Clinical Cancer Investigation Journal-ISSN: 2278-0513

The Effect of Expiratory Volume Techniques to Oxygenation and Expiratory Volume in Premature Infants with Respiratory Distress Syndrome

Abstract

Background: Chest physiotherapy in premature infants reduces respiratory work, improving oxygenation, and increasing expiration volume. Therefore, this study aimed to determine the effect of expiratory volume techniques to oxygenation and expiratory volume in premature infants with respiratory distress syndrome.

Methods: In this randomized clinical trial, 32 premature infants with respiratory distress syndrome were included. The subjects were randomly divided into a routine chest physiotherapy group, and expiratory volume techniques group. Intervention was conducted two times per day for five days. Overall, FiO2, PEEP, PIP, MAP, respiratory rate, O2sat, and expiratory volume were evaluated before and after intervention with the ventilator system. Data were analyzed with the paired sample and independent t-tests ($p<0.05$).

Results: In the expiratory volume techniques group, the overall expiratory volume changed from 8.05±3.1 to17.50±7.3, the FiO2 significantly changed from 71.7±22.0 to 42.0±11.8, the PEEP significantly changed from 6.20±0.5 to 5.80±0.4, the PIP significantly changed from 15.40±3.03 to 11.60±2.9, and the MAP significantly changed from 8.6±1.4 to 7.7±0.9 ($p<0.05$). There is no significant difference in the expiratory volume and FiO2 between routine chest physiotherapy and expiratory volume techniques groups ($p>0.05$).

Conclusion: According to the results of the study, the positive effects of expiratory volume techniques to oxygenation were shown, so we suggest that in addition to routine chest physiotherapy, expiratory volume techniques should also be considered in infants with respiratory distress syndrome.

Keywords: *Chest Physiotherapy, Expiratory Volume Techniques, Respiratory Distress Syndrome, Oxygenation, Expiratory Volume*

Neda Madadizadeh[1], Fateme Ghiasi*[2], Mohammad Hosseini far[3], Hasan Namvar[3], Ahmadreza Askari[3]

1.MS.c. P.T., Zahedan University of Medical Sciences, Zahedan, Iran.
2. Assistant Professor, Rehabilitation Sciences Research Center, Zahedan University of Medical Sciences, Zahedan, Iran. (https://orcid.org/0000-0001-9849-6670)
Correspondence: Fateme Ghiasi, Assistant Professor, Rehabilitations Sciences Research Center, Zahedan University of Medical Sciences, Zahedan, Iran. (https://orcid.org/0000-0001-9849-6670)
Dept. of Physiotherapy, School of Rehabilitation Sciences, Zahedan University of Medical Sciences, Dr. Hesabi Sq., Zipcode: 9816743175, Zahedan, Iran.
Tel & Fax: +98-541-342-4675
E-mail: F_ghiasi_p@yahoo.com
3. Assistant Professor, Rehabilitation Sciences Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.
E-mail: Fardash_s@yahoo.com, hassan753@yahoo.com, Askarisaeeid41@gmail.com

Introduction

Infant mortality is one of the most important health indices in any country. Premature birth accounts for about 8-10% of all births and prematurity is the most important cause of death and morbidity worldwide in infants (1). Iran is one of the regions with a high prevalence of premature birth and premature infants make up approximately 10% of births (2). Respiratory distress syndrome is the most common cause of hospitalization of newborns in neonatal intensive care units and, along with severe prematurity, is the most important cause of infant death in our country (3, 4). The treatment plan of infants with respiratory problems includes using corticosteroids, antibiotics, magnesium sulfate, CPAP, oxygenation, surfactant, non-invasive lung ventilation methods and chest physiotherapy (5, 6).

Neonatal physiotherapy is an advanced branch of pediatric physiotherapy. Physiotherapy interventions include proper positioning, chest physiotherapy, and exercise therapy (7). Chest physiotherapy along with mechanical ventilation of infants has been done to increase the survival probability of premature infants and reduce the complications of prematurity (8, 9). Chest physiotherapy in premature infants reduce respiratory work, improving oxygenation, increasing expiration volume, faster separation from the mechanical ventilation device and earlier discharge of the hospital (10,11). Routine chest physiotherapy includes percussion, vibration, and postural drainage (12). Expiratory volume techniques along with monitoring the respiratory parameters of premature infants is particularly important due to the limitations in the chest physiotherapy of infants, including the lack of the possibility of teaching the patient and performing breathing exercises by the patient(13,14,15). So performing expiratory techniques by a physiotherapist prevents complications caused by long-term hospitalization of infants, causes weaning of mechanical ventilation faster, increases the lung volumes and respiratory independence of premature infants with non-

invasive rehabilitation treatments in a shorter time (16,17,18,19).

Raval et al.'s (1987) study showed chest physiotherapy is beneficial for premature infants with respiratory distress syndrome (RDS) (20). Kole and et al. (2014) showed that the Vojta technique including reflex rolling was a safe and effective method in improving oxygenation of premature infants with respiratory problems, and a technique such as lung squeezing and reflex rolling or Vojta had the same effect in improving oxygenation of premature infants with respiratory problems (21). Giannantonio et al. (2010) showed that Vojta increased the values of PtcO2 and SatO2 in premature infants. Therefore, they suggested that the Vojta method is safe for premature infants, but further research is necessary to confirm its positive effects and evaluate long-term respiratory outcomes (22). In the 2005 study by Almeida et al., was shown the usefulness of the expiratory flow increased technique in a short period in the oxygenation of newborns (23). Also, another study was conducted in 2005 by LCO and et al. showed that expiratory flow increased techniques create less stress than routine respiratory physiotherapy in premature infants after extubating, and is also safer and more useful (24).

Therefore, the aim of study was the effect of expiratory volume techniques for oxygenation and expiratory volume of premature infants with respiratory distress syndrome. These techniques affecting oxygenation and expiratory volume identified and used in the form of expiratory volume techniques that are safe and effective on premature infants with the same disease of respiratory distress syndrome and are under a ventilator, and if approved in the form of chest physiotherapy techniques in a routine form and shorten the duration of intubation of infants and reduce the complications of respiratory disease and improve the health level of infants.

Methods

This study was non-blinded randomized controlled trial. Thirty-seven subjects with respiratory distress syndrome participate in this study and were divided into two groups by simple non-probability sampling method. The medical ethics committee at the Zahedan University of Medical Sciences approved the study ethics and issued the ethics certification number as IR.ZAUMS.REC.1402.233 and registered with the region's Clinical Trials Registry (IRCT20180714040466N5). All participants signed written informed consents.

Inclusion criteria

Inclusion criteria included neonates aged between 32 and 37weeks pregnancy, weight less than 3 kg, intubation, RSD, no history of neurological and surgical cases.

Exclusion criteria

Exclusion criteria included receiving other treatment during the research, parents' unwillingness to continue treatment, not completing the course of treatment.

Sample Size

The sample size was determined based on a pilot study. Ten subjects were divided randomly into two equal groups, and the main part of study was conducted on them. The means and SDs for the parameters from this pilot study, with $\alpha = 0.05$ and 90% power were used to calculate the sample size. According to the results of the pilot and the formula stated, the sample size in each group was considered 18 patients.

The sampling method was the simple, non-probabilistic sampling method and from the available population. The participants will then be allocated randomly to two intervention groups, the routine chest physiotherapy group and expiratory volume techniques. Randomization would be performed using random number sequence. The administrator and participants were informed about the grouping data and the physiotherapist assessed the subjects, recorded the outcome, and analyzed the data about the grouping.

Procedure

The initial clinical examination study was performed by demographic information, patient's history for diagnostic RSD. Then, the individuals were selected to enter the study by examining the inclusion and exclusion criteria.

Outcome

Expiratory volume: The volume of air that an individual can exhale during a breath (25).

Respiratory rate: The number of breaths per minute in the ventilator plays an essential role in minute ventilation and has a direct effect on PCO2 excretion (25).

Foi2: The amount of oxygen delivered to the patient by the ventilator in each breath (25).

PEEP: The pressure in the lungs at the end of each breath (exhalation) which in intubated patients acts against the passive emptying of the lungs and the collapse of the alveoli (25).

PIP: The peak of the pressure that is applied to the lungs during inspiration and plays an essential role in tidal volume (25).

MAP: It is the medium pressure in the airways from the beginning of a breath to the next breath (25).

O2sat: Oxygen saturation measures the percentage of oxyhemoglobin (oxygen-bound hemoglobin) in the blood, and it is represented as arterial oxygen saturation (25).

Intervention

Subjects were randomly divided into two groups: Routine group and expiratory volume techniques group. Premature infants in both groups received routine chest physiotherapy treatment including vibration, postural drainage, percussion (26, 27,28).

In expiratory volume techniques group, neonates received expiration techniques including: prolonged slow expiratory technique ،expiratory flow increased technique ،lung squeezing and vojta (29, 30,31).

Intervention has done twice a day with a time interval of eight hours, for five days. The variables were recorded before and after intervention by the ventilator device (Ventilator model i5 is made by eVent medical company , F75123AS016 - 102 R02).

Data analysis

Results were presented as mean values and standard deviation (SD). Criterion of significancy was set as $p<0.05$. Data analysis was performed with SPSS version 27. The assumption of a normal distribution was assessed using the Shapiro-Wilk test. The assumption of equality of variances was tested using Levene's test. The paired and student t-tests were used for within- and between-group comparisons.

Results

Thirty-seven infants were nominated for this study, and 37 patients were divided into two groups: routine group and expiratory volume techniques group (Fig-1).

The pilot study showed that 20 subjects would be needed for each group (a total of 67 subjects). Ultimately, 32 subjects finished the study procedure. Thirteen of them were not eligible based upon the inclusion and exclusion criteria.

The flowchart of is shown in Figure 1.

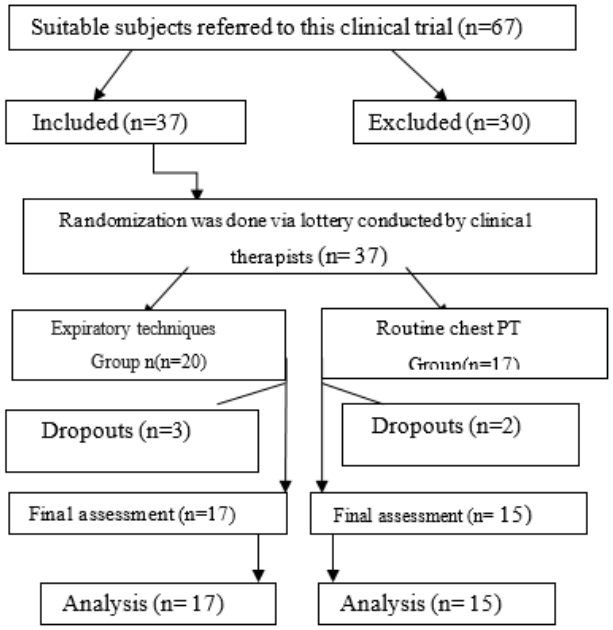

Fig-1: Flow diagram of study selection.

Data were analyzed in SPSS 27 software. The normality of data distribution was examined by the Shapiro-Wilk test. The p-value was not less than 0.05 in the variables of the study. Thus, the tests do not reject the hypothesis of normality and the data are normal ($p>0.05$).

Table-1- Comparison of demographic characteristics between two groups

Variable	Routine group (n=18)*	Respiratory volume Group (n=18) *	P-value
Age (days)	10.05 ± 5.3	8.90± 4.4	0.46
Weight (g)	2429.00±823.6	2200.75±795.4	0.37
Height (Cm)	47.60±4.4	43.95±5.1	0.22
the age of pregnancy(weeks)	34.75±1.7	34.35±1.8	0.48

*mean ± standard deviation. ** A significance level of less than 0.05.

Table-1 presents the demographic characteristics of patients including age, height, weight, and the age of pregnancy. The demographic characteristics of the patients, which were recorded before intervention, were compared between the two groups. There was no significant difference between the two groups (Table-1).

To examine the homogeneous of samples in the two studied groups before intervention, a t-test was used. The results show that the samples in the two groups were equal and homogeneous ($p>0t.05$).

Within group and between group comparison

Table-2 within and between groups comparison.

	Routine group (n=18)*		P-value within group**	Expiratory volume techniques Group (n=18) *		P-value within group**	P-value between group**
	Before	After		Before	After		
Expiratory volume	7.34±10.3	7.32±16.1	0.01	3.13±8.0	7.32±17.5	0.000	0.56

Respiratory rate	52.40±13.7	13.00±53.0	0.88	45.8±11.9	13.28±50.4	0.15	0.53
Fio2	79.75±22.9	50.25±19.6	0.000	71.75±22.0	42.00±11.8	0.000	0.11
PEEP	6.85±0.8	6.10±0.4	0.003	6.20±0.5	5.80±0.4	0.008	0.03
PIP	15.95±3.0	14.10±3.0	0.08	15.40±3.0	11.60±2.9	0.000	0.01
MAP	8.95±1.5	8.35±0.7	0.09	8.65±1.4	7.70±0.9	0.009	0.01
O2 sat	87.65±18.8	95.10±2.4	0.09	91.20±5.4	94.20±8.4	0.02	0.64

*mean ± standard deviation. ** A significance level of less than 0.05.

The results of Table 2 show that the changes in the Expiratory volume, Respiratory rate, Fio2, PEEP , PIP , MAP , O2 sat before and after intervention in both groups ($p<0.05$). The results of the between group comparison show no significant difference in expiratory volume, respiratory rate, Fio2 and O2sat after intervention ($p>0.05$). There was significant difference between the two groups in PIP, MAP and PEEP after intervention ($p<0.05$).

Discussion

The most important finding of this research showed that expiratory volume techniques effect on the oxygenation. A greater increase in the average expiratory volume in the group of expiratory volume techniques indicates a greater effect of these techniques on the expiratory volume of the premature infants. Also, the positive changes in Fio2, PEEP, and PIP parameters in the expiratory volume technique group indicate that the infant's dependence on the ventilator decreased and expiratory volume training was more effective. In general, MAP, which is a combination of the above parameters and indicates the amount of oxygenation, also has a greater improvement in the expiratory volume techniques group.

Expiratory volume is the volume of air in breathing that is passively given to the ventilator by the infants. The volume of expiration shows the volume of air entering and leaving the lungs. So the volume of expiration is an important parameter because it is exactly the amount of volume that show the air that enters and exits the lungs. Physiological findings report that the lung's extensibility or compliance is one of the important factors in oxygen delivery. The more it is, the greater the lung capacity is, and it is directly related to lung extensibility or compliance (33).

According to the results of the current study, Giannantonio et al. (2010) conducted a study to test the use of "reflex rolling" of the Vojta method in premature infants. The results showed that in the first stage, Vojta increased the values of PtcO2 and SatO2. Finally, they suggested that using the Vojta method is a safe method for premature babies (22). We also used the Vojta method for premature infants and the result showed that the combination of Vojta with expiratory volume techniques can improve oxygen delivery. Lanza et al. (2011) investigated the effect of the Prolonged slow expiratory technique on the respiratory system of infants and observed the improvement of respiratory sound and expiration volume at the same time (34).

We also used the above technique in this study and it showed that the expiration volume techniques increased significantly in the group of expiratory volume techniques. Évelim et al. (2021) showed that the expiratory volume techniques along with the routine chest physiotherapy and oxygenation had a faster and faster recovery (29). Almeida et al. (2005) showed the usefulness of the expiratory flow increased technique in a short period in oxygenating infants (23). Also, another study by Antunes LCO and et al. (2005) found that expiratory flow increased technique causes less stress than routine respiratory physiotherapy in premature infants after extubating, and it was also shown to be safer and more useful in a short period in performing this technique (26). In our study the significant increase in the expiratory volume and the decrease in PEEP, PIP, MAP, and FiO2 were seen that these changes indicate better oxygenation and less dependence on ventilators in infants with respiratory distress syndrome. The results of the above studies were confirmed and the effects of expiratory volume techniques were used to reduce ventilator parameters such as PIP, PEEP, MAP, and FiO2, and improve oxygenation. In addition, performing these techniques led to the improvement of ventilation and respiratory capacity of the lungs of infants. Therefore, we also recommend this common treatment method in the respiratory recovery of patients with respiratory distress syndrome.

According to the above documents as well as the results obtained from the present study, and the effect that this treatment method has on reducing the duration of intubation and improving oxygenation, as well as improving ventilation and ventilator parameters.

Conclusion

Based on the results of the present study, the expiratory volume technique with routine chest physiotherapy improved oxygenation and expiratory volume in subjects with respiratory distress syndrome. The present study indicated the importance of task expiratory volume in MAP, PIP, PEEP, and oxygenation in premature infants with respiratory distress syndrome, especially in specific conditions such as intubation. Therefore, we suggest that respiratory volume techniques should also be considered in rehabilitation programs for infants with respiratory distress syndrome in addition to routine chest physiotherapy.

Funding

This study was supported and approved by the Zahedan University of Medical Sciences.

Authors' contributions

All authors made substantial contributions to the conception, design, acquisition, analysis, and interpretation of data.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

This paper was derived from a MSc. thesis on physiotherapy. The authors of this paper appreciate the cooperation of the Research Deputy of the Medical Science University of Zahedan due to their collaboration in conducting this project and all the people who participated in this study.

References

1.Berminezhad L ,Mehrnoosh N, Fatemi N ,Haqani H, Maternal stressor agents with premature infants in neonatal intensive care units. 2011;4(1):39-44.

2. Keshavars M, Eskandaril N, Jahdi F, Ashaieri H, Hoseini F, Kalani MJK. The effect of holly Quran recitation on physiological responses of premature infant. 2010;11(3):169-78.

3. Dadipoor S, Alavi A, Pormehr-Yabandeh A, Golnam M, Safari-Moradabadi AJKJ. Investigation on some maternal factors affecting the birth of preterm infants: a case–control study. 2017;20(6):551-6.

4. Donda K, Vijayakanthi N, Dapaah-Siakwan F, Bhatt P, Rastogi D, Rastogi SJPp. Trends in epidemiology and outcomes of respiratory distress syndrome in the United States. 2019;54(4):405-14.

5. Marcdante K, Kliegman RM, Jenson H, Behrman RJE, Philadelphia. Essentials of pediatrics. 2015;11(14):231.

6. Qari SA, Alsufyani AA, Muathin SH, El Margoushy NMJTEjohm. Prevalence of respiratory distress syndrome in neonates. 2018;70(2):257-64.

7. Chokshi T, Alaparthi GK, Krishnan S, Vaishali K, Zulfeequer CJIJoCCMP-r, Official Publication of Indian Society of Critical Care Medicine. Practice patterns of physiotherapists in neonatal intensive care units: A national survey. 2013;17(6):359.

8. Islamian M, Sabzevari F. Comparison of the efficacy of two natural types of surfactant (BERAKSURF and BLES) in the treatment of respiratory distress syndrome among preterm neonatesadmitted to NICU of Kerman Afzalipour hospital in 2020-2021: Kerman University of Medical Sciences; in Persian.

9. Verma RP. Respiratory distress syndrome of the newborn infant. Obstet Gynecol Surv. 1995;50(7):542-55.

10. Macooie AA, Fakour Z, Roanaghi P. Comparative evaluation of the effects of BLES and Survanta on treatment of respiratory distress syndrome in newborns. J Family Med Prim Care. 2018;7(5):1063-7.

11. van Kaam AH, De Luca D, Hentschel R, Hutten J, Sindelar R, Thome U, et al. Modes and strategies for providing conventional mechanical ventilation in neonates. 2021;90(5):957-62 .

12. Chen L, Wang L, Ma J, Feng Z, Li J, Shi YJC. Nasal high-frequency oscillatory ventilation in preterm infants with respiratory distress syndrome and ARDS after extubation: a randomized controlled trial. 2019;155(4):740-8.

13. Chong D, Kayser S, Szakmar E, Morley CJ, Belteki GJPP. Effect of pressure rise time on ventilator parameters and gas exchange during neonatal ventilation. 2020;55(5):1131-8

14. Ghorbani F, Valizadeh S, Asadollahi M. Comparison of Prone and Supine Positions on Oxygenation of Premature Infants with Respiratory Distress Syndrome Treated with Nasal CPAP in Tabriz Alzahra Hospital, 2010, Tabriz, Iran. 2013.

15. Johansson J, Curstedt TJJoim. Synthetic surfactants with SP-B and SP-C analogues to enable worldwide treatment of neonatal respiratory distress syndrome and other lung diseases. 2019;285(2):165-86.

16. ROSTAMI N, Atarian M. Early nasal CPAP treatment in premature neonates with respiratory distress syndrome. 2007

17. Mehta Y, Shetye J, Nanavati R, Mehta AJJoN-PM. Physiological effects of a single chest physiotherapy session in mechanically ventilated and extubated preterm neonates. 2016;9(4):371-6.

18. Tudehope DI, BAGLEY CJJoP, Health C. Techniques of physiotherapy in intubated babies with the respiratory distress syndrome. 1980;16(4):226-8.

19.WHO. Preterm birth 19 February 2018 [Available from: https://www.who.int/news-room/fact-sheets/detail/preterm-birth.

20.Raval D, Yeh T, Mora A, Cuevas D, Pyati S, Pildes RJJoP. Chest physiotherapy in preterm infants with RDS in the first 24 hours of life. 1987;7(4):301-4.

21. Kole, Jaitty; Metgud, Deepa, Effect of lung squeeze technique and reflex rolling on oxygenation in preterm neonates with respiratory problems A randomized controlled trial Indian Journal of Health Sciences and Biomedical Research (KLEU) 7(1):p 15-21, Jan–Jun 2014.

22. Giannantonio C, Papacci P, Ciarniello R, Tesfagabir MG, Purcaro V, Cota F, et al. Chest physiotherapy in preterm infants with lung diseases.2010;36(1):1-5.

23. Almeida, Celize CB Almeida, Jose D Ribeiro, Armando A Almeida-Junior, Angelica MB Zeferino First published: 17 March 2006 https://doi.org/10.1002/pri.15 2005.

24. ANTUNES LCO, SILVA EG, BOCARDO P, DAHER DR, FAGGIOTTO RD & RUGOLO LMSS Technical Rehabilitation Sector, University Hospital, Faculty of Medicine of Botucatu, São Paulo State University Julio de

Mesquita Filho, Botucatu, SP – Brazil, Rev. bras. fisioter. Vol.10, No.1 (2006), 87-92.
25. Jay P. Goldsmith – Edward Karotkin – Gautham Suresh – Martin Keszler. Assisted Ventilation of the Neonate: Evidence-Based Approach to Newborn Respiratory Care 6th Edition2017, Elsevier, P8-30
26. Jay P. Goldsmith – Edward Karotkin – Gautham Suresh – Martin Keszler Assisted Ventilation of the Neonate: Evidence-Based Approach to Newborn Respiratory Care 6th Edition, 2017 ,P299 .
27. Wong and co-workers, 1997 ARJAN B. TE PAS, CONNIE WONG, C. OMAR F. KAMLIN, JENNIFER A. DAWSON, COLIN J. MORLEY, AND PETER G. DAVIS
Division of Newborn Services, Royal Women's Hospital, Carlton, Victoria 3053, Australia, Vol. 65, No. 3, 2009, Breathing Patterns in Preterm and Term Infants Immediately After Birth, Printed in U.S.A
28. Thomas Thomas J, DeHueck A, Kleiner M, Newton J, Crowe J, Mahler S. To
vibrate or not to vibrate: Usefulness of the mechanical vibrator for clearing bronchial secretions. Physiotherapy Canada 1995; 47: 120.
29. Évelim L.F.D, Évelim L. F. D. Gomes1, Guy Postiaux2, Denise R. L. Medeiros3, Kadma K. D. S. Monteiro4, Luciana M. M. Sampaio5, Dirceu Costa 2012, Chest physical therapy is effective in reducing the clinical score in bronchiolitis: randomized controlled trial, Rev Bras Fisioter, São Carlos, v. 16, n. 3, p. 241-7, May/June 2012©Revista Brasileira de Fisioterapia.
30. Ivor Wong MPhil, PT a, Tai-Fai Fok MD, FRCP(Edin), Effects of Lung Squeezing Technique on Lung Mechanics in Mechanically-Ventilated Preterm Infants with Respiratory Distress Syndrome, Hong Kong Physiotherapy Journal
Volume 24, Issue 1, 2006, Pages 39-46
31. P.Maggie McIlwaine MCSP, CPA, Lawrence T. Wong MB, BS, FRCPC, Donlim Peacock MB,CHB, FRCPC, A.George F. Davidson BSC, MD, FRCPC, From Department of Paediatrics, University of British Columbia; and the Department of Physiotherapy and the Cystic Fibrosis Clinic, B.C.'s Children's Hospital, Vancouver, British Columbia, Canada, Long-term comparative trial of conventional postural drainage and percussion versus positive expiratory pressure physiotherapy in the treatment of cystic fibrosis, The Journal of Pediatrics Volume 131, Issue 4, October 1997, Pages 570-574.
32. Manual of Neonatal Respiratory Care, Editors: Steven M. Donn, Mark C. Mammel, Anton H.L.C. van Kaam, 2022.
33. Core Curriculum for Neonatal Intensive Care Nursing, 6th Edition - March 22, 2020, Author: Fay Rycyna AWHONN, Paperback ISBN: 9780323554190, 9 7 8 - 0 - 3 2 3 - 5 5 4 1 9 – 0, eBook ISBN: 9780323672337.
34. Fernanda C Lanza, Gustavo Wandalsen, Ana Caroline Dela Bianca, Carolina L Cruz, Guy Postiaux and Dirceu Solé, Respiratory Care December 2011, 56 (12) 1930-1935; DOI: https://doi.org/10.4187/respcare.01067