normal value 50–70 mm Hg).

(4) They were mechanically ventilated in the incubator.
(5) They were monitored with oxygen support.

Babies were equally assigned randomly to either of the following groups using flipping coins for randomization:

(1) Control group (G1): in this group, 15 neonates who had received medical treatment only without any physical therapy treatment with a duration of medical therapy recorded from the first day on the mechanical ventilator to weaning according to their medical condition were recruited.
(2) Study group (G2): the other 15 neonates were involved and had received medical treatment and chest physical therapy sessions, including postural drainage as each drainage position was applied for 3–5 min with vibration and percussion, followed by about 2 min suctioning or until clear fluid returned to the tube.

Each session was applied daily for 30 min until the baby was weaned off a mechanical ventilator according to their medical condition.

Materials and instrumentation

For evaluation

(1) Medical records included: hospital chart, bedside flow sheets, arterial blood gases reports, chest radiograph reports, and any information relevant to the neonate, written by the neonatologist. All these were recorded for patients of both groups.
For both groups, blood gases and vital signs were measured at the time of their admission, at 48 and 72 h, and before extubation.
(2) A stethoscope for auscultation of chest sounds, especially before and after CPT sessions for the study group by a neonatologist.
(3) Intensive Care Unit (ICU) monitors in the neonatology department were involved in measuring the vital signs (HR (beat/min), respiratory rate (RR) (breath/min), temperature (°C), blood pressure (mm Hg)) each pre- and post-CPT session for patients of the study group under the supervision of the neonatologist.
(4) Percutaneous pulse oximetry (Nellcor, 1-ser. No. G 02828122, 2-ser. No. G 02812922) was used to measure oxygen saturation; attention was given at each pre- and post-CPT session for patients of the study group.
(5) Weighing scale was used to measure each baby's body weight (kg) before being mechanically ventilated and after weaning off the ventilator for all participants.
(6) Length meter was used to measure skull circumference in cm.
(7) Assessment sheet was used to record the obtained data for all patients.

Instruments used for treatment

(1) The following mechanical ventilators were used for respiratory support:
  (a) CARESCAPE R860 Ventilator: model G1500197 GE *P*/N M1229957, Datex – Ohmeda, Inc(3030 Ohmeda Drive Madison, WI 53718 United States. Mabara Misr El Qadema Hospital).
  (b) Puritan Bennett™ 840 Ventilator: Puritan Bennett Corporation Pleasanton, CA (Mabara Misr El Qadema Hospital).
  (c) Drager: Babylog 8000 plus Ventilator. Manufacturer: Drägerwerk AG & Co. K GaA Moislinger Allee 53–55 23542, Lubeck, Germany (Mabara Maadi Hospital & El Galaa Teaching Hospital).

All these types of mechanical ventilators are microprocessor controlled, pressure limited, time cycled, and continuous flow ventilators, specifically designed for the ventilation of neonates, with an integrated O_2 blender 20%–100% with FiO_2 monitoring. So, there would be no differences or alterations in the collected data and the final results.

(2) A cup for cupping therapy was used for percussion during specific drainage positions for patients of the study group (Fig. 1).

Procedures

For evaluation

(1) The medical records for all participants were reviewed daily (hospital chart, bedside flow sheet, arterial blood gases reports, chest radiograph reports, and any information pertinent to the neonate).
(2) Observation of the neonates for:
  (a) Signs of respiratory distress, intercostal, subcostal, and suprasternal retraction, nasal flaring, tachypnea or apnea, expiratory grunting, cyanosis, or pallor, seesaw motion between the abdomen and chest wall, or head bobbing.
  (b) Skin conditions (pale, shiny, dermatological conditions, scars, etc.).
  (c) c) Vital signs, such as HR (beat/min), RR (breath/min), blood pressure (mm Hg), temperature (°C).

(d) Posture and muscle tone.
(3) Bodyweight in kg was recorded for each baby to adjust intravenous fluids to guard against fluid overload, which may compromise respiration and also to adjust the doses of medications and monitor adequate weight gain, which is a sign of improvement.
(4) Head circumference in cm was recorded for each baby because a rapid increase in head circumference may be a sign of intracranial bleeding.
(5) Oxygen saturation was recorded using percutaneous pulse oximetry.
(6) The amount of oxygen administration by the oxygen analyzer.
(7) The neonatologist did an auscultation of chest sound.
(8) Ventilators mode, rate, and pressure were assessed (ventilator settings).

All procedures were conducted before and after each CPT session for the study group and daily for the control group while being incubated.

For treatment

Patients of both groups were mechanically ventilated and controlled medically by neonatologists.
(1) Patients of the control group (G1) were only monitored daily while being incubated. They did not receive any CPT program.
(2) Patients of the study group (G2) received a specially designed CPT program daily; each session was conducted for 30 min until weaning the baby off the mechanical ventilator.

For patients of the study group, the CPT program included the following.

Drainage positions

In postural drainage, the patient was positioned so that gravity had the greatest effect on the lung segment that has to be drained [14].

According to Koff [15], a basic understanding of the segmental branches of the lungs was essential in determining the position of appropriate postural drainage as well as the application of percussion to the affected area. The patient's chest radiograph was reviewed, and chest auscultation was performed by a neonatologist before CPT to identify areas of particular involvement. Thereby, appropriate positioning was performed to treat the affected areas. Depending on the location of course crepitations, presence of secretions and according to patient tolerance drainage positions were applied with avoidance of head-down position and excessive neck flexion/extension. The selected drainage positions used in the present study were done by specialized physiotherapists as follows:
(1) Anterior segments of the right and left upper lobes were drained while the patient was in the flat, supine position. The percussion was done over the side of the chest directly under the clavicles to around the nipple area, without direct pressure on the sternum (Fig. 2).

Figure 1: The used cup for percussion.

Figure 2: Drainage position and percussion of anterior segments of upper lobes of the left lung.

Figure 3: Drainage position and percussion of lateral basal segments of lower lobes of the right lung.

(2) Right and left lateral basal segments of lower lobes were drained at 30 degrees leaning forward, with percussion over uppermost portions of lower ribs (Fig. 3).
(3) Right and left anterior basal segments of lower lobes were drained at 30 degrees modified Trendelenburg, while the patient is lying on the appropriate side with 30 degrees turn backwards. The percussion was done at the anterior lower margin of the ribs.
(4) Drainage positions were applied 5 min for each position while the baby was incubated and rested on the forearm

and hand of the therapist or by using cushions and towels. Every child was maintained in 3–4 positions according to coarse crepitations.

Percussion

(1) Chest percussion was applied for each patient of the study group using the cup of cupping therapy.
(2) The important technical considerations during the application of cupping were maximized control, enlarged surface area to absorb the blow, and maintained cupping effect. It was important to avoid being overly aggressive in the delivery of percussion to the neonates.

Chest percussion was administrated with motion primarily from the wrist, with firm support applied to the side of the thorax opposite that being percussed. The percussion was applied for about 2 min during each postural drainage position, according to the treated segment.

Active gentle vibrations

The vibration was done through a rapid, fine "ripple" type of movement applied during exhalation. Percussion was followed by gentle vibrations to mobilize secretion toward the larger airways.

The vibration of each newborn chest was done manually by placing the fingers of one hand on the chest wall over the segment being drained and isometrically contracting the muscles of the forearm and hand to cause a gentle vibratory motion and the other hand support the baby's head. According to Lacey [16], vibration is done with the fingers of one hand molded to the shape of the child's chest wall, with lateral control support for the thumb. It was applied at a rapid rate with minimal pressure stress and within the child's tolerance of it. The other hand was cupped to support the baby's head for the whole duration of treatment [17].

Suctioning

Nasotracheal suctioning (NTS) for tracheal aspiration was done by the nurse as a component of resuscitation and bronchial hygiene therapy. According to Fiorentini [18], the purpose of the NTS was to remove accumulated saliva, pulmonary secretions, blood, vomitus, and other foreign matter from the trachea and nasopharyngeal area that could not be removed by the patient's spontaneous coughing or other less invasive procedures. It has been used to maintain a patent airway thus ensuring adequate oxygenation and ventilation. The clearance of secretions was accomplished by application of subatmospheric pressure applied to a sterile, flexible, multieyed catheter on withdrawal only that was done by the nurse. According to James *et al.* [19], appropriate subatmospheric pressure was 60–80 mm Hg for neonates. A baseline assessment for indications of respiratory distress and the need for NTS was performed; auscultation of the chest, monitor patients HR, RR, cardiac rhythm, oxygen saturation, skin color and perfusion, and effectiveness of cough [20]. Suctioning was performed after the use of active gentile vibrations. It was repeated as tolerated by newborn until clear return of the fluid to the tube. If secretions were excessively tenacious, saline instillation was considered, instilled up to 0.25 m/s NaCl with a stabilized endotracheal tube. Suctioning was applied by the nurse under the supervision of a neonatologist [21]. The effectiveness of NTS was reflected by assessing the patient by neonatologist after suctioning for improved breath sound, removal of secretions, improved blood gases data or pulse oximetry, and decreased work of breathing [22].

Duration of the chest physiotherapy session

According to Shann [14], each postural drainage position was applied for 3–5 min with vibration and percussion, followed by about 2 min suctioning or until clear return of the fluid to the tube, according to the patient's tolerance. The period of ventilation and incubation was determined by the neonatologist according to the progress of the case through repeated evaluations of vital signs, blood gases, and general condition of the case. The physiotherapy sessions have been done daily until the baby weaned from the mechanical ventilator depending on the response and the improvement of the case.

Principles for stopping chest physiotherapy

The CPT sessions in the present study were ended after the baby was weaned off the ventilator but still present in the incubator to regulate the temperature, respiratory status, and give O_2 as needed.

Criteria of weaning off the ventilator were as following:

(1) Improvement of blood gases ($PO_2 \rightarrow$ 50–70 mm Hg, $PCO_2 \rightarrow$ 40–65 mm Hg, and pH → 7.25–7.4). Improvement of vital signs (RR → less than 60 bpm, HR → less than 160 bpm, and DBP ↑ 60 mm Hg). Evidence of reexpansion of collapsed/consolidated lung (in the chest X-ray and the absence of retractions). Significant reduction in the production of excessive or tenacious secretions.
    (a) Follow-up of the patient during the postextubation period for signs of distress or deterioration in oxygen saturation and general condition was done.

Statistical procedures

The collected data were analyzed and described as mean and SD. Comparative analysis of variables within each group was analyzed using paired *t*-test to determine significance differences, whereas unpaired *t*-test was used to compare each variable between the two groups to determine significance. The level of significance was set at $P < 0.05$.

Results

Demographic characteristics of neonates in both groups

Comparison between chronological age, gestational age, and sex has revealed no statistically significant difference between both groups.

(1) Comparative analysis between study and control groups at the admission time:

(a) Comparative results of vital signs between both groups at the admission time: as demonstrated in Table 1, the mean values of vital signs (HR/bpm, RR/bpm, systolic and DBP/mm Hg) at the admission time revealed no statistically significant differences ($P > 0.05$) between study and control groups.
(b) Results of arterial blood gases between both groups at admission time:

As illustrated in Table 2, comparison of mean values of arterial blood gases at admission time revealed no statistically significant differences ($P > 0.05$) between both groups.

(2) Results of control group (group I)
(a) Results of control group (group I) after 48 h of admission.
i. Results of vital signs for the control group after 48 h of admission:

As indicated in Table 3, the mean value of HR at admission time revealed high statistical decrease in HR ($P < 0.01$), whereas the RR at admission time revealed high statistical decrease ($P < 0.05$). Also, the mean value of systolic blood pressure (SBP) (mm Hg) at admission time revealed statistical decrease ($P < 0.05$), whereas the DBP (mm Hg) were increased yet, with no statistical significance ($P > 0.05$).

ii. Results of arterial blood gases for the control group after 48 h of admission:

As demonstrated in Table 4, the mean values of pH was increased after 48 h (<0.01), whereas $PaCO_2$ was slightly reduced after 48 h of admission yet, with no statistical significance. As well, PaO_2 and SaO_2 were both increased after 48 h of admission with no statistical ($P > 0.05$).

(b) Results of control group after 72 h of admissions:
i. Results of vital signs for control group after 72 h of admission:
As indicated in Table 5, HR was decrease ($P < 0.01$) after 48 h of admission as well as the RR ($P > 0.05$). As well, a slight decrease in the mean value of SBP (mm Hg) was observed after 72 h of admission, whereas the DBP (mm Hg) was insignificantly increased ($P < 0.05$).
ii. Results of arterial blood gases for the control group after 72 h of admission:

As shown in Table 6, arterial blood gases after 72 h of admission showed a slight but significant increase in mean of pH (<0.01). The $PaCO_2$ was significantly decreased ($P < 0.05$) unlike the value of PaO_2 that was significantly increased as well as SaO_2 that showed a significant increase after 72 h of admission ($P < 0.01$).

(c) Results of control group before extubation:
i. Results of vital signs for control group before extubation:

Table 1: Comparison of mean values of vital signs at admission time between both groups

	X±SD		MD	*t*	*P*
	Study	Control			
HR (bpm)	164.6±4.51	164.13±3.6	0.47	0.31	>0.05
RR (bpm)	67.6±3.66	64.66±15.54	2.94	0.71	>0.05
SBP (mm Hg)	60.2±10.42	58.93±4.93	1.27	0.42	>0.05
DBP (mm Hg)	38.93±9.12	39.6±8.43	−0.67	0.2	>0.05

bpm, breath per minute; HR, heart rate; MD, mean differences; NS, nonsignificance; RR, respiratory rate; X, mean.

Table 2: Comparison of mean values of arterial blood gases at admission time between both groups

	X±SD		MD	*t*	*P*
	Study	Control			
pH	7.09±0.1	7.04±0.06	0.05	1.5	>0.05
PCO_2 (mm Hg)	66.18±4.87	67.86±2.72	−1.68	1.16	>0.05
PaO_2 (mm Hg)	38.3±5.29	39±5.95	−0.7	0.34	>0.05
SaO_2 (mm Hg)	72.26±7.78	71.61±4.37	0.65	0.28	>0.05

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Table 3: Comparison of mean values of vital signs for control group at admission time and after 48 h of admission

	X±SD		MD	*t*	*P*
	Admission time	After 48 h			
HR (bpm)	164.13±3.6	158±7.96	6.13	3.55	<0.01
RR (bpm)	64.66±15.54	60.8±12.45	3.86	3.21	<0.01
SBP (mm Hg)	58.93±4.93	56±4.7	2.93	2.05	<0.05
DBP (mm Hg)	39.6±8.43	41±6.32	−1.4	0.8	>0.05

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 4: Comparison of mean values of arterial blood gases for control group at admission time and after 48 h of admission

	X±SD		MD	*t*	*P*
	Admission time	After 48 h			
pH	7.04±0.06	7.11±0.07	−0.07	3.19	<0.01
$PaCO_2$ (mm Hg)	67.86±2.72	67.53±4.45	0.33	0.25	>0.05
PaO_2 (mm Hg)	39±5.95	42.86±4.85	−3.86	1.7	>0.05
SaO_2 (mm Hg)	71.61±4.37	78.97±3.69	−7.36	6.02	<0.01

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

As indicated in Table 7, comparison of mean values of vital signs before extubation revealed a highly statistically significant value of HR, RR,

Table 5: Comparison of mean values of vital signs for control group at admission time and after 72 h of admission

	X±SD		MD	t	P
	Admission time	After 72 h			
HR (bpm)	164.13±3.6	153.93±7.33	10.2	7.8	<0.01
RR (bpm)	64.66±15.54	61.2±6.41	3.46	1.04	>0.05
SBP (mm Hg)	58.93±4.93	57.93±5.47	1	0.49	>0.05
DBP (mm Hg)	39.6±8.43	45.93±6.45	−6.33	2.33	<0.05

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 6: Comparison of mean values of arterial blood gases for the control group at admission time and after 72 h of admission

	X±SD		MD	t	P	Sig.
	Admission time	After 72 h				
pH	7.04±0.06	7.13±0.11	−0.09	2.72	<0.01	HS
$PaCO_2$ (mm Hg)	67.86±2.72	64.52±4.8	3.34	2.1	<0.05	S
PaO_2 (mm Hg)	39±5.95	44.88±3.69	−5.88	3.38	<0.01	HS
SaO_2 (mm Hg)	71.61±4.37	83±4.42	−11.39	8.52	<0.01	HS

HS, highly significant; MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; S, significant; SaO_2, oxygen saturation; X, mean.

Table 7: Comparison of mean values of vital signs for the control group at admission time and before extubation

	X±SD		MD	t	P
	Admission time	Before extubation			
HR (bpm)	164.13±3.6	143.73±7.39	20.4	9.51	<0.01
RR (bpm)	64.66±15.54	55.73±5.87	8.93	2.47	<0.05
SBP (mm Hg)	58.93±4.93	64.33±4.68	−5.4	3.15	<0.05
DBP (mm Hg)	39.6±8.43	61.66±1.98	−22.06	10.3	<0.01

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

SBP (mm Hg), and DBP.

ii. Results of arterial blood gases for control group before extubation:

As demonstrated in Table 8, comparison of mean ± SD values of arterial blood gases before extubation revealed an increase in pH, $PaCO_2$, PaO_2, and SaO_2 at admission time and before extubation.

(3) Results of study group (group II)

(a) Results of study group at 48 h of admission:

i. Results of vital signs for study group at 48 h of admission (before and after physical therapy session):

As indicated in Table 9, the mean values of vital signs at 48 h of admission before and after each CPT session revealed a higher significant decrease between pre- and postsession HR (bpm). Also, the RR (bpm) has decreased compared with the preapplication of CPT sessions. In addition, a significant decrease in systolic and DBP (mm Hg) was observed after the application of CPT sessions.

ii. Results of arterial blood gases for study group at 48 h of admission before and after physical therapy session:

As demonstrated in Table 10, comparison of mean ± SD values of arterial blood gases at 48 h of admission before and after CPT session revealed a statistically significant increase in the pH after the application of various techniques of CPT session, a significant decrease in values of $PaCO_2$, an increase in the mean value of PaO_2 as well as SaO_2.

(b) Results of the study group at 72 h of admission:

i. Results of vital signs for study group at 72 h of admission before and after physical therapy session:

As indicated in Table 11, the mean value of HR has been decreased as well as the values of RR, whereas both values of systolic and DBP (mm Hg) have been increased at postapplication therapy.

ii. Results of arterial blood gases for a study group at 72 h of admission before and after physical therapy session:

Table 8: Comparison of mean values of arterial blood gases for the control group at admission time and before extubation

	X±SD		MD	t	P	Sig.
	At admission time	Before extubation				
pH	7.04±0.06	7.29±0.05	−0.25	11.15	<0.01	HS
$PaCO_2$ (mm Hg)	67.86±2.72	50.6±11.74	17.26	5.87	<0.01	HS
PaO_2 (mm Hg)	39±5.95	62.26±3.99	−23.26	10.09	<0.01	HS
SaO_2 (mm Hg)	71.61±4.37	90.13±1.72	−18.52	18.57	<0.01	HS

HS, highly significant; MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Table 9: Comparison of mean values of vital signs for study group before and after physical therapy session at 48 h of admission

	X±SD		MD	t	P
	Pre	Post			
HR (bpm)	155.2±8.03	146.45±9.41	8.75	5.49	<0.01
RR (bpm)	63.26±4.47	58.73±5.33	4.53	7.75	<0.05
SBP (mm Hg)	59.8±6.13	63.2±7.13	−3.4	3.1	<0.01
DBP (mm Hg)	44.33±4.16	48.66±4.8	−4.33	4.51	<0.01

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 10: Comparison of mean values of arterial blood gases for study group before and after physical therapy session at 48 h of admission

	X±SD		MD	t	P
	Pre	Post			
pH	7.19±0.09	7.26±0.06	−0.07	5.78	<0.01
$PaCO_2$ (mm Hg)	53.21±12.58	45.31±14.6	7.9	5.1	<0.01
PaO_2 (mm Hg)	41.36±7.78	49.28±9.76	−7.92	4.94	<0.01

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; X, mean.

Table 11: Comparison of mean values of vital signs for study group before and after physical therapy session at 72 h of admission

	X±SD		MD	t	P	Sig.
	Pre	Post				
HR (bpm)	147.8±10.53	139±8.37	8.8	6.23	<0.01	HS
RR (bpm)	58.2±6.01	52.6±4.5	5.6	5.26	<0.01	HS
SBP (mm Hg)	65.06±9.24	69.26±7.53	−4.2	3.1	<0.01	HS
DBP (mm Hg)	50.93±5.95	58.53±5.01	−7.6	7.14	<0.01	HS

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; HS, highly significant; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 12: Comparison of mean values of arterial blood gases for study group before and after physical therapy session at 72 h of admission

	X±SD		MD	t	P
	Pre	Post			
pH	7.25±0.09	7.32±0.07	−0.07	2.84	<0.01
$PaCO_2$ (mm Hg)	49.99±12.41	42.77±15.43	7.22	5.1	<0.01
PaO_2 (mm Hg)	45.86±5.91	53.82±5.47	−7.96	7.91	<0.01
SaO_2 (mm Hg)	84.2±4.1	89.8±3.06	−5.6	7.18	<0.01

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

The mean ± SD values of pH showed high increase in their values the session, whereas values of $PaCO_2$ showed a significant decrease after the CPT session. The mean value of PaO_2 has increased after the session as well as the mean value of SaO_2, as shown in Table 12.

(4) Results of study group before extubation:

(a) Results of vital signs for study group before extubation at admission time and before extubation: A significant decrease in HR was observed before extubation as well as in RR, whereas an increase in the mean values of both systolic and DBP (mm Hg) was detected at preextubation compared with their values at admission time Table 13.

(b) Results of arterial blood gases for study group before extubation:
The mean values of pH showed high significant increase compared with values at admission. The values of $PaCO_2$ showed a significant decrease, whereas value of PaO_2 was increased. Values of SaO_2 showed highly significant increase ($P < 0.01$) in favor of preextubation time, as shown in Table 14.

Comparative analysis between study and control group

Results of vital signs between both groups after 48 h of admission

As shown in Table 15, a highly statistical reduction in the mean values of HR between both groups, and in favor of to study group was detected. The mean values of RR showed a nonstatistical reduction between both groups.

As observed in Table 15, the mean SBP revealed a statistically significant increase between both groups, whereas the mean values of DBP revealed a highly statistical increase in favoring to study group.

Results of arterial blood gases between both groups after 48 h of admission

As shown in Table 16, the pH revealed highly statistical significance values in the mean values, whereas a significant reduction was observed in $PaCO_2$ values in favoring to study group. PaO_2 showed a significant increase in the mean values in favoring to study group, whereas SaO_2 revealed highly statistical significance values in the mean values in favoring to study group.

Results of vital signs between both groups after72 h of admission

The mean values of HR revealed highly significant reduction ($P < 0.01$) as well as RR as shown in Table 17. SBP revealed highly statistical increase in favoring to study group. The DBP showed highly statistical significance increase ($P < 0.01$) in favoring to study group.

Table 13: Comparison of mean values of vital signs for a study group at admission time and before extubation

	X±SD		MD	t	P	Sig.
	Time of admission	Before extubation				
HR (bpm)	164.6±4.51	130.06±7.81	34.54	23.54	<0.01	HS
RR (bpm)	67.6±3.66	50.8±3.46	16.8	17.37	<0.01	HS
SBP (mm Hg)	60.2±10.42	71±6.32	−10.8	5.19	<0.01	HS
DBP (mm Hg)	38.93±9.12	64.2±3.72	−25.27	10.21	<0.01	HS

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; HS, highly significant; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 14: Comparison of mean values of arterial blood gases for study group at admission time and before extubation

	X±SD		MD	t	P	Sig.
	Time of admission	Before extubation				
pH	7.09±0.1	7.34±0.06	−0.25	8.25	<0.01	HS
$PaCO_2$ (mm Hg)	66.18±4.87	33.44±16.29	32.74	7.23	<0.01	HS
$PaoO_2$ (mm Hg)	38.3±5.29	66.49±5.59	−28.19	19.88	<0.01	HS
SaO_2 (mm Hg)	72.26±7.78	91.8±2.17	−19.54	8.66	<0.01	HS

HS, highly significant; MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Table 15: Comparison of mean values of vital signs after 48 h of admission between both groups

	X±SD		MD	t	P	Sig.
	Study	Control				
HR (bpm)	146.46±9.41	158±7.96	−11.54	3.62	<0.01	HS
RR (bpm)	58.73±5.33	60.8±12.45	−2.07	0.59	>0.05	NS
SBP (mm Hg)	63.2±7.13	56±4.7	7.2	3.26	<0.05	S
DBP (mm Hg)	48.66±4.8	41±6.32	7.66	3.73	<0.01	HS

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; HS, highly significant; MD, mean differences; RR, respiratory rate; S, significant; SBP, systolic blood pressure; X, mean.

Table 16: Comparison of mean values of arterial blood gases after 48 h of admission between both groups

	X±SD		MD	t	P
	Study	Control			
pH	7.26±0.06	7.11±0.07	0.15	5.75	<0.01
$PaCO_2$ (mm Hg)	45.31±14.6	67.53±4.45	−22.22	5.63	<0.01
PaO_2 (mm Hg)	49.28±9.76	42.86±4.85	6.42	2.25	<0.01
SaO_2 (mm Hg)	83.73±4.46	78.97±3.69	4.76	3.18	<0.01

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Table 17: Comparison of mean values of vital signs after 72 h of admission between both groups

	X±SD		MD	t	P
	Study	Control			
HR (bpm)	139±8.37	153.93±7.33	−14.93	5.19	<0.01
RR (bpm)	52.6±4.5	61.2±6.41	−8.6	4.25	<0.01
SBP (mm Hg)	69.26±7.53	57.93±5.47	11.33	4.71	<0.01
DBP (mm Hg)	58.53±5.01	45.93±6.45	12.6	7.97	<0.01

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; MD, mean differences; RR, respiratory rate; SBP, systolic blood pressure; X, mean.

Table 18: Comparison of mean values of arterial blood gases after 72 h of admission between both groups

	X±SD		MD	t	P
	Study	Control			
pH	7.32±0.07	7.13±0.11	0.19	5.15	<0.01
$PaCO_2$ (mm Hg)	42.77±15.43	64.52±4.8	−21.25	5.21	<0.01
PaO_2 (mm Hg)	53.82±5.47	44.88±3.69	−8.64	5.23	<0.01
SaO_2 (mm Hg)	89.8±3.06	83±4.42	6.8	4.89	<0.01

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Results of arterial blood gases between both groups after 72 h of admission

As shown in Table 18, pH was significantly higher in the study group. As well, the mean values of $PaCO_2$ have been highly reduced in favoring to study group. In addition, the mean of PaO_2, as well as SaO2, revealed high significant values in the study group.

Results of vital signs before extubation between both groups

As demonstrated in Table 19, the mean HR reduced as well as RR. Also, both diastolic and SBP showed increased values in favoring to study group.

Results of arterial blood gases before extubation between both groups

As shown in Table 20, pH has been higher in the control group. The mean values of $PaCO_2$ have been reduced in

Table 19: Comparison of mean values of vital signs before extubation between both groups

	X±SD		MD	t	P	Sig.
	Study	Control				
HR (bpm)	130.06±7.81	143.73±7.39	−13.67	4.92	<0.01	HS
RR (bpm)	50.8±3.46	55.73±5.87	−4.93	2.8	<0.01	HS
SBP (mm Hg)	71±6.32	64.33±4.68	6.67	3.28	<0.01	HS
DBP (mm Hg)	64.2±3.72	61.66±1.98	2.54	2.32	<0.05	S

bpm, beat per minute; DBP, diastolic blood pressure; HR, heart rate; HS, highly significant; MD, mean differences; RR, respiratory rate; S, significant; SBP, systolic blood pressure; X, mean.

Table 20: Comparison of mean values of arterial blood gases before extubation between both groups

	X±SD		MD	*t*	*P*
	Study	Control			
pH	7.34±0.06	7.29±0.05	0.05	2.05	<0.05
$PaCO_2$ (mm Hg)	33.44±16.29	50.6±11.74	−17.16	3.3	<0.01
PaO_2 (mm Hg)	66.36±5.58	62.26±3.99	4.1	2.31	<0.05
SaO_2 (mm Hg)	91.8±2.17	90.13±1.72	1.67	2.32	<0.05

MD, mean differences; $PaCO_2$, arterial carbon dioxide pressure; PaO_2, arterial oxygen pressure; pH, hydrogen ion concentration; SaO_2, oxygen saturation; X, mean.

Table 21: Comparison of mean values of hospital stay and ventilatory stay between studied groups

	X±SD		MD	*t*	*P*
	Study	Control			
Hospital stays (days)	11.2±2.17	24.8±12.81	−13.6	4.05	<0.01
Ventilatory stay (days)	5.46±1.3	11.06±3.71	−5.6	5.51	<0.01

MD, mean differences; X, mea.

the study group. PaO_2 and SaO_2 were both increased in the study.

Comparative analysis of hospital and ventilatory stay between both groups

According to Table 21, hospital stay in the study group was much less than that observed in the control group. As well, ventilatory stay in the study group was lower than that observed in the control group by almost half the indicated days.

Result of postextubation failure and reintubation

Regarding the postextubation failure and reintubation, the results showed that 53.33% of the control cases were subjected to reintubation, whereas the study cases experienced a successful extubation with no postextubation complications.

Discussion

Neonatal RDS is known to be the most common sequelae in premature infants. This condition makes breathing difficult [2–24]. Surfactant deficiency is the main cause of neonatal RDS, especially in the context of immature lungs. The surface tension within the small airways and alveoli increases due to deficiency of surfactant, thus reducing the compliance of the immature lung [2]. The objectives of ideal management of neonatal RDS include reducing the incidence and severity with prenatal corticosteroids, followed by optimal management using respiratory support and surfactant therapy. Supportive care include thermoregulation, nutritional support, fluid and electrolyte management, antibiotic therapy, etc., and full care of premature babies [25,26].

Hough *et al.* [22] had mentioned that the respiratory assistance required to support breathing in preterm infants increases the risk of lung damage. One intervention that can be used to improve ventilation is CPT through the removal of excess tracheobronchial secretions. There are a variety of CPT techniques used as a bundle in premature infants including postural drainage, positioning, and active techniques such as percussion, vibration, and suction. The use of these techniques, in various combinations, has become a traditional treatment for a variety of acute and chronic lung conditions.

In addition, Bae *et al*. [27] reported that insufficient level of surfactant in the neonate's lung is the most common cause of RDS and that most deaths from RDS occur within 72 h after birth and recoveries begin after 72 h. The preferred age group for this study ranged from 1 to 2 days after birth until weaning from the ventilator. The comparison between both groups regarding basic characteristics showed no significant differences in all measured parameters including vital signs, blood gases, and gestational and chronological age.

Regarding the vital signs, results of comparing their mean values of control group after 48 and 72 h of admission and before extubation showed statistically significant ($P < 0.01$) decrease in HR, a reduction in RR ($P < 0.05$), and an increase in SBP and DBP. These results may be attributed to the improvement of hypovolemia, or depression of cardiac and vascular responses due to severe metabolic disturbance and hypoxemia by medical treatment [28]. These results came in agreement with Kalyn *et al.* [29] and Sakuramoto *et al.* [30] who found that there were maintenance of better physiologic stability in HR, RR, and blood pressure of the intubated neonates.

Concerning blood gases, the results of the present study revealed statistically significant differences in pH, $PaCO_2$, and PaO_2 after 48 and 72 h of admission, and before extubation. These results may be due to improved oxygenation, elimination of carbon dioxide, and balancing achieved between hypoxia and acidosis by ventilatory support. This was confirmed by Pramanik in 2020 [1]. Also, it may be a result of decreased severity of RDS, improved gas exchange, lowered the oxygenation and ventilatory requirements, and decrease in the incidence of interventricular hemorrhage (IVH) by using the medications as confirmed by McPherson *et al.* [31]. That comes in the line with Chakkarapani *et al.* [32] who reported that there was an improved oxygenation during synchronized intermittent mandatory ventilation in neonates with RDS, which allowed a reduction in ventilation pressure or oxygen exposure in this group of neonates who were at risk of having complications of ventilation. Miao *et al*. [33] attributed the same results in their study to lowering the surface tension that allowed the alveoli to remain inflated and allowed gas exchange due to the combined administration of surfactant with CPAP in neonatal respiratory distress syndrome (NRDS) treatment. The authors contributed to enhancing efficacy, promoting recovery of the blood gas index, and reducing parameters of mechanical ventilation and the incidence of complications to improve respiratory function of the newborn. However, Sweet *et al*. [34] stated that multiple doses of surfactant result in a greater improvement in ventilation and reduce risk of acute lung injury. As well, this comes in the line with the study made by Abdeen *et al.* [35] who attributed these results to improvement of oxygenation, improvement in air way resistance, and inflating the collapsed or atelectatic lung in patients who received CPT.

These results also came in agreement with El-Tohamy *et al.* [8] who confirmed that CPT has a positive effect on blood gases. Also, El-Tohamy *et al.* reported that CPT has acquired a role in the management of neonates with RDS. Roqué i Figuls *et al*. [36] also confirmed that CPT increases the clearance of the lung secretion, maintain lung expansion improving oxygenation, improving air way resistance, and lessen the hypoxemic episodes after chest physical therapy. These effects will lead to better ventilation and improved gas exchange [11]. Also, these results come in agreement with Abd El-Fattah *et al.* [11] as they confirmed that the follow-up of blood gases in their study showed that patients who were subjected to CPT had significant decrease of their $PaCO_2$ after 48 h. Also, Main and Stocks [37] reported that there were a significant increase in physiological dead space, alveolar dead space, and tidal volume but there were no significant changes after the treatment in $PaCO_2$ that may be attributed to the design of their study that involved comparison between chest physical therapy program (postural drainage, percussion, and vibration) and suctioning, whereas the present study combined them together in the CPT program.

The comparison between control and study group after 48 and 72 h of admission and before extubation revealed a highly statistical significance reduction in the mean values of HR (bpm) in the study group but showed no significant differences in the mean values of RR (bpm) between study and control groups after 48 h and the differences become highly significant after 72 h and before extubation.

Regarding the blood pressure, comparison between study and control groups at 48 and 72 h of admission and before extubation revealed that there was a highly statistically significant increase in the mean values of SBP and DBP in the study group. The posttreatment results of the present study could be attributed to improving the ventilation/perfusion ratio, circulatory status, and peripheral perfusion, which lead to improving HR, RR, and blood pressure as mentioned by Pramanik [1] who ended with the same results in his study. This also came in agreement with Abdeen *et al.*'s [35] study who found that there was an initial blood pressure drop followed by a greater blood pressure rise of longer duration after application of CPT sessions. Also, Battaglini *et al*. [12] stated that the wider role that physiotherapy may play should be considered in terms of positioning to optimize ventilation and perfusion. Once the consolidator phase begins to resolve, CPT techniques might have some benefit in mobilizing and clearing secretions, especially in the weak neonate.

Morrow *et al.* [23] also stated that endotracheal suctioning should be performed regularly in ventilated neonates to remove obstructive secretions. Sakuramoto *et al.* [30] reported that the endotracheal suctioning is performed in the pediatric intensive care unit, by both physiotherapist and nursing stuff. The primary purpose of endotracheal suctioning is to remove secretions and prevent airway obstruction, through preventing atelectasis while optimizing oxygenation and ventilation and decreasing the work of breathing.

Regarding the length of hospital stay, the comparison between both groups revealed that the mean value of hospital stay of the study group that received CPT was 11.2 ± 2.17 days and it was significant ($P < 0.05$), shorter than those in the control group (27.8 ± 12.81 days), whereas the results of ventilatory stay revealed that the mean value in the study group was 5.46 ± 1.3 days, and for the control group was 11.06 ± 3.71 days that indicated significant shorter days on ventilation for patients in the study group. These results of the present study may be attributed to the combination of both medical treatments that involved mechanical ventilator for oxygen support, medications (bronchodilators, diuretics, pain medicine, sedatives, steroids, and surfactant therapy), and supportive therapy (temperature control, electrolyte and acid-base balance, circulation and anemia management, nutrition, and support of parents), and the well-designed physical therapy program that included postural drainage, percussion, vibration, and suction. These results come in agreement with those obtained by Battaglini *et al.* [12] who stated that the duration of ventilation was less in those who were subjected to CPT. In addition, the use of an appropriate type of ventilation as synchronized intermittent mandatory ventilation has shorten the duration of mechanical ventilation and reduced the need for reintubation in preterm neonates with RDS. Moreover, it reduced the incidence of some serious complications of mechanical ventilation such as IVH that was suggested by. El-Tohamy *et al.* and Spapen *et al*. [8,13]. Matthay *et al*. [38] reported that mechanical ventilation is a lifesaving for many very preterm babies but prolonged use can have adverse effects increasing the risk of subglottic injury and chronic lung disease. In the contrary, Cooper *et al.* [39] stated that long-term complications of mechanical ventilators may develop as a result of oxygen toxicity, high pressures delivered to the lungs, the severity of the condition itself, or periods when the brain or other organs did not receive enough oxygen.

According to Halliday [40], the clinical and physiological factors that assessed the successful extubation of neonate were arterial blood gases, pulmonary mechanics, lung volume measurements, and clinical profiles and which should be determined before and after extubation. Regarding the postextubation failure and intubation, the results showed that 53.33% of the control cases were subjected reintubation, whereas the study cases experienced successful extubation. Halliday [40] concluded that CPT after extubation did not reduce alveolar atelectasis but decreased the need for reintubation. Schechter [41] proved that airway clearance therapy may be of benefit in preventing postextubation atelectasis in neonates. In the contrary, complications of CPT in neonates were reported. Bassani *et al.* [42] found that in many neonatal nurseries, CPT has been used around the world to increase airway clearance and to treat lung collapse; however, the evidence to support its use has been conflicting. In spite of the huge number of studies, there is little evidence of good enough quality to base current practice on. Larger randomized controlled trials are needed to address these issues. Also, one cohort study of preterm neonates with RDS at Royal Prince Alfred Hospital has found no association between application of active CPT and cerebral ischemic lesions (intraventricular hemorrhage or periventricular leukomalacia) as a complication for CPT treatment of ventilated neonates [16]. As well, Raval *et al.* [43] showed in a single randomized trial an increased incidence of severe IVH in preterm neonates with RDS receiving active CPT on the first day of life, but this may be attributed to old techniques in the management of RDS previously used. The results of the current study do not agree with those mentioned in the Royal College of Pediatrics and Child Health [44] where the routine CPT was not recommended in neonatal RDS. Oberwaldner [45] concluded that CPT strategies applied in this age group have to incorporate appropriate techniques for raising lung volume and redistributing ventilation.

CPT in the mechanically ventilated newborn neonate has belonged to standard treatment methods of neonatal intensive care unit in many countries for more than 20 years that was mentioned by Hawkins and Jones [46] who stated that there were several studies that demonstrated a beneficial effect of CPT on short time improvement of oxygenation in those newborns treated. This was also mentioned by Longhini *et al.* [47] as CPT has been used in many neonatal nurseries around the world to improve airway clearance and treat lung collapse.

Conclusion

It can be concluded that the specially designed chest physical therapy program used in this study can be considered as a beneficial therapeutic program that can be used to treat and improve the ventilatory status of the mechanically ventilated neonates with RDS and also economically it is cost-effective for patients and hospitals.

Recommendations

This study recommends further studies to evaluate the effect of chest physical therapy on pulmonary functions in mechanically ventilated neonates with RDS. Long-term follow-up for these cases to detect the complications if any and how to prevent them is required.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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