Effect of Lung Squeezing Technique on Vital Signs and X-Ray Findings in Neonates with Respiratory Distress Syndrome

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Abstract

Background: Respiratory problems like Respiratory Distress Syndrome (RDS)in neonates is one of the leading causes of neonatal morbidity and mortality in developing countries.These respiratory problems are seen in premature neonates, which mainly include RDS.

Objective: To investigate the efficacy of lung squeezing technique onvital signs and X-ray findingsin neonates with respiratory distress syndrome.

Study Design: Prospective, randomized controlled study.

Subjects, Materials and Methods: This randomized controlled trial included 30 neonates with RDS under mechanical ventilation. Their ages ranged from 3-15 days.The participants were randomly allocated into 2 equal groups. The control group received conventionalphysiotherapy (CPT), while the study group received CPT in addition to Lung Squeezing Technique (LST) for 20 minutes duration per session, two sessions per day, for a period of 7 days. Vital signs [heart rate (HR), respiratory rate (RR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP),Temperature and oxygen saturation (SaO_2)] were measured and chest X-ray was done.All measurementswere recorded at baseline, 2 days and 7 days of intervention in this study.

Results: Significant improvement was recorded invital signs (HR, RR, SAP, DAP, Temperature, SaO_2) in favor to study group,while there was no significant difference regarding X-ray findings between both groups.

Conclusion: Lung squeezing technique is an excellent supplement to conventional chest physiotherapy in managing RDS in neonates.

Key Words: Lung squeezing technique, Neonates,Respiratory distress syndrome , Vital signs ,X-ray findings .

1. Introduction

The RDSis common, affecting up to 7% of all term newborns, and is increasingly common in even modest prematurity [1]. Deaths, associated to the disease, usually occur during acute phase of respiratory failure and are largely limited to extremely immature newborns which birth weight is lower than 1000 g [2]. In fact, nearly all infants born before 28 weeks of pregnancy develop RDS [3].Although the primary risk factor is prematurity, a number of additional factors need to be contemplated. In addition to prematurity, short gestational age, acidosis, asphyxia, maternal diabetes and cesarean section can increase the risk of RDS[4].Progressive and high-frequency

respiratory insufficiency, breathlessness due to immaturity and atelectasis of the lungs characterize the RDS .It is reported that although it has been linked to a qualitative and quantitative dysfunction of the pulmonary surfactant system, its replacement has been associated with a sustained improvement in lung function and a reduction in the mortality rate [5].

Clinical manifestations of RDS have varying degrees of tachypnea, nasal flaring, retractions, moaning, and cyanosis. Apnea can occur secondary to hypoxemia and respiratory failure. In more severe cases, with disseminated micro atelectasis, there is a reduction of vesicular murmur [6].

Oxygen therapy is commonly used in Neonatal Intensive Care Unit(NICU) as an integral part of respiratory support. Prolonged oxygen therapy can lead to accumulation of excess of bronchial secretions, which need to be removed using chest physiotherapy. [7].

Conventional chest physiotherapy (CPT) has become anintegral part of airway management in NICU settings[8] with an aim to remove excess of bronchial secretions, thus improving oxygenation [9]. Various manual techniques for airway clearance are used in neonatalsettings, including postural drainage, percussion, andvibrationbased on rationale to facilitate secretion removal and are used as conventional treatment [10]. Lung Squeezing Technique is one of these techniques that have been shown to be beneficial in correcting atelectasis in infants.

Reported complications of CPT include hypoxemia, rib fractures and cerebral injuries and encephaloclasticporencephaly [11].Therefore, this study was conducted to test the hypothesis that LST in addition to CPT program would reduce RDS and improve vital signs and chest X-ray findings of newborns when compared with a program of CPT alone.

2. Subjects, Materials and Methods

Subjects

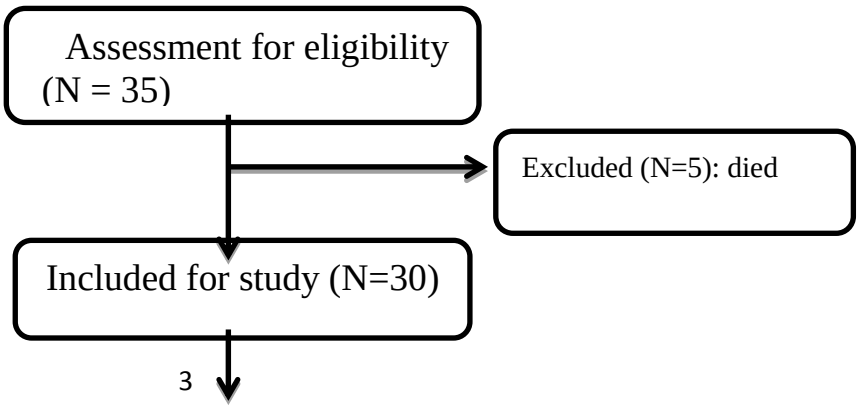
Thirty five incubated neonates of both sexes suffering from Respiratory Distress Syndrome were selected from neonatal intensive care unit of Benha Children Hospital, they were equally divided in random into two groups : (Control group and

Study group).

We considered the following inclusion criteria:gestational age of 30 to 37 weeks under O2 therapy;clinical and radiological diagnosis of RDS. The radiological diagnosis (X-ray findings) was based on diffuse reticulogranular infiltrate (ground glass appearance) [12]. Clinical diagnosis was established when the newborn presented early respiratory distress (tachypnea, expiratory grunt, nasal flaring, chest retraction and cyanosis),early onset and progressive evolution [13]. They had RDS score ≥ 6 according to Downes' score [14].

The newborn who had one or more of the following criteria were excluded from the study: newborn with congenital malformations, asphyxia at time of birth, genetic syndromes, neurological disorders or congenital infection with clinical manifestations, seizures, who underwent surgical procedures, withintra-ventricular hemorrhage (IVH) or major cerebral abnormality. Intra-ventricular hemorrhage was defined according to the classification described by Tudehope et al. [15]: Grade 1- IVH subependymal hemorrhage, grade 2- IVH filling<50% of the ventricle, grade3-IVH filling>50% of the ventricle and grade 4-IVH with parenchymal involvement. Major cerebral abnormality defined as one or more of the following: cerebral cyst formation (porencephalic cyst, periventricular leukomalacia,Periventricular-intraventricular hemorrhage , hydrocephalus [16].

35 newborns were assessed for eligibility. 5 were discontinued as they died while conducting the experimental protocol and 30 were enrolled in the study. Following the baseline measurements, randomization process was performed using closed envelopes. The investigator prepared two closed envelopes with each envelope containing a card labeled with either control group or study group. Finally, for each newborn we drew aclosed envelope that contained one of the two groups.The study design is demonstrated as a flow chart in **Fig.1**.



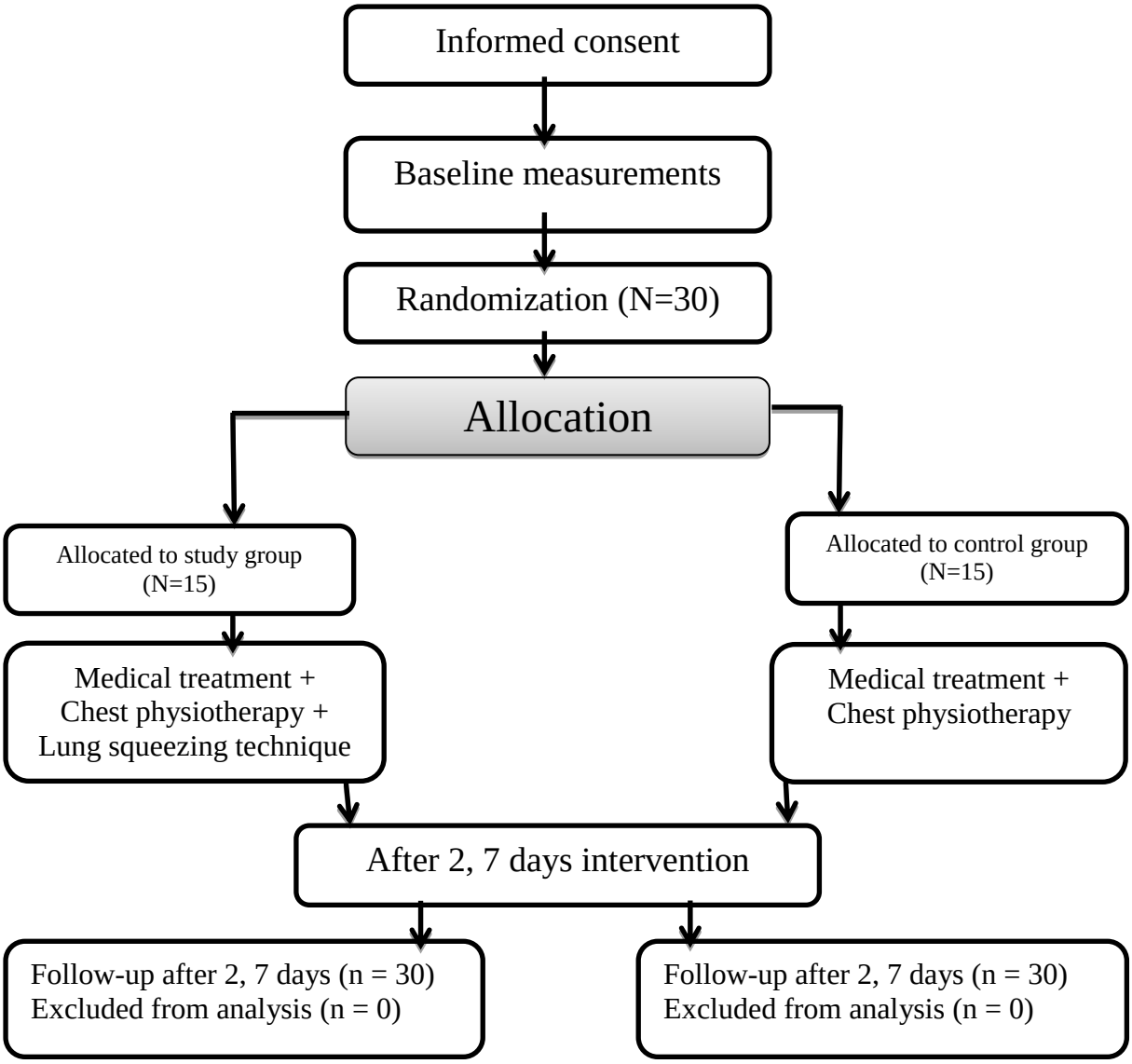


Figure (1): Flow chart explain the randomization process

Materials and equipment:

- **For Evaluation**

Vital signs data were recorded from the monitors in the NICU and from recording sheets of each case. Chest X ray was done using portable X-ray machine (PLX101).

- For Treatment

Vibrator (THRIVE 714) was used for applying vibration during postural drainage positions. Suction apparatus (LT9A-26D)used for suction of endotracheal tube and nasopharyngeal secretions

Methods

- **For evaluation**

Vital signsincluding heart rate (HR), respiratory rate (RR), systolic arterialpressure (SAP) and diastolic arterial pressure (DAP),temperature and oxygen saturation (SaO_2) measured. Chest X-ray was done.X-rays were interpreted by a pediatric radiologist who was blinded to group allocation. All measurements were recorded pre,after 2 days and 7 days of intervention.

- **For treatment**

Patients of both groups were incubated and controlled medically by neonatologist. Outcome measures were assessed at baseline, after 2 days and after 7 days from the beginning of the study.

A. Control group

Newborns of the control group received medical treatment and conventionalchest physiotherapy program sessions which include; postural drainage positions which were applied for 3-5 minutes for each segment with vibration and percussion [17].The chest physical therapy sessions were applied 2 times daily for 6 days/week, eachsession was about 20 minutes, according to the neonate tolerance.(SaO_2) and HR were maintained and analyzed during the entire CPT.According to Santos et al. [18] in cases of SpO2 reduction below 87%,tachycardia or bradycardia (alterations >15% ofthat predicted for the age), the intervention wasinterrupted and FiO2 increased by 10% over thebaseline level.The CPT included the following:

i. Postural drainage

The patient's chest radiograph was reviewed and chest auscultation was performed prior to CPT to identify areas of particular involvement. Depending on the location of coarse crepitations, presence of secretions and the newborn tolerance, appropriate drainage positions were applied with avoidance of head down position and excessive neck flexion/extension.

ii. Percussion

Chest percussion is refined by the utilization of rising three fingers, four fingers, or utilizing any of the financially accessible percussion gadgets made for neonates. A little anesthesia veil or "palm glass" was utilized successfully.

iii. Vibration

It takes after percussion through manual vibratory movement of the advisor's fingers on the baby's chest divider vibrator. Physically by putting the fingers of one hand on the chest divider over the section being depleted with isometric getting the muscles of the lower arm and hand to cause a delicate vibratory movement and other hand bolster the child's head**.**

B. Study group

Newborns of study group received the same program for control group in addition to LST.LST is used to restore homogeneous inflation of the lungs by means of small amplitude oscillatory chest wall compressions. It differs from conventional chest vibration and percussion in the following aspects: each set of "Lung Squeezes"consists of three to four cumulative chest compressions lasting for 5 seconds, followed by a gentles low "release phase", with the chest wall completely released; the second compressions are performed successively for 5 minutes on one hemi thorax, then 5 minutes on the other hemi thorax**.** [19].The infant should be in

supine position, and without body tilt, for a total of 10 minutes. Use both hands to perform the squeeze on one hemi thorax at one time. Place One hand on the posterolateral aspect of the hemi thorax and the other hand covered the anterior chest extending from the lower ribs to above the clavicle of the infant. [20].These compressions are given without vibration and not in a gravity-assisted position. In order to minimize the potentially deleterious effect of lowering the end expiratory lung volume, the delivery of the chest compressions is not intended to be in synchrony with the infant's breathing pattern, and full range compression from full inspiration to end expiration is avoided. [21].

Statistical analysis

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, United states).Comparisons between two groups were done using Mann Whitney U test for numerical data. Categorical data was compared using Chi-square test or Fisher's exact test when appropriate. All P values were two sided. P values less than 0.05 were considered significant.

3. Results

- **Characteristics of the Enrolled Newborns:**

The mean and standard deviation of the characteristics of enrolled newborns at the beginning of the study including;age (days) at enrollment and gender are presented in **Table 1**.No significant differenceswere recorded between both groups (P>0.05) which

revealed that both groups were matched before starting of the study.

Table (1) Demographic characteristics in both groups

Variable		Study (n = 15)	Control (n = 15)	P value
Age (days)	Median (range)	5 (3 - 15)	5 (1 - 20)	0.389
Gender	Males	12 (80)	8 (53.3)	0.121
	Females	3 (20)	7 (46.7)	

Mann Whitney U test was used for age. Chi-square test was used for gender

- **Vital Signs:**

The collected data from this study represent thestatistical analyses of the vital signs includingHR, RR, SAP, DAP,Temperature and SaO_2.

There were no significant differences betweenboth groups in all measuring variables beforestarting the treatment suggesting propersample subdivision, while after 7 days ofintervention, the results showed significantdifferences in all measuring vital signs betweenboth groups ($P < 0.05$) in favor of the study group as demonstrated in **table 2**and **figure 2**.

Table (2) Vital signs pre procedure, after 2 days and after 7 days in both groups

Variable	Timing		Study (n = 15)	Control (n = 15)	P value
Heart rate	Pre	Mean ±SD	144 ±6	148 ±10	0.258
	After 2 days	Mean ±SD	139 ±5	149 ±6	<0.001
	% change	Median (range)	-4.1 (-9.1 - 8.6)	1.4 (-6.7 - 10.3)	0.013
	After 7 days	Mean ±SD	134 ±6	151 ±7	<0.001

	% Change	Median (range)	-7.1 (-15.5 - 1.5)	2.1 (-6.1 - 11.9)	<0.001
Respiratory rate	Pre	Mean ±SD	48 ±3	47 ±6	0.174
	After 2 days	Mean ±SD	42 ±4	48 ±5	<0.001
	% change	Median (range)	-11.1 (-32.7 - -4)	-2.2 (-16.7 - 25)	<0.001
	After 7 days	Mean ±SD	35 ±7	49 ±4	<0.001
	% Change	Median (range)	-27.1 (-46.2 - -4.0)	6.4 (23.1 - 20.9)	<0.001
SBP	Pre	Mean ±SD	91 ±6	88 ±9	0.539
	After 2 days	Mean ±SD	94 ±3	91 ±8	0.25
	% change	Median (range)	2.2 (-7.1 - 20)	3.4 (-6.8 - 13.6)	1
	After 7 days	Mean ±SD	99 ±4	90 ±9	<0.001
	% Change	Median (range)	9.4 (-10 - 22.5)	2.3 (-6.3 - 15.9)	0.004
DBP	Pre	Mean ±SD	55 ±9	54 ±10	0.775
	After 2 days	Mean ±SD	57 ±7	54 ±9	0.486
	% change	Median (range)	7.7 (-29.2 - 75)	-3.8 (-24.3 - 37)	0.345
	After 7 days	Mean ±SD	64 ±6	54 ±7	<0.001
	% Change	Median (range)	18.2 (-16.1 - 80.6)	1.7 (-31.9 - 50)	0.041
Temperature	Pre	Mean ±SD	37.1 ±0.3	37 ±0.4	0.539
	After 2 days	Mean ±SD	37.1 ±0.1	37 ±0.3	0.87
	% change	Median (range)	0 (-0.8 - 1.4)	0 (-1.4 - 2.5)	0.935
	After 7 days	Mean ±SD	37 ±0.1	37.2 0±.2	0.002
	% Change	Median (range)	-.5 (-1.3 - 1.9)	0.3 (-0.5 - 2.5)	0.009

Mann Whitney U test was used.SBP = Systolic blood pressure. DBP = Diastolic blood pressure.
% Change was calculated from baseline

- **Chest X-ray :**

According on chest X-ray findings, commenting onopacity, bronchoalveolar markings and costophrenic angles, results also show there is no significant differences in chest X-ray findings ($p > 0.05$) as demonstrated in **table 3**.

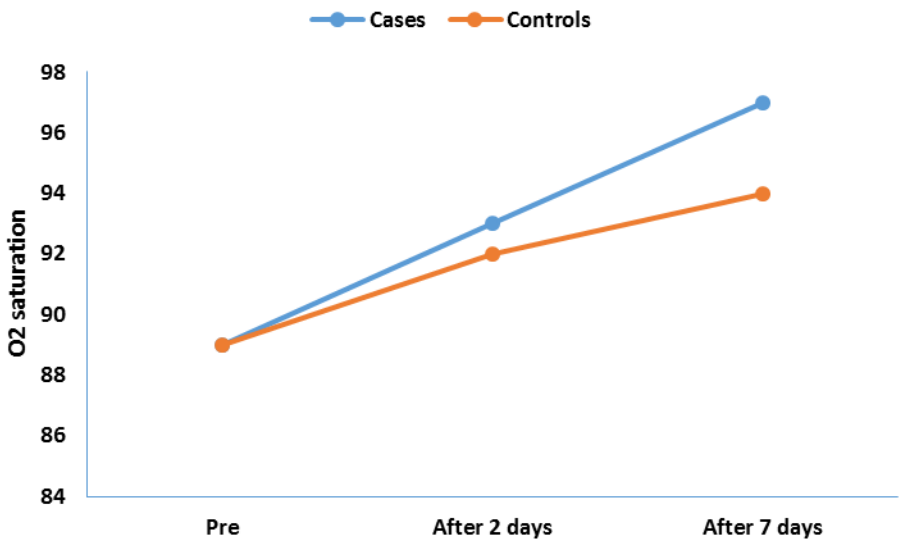


Figure (2): Oxygen saturation pre procedure, after 2 days and after 7 days in both groups

Table (3): Chest X-ray findings pre procedure, after 2 days and after 7 days in both groups

Variable	Timing	Study (n = 15)	Control (n = 15)	P value
Opacity	Pre	15 (100.0)	14 (93.3)	1.0
	After 2 days	15 (100.0)	13 (86.7)	0.483
	After 7 days	2 (13.3)	5 (33.3)	0.39
Broncho-alveolar Markings	Pre	14 (93.3)	10 (66.7)	0.169
	After 2 days	7 (46.7)	10 (66.7)	0.269
	After 7 days	3 (20.0)	8 (53.3)	0.058
Costo-phrenic Angles	Pre	12 (80.0)	10 (66.7)	0.682
	After 2 days	3 (20.0)	2 (13.3)	1.0
	After 7 days	1 (6.7)	1 (6.7)	1.0

Chi-square or Fisher's exact test was used

4. Discussion

Chest physiotherapy has been used to clear secretions, prevent accumulation of debris, improve mobilization of airways secretions and help lung ventilation in newborn with respiratory problems and this improves the efficiency and delivery of oxygenation[22].

During the last few decades, the survival of neonates and infants with RDS has increased dramatically. This improvement is mainly due to advances in perinatal medicine and neonatal intensive care [23].Treatment of RDS consists of respiratory support by different ways of oxygen administration and endotracheal intubation, medications such as (surfactant replacement therapy, bronchodilators, diuretics, sedative and steroids), supportive therapy which is temperature control, adequate nutrition and management of anemia [24].The present study is a controlled randomizedstudy,comparing between theeffects of conventional chest physiotherapy (including postural drainage, suctioning and positioning) and lung squeezing technique on neonates who were mechanically ventilated withRDS.The measuring variables were vital signs and chest X-ray findings.

Comparing between the mean values of vital signs at the starting of the study, after 2 days and after 7 days for both groups showedstatistical significant differences ($P<0.05$)which was in the form of decreasing in HR and RRwhile there was increase in SAP, DAP and SaO_2 in favor of the study group.Results also showed that there was no significant differences ($p >0.05$) when comparing the mean values of findings of chest X-ray (opacity, bronchoalveolar markings and costophrenic angles).

The improvement recorded could be attributed to the combined effects ofmedical treatment and routine suctioning of theneonates. This could be explained by Cleary et al. [25] who stated that, an improved oxygenation during SIMV in neonates withRDS,

allowed a reduction in ventilationpressure or oxygen exposure in this group ofneonates, who were at risk of havingcomplications of ventilation.Early supportive care of premature infants,especially in the treatment of acidosis, hypoxia,hypotension, and hypothermia, may lessen theseverity of RDS [26].

This improvement also could beattributed to the combined effects of the designed CPT and the medical treatment. There wasdecreasing in HR, RR, and PaCO2 andincreasing in SBP, DBP, SaO2and PaO2.These findings could be explained by Hough et al. [27] who stated that, CPT results in lungmechanical effects, providing optimalrespiratory function in order to facilitate gasexchange and adjust ventilation-perfusionadequacy of respiratory support, to preventand treat pulmonary complications, to providegood maintenance of airways and to facilitateweaning from mechanical ventilation andoxygen therapy.

Abd El-Fattah et al. [28] confirmed that, CPT hadsignificant decrease of PaCO2 of neonatesafter 48 hours. So The results of our study come in agreement with thoseobtained by Abd-El-Fattah et al. [29]whostated that the duration of ventilation was less inthose who subjected to CPT.

Scaparrotta et al.had demonstrated that the more extensive part that physiotherapy may play, ought to be considered as far as situating to enhance ventilation and perfusion, once the consolidator stage starts to determine, chest physical therapy (CPT) systems may have some advantage in preparing and clearing emissions. [30]

The results of the current study disagree withthat mentioned in Royal college pediatrics and child health [31]which stated that routine CPT is notrecommended in neonatal RDS.

Prolonged mechanical ventilation inducespulmonary inflammation in preterm infants. Lunginflammation plays an important role in pathogenesisof chronic lung disease in preterm infants. Resultsshow a strong correlation between duration ofmechanical ventilation and the amount of proinflammatorymediators, so it is achievement toreduce the duration of exposure to mechanicalventilation [32].

Conclusion

This study was done to evaluate the effect lung squeezing technique, a recent described chest physiotherapy technique, in comparison between it and the conventional chest physiotherapy (postural drainage, suctioning, and positioning) on mechanically ventilated neonates having RDS. The obtained results showed significant improvement after 2 and 7 days of treatment in vital signs and of the group received lung squeezing technique.

Reference

1.Edwards MO, Kotecha SJ, Kotecha S. Respiratory distress of theterm newborn infant. PaediatrRespir Rev. 2013;14(1):29–36

2. Vartany E, Caldwell CA, Trow TK. Adult respiratory distress syndrome after treatment with pegylated interferon alpha- 2a and ribavirin. Heart Lung. 2008;37:1536.

3.National heart and lung institute.What Is Respiratory DistressSyndrome?Available:http://www.nhlbi.nih.gov/health/healthtopics/topics/rds/

4.Rocha G, Rodrigues M, Guimarães H. Respiratory distress syndrome of the preterm neonate - placenta and necropsy as witnesses. J Matern Fetal Neonatal Med 2011; 24(1):148-51.

5. Hyaline membrane disease: the use of surfactant in this pathology.International Meeting of Scientific Production. Cesumar, October 23rd to 26th2007.

6. Nascimento Jٟnior FJM, Silva JVF, Ferreira ALC, Rodrigues APRA. The respiratory distress syndrome of the newborn: pathophysiology and care challenges. Rev CiênciasBiolٛgicas e da Saٟde. 2014; 2(2): 189-98.

7. Avery ME, Taeush HW. Pneumonia. In: Schaffer's Diseases of the Newborn. 5th ed. Williams & Wilkins?; 2000. p. 165-71.

8. Lewis JA, Lacey JL, Henderson-Smart DJ. A review of chestphysiotherapy in neonatal intensive care units in Australia. J Paediatr Child Health 1992;28:297-300.

9. Unoki T, Kawasaki Y, Mizutani T, Fujino Y, Yanagisawa Y,Ishimatsu S, et al. Effects of expiratory rib-cage compression on oxygenation, ventilation, and airway-secretion removal in patients receiving mechanical ventilation. Respir Care 2005;50:1430-7.

10. Bertone N. The role of physiotherapy in a neonatal intensive care unit.Aust J Physiother 1988;34:27-34.13. Medscape Reference. Respiratory Syndrome medicine specialties; 2006.

11.Medscape Reference. Respiratory Syndrome medicine specialties; 2006.Available:http://www.emedcine.com/Ped/to pilc993.htm

12. Martin K, Thomas H. Chest physiotherapyin mechanically ventilated children: A review. Crit Care Med. 2000;28:1648-51.

13. Halliday HL. What interventions facilitate weaning from the ventilator? A review of the evidence from systematic reviews.PaediatrRespir Rev. 2004;5(Suppl A):S347-S352.

14. De Abreu LC, Valenti VE, Oliveira AG, Leone C, Siqueira AA, Herreiro D, et al. Chest associated to motor physiotherapy improves cardiovascular variables in newborns with respiratory distress syndrome. Int Arch Med. 2011;4:37.

15. Wood DW, Downes JJ, Lecks HI. A clinical score for the diagnosis of respiratory failure: Preliminary Report on Childhood Status Asthmaticus.Amr J Dis Child. 1972;123(2):227-228

16. Tudehope DI, Masel J, Mohay H, O'Callaghan M, Burns Y, Rogers Y, et al. Neonatal cranial ultrasonography at predictor of 2 year outcome of very low birth weight infants. AustPaediatr J. 1989;25(2):66-71.

17.Cattano, Davide. "Airway Management and Patient Positioning: A Clinical Perspective." Anesthesiology News (2011): 17-23. Anesthesiology News.Web. 10 July 2015.

18.Santos ML, Souza LA, Batiston AP, Palhares DB. Results of airway clearance techniques in respiratory mechanics ofpreterm neonates under mechanical ventilation. Rev. Bras. Ter. Intensive.2009;21(2):183-189. DOI:10.1590/S0103-

507X2009000200011.[Scopus]

19. Bagley CE, Gray PH, Tudehope DI, Flenady V, Shearman AD, Lamont A. Routine neonatal post-extubation chest physiotherapy: A randomized controlled trial. J Paediatr Child Health 2005;41(11):592-7

20. Wong I, FokTF.Randomized comparison of two physiotherapy regimens for correcting atelectasis in ventilated pre-term neonates. Hong Kong Physiother J 2003; 21: 43-50.

21. Ivor Wong,Tai-Fai Fok.Effects of Lung Squeezing Technique on Lung Mechanics in Mechanicallyventilated Preterm Infants with Respiratory Distress Syndrome. Hong Kong Physiotherapy journal 2006.

22.American Academy of Pediatrics. Pnumonia.In: Red Book: 2015 Report of the Committee on Infectious Diseases, 30th ed, Kimberlin DW (Ed), American Academy of Pediatrics, Elk Grove Village, IL 2015. p.432.

23. Unoki T, Kawasaki Y, Mizutnai T. Effects of expiratoryrib – cage compression on oxygenation, ventilation, and air way - secretion removal in patients receiving mechanical Ventilation. Respir Care 2005; 50:1430-7.

24. Fanaroff AA, Stoll BJ, Wright LL, Carlo WA, Ehrenkranz RA, Stark AR, etal.Trends in neonatal morbidity and mortality for very low birth weight infants. Am J Obstet Gynecol. 2007;196(2):147.e1-8.

25.Micromedex T. (2006): Respiratory distress syndrome in newborn. www.healthtouch.com.

26.Cleary JP, Bernstein G, Mannino FL, Heldt GP. Improved oxygenation during synchronized intermittent mandatoryventilation in neonates with respiratorydistress syndrome: A randomized,crossover study. J Pediatr.1995;126(3):407-11.

27. Kliegman RM, Stanton BF, Schor NF, Gem J, Behrman RE. Nelson Textbook ofPediatrics.19th ed.2011 W.B. Saunders,Philadelphia.

28. Hough JL, Flenady V, Johnston L, Woodgate PG. Chest physiotherapy forreducing respiratory morbidity in infantsrequiring ventilatory support. CochraneDatabase Syst Rev. 2008;(3):CD006445.

29. Abd El-Fattah S, Abd El-Monim MT, Abd El-Aziz E. Chest physical therapy and itseffects on lung functions in mechanically ventilated critically ill neonates. The Egyptian Journal of Neonatology.2001;2(3):177-184.

30.Scaparrotta A, Attanasi M, Di Pillo S, Chiarelli F. Pediatric Lower Respiratory Infections, OMICS International. 2014.

31.Royal Collage of Pediatrics and Child Health (2008): Guidelines for good practice.Management of neonatal respiratory distress,RCP CH: London.

32.Schultz C., Tautz J., Rciss I., Mller J.C. (2005): Prolonged mechanical ventilation inducespulmonary inflammation preterm infants.Biology of the neonate, 84: 64-66.