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Effect of Prolonged Slow Expiration Technique on Oxygen Saturation and Blood Pressure Among Neonates with Pneumonia

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Abstract

Background: Pneumonia is one of the leading causes of neonatal morbidity and death in many developing countries. It is Characterized by inflammation of lungs, pneumonia leads to an accumulation of respiratory secretions in the airways, which contribute to worsen clinical symptoms and increase airway resistance, making it difficult for children to breathe.

Aim of Study: To investigate the efficacy of prolonged slow expiration technique on oxygen saturation and blood pressure among neonates with pneumonia.

Subjects, Material and Methods: This randomized controlled trial included 32 neonates with pneumonia. Their gestational age is from (33-36) weeks and chronological age from birth till 28 days. The participants were randomly allocated into 2 equal groups. The control group received conventional chest physiotherapy, while the study group received conventional chest physiotherapy in addition to Prolonged Slow Expiration Technique (PSET) for 20 minutes duration per session, two sessions (each session was two hours after feeding to avoid vomiting) per day. First session in the morning and the second session in the afternoon, from admission in neonatal intensive care unit (NICU) till discharge. Oxygen saturation (SaO_2) and blood pressure (BP) were measured and chest X-ray was done. All measurements were recorded at baseline and at discharge in this study.

Study Design: Prospective, randomized controlled trial.

Results: Significant increase in O_2 saturation of control and study groups post treatment compared with pretreatment ($p<0.01$). There was no significant difference in blood pressure and number of sessions between groups post treatment ($p>0.05$).

Conclusion: A prolonged slow expiration techniqueincreases O_2 saturation of study group compared with that of control group post treatment. So prolonged slow expiration technique is an excellent supplement to conventional chest physiotherapy in managing pneumonia in neonates.

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Key Words: *Prolonged slow expiration technique – Neonates – Pneumonia – O_2 saturation – Blood pressure.*

Introduction

ONE of the illnesses that has been a growing focus of research in recent years is still pneumonia. A virus or bacteria are the most frequent causes of pneumonia, The pulmonary alveoli, which are the little balloon-shaped sacs at the end of the bronchioles, are the primary site of the disease **[1]**. The World Health Organization (WHO) estimates that there are around 156 million new cases of neonatal pneumonia globally each year, with poor nations accounting for 95% of all cases. A hospitalization is necessary in nearly 8.7% of these cases because they are life-threatening **[2]**.

Mainly in underdeveloped nations, pneumonia is a major cause of newborn morbidity and mortality. Pneumonia is thought to have contributed significantly to 44% death during the newborn period **[3]**. Newborn pneumonia affects 1% of term babies and 10% of preterm babies, according to statistics that are frequently cited **[4]**.

Certain risk factors, such as decreased gestational age leads to three times more possibilities of developing pneumonia at 37 weeks of pregnancy than at 39-40 weeks, increase the susceptibility to newborn pneumonia **[5]**. Low birth weight (birth weight 250,000g), premature infants (gestational age 37 weeks), parenteral nutrition, bronchopulmonary dysplasia, and tracheal intubation are all risk factors for neonatal pneumonia **[6]**.

Most of pneumonia pathogens are bacteria, followed by viruses and fungi, which cause an inflammatory lung disease that could harm the epithelium lining the airways and let proteinaceous

rich fluid infiltrate into the interstitium and alveoli, which could cause surfactant deficiencies or malfunction [4]. So introducing surfactant treatment by neonatologists has greatly reduced preterm death, and surfactant replacement therapy is a lifesaving medication for premature babies [7].

Clinical signs of newborn pneumonia include noise; fast or difficult breathing; respiratory rate greater than 60 beats per minute; chest retractions; coughing or grunting. Nodular or coarse patchy infiltrate on a chest X-ray that is diagnostic of pneumonia; diffuse haziness or granularity on an air bronchogram and lobar or segmental consolidation, as well as radiological abnormalities that do not improve within 48 hours and a sepsis-like clinical presentation [8]. If there are signs of severe respiratory distress or if the oxygen saturation is 90% or below, give supplementary oxygen [9]. With the use of oxygen, newborn and infant mortality could be significantly decreased on the basis of objective proof of hypoxemia [10]. Long-term use of oxygen therapy produces excessive bronchial secretions that must be cleared using chest physical therapy [11].

Conventional chest physiotherapy is a popular adjunct therapy for pneumonia in neonatal intensive care unit (NICU) that works to improve gas exchange, remove tracheobronchial secretions, and decrease airway resistance [12]. When left untreated, pneumonia has the greatest fatality rate among infants (approximately 40-50% of fatal cases), making it the most common respiratory condition that requires hospitalization. Antibiotics can, however, effectively treat pneumonia, and newborns also need supportive care like CPT and oxygen therapy [13]. It is common practice in newborn settings to use a variety of manual airway clearance procedures, including as postural drainage, percussion, and vibration, to assist secretion clearance and are utilized as traditional therapy [11].

Prolonged slow expiration technique (PSE) is an advanced kind of chest physiotherapy that can help babies' clear their lungs from secretions while also increasing oxygenation [14]. Hypoxemia, rib fractures, brain damage, and encephaloclastic porencephaly are among the reported side effects of conventional chest physiotherapy in fragile neonates [15]. This research was applied to support claims for the benefits of PSET in the treatment of preterm neonates with pneumonia. Hence, it is important from physiotherapeutic point of view to use an effective approach that aids in improving and maintaining adequate oxygen saturation levels and blood gas parameters in preterm neonates with pneumonia.

Subjects and Methods

All participants' parents signed a consent form that they agree that their babies participate in this study after an explanation of the experimental protocol. The study was also approved by The Ethical Committee of the Faculty of Physical Therapy, Cairo University on NO: P.T.REC/012/003676.

Subjects:

Thirty-two incubated neonates of both sexes suffering from pneumonia were selected from neonatal intensive care unit of Obstetrics and Gynecology Hospital, Cairo University Hospitals, from March 2022 to March 2023, they were equally divided into two groups: (Control group and study group).

We considered the following criteria: Gestational age starts from 32 weeks under O_2 therapy, clinical and radiological diagnosis of pneumonia. The radiological diagnosis (X-ray findings): (Segmental consolidation, lobar, multi-lobar, nodular or coarse, patchy nonhomogenous infiltrates, and air bronchograms). Clinical diagnosis was established to present early respiratory distress (Tachypnea, fever, retractions, grunting and hypoxemia).

The neonates who had one or more of the following criteria were excluded from the study: Congenital malformations, genetic syndromes, neurological disorders, seizures, who underwent surgical procedures, with intraventricular hemorrhage or major cerebral abnormality [15].

Thirty-six neonates were assessed for eligibility. 4 were discontinued as they died while conducting the experimental protocol and 32 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 a closed envelope that contained one of the two groups. The study design is demonstrated as a flow chart in Fig. (1).

Methods:

• For Evaluation:

Daily review of the medical records was done. Observation for any signs of pneumonia, evaluation of posture and muscle tone by modified Ashworth scale were conducted pre and post each CPT session for study group and for the control group.

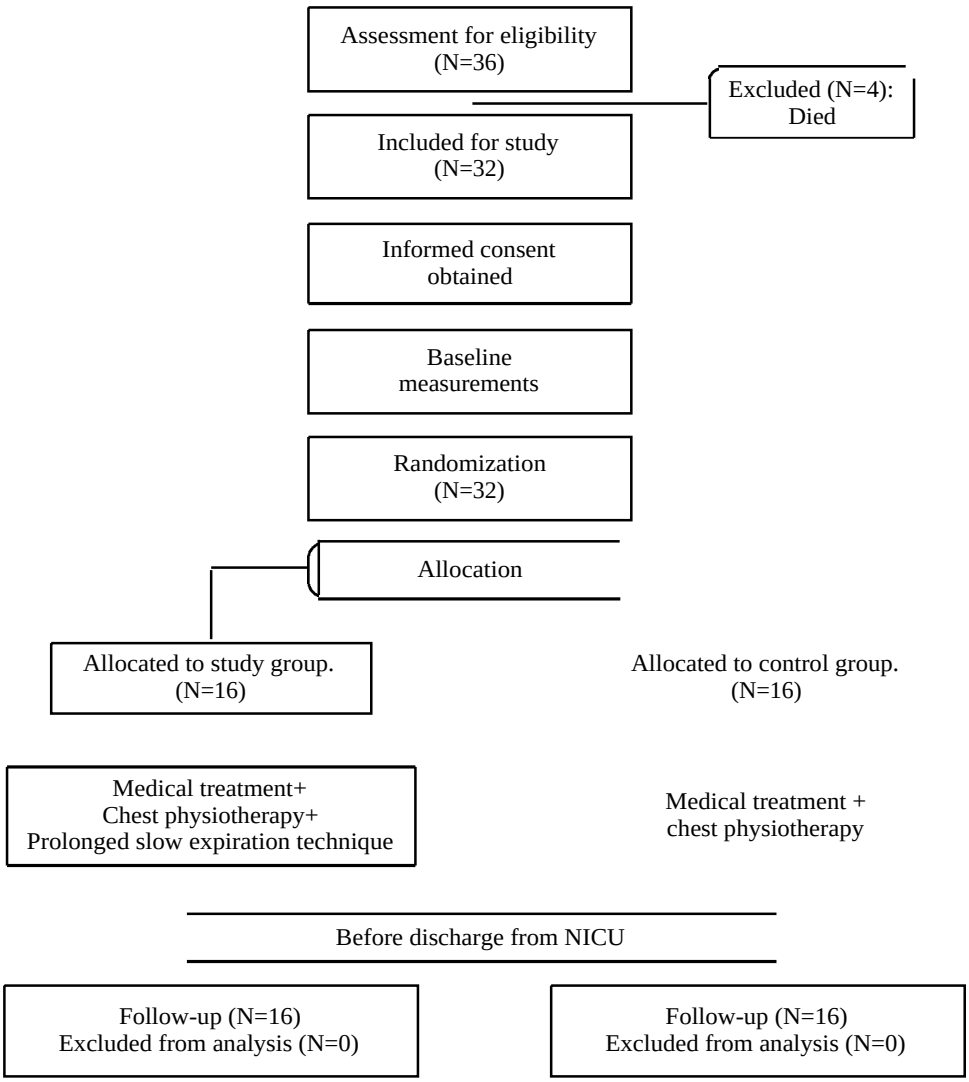

Fig. (1): Flow chart of the study design.

O_2 saturation and blood pressure 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).

Oxygen saturation (SaO_2) and blood pressure (BP) were 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 the first day and last day of intervention.

Methods:

Patients of both groups were incubated and controlled medically by neonatologists. Outcome measures were assessed at baseline, before discharge from NICU.

• For treatment.

A- *Control group:*

In addition to receiving medical care and receiving routine nursery care of neonates included suctioning. neonates of the control group also had chest physical therapy, which included postural drainage. Each drainage position was administered for three to five minutes while being vibrated and percussion was used **[16]**. The chest physical therapy sessions were applied 2 times daily for 6 days/week, each session was about 20 minutes, according to the neonate tolerance. SaO_2 was maintained and analyzed during the entire CPT. According to Santos et al. **[17]**. Throughout the entire physical therapy session, non-invasive monitoring of oxygen saturation (SpO_2) was monitored and assessed. SpO_2 levels under 87%, tachycardia, or bradycardia (alterations >15% of that expected for age) resulted in interruption of the therapy and a rise in FiO_2 of 10% above baseline. 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 raising 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.

IV- Positioning:

The goal of therapeutic placement is to maximize ventilation/perfusion (V/Q) matching and mucociliary secretion clearance to decrease the work of breathing. There are several standardized "postural drainage" positions for the removal of particular lung segments. Some of the positions suggested tilting the patient into a head-down, inverted position. can allow for "continuous draining" of the lung, holding PD placements for up to hours at a time.

V- Suctioning:

Before suctioning, newborn nurses administered 0.25-0.5ml of sterile saline into the nasotracheal tube and used an ETT **[15]**.

B- *Study group:*

Newborns of study group received the same medical treatment, routine nursery care and the same conventional chest physiotherapy program to control group in addition to PSET. PSET is an advanced kind of chest physiotherapy that can help babies' diaphragms contract and clear their lungs from secretions while also increasing oxygenation **[14]**. It differs from conventional chest vibration and percussion in the following aspects: (PSET) is achieved by applying bimanual pressure over the thoracic cage and the abdomen, maintaining it for two to three breathing cycles beginning at the beginning of the expiratory phase down to the residual volume. This method enhances drainage of the distal airways and permits complete expiration even when there is bronchial obstruction **[18]**. The therapist puts the hypothenar eminence of one hand below the newborn's sternal notch and the hypothenar eminence of the other hand beneath the newborn's umbilicus. Using both hands, mild compression is provided at the end of the expiratory phase to help the newborn reach the expiratory reserve volume. The chest hand moves in the cranial-caudal direction, while the other hand moves in the caudal- cranial direction. This compression is maintained for no more than two or three cycles of breathing. After a break of around 5 or 10 normal breaths in between each application, this procedure is done multiple times **[19]**. The compression that occurs at the end of expiration at the thorax and abdomen provides resistance to active inspiration. The outcome is a longer expiratory phase. Moreover, this mild compression helps to remove pulmonary secretions **[20]**.

Statistical analysis:

Unpaired *t*-test was conducted for comparison of gestational age between groups. Chi-squared test was conducted for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Unpaired *t*-test was conducted to investigate the effect of treatment on O_2 saturation and blood pressure and also for comparison of number of sessions between groups. The level of significance for all statistical tests was set at $p<0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics:

Thirty-two neonates with pneumonia participated in this study. Their gestational age ranged from 33 to 36 weeks. There was no significant difference between groups in gestational age and sex distribution ($p>0.05$). (Table 1).

Table (1): Basic characteristics of participants.

	Control group	Study group	Statistics	*p*-value
Age, mean ± (SD), weeks	34.62±1.08	34.43±1.15	*t*=0.47	0.64
Sex, n (%):				
Girls	9 (56.3%)	10 (62.5%)	χ^2=0.13	0.71
Boys	7 (43.8%)	6 (37.5%)		

SD: Standard deviation.
$\chi 2$: Chi squared value *p*-value, level of significance.

Effect of treatment on O_2 saturation, blood pressure and number of sessions:

Within group comparison:

There was a significant increase in O_2 saturation and significant decrease in blood pressure of control and study groups post treatment compared with pretreatment (p<0.01).

The percent of change of O_2 saturation, systolic and diastolic blood pressure of control group was 2, 11.76 and 21.17% respectively; and that of study group was 3.76, 13.4 and 22.87% respectively. (Table 2).

Between group comparison:

There was no significant difference between groups pretreatment (p>0.05). There was a significant increase in O_2 saturation of study group compared with that of control group post treatment (p<0.05). There was no significant difference in blood pressure and number of sessions between groups post treatment (p>0.05). (Table 2).

Table (2): Mean O_2 saturation, blood pressure and number of sessions pre and post treatment of control and study groups.

	Control group	Study group	MD between groups	*t*-value	*p*-value
	Mean ± SD	Mean ± SD			
O_2 Saturation (%):					
Pre treatment	97±1.31	96.25±1.65	0.75	1.41	0.16
Post treatment	98.94±0.68	99.87±0.34	–0.93	–4.92	0.001
MD	–1.94	–3.62			
% of change	2	3.76			
t-value	–6.56	–9.66			
	p=0.001	*p*=0.001			
Systolic blood pressure (mmHg):					
Pre treatment	77.06±10.50	75.13±9.77	1.93	0.54	0.59
Post treatment	68±5.89	65.06±4.11	2.94	1.63	0.11
MD	9.06	10.07			
% of change	11.76	13.40			
t-value	2.78	3.82			
	p=0.01	*p*=0.002			
Diastolic blood pressure (mmHg):					
Pre treatment	51.06±6.13	49.5±7.39	1.56	0.65	0.52
Post treatment	40.25±5.45	38.18±3.67	2.07	1.26	0.22
MD	10.81	11.32			
% of change	21.17	22.87			
t-value	5.41	4.83			
	p=0.001	*p*=0.001			
Number of sessions	8.93±1.18	8.56±1.78	0.37	0.7	0.48

SD: Standard deviation. MD: Mean difference. *p*-value: Probability value.

Discussion

As a result of the effectiveness of chest physical therapy in clearing airway obstruction, reducing airway resistance, enhancing gas exchange, and reducing the work of breathing, this modality has been and is still often used with pneumonic children in pediatric practice, the breathing rates and arterial oxygen saturation of children who received chest physiotherapy improved more **[21]**.

Chest physiotherapy is commonly employed as most pneumonia-related fatalities in children may be prevented if efficient therapies were applied extensively among the most suspected populations **[22]**. While other treatments are primarily supportive, antibiotics are the cornerstone of the pneumonia therapy. These supplementary treatments include additional oxygen, intravenous fluids, and chest physical therapy. A treatment for clearing the airways known as chest physical therapy combines positioning the patients for mucus drainage with manual percussion of the chest wall **[23]**.

The present study is a controlled randomized study, comparing between the effects of conventional chest physiotherapy (including postural drainage, percussion, vibration and suctioning) and prolonged slow expiration technique on neonates with pneumonia. The measuring variables were O_2 saturation and blood pressure.

Comparing between the mean values of O_2 saturation and blood pressure in the starting of the study and before discharge for both groups showed that there was no significant difference between

groups pretreatment ($p>0.05$). There was a significant increase in O_2 saturation of study group compared with that of control group post treatment ($p<0.05$). There was no significant difference in blood pressure number of sessions between groups post treatment ($p>0.05$).

The results of the current study were in agreement with what found by Mishra who stated that in the treatment of newborns with pneumonia sent to NICUs, the PSE technique in combination with other respiratory physiotherapy protocols may be an efficient respiratory rehabilitation strategy.

This improvement also could be attributed to the combined effects of the designed CPT and the medical treatment. There was a significant increase in O_2 saturation. These findings could be explained by Abdelbasset & Elnegamy **[21]** who stated that chest physiotherapy improved arterial oxygen saturation while successfully removing tracheobronchial mucus in children with pneumonia, Postural drainage and percussion work to loosen up the pulmonary mucus so that it may be suctioned, clearing the airways of mucus, enhancing gas exchange, and reducing the effort required to breathe.

Regarding the blood pressure, our results are not in agreement with studies by Hamed, et al., **[16]** who found that there wasa highly statistically significant increase in the mean values of SBP and DBP in the study group.

The results of the study are in contradiction with what stated by Paludo, et al., **[25]** and Lukrafka, et al., **[26]** as they mentioned that no evidence to suggest that chest physiotherapy should be routinely done in pneumonia.

Methods for passive expiration, like prolonged slow expiration, seem to be more effective than traditional methods to avoid the bronchial collapse and disturbance of the flow that happen during forced expirations, intrathoracic pressure progressively increases during prolonged slow expiration by thoracoabdominal compression **[19]**.

PSE technique is quite simple in comparison to traditional chest physiotherapy treatments, which might discomfort newborns. Traditional chest physical therapy has various contraindications and precautions that must be observed, but PSE method does not. Thus, PSE can be chosen over traditional techniques to decrease the risk of consequences **[20]**.

Conclusion:

This study was done to evaluate the effect of prolonged slow expiration technique, a recent described chest physiotherapy technique, in comparison between it and the conventional chest physiotherapy (postural drainage, percussion and vibration) on neonates having pneumonia. The obtained results showed significant improvement in O_2 saturationof the group who received prolonged slow expiration technique.

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تأثير تقنية الزفير البطئ الممتد على تشبع الدم بالأكسجين وضغط الدم لحديثى الولادة المصابين بالألتهاب الرئوى

صممت هذه الرسالة لدراسة: تأثير تقنية الزفير البطئ الممتد على تشبع الدم بالأكسجين وضغط الدم لحديثى الولادة المصابين بالألتهاب الرئوى. شارك فى هذه لدراسة أثنان وثلاثون طفل من حديثى الولادة الذين تم تشخيصهم على أنهم مصابون بالألتهاب الرئوى. وقد تم تقسيمهم عشوائياً إلى مجموعتين المجموعة الضابطة تلقى المشاركين فيها العلاج الطبى وكذلك تقنيات العلاج الطبيعى المعتادة، أما مجموعة الدراسة فقد تلقى المشاركين فيها نفس البرنامج العلاجى للمجموعة الضابطة بالإضافة لتقنية الزفير البطئ الممتد. بدأ البرنامج العلاجى منذ إدراج الأطفال فى الدراسة بواقع جلستين يومياً وحتى خروجهم من العناية المركزة لحديثى الولادة. بمستشفى النساء والتوليد بمستشفيات جامعة القاهرة وتم تسجيل المتغيرات فى المجموعتين فى بداية الدراسة، وقبل خروجهم من العناية المركزة لحديثى الولادة.

الأستنتاج : تشير نتائج الدراسة إلى حدوث تحسن فى نسبة تشبع الدم بالأكسجين فى مجموعة الدراسة أكثر من نتائج المجموعة الضابطة.