original article

BJPT Brazilian Journal of Physical Therapy

Response of oxygen saturation in preterm infants receiving rib cage stabilization with an elastic band in two body positions: a randomized clinical trial

Marisa A. A. Brunherotti[1], Francisco E. Martinez[2]

ABSTRACT | **Background:** Preterm newborns have higher thoracic compliance, providing less stability to the different forces of distortion imposed on the rib cage, leading to instability of the chest. Adequate body position may reduce this instability and facilitate respiratory work. **Objective:** To assess the oxygen saturation response of preterm newborns receiving rib cage stabilization with an elastic band in two body positions. **Method:** A clinical, prospective, randomized crossover study was conducted, including sixteen newborns with a gestational age of 31 to 35 weeks (mean 32.8 weeks) at a tertiary care facility, who did not receive supplemental oxygen. The infants were placed in a sequence of prone and supine positions with and without chest stabilization with an elastic band. Respiratory rate, heart rate, and oxygen saturation were measured at 10-minute intervals, corresponding to 7 samplings of 60 minutes. Data collection was interrupted when oxygen saturation was less than 90%. **Results:** The mean gestational age of the infants was 32.8±1.5 weeks and the mean birth weight was 1,789±255g. Better values for the variables studied were observed in the supine position with an elastic chest band compared to the supine position without the band. The positions using an elastic band resulted in lower mean respiratory rate and heart rate and higher oxygen saturation. **Conclusion:** The use of an elastic chest band improves respiratory indicators such as oxygen saturation.

Keywords: respiratory mechanics; preterm newborn; supine position; prone position; movement.
Article registered in Registro Brasileiro de Ensaios Clinicos (ReBEC) under number RBR-7wm8mz.

HOW TO CITE THIS ARTICLE

Brunherotti MAA, Martinez FE. Response of oxygen saturation in preterm infants receiving rib cage stabilization with an elastic band in two body positions: a randomized clinical trial. Braz J Phys Ther. 2013 Mar-Apr; 17(2):105-111. http://dx.doi.org/10.1590/S1413-35552012005000082

Introduction

The behavior of oxygen saturation is dependent on body position. Scientific records have shown that postural positions interfere positively in preterm newborns, contributing to improvement in oxygenation, reduction in gastroesophageal reflux episodes, reduction in thoracoabdominal asynchrony, among others[1-3].

The prone position stabilizes the rib cage and provides the best length for the diaphragm muscle fibers and enhances its angle of contraction. Thus, it has been associated with greater advantages, such as increase in tidal volume, improvement in diaphragm function, reduction in thoracoabdominal asynchrony, increase in oxygenation, and also decrease in carbon dioxide[4-6].

On the other hand, the supine position has some disadvantages due to a greater action of gravity on the chest, which hinders the work of the diaphragmatic muscles, reduces the anteroposterior diameter of the chest, decreases functional residual capacity, lung compliance, and efficiency of gas exchange. There is also increased respiratory workload[7-9]. In the supine position, the diaphragm muscle is stretched, causing reduction in muscle strength and in the diaphragm's zone of apposition.

There are several studies on oxygen saturation and oxygen partial pressure in adults and children that show that both of them improve in the prone position compared to supine, and this improvement is more evident in the presence of lung pathology[7-10].

[1] Physical Therapy Department, Universidade de Franca (Unifran), Franca, SP, Brazil
[2] Department of Well-Child Care and Paediatrics, Faculdade de Medicina, Universidade de São Paulo (USP), Ribeirão Preto, SP, Brazil
Received: 11/11/2011 – Revised: 05/01/2012 – Accepted: 08/29/2012

However, the supine position is still widely used in newborn care because it allows better venous access and access to clinical exams and hygiene care. However, no study to date has demonstrated a feature to minimize the undesirable effects of the supine position on respiratory biomechanics. This study aims to determine the behavior of oxygen saturation in preterm newborns under stabilization of the rib cage with elastic band in two body positions.

Method

The design of the study was a prospective randomized clinical trial, and each newborn was his/her own control. The study was conducted in the maternity ward of Santa Casa de Franca in 2008. The study was approved by the Ethics Committee of Universidade de Franca (Unifran), Franca, SP, Brazil, Protocol No 0002.0.393.000-08. The consent form was signed and authorized by the newborns' parents.

The study included 16 preterm newborns of both sexes, with a minimum weight of 1,445g and maximum of 2,270g at birth and gestational age from 31 to 35 weeks. Gestational age was determined by the best obstetric estimation obtained by ultrasound in the first trimester or the last menstrual period or by physical examination of the newborn by the New Ballard method[11]. The children selected were not on ventilatory support or supplemental oxygen, had normal red and white blood count, and remained in the unit to gain weight.

Newborns were excluded if classified as extremely premature, term newborns or small for gestational age (SGA) and if they had a history of apnea, heart disease, congenital malformations, severe anoxia, hydrocephalus, abdominal surgery, neonatal infection, and history of positive pressure ventilation use. The newborns had exceeded seven days of life or were referred from other care units.

The newborns who took part in this study were assessed and randomized to a sequence of four postural positions:

- A - supine without elastic band;
- B - supine with elastic band;
- C - prone without elastic band;
- D - prone with elastic band.

The sequences were as follows:

- Sequence 1 - A, D, C, B;
- Sequence 2 - C, A, B, D;
- Sequence 3 - B, C, D, A; and
- Sequence 4 - D, B, A, C.

The data collection form was composed of non-dependent variables, including identification, weight, gender, gestational age, date of birth, time of hospital stay, Apgar score, anthropometric measurements, type of delivery, maternal age, use of maternal corticosteroids, use of surfactant, maternal complications, newborn complications, clinical diagnosis, prescriptions, respiratory rate, heart rate, saturation, and Silverman-Andersen score. The first collection was after 30 minutes in the selected position. Data recording was done every 10 minutes over a period of 60 minutes, and the time interval between positions with and without the use of the elastic band was one hour.

All participants were assessed by a single evaluator starting at 7 p.m. At that time, they would not disturbed by other procedures that occurred during the day. Personal hygiene and diet were maintained during the interval between the body positions. Data collection would cease if saturation was less than 90%.

A thoracic elastic band (38% cotton, 34% polyamide, and 28% elastodiene) with horizontal centimeter markings was used to stabilize the rib cage. The chest was wrapped with the band at the end of the inspiratory cycle movement. From this point, the closure of the band was in the second centimeter of the marking. The track was positioned below the inframammary line until the umbilicus.

The data are shown as mean, standard deviation, median, 95% confidence interval, and minimum and maximum variation. For comparative analysis, we used analysis of variance (ANOVA) with Tukey's post hoc test ($p<0.05$) in the statistical program Instat 3.

Results

The present study included 16 preterm newborns, 62.5% female and 37.5% male, with a mean gestational age of 32.8±1.5 weeks, birth weight of 1,789±255g and weight during the study period of 1,669±245g, showing a weight loss of 120g in

Table 1. General characteristics of preterm infants studied.

Infants	Days old (days)	gestational age (weeks)	Birth weight (g)	Actual weight (g)	Sex	Apgar 1' – 5'
1	6	35	1,530	1,470	M	6 – 8
2	4	32	1,970	1,840	F	7 – 8
3	5	33	1,445	1,415	M	6 – 8
4	2	34	1,785	1,750	F	9 – 10
5	3	34	1,880	1,620	F	9 – 10
6	3	33	1,720	1,620	F	8 – 9
7	2	35	2,200	2,045	F	9 – 10
8	6	34	2,270	2,120	M	4 – 7
9	6	32	1,475	1,340	M	7 – 9
10	6	31	1,850	1,800	M	9 – 9
11	4	31	1,530	1,380	F	9 – 10
12	6	33	1,525	1,340	F	9 – 10
13	4	34	1,950	1,870	M	8 – 8
14	2	34	1,615	1,515	F	7 – 8
15	3	31	1,890	1,770	F	9 – 9
16	4	31	1,990	1,815	F	6 – 9
Mean±SD	**4.1±1.5**	**32.8±1.5**	**1,789±255**	**1,669±245**		**7.6±1.5** **8.8±1.0**

4.1 days of life. All were in stable clinical condition, spontaneously breathing room air. The group's mean Apgar score was above seven, however four children scored under seven in the first minute, recovering the value in the fifth minute (Table 1). The study group was randomized to a postural sequence, starting with sequence number 4. Each sequence was repeated four times. During the study, none of the participants were excluded.

We measured the variables respiratory rate, heart rate, and oxygen saturation in the positions studied and calculated the mean. The best value was obtained in the postural positions in which the stabilizing chest band was used. However, we found normal mean values in all variables analyzed (Table 2).

Oxygen saturation was maintained in all positions with mean desired values for adequate oxygenation. The lowest value for saturation was in supine without the elastic band, and the best was in prone with the elastic band (94.0±0.5% - 96.2±0.2%), and supine with elastic band was similar to prone without elastic band. The lowest value and variability for respiratory rate were in supine with elastic band, and the highest was in supine without elastic band (48.2±1.1 rpm - 51.5±3.2 rpm). In contrast, prone with and without band and supine with band had equivalent values. Regarding heart rate, the lowest mean value was in the supine position with elastic band, however all values were within normal limits in the postural positions assessed (Table 2).

Statistical analysis was used to compare the postural positions. The variable oxygen saturation varied according to position. The supine position without elastic band was different from the prone position without band ($p<0.001$). When comparing the prone and supine positions with band, the difference was lower ($p<0.01$), however supine with elastic band did not differ from prone without elastic band, and there were no significant statistical differences. The smallest difference was between

prone with and prone without elastic band ($p<0.05$), and the greatest difference was between supine with and supine without elastic band ($p<0.001$). The comparison between the body positions and the variable oxygen saturation showed a trend toward better values, despite being within desired target values.

Respiratory rate behaved differently in the supine position with elastic band and in the prone with elastic band ($p<0.05$), however in the positions without stabilizing chest band, the supine and prone positions did not differ. The supine position without elastic band had the highest mean value in this variable. When comparing the supine positions with and without elastic band, the mean value decreased 3.3 rpm. The prone position with and without chest band showed no difference. Likewise the respiratory rate in the supine and prone positions without the elastic band behaved similarly (Table 3). In contrast, heart rate showed no significant difference in the comparison between the positions, reaching clinically desirable values (Table 3).

Discussion

Preterm newborns have some peculiarities that lead to greater rib cage instability. Proper body positioning can reduce that disadvantage, facilitating respiratory work. The scientific literature indicates the prone position as advantageous for thoracoabdominal biomechanics because it increases the diaphragm's zone of apposition, stabilizes the rib cage, and reduces energy expenditure. However, the literature does not describe the response of cardiorespiratory indicators to supine posture with a resource that promotes rib cage stabilization.

In the present study, we observed the behavior of respiratory indicators, such as oxygen saturation, in different postures combined with stabilization of the rib cage with the use of a chest band. Both supine and prone positions were observed, and positive results were found between postural positioning

Table 2. Data on respiratory rate, heart rate, and oxygen saturation of premature newborns in different body positions.

Variables	S	BS	P	BP
	Mean±SD Min-Max	Mean±SD Min-Max	Mean±SD Min-Max	Mean±SD Min-Max
Oxygen saturation (%)	94.0±3.1 86–99	95.3±2.2 88–99	95.4±1.6 90–99	96.2±1.7 91–99
Respiratory rate (RR)	51.5±12.7 25–78	48.2±10.9 23–80	48.7±11.0 31–80	48.4±10.7 25–75
Heart rate (bpm)	138.3±10.6 112–166	135.5±10.2 109–160	136.8±11.6 115–167	137.0±8.8 117–156

S: supine without elastic band; BS: supine with elastic band; P: prone without elastic band; BP: prone with elastic band; %: percentage; RR: Respiratory rate; bpm: beats per minute; SD: standard deviation.

Table 3. Results of ANOVA to compare the positions supine without elastic band (S), supine with elastic band (SB), prone without elastic band (P), and prone with elastic band (PB) with varying oxygen saturation, respiratory rate, and heart rate in premature newborns.

Variables	S vs. SB	P vs. PB	S vs. P	SB vs. PB	SB vs. P	PB vs. S
	p	*p*	*p*	*P*	*p*	*P*
Oxygen saturation (%)	<0.001	<0.05	<0.001	<0.01	NS	<0.001
Respiratory rate (RR)	<0.05	NS	NS	NS	NS	<0.05
Heart rate (bpm)	NS	NS	NS	NS	NS	NS

%: percentage; RR: respiratory rate; bpm: beats per minute; NS: not significant.

and support of the rib cage with the elastic band. Previous studies only investigated the correlation between postural positioning and thoracoabdominal synchrony, describing enhancements in diaphragm function, oxygen saturation, and oxygen partial pressure, as well as reductions in heart rate and gastroesophageal reflux episodes[3,5,12-14].

The respiratory rate in our findings had the lowest mean value in the supine position with the elastic band, with a reduction of 3.3 rpm, compared with the highest mean value in the supine position without the elastic band, however the prone position with and without elastic band had a mean value very close to the mean value of the supine with elastic band. However, in the respiratory rate observed in the comparison of positions, there was a significant difference between the supine position without elastic band and both supine and prone with elastic band, showing positive evidence for the elastic band, but we found no difference between the positions prone without band and prone and supine with elastic band. The mean respiratory rate values were similar for these positions.

Positioning vs. respiratory rate is described in the literature as low respiratory rate in prone position[3]. The study by Leipälä et al.[15] highlighted prone as the body position with the lowest mean respiratory rate for the group of preterm newborns dependent on oxygen therapy. In contrast, the study by Oliveira et al.[16] showed that, in spontaneously breathing and clinically stable newborns after respiratory distress syndrome, the respiratory rate had a higher mean value in supine than in prone (74.22 vs. 68.67 rpm). In our study, the mean value in supine without elastic band was higher than in prone without elastic band (51.5 vs. 48.7 rpm), and supine and prone with elastic band (48.2 rpm vs. 48.4 rpm) were very similar to the value of prone without elastic band. Thus, the studied group was classified as eupneic. Another point that may explain the difference between the mean respiratory rate values of our study and those found by Oliveira et al.[16] is that, despite the prematurity, our newborns did not suffer from respiratory distress syndrome.

With regard to heart rate, some studies show reduction[14] and others, an increase[1] in the mean value in the prone position. In our study, we found no significant differences between positions or evidence of association between comparisons. The lowest value for mean heart rate was in the supine position with elastic band (135.5 bpm), whereas the highest value was observed in the supine position without elastic band (138.3 bpm) with similar values in the prone position with and without elastic band (137.0 bpm vs. 136.9 bpm). During the study, we noted that the values for heart rate remained within normality values. Heart rate behavior was also demonstrated by a prospective, crossover, randomized trial, regarding the sequence of supine-prone-supine and prone-supine-prone positions in ten preterm newborns without ventilatory support and with gestational age of 24-32 weeks. The result showed significantly increased heart rate in the supine position and lower variability in prone[17]. Another study demonstrates lower and more stable heart rate levels in the right lateral and prone positions in 16 preterm newborns with gestational age of 32 weeks and mean weight of 1,722g, submitted to increase in gastric volume[18].

In other studies, the indicator that most improved oxygenation and oxygen saturation and reduced hypoxia was the prone position, thus promoting its use in newborns[6,18-21]. Our results show that the elastic chest band had a strong influence on oxygen saturation. While comparing the positions supine with elastic band and prone, we found no significant difference with similar mean values, and in the comparison between supine and prone, there was a significant difference with a lower mean value in supine. Therefore, all comparisons between the supine and prone positions showed better mean values and statistical significance when the elastic chest band was used.

However, the positive effect of the elastic chest band as a rib cage stabilizer stems from the biomechanical response of the thorax. In newborns, the thoracic arches are in a horizontal position, which changes the length-tension relationship of rib cage muscles[22]. However the postural positions influence the support area for the muscles to produce contraction strength, thus, postural positions that generate greater chest support have advantages for respiratory indicators.

In the prone position, the rib cage is supported by the bed, and the diaphragm's gains a greater zone of apposition in the anterior chest wall. In the supine position, however, the zone of apposition

decreases, demanding greater respiratory work with thoracoabdominal distortions[13]. Thus, our study showed that, when the chest band is worn in the supine position, the rib cage stabilizes and makes breathing easier for small amplitudes with mobile phrenic center, stable ribs, and fixed lower back, which creates a stronger contraction of the diaphragm, causing greater alveolar distensibility[23], generating greater saturation with lower respiratory rate values.

The prone position is highlighted in studies demonstrating better values of oxygen saturation. A study with 21 preterm newborns with a mean weight of 884g, 26 weeks of gestational age, and dependent on oxygen therapy, showed evidence of improvement of the $SatO_2$ variable with p=0.02 in the prone position compared with supine[2]. Another study assessed 12 spontaneously breathing and clinically stable preterm newborns weighing less than 1,000g after respiratory distress syndrome. The $SatO_2$ variable had better mean values in the prone position compared to supine (95.1% vs. 93.4%)[16].

With the findings of this study, we concluded that the use of the elastic band to stabilize the chest can improve respiratory indicators, particularly oxygen saturation, and can mitigate the undesirable effects of the supine position.

References

1. Ammari A, Schulze KF, Ohira-Kist K, Kashyap S, Fifer WP, Myers MM, et al. Effects of body position on thermal, cardiorespiratory and metabolic activity in low birth weight infants. Early Hum Dev. 2009;85(8):497-501. PMid:19419824. http://dx.doi.org/10.1016/j.earlhumdev.2009.04.005
2. Kassim Z, Donaldson N, Khetriwal B, Rao H, Sylvester K, Rafferty GF, et al. Sleeping position, oxygen saturation and lung volume in convalescent, prematurely born infants. Arch Dis Child Fetal Neonatal Ed. 2007;92(5):F347-50. PMid:17012305 PMCid:PMC2675354. http://dx.doi.org/10.1136/adc.2006.094078
3. Corvaglia L, Rotatori R, Ferlini M, Aceti A, Ancora G, Faldella G. The effect of body positioning on gastroesophageal reflux in premature infants: evaluation by combined impedance and pH monitoring. J Pediatr. 2007;151(6):591-6. PMid:18035136.
4. Amemiya F, Vos JE, Prechtl HF. Effects of prone and supine position on heart rate, respiratory rate and motor activity in fullterm newborn infants. Brain Dev. 1991;13(3):148-54. PMid:1928606. http://dx.doi.org/10.1016/S0387-7604(12)80020-9
5. Adams JA, Zabaleta IA, Sackner MA. Comparison of supine and prone noninvasive measurements of brething patterns in fullterm newborns. Pediatr Pulmonol. 1994;18(1):8-12. PMid:7970915. http://dx.doi.org/10.1002/ppul.1950180105
6. Dimitriou G, Greenough A, Pink L, McGhee A, Hickey A, Rafferty GF. Effect of posture on oxygenation and respiratory muscle strength in convalescent infants. Arch Dis Child Fetal Neonatal Ed. 2002;86(3):F147-50. PMid:11978742 PMCid:PMC1721414. http://dx.doi.org/10.1136/fn.86.3.F147
7. Wells DA, Gillies D, Fitzgerald DA. Positioning for acute respiratory distress in hospitalised infants and children. Cochrane Database Syst Rev. 2005;(2):CD003645. PMid:15846674.
8. Oliveira LC, Rugolo LMSS. O efeito da postura na saturação de O_2 em recém-nascidos de UTI neonatal. Fisioter Mov. 1994;6(2):54-64.
9. Tecklin JS. Fisioterapia pediátrica. 3ª ed. Porto Alegre: Artmed; 2002.
10. Numa AH, Hammer J, Newth CJL. Effect of prone and supine positions on functional residual capacity, oxygenation, and respiratory mechanics in ventilated infants and children. Am J Respir Crit Care Med. 1997;156(4 Pt 1):1185-9. PMid:9351620.
11. Ballard JL, Khoury JC, Wedig K, Wang L, Eilers-Walsman BL, Lipp R. New Ballard Score, expanded to include extremely premature infants. J Pediatr. 1991;119(3):417-23. PMid:1880657. http://dx.doi.org/10.1016/S0022-3476(05)82056-6
12. Heldt GP, Mcllroy MB. Dynamics of chest wall in preterm infants. J Appl Physiol. 1987;62(1):170-4. PMid:3558177.
13. Wolfson MR, Greenspan JS, Deoras KS, Allen JL, Shaffer TH. Effect of position on the mechanical interaction between the rib cage and abdomen in preterm infants. J Appl Physiol. 1992;72(3):1032-8. PMid:1533209.
14. Mendoza JC, Roberts JL, Cook LN. Postural effects on pulmonary function and heart rate of preterm infants with lung disease. J Pediatr. 1991;118(3):445-8. PMid:1999790.

15. Leipälä JA, Bhat RY, Rafferty GF, Hannam S, Greenough A. Effect of posture on respiratory function and drive in preterm infants prior to discharge. Pediatr Pulmonol. 2003;36(4):295-300. PMid:12950041

16. Oliveira TG, Rego MAS, Pereira NC, Vaz LO, França DC, Vieira DSR, et al. Posição prona e diminuição da assincronia toracoabdominal em recém-nascidos prematuros. J Pediatr (Rio J). 2009;85(5):443-8. http://dx.doi.org/10.1590/S0021-75572009000500013

17. Maynard V, Bignall S, Kitchen S. Effect of positioing on respiratory synchrony in non-ventilated pre-term infants. Physiother Res Int. 2000;5:96-110. PMid:10863716.

18. Pádua G, Martinez EZ, Brunherotti MAA. Efeitos cardiorrespiratórios frente à posição do corpo em recém-nascidos pré-termo submetidos ao aumento do volume gástrico. Arq Gastroenterol. 2009;46(4):321-7. http://dx.doi.org/10.1590/S0004-28032009000400014

19. Sahni R, Schulze KF, Kashyap S, Ohira-kist K, Myers MM, Fifer WP. Body position, sleep states, and cardiorespiratory activity in developing low birth weight infants. Early Hum Dev. 1999;54(3):197-206. PMid:10321786.

20. McEvoy C, Mendoza ME, Bowling S, Hewlett V, Sardesai S, Durand M. Prone positioning decreases episodes of hypoxemia in extremely low birth weight infants (1000 grams or less) with chronic lung disease. J Pediatr. 1997;130(2):305-9. PMid:9042137.

21. Bhat R, Leipälä JA, Singh NR, Rafferty GF, Hannam S, Greenough A. Effect of posture on oxygenation, lung volume, and respiratory mechanics in premature infants studied before discharge. Pediatrics. 2003;112(1 Pt 1):29-32. PMid:12837864.

22. Mortola JP, Saetta M, Fox G, Smith B, Weeks S. Mechanical aspects of chest wall distortion. J Apll Physiol. 1985;59(2):295-304. PMid:4030581.

23. Souchard PE. Respiração. In: Souchard PE. O diafragma. 4. ed. São Paulo: Ed. Summus Editorial; 1990. p. 11-31.

Correspondence

Marisa Afonso Andrade Brunherotti
Rua Padres Agostinianos, 1265, Santo Agostinho
CEP 14401-380, Franca, SP, Brazil
e-mail: brunherotti@uol.com.br