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Effect of Different Body Positions on Cardiorespiratory Parameters of Preterm Neonates Undergoing Mechanical Ventilation

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Abstract High prevalence of preterm infants' birth is considered a serious problem in health system in recent decades. Positions of the body in preterm neonates who receive respiratory support are accounted an important factor for ventilation and tissue oxygenation. Therefore, this study **aimed** to determine the effects of different body positions on cardiorespiratory parameters of preterm neonates undergoing mechanical ventilation**.** Crossover non-randomized clinical trial study **design** was used. **Setting:** The study was conducted at neonatal intensive care unit (NICU) in Assiut University Children Hospital. The study subjects included 40 preterm neonates undergoing mechanical ventilation and met the inclusion criteria. A structured questionnaire was designed especially to collect the required data for this study; it included three parts: preterm neonates' personal and clinical data, and assessment of cardiorespiratory parameters including: Heart Rate (HR), Respiratory Rate (RR), and oxygen saturation (SpO2) in each position. Each preterm neonate was placed in three different positions (supine, right lateral and semi-prone). **Results** of the current study revealed a significant improvement in heart rate, respiratory rate and increase in oxygen saturation in neonates placed in semi-prone position with statistically significant differences were found between them during the three different body positions (p=0.02*, p=0.012*&p<0.001)respectively. The study **concluded** that positioning of preterm neonates can be considered as an effective way of modifying the cardiorespiratory parameters and improving oxygenation in neonates undergoing mechanical ventilation. Likewise, semi-prone position was a safe, simple, noninvasive method which can be helpful in stabilizing preterm neonates' cardiorespiratory status. Also, the right lateral position was slightly effective while, the supine position was the least effective. **Recommendation:** Use of semi-prone position in the routine pediatric care of ventilated neonates as it is a safe, simple, non-invasive method that can help in improving oxygenation of preterm neonates'.

Keywords: *Body positions, cardiorespiratory parameters, mechanical ventilation, preterm neonates*

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1. Introduction

Preterm neonates are considered as a highly vulnerable group of the population who need advanced medical management and a highly specified nursing care to thrive and survive. About 15 million neonates are born preterm and this number is rising every year that is more than one in ten babies [1,2]. While, the reported incidence of preterm birth has been ranged from 5-7% of live births in some developed countries and is estimated to be substantially higher in developing countries. In Egypt, the number of preterm births at 32 - <37 weeks were 123.13 and this statistic may point to the higher rate of hospital admission in NICUs every year [3].

Moreover, a high prevalence of preterm infants' birth is considered a serious problem to the health care system in recent decades. Preterm neonates often have poor muscular tonicity and their neck, thoracic area, and most of their limbs are in extended position influencing the development of their neuro-psychomotor skills [4].

Preterm infants facing common problems after birth such as lung tissue prematurity and respiratory distress syndrome which clarify the need for extraordinary consideration for respiratory care. Management using oxygen therapy and mechanical ventilation is done according to the infant's needs; however administering high oxygen concentration can lead to pulmonary damage and subsequently chronic lung problems. So, the use of proper care measures in neonates undergoing mechanical ventilation with the aim of decreasing the necessity for oxygen are important measures in intensive care units [5].

Mechanical ventilation (MV) is necessary when ill neonates are treated, mainly when born preterm. It is usually used for a short time, but in some cases may be used for a long period, which is linked with adverse health effects and impaired long-term respiratory and developmental outcomes [6].

Lung immaturity is accounted as the main risk factor for mortality or morbidity in preterm neonates next to the immature brain which is a compact the lung function. Neonates born at or less than 32 weeks of gestation have immature lungs with impaired gas exchange. Most of these preterm neonates are at high risk for respiratory failure and their primary care includes respiratory function promotion. Repositioning can increase lung function by improving respiratory rate (RR).The fact of a "change" in body position leads to a modification in lung function and not just the position on its own [7].

Positioning of preterm neonates is a fundamental neonatal nursing care. It comprises supine, prone, side-lying, and head up tilted position. The preterm neonate needs support to assist and sustain postures that increase motor control, physiological functioning and diminish stress [8,9]. Positioning is also aims to improve various respiratory outcomes which may eventually aid in early weaning so decreasing the overall period of mechanical ventilation [10].

Body positioning is an easy, practical, and effective intervention as compared with other invasive measures. Each position has its own advantages and disadvantages that should be identified by the nurses. It seems that these positions can be applied to the preterm neonates to improve their comfort and health. Both of them are easy and cost-effective for health care workers [4,8].

Nurses who are caring of neonates undergoing MV face numerous encounters. Expertise and safe care are significant features in giving a safe and effective nursing care**.** It has been proven that each mechanically ventilated neonate needs on average one nurse for caring during 60% of the time [11]. The role of NICU nurse is to apply successfully developmental care and the provision of an optimal NICU environment. Neonatal nurses are central in NICUs efforts to improve quality of care. Comforting interventions in the field of nursing care will contribute to high neonatal outcomes. Consequently, developmental care in NICU is becoming a worldwide standard [1,12].

1.2. Significance of the Study

Numerous researches verified a diversity of outcomes affected by different body positioning of preterm infants. However, there are several results about their effect on preterm infants' cardiorespiratory status. Indeed, there is a disconnect between what is practiced in some NICUs and what is known in the evidence. Furthermore, it has been proposed that body positioning is an easy, practical and effective intervention as compared with other, invasive measures [8]. Therefore, this study was conducted.

1.3. Operational Definition

Cardiorespiratory parameters refer to physiological parameters of the neonate which include; Heart Rate (HR), Respiratory Rate (RR), and Oxygen Saturation (SpO2).

2. Aim of the Study

This study was aimed to determine the effect of different body positions on cardiorespiratory parameters of preterm neonates undergoing mechanical ventilation**.**

3. Hypotheses

1. Preterm neonates who are sleeping in the right lateral position have significant changes in their cardiorespiratory parameters than those who are sleeping in the supine position.
2. Preterm neonates who are sleeping in the semi-prone position have significant changes in their cardiorespiratory parameters than those who are sleeping in the supine position.
3. Preterm neonates who are sleeping in the semi-prone position have significant changes in their cardiorespiratory parameters than those who are sleeping in the right lateral position.

4. Subjects and Method

4.1. Study Design

Crossover (non-randomized clinical trial) study design was used.

4.2. Study Setting

The study was conducted at the neonatal intensive care unit (NICU) affiliated to Assiut University Children Hospital. The NICU has 50 incubators. An average of 127 cases admitted at the month with total 1511 neonates during 2018 year and it serves from El-Minia to the Red Sea governorate.

4.3. Study Subjects

The study subjects were included 40 preterm neonates' undergoing mechanical ventilation. Each preterm neonate was considered as his/her own control (crossover design) and they were enrolled in the study according to the following inclusion and exclusion criteria:

Inclusion Criteria:

1) Preterm neonates who had gestational age less than 36 weeks.
2) Preterm neonates who admitted to the neonatal intensive care unit.
3) Preterm neonates who undergoing mechanical ventilation.

Exclusion Criteria:

1) Preterm neonates with a confirmed diagnosis of congenital anomalies.
2) Preterm neonates known to be at risk for intraventricular hemorrhage.

3) Preterm neonates whose mothers refused to participate in the study.

4.3.1. Sample Size Calculations

The sample size was calculated after the pilot study conduction using the mean difference 15.57 between heart rate of the preterm neonates during the three positions as a primary outcome. With a p-value < 0.05 and power analysis 80%, confidence level 0.95. The minimum sample size was 31 preterm neonates. However, 40 preterm neonates were attempted in this study work to avoid non-response rate. This calculated using G Power 3.1.

4.4. Tool of Data Collection

One tool was used in this study: A structured questionnaire was designed especially to collect the required data for this study. It was included **three parts**: **Part 1:** Preterm neonate's personal data as: Gender, gestational age, birth weight. **Part 2:** Preterm neonate's clinical data as; type of delivery, oxygen therapy, number of days on mechanical ventilation, diagnosis, and treatment. **Part 3:** Assessment form for recording of cardiorespiratory parameters as Heart Rate (HR), Respiratory Rate (RR) and oxygen saturation (SaO2) in each position.

4.5. Method of Data Collection

- Formal permission was obtained from the chairman of NICU in Assiut University Children Hospital
- **Tool one** was developed by the researchers and it was tested for its content **validity** by five experts in the field of pediatric nursing. It was done using 5 points Likert scale that starts with very related (5) to very not related (1). The content validity was calculated by the sum of very related and related items on the sum of total items of the sheet in a number of five experts and it was 0.85. Also, the internal consistency of reliability for tool one was evaluated by using alpha - Cronbach test which was 0.88.
- **Ethical considerations**: The study researchers were prepared a proposal and it was accepted from the Ethical Committee of the Faculty of Nursing. After that; written consent was obtained from the mothers who were willing their neonates to participate in the study, after clarifying the nature and purpose of the study. Confidentiality and anonymity were ensured and the researchers told the mothers that there was no risk for their neonates during the implementation of the study. Also, the researchers confirmed that the research paper was following the common ethical principles in clinical research.
- **The pilot study** was applied on four preterm neonates (10 %). It was done to assess the clarity and applicability of the tool. It was incorporated in the total sample because no changes were performed.

4.6. Study Intervention

- The preterm neonates' personal and clinical data were extracted from their medical files.
- Each preterm neonate was attached with pulse oximetry and monitor.
- The preterm neonate's have positioned in three different body positions supine, right lateral and semi-prone.
- The preterm neonates were positioned by the nurse (under supervision of the researchers) on one position of the three positions by the following sequence first supine, after that right lateral, and finally semi-prone for about 90 minutes for each one.
- The preterm neonate were kept in each position for 30 minutes (washout period) until his or/ her state become stable due to the potential physiological respiratory instability and to eliminate any effect of changing the position or of the previous position and thereafter, for 60 minute when the infant was in a stable physiologic status, the respiratory rate, heart rate, and oxygen saturation were displayed by the monitor and pulse oximeter and recorded at intervals of 10 minutes. This duration was chosen to allow sufficient time for changes in cardiorespiratory parameters to be noted, as used by [13]
- The preterm neonates' cardiorespiratory parameters (HR, RR, and SpO2) were assessed for each preterm neonate in the study by the researchers. It was observed from the monitor connected by pulse oximeter every 10 minutes for 60 minutes in the same position. Then, the mean values of heart rate, respiratory rate and oxygen saturation of preterm neonate in 60 minutes were recorded and the same for each position.
- Each preterm neonate when positioned supine was laid on back and their head was a little to the sides to adjust with the ventilator tubes and supported by a roll beneath his or / her shoulders. Likewise, when positioned in the right lateral position, a neck roll was also used. Also, when positioned in semi-prone, two small towels were rolled and placed under preterm neonate's knees and abdomen to prevent from pressure to knees and chest. In this position, elbows were bent and arms were placed at the two sides of the body, while hands were placed at the two sides of the head and the head was placed towards ventilator tubes. The infant's forehead was supported by a rolled towel to ensure the nasal prongs over the face would not touch the bed and that the corrugated tubing did not occlude an optimal airway. In addition, this positioning was allowed the forearms to rest flat on the bed surface, ensuring neck extension and flexion were as close to neutral alignment as possible with proper contours of the flexor muscles (semi flexion/adduction at the hip and semi flexion at the knee).

4.7. Field of the Work

The study was conducted over a period of six months; from the beginning of August 2019 to the end of January 2020. Data collection was done two days per week in the morning shift, for about (1-2 neonates/day). The time required for each neonate ranged from 4-5 hours.

4.8. Statistical Analysis

Data were analyzed using Software (SPSS) version 20. Data were summarized, tabulated, and presented using descriptive statistics in the form of frequency distribution, percentages, means and the standard deviations as a measure of dispersion. Variables were compared using the ANOVA test and chi-square test. P value≤ 0.05 was considered as significant.

5. Results

Table 1: Shows the personal characteristics and medical data of preterm neonates. It was found that more than two-thirds (67.5%) of the preterm neonates were males. As regards the gestational age it was noticed that near half (45.0%) of preterm neonates ranged from 30-<32 weeks with Mean ±SD 29.78±2.8. Also the birth weight was ranged from 500 to less than 1000 grams among 47.5% of them. Moreover, 62.2% of the preterm neonates were delivered by cesarean sections. Regarding the medical data; the majority (92.5% and 87.5% respectively) of the preterm neonates did not use neither the surfactant nor steroid therapy. More than half (57.5%) of them stayed on MV from 1-2 days. Finally, the Apgar score at 1 minute was 0-2 for 62.5% of the cases while it was 3-6 for 100.0 % at 5th minute after delivery with Mean ±SD (2.38±0.49 and 4.2±0.79 respectively).

Figure 1: Indicates the preterm neonates' heart rate measures during the three different body positions. It was found that tachycardia was noticed among 52.5% of the neonates in the supine position, which decreased to 45.0% and 35.0% in the right lateral and semi-prone positions respectively. Statistically significant differences were found between the preterm neonates during the three different body positions (X^2=4.50, p=0.02*).

Table 1. Personal characteristics and medical data of preterm neonates (n=40):

I- Personal characteristics:	No.	%
- Gender:		
• Male	27	67.5
• Female	13	32.5
- Gestational age/ weeks:		
• < 28	6	15.0
• 28-	5	12.5
• 30-	18	45.0
• 32-34	11	27.5
Mean ± SD (Min-Max)	**29.78 ± 2.8 (24-34)**	
- Birth weight/ gm.:		
• 500-	19	47.5
• 1000-	15	37.5
• ≥1500	6	15.0
Mean ± SD (Min-Max)	**1172.75 ± 316.7 (700-1800)**	
- Types of delivery:		
• Normal	25	62.5
• Cesarean delivery	15	37.5
II- Medical Data:		
- Surfactant Therapy:		
• Not use	37	92.5
• Used	3	7.5
- Steroid Therapy:		
• Not use	35	87.5
• Used once	3	7.5
• Twice or more	2	5.0
- Number of days on MV:		
• 1-2 days	23	57.5
• 3-5 days	13	32.5
• More than 5 days	4	10.0
Mean ± SD(Min-Max)	**3.05 ± 2.6 (1-15)**	
- 1st minute Apgar score:		
• 0- 2	25	62.5
• 3- 6	15	37.5
• 7-10	0	0.0
Mean ± SD(Min-Max)	**2.38 ± 0.49 (2-3)**	
- 5 th minute Apgar score:		
• 0- 2	0	0.0
• 3- 6	40	100.0
• 7-10	0	0.0
Mean ± SD(Min-Max)	**4.2 ± 0.79 (3-5)**	

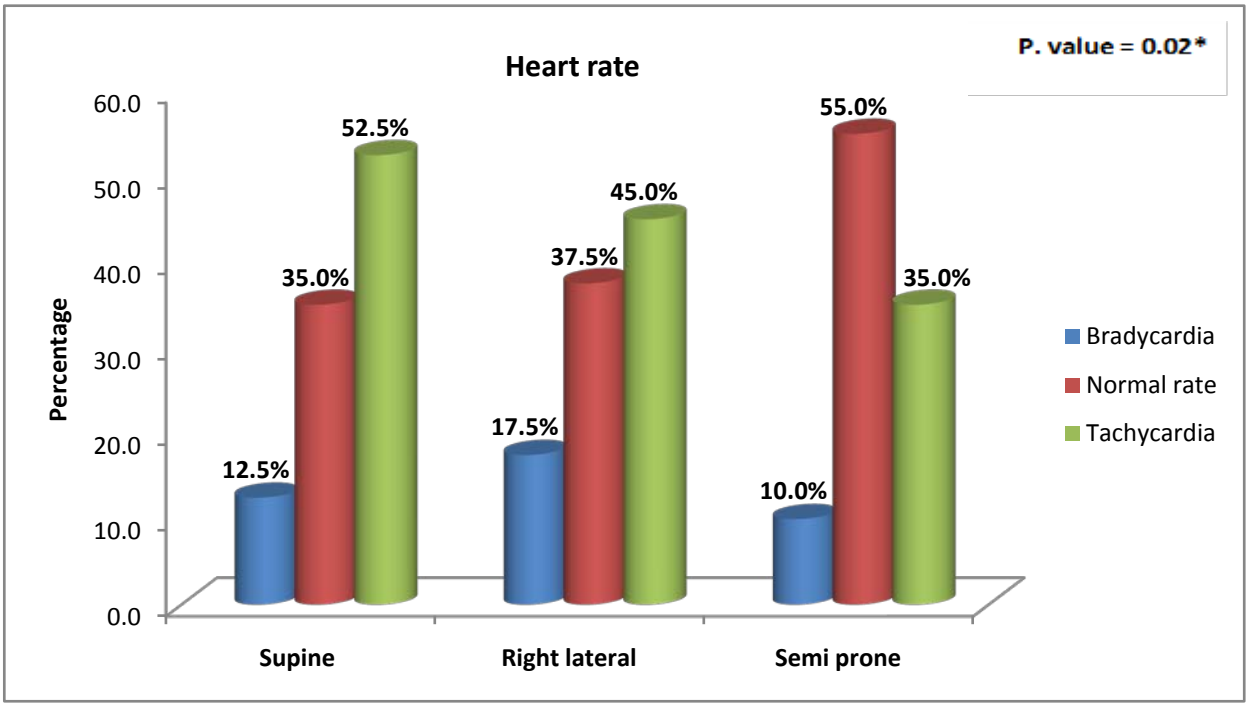

Figure 1. Preterm neonates' heart rate measures during the three different body positions.

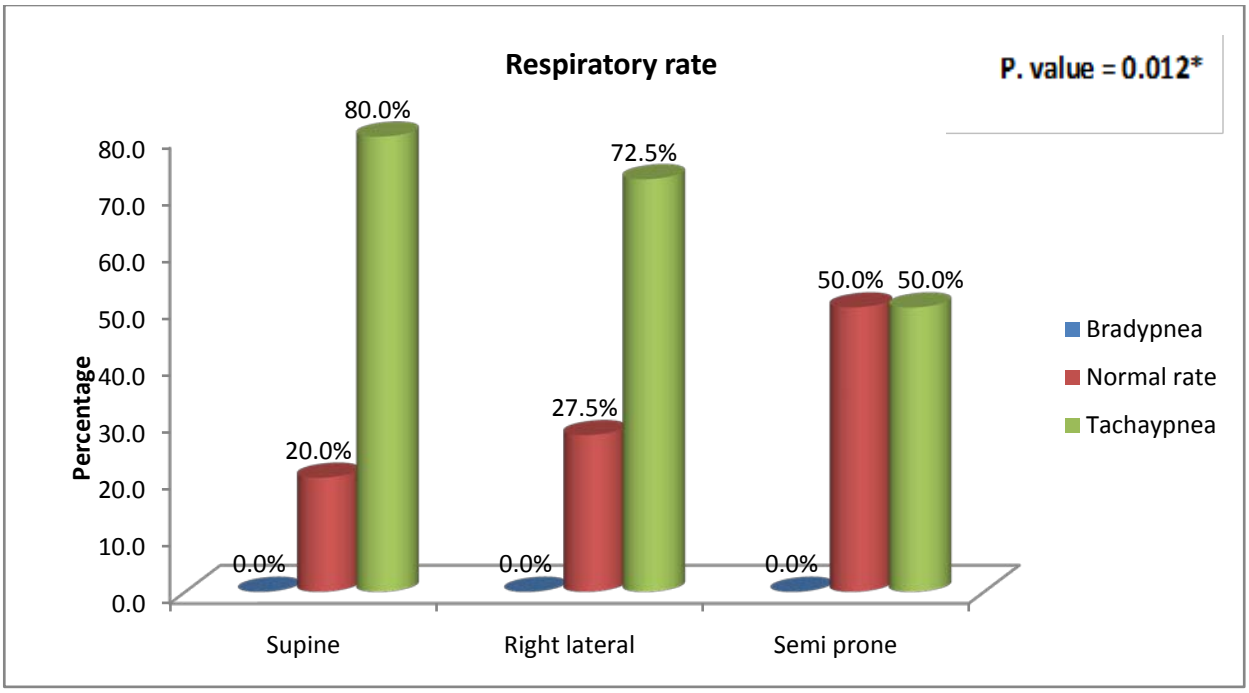

Figure 2. Preterm neonates' respiratory rate measures during the three different body positions

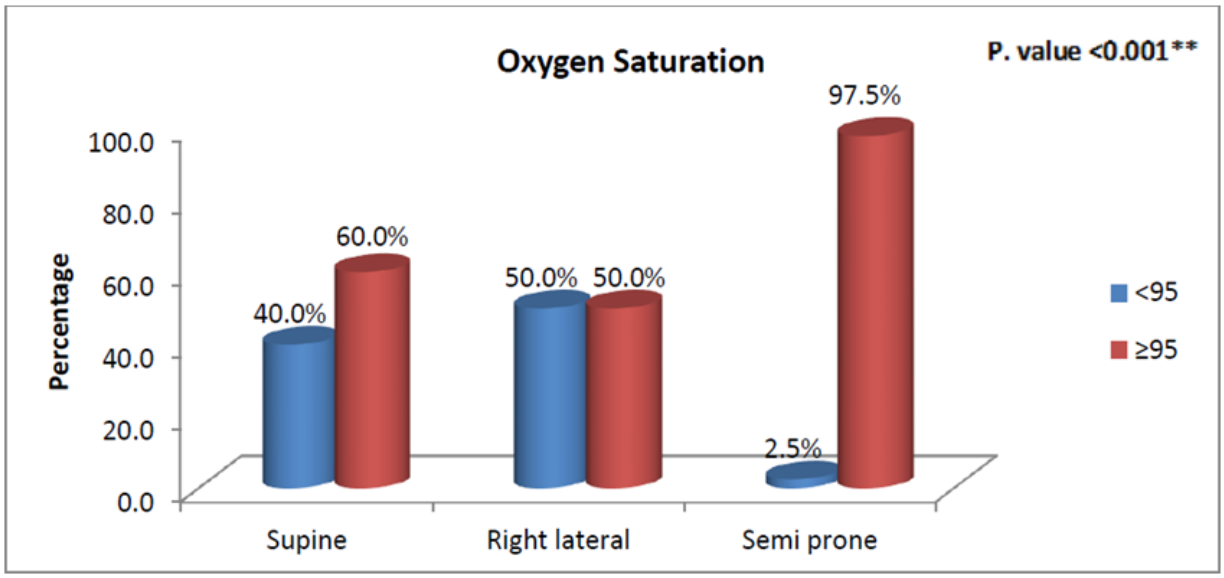

Figure 3. Preterm neonates' oxygen saturation measures during the three different body positions

Figure 2: Reveals the preterm neonates' respiratory rate measures during the three different body positions. The results reported that statistically significant differences were detected as regards the respiratory rate between the three positions (X^2=8.88, p=0.012*). Also it was noticed from this figure that most of the preterm neonates (80.0%) had tachypnea during the supine position while this percentage decreased to 72.5% and 50.0%in the right lateral and semi-prone positions respectively.

Figure 3: Shows the preterm neonates' oxygen saturation measures during the three different body positions. This figure reveals that the vast majority (97.5%) of the studied preterm neonates their oxygen saturation were ≥95% during the semi-prone position followed by (60.0%, 50.0%) of them during supine position and right lateral positions respectively with a statistically significant difference(X^2=23.52, p=0. 001**).

Table 2. Mean score of preterm neonates' cardiorespiratory parameters during supine, right lateral and semi body positions (n=40):

Variable	Position	Mean ± SD	F	P. value
• Heart rate	Supine	152.5±25.55	**5.099**	**0.008****
	Right lateral	147.83±24.08		
	Semi-prone	136.93±16.45		
• Respiratory rate	Supine	60.45±8.06	**16.707**	**<0.001****
	Right lateral	57.43±7.89		
	Semi-prone	50.55±7.59		
• Oxygen saturation	Supine	95.93±10.03	**4.051**	**0.020***
	Right lateral	94.63±6.43		
	Semi-prone	98.93±1.44		

Statistically Significant difference P≤0.05.

Table 2: Illustrates the Mean score of preterm neonates' cardiorespiratory parameters during supine, right

lateral and semi-prone positions. The results indicated that statistically significant differences were detected as regards heart rate, respiratory rate and oxygen saturation during supine, right lateral and semi prone body positions (F=5.099, 16.707, 4.051 and P=0.008**, 0.001** and 0.020* respectively).

6. Discussion

Positions of the body in preterm neonates who receive respiratory support are accounted as an important factor for ventilation and tissue oxygenation. So, several changes of the preterm's body position are essential every 2-3 hours. Still now, preterm neonates are often positioned in supine position due to the easier supervision and neonatal care. The use of prone position is a well-established method to improve oxygenation in the NICU, especially in mechanically ventilated neonates [14]. It appears that these measures can be applicable among the preterm neonates to improve their comfort and health. Both of them are easy and cost effective for health care workers [(4)]. Therefore, this study aimed to determine the effect of different body positions on cardiorespiratory parameters of preterm neonates undergoing mechanical ventilation.

Finding of the current study indicates that tachycardia was noticed among more than half of the studied preterm neonates during the supine position, which decreased to less than half and more than one-third in the right lateral and semi-prone positions respectively with statistically significant differences between the preterm neonates during the three different body positions. These finding are in accordance with Ghorbani, et al., (2013) Brunherotti, et al., (2013), Hough, et al., (2016), and Babuyeh, et al., (2018), [7,14,15,16] who reported a significant difference in HR after infants' position changes. When premature infants with respiratory complications and similar clinical conditions were placed in prone as first or second position, their heart rates reduced, so their tachycardia improved and they got more stable and calm. At the same time, this result disagreed with Ma, et al., (2015), Santos, et al., (2017), and Elsagh, et al., (2019), [4,17,18] who mentioned that prone position reduced cardiac output. The finding of the current study might be explained in the light of the fact that semi-prone position may affect preterm infants' respiratory mechanisms i.e. changes in gas exchanges which showed a significant improvement in oxygenation in a prone position when compared to supine.

Even more importantly, result from the present study further demonstrated that there was a significantly noticeable improvement detected as regards the respiratory rate between the preterm neonates during the three positions. Also, it was observed that most of the preterm neonates had tachypnea during the supine position significantly which improved to the normal rate during both the right lateral and semi-prone positions respectively. This result may be contributed to that positions other than the standard supine position, such as the semi-prone and right lateral positions, may improve respiratory performance [11]. This finding appears in agreement with Malagoli, et al., (2012) and Alinejad, (2014) [19,20] who reported that prone position leads to better lung ventilation and capacity so that the surface the infant is on acts as a brace and improves poor respiratory chest muscles. This position also blocks the movement of other limbs that may impair respiration. While findings of the current study were in contrast with Hough, et al., (2016), Santos, et al., (2017), and Babaei, et al., (2019), [7,17,21] who reported that, there were no significant changes in RR over the study period for any of the study neonates and also disagree with Heimler, et al., (2016) [22] who demonstrates an increase in the incidence of apnea in the supine compared with the prone position. The study researcher's view that the preterm neonates during the prone position had better oxygenation which might suggest a higher efficacy of the diaphragm during its contraction, generating more strengthen to the muscle, improving ventilation and, thus, optimizing gas exchange consequently, leads to stabilization of the chest wall with more synchrony between thorax and abdomen.

Surprisingly, on investigating the preterm neonates' oxygen saturation measures (SpO2) during the three different body positions. It was found that the vast majority of the studied preterm neonates their oxygen saturation (SpO2) were ≥95% during the semi -prone position followed by near two-thirds and half of them during the supine position and right lateral positions respectively with a statistically significant difference between them. This finding was congruent with Babaei, et al., (2019) [21] who reported that the SpO2 in the prone position was significantly higher than the supine position and apparently go on line with Brunherotti, et al, (2013) [15] who reported that the highest mean oxygen saturation was observed in the prone position and the lowest level in the lateral decubitus position. This result might be due to preterm infants have better physiological stability in semi-prone position. Moreover, prone position is considered to be a therapeutic maneuver to improve arterial oxygen saturation in neonates. The use of prone position is a well-established method to improve oxygenation in the ICU, especially in mechanically ventilated neonates, secondary to improve ventilation [14]. Although several studies (Malagoli, et al., (2012), Gouna, (2013), Ghorbani, et al., (2013), Balaguer, et al., (2013) and Vafaienejad, et al., (2015), [16,20,23,24,25] have reported that prone positioning rather than supine positioning improves oxygenation and lung function by optimizing breathing strategy. This result was in contrast with study by Hough, et al., (2016) , Balali, et al. (2017), and with Santos, et al., (2017) [7,17,26] they showed that there is no significant difference between mean arterial oxygen saturation in the supine and prone positions and also with a meta-analytic study conducted by Bredemeyer and Foster, (2012) [27] on 14 infants, who documented that no differences were found between prone, supine and lateral positions based on oxygenation and hypoxic attacks. Furthermore, studies on the effect of lateral positioning on oxygenation show conflicting results, with some reporting improvement and others describing no change in oxygenation (Gouna 2013; Brunherotti 2014; and Burg, et al., 2016) [23,28,29].

Ultimately, the results of the current study indicated that statistical significant differences were detected as regards mean score of preterm neonates' heart rate, respiratory rate and oxygen saturation during supine, right lateral and semi-prone body positions. Hence, using

simple methods such as prone position is recommended, to stabilize physiological parameters in preterm infants and improve oxygenation and reduce the duration of oxygen therapy in preterm newborns [21]. In addition, a prone position has some probable positive effects including decreased heart rate variability, improved breathing control and improved oxygenation [30] Meanwhile, several studies have reported a variety of outcomes affected by different body positioning of preterm neonates; some studies; Hough, et al., (2016), and Babuyeh, et al., (2018), [7,14] found that in prone position the infants' cardio-respiratory status is improved while some other studies Malagoli, et al., (2012) and Alinejad, (2014) [19,20] showed that supine position had better effect. In some studies; Brunherotti, et al, (2013), Santos, et al., (2017), and Babaei, et al., (2019) [15,17,21] there was no significant difference among different positions too.

It is clear that placing preterm infants with respiratory complications in prone position is safe when they are being monitored and supervised carefully in NICUs. Prone positioning was shown to have many advantages for preterm born infants. Preterm infants in the prone position spend less time awake and more time quiet and asleep. It can improve lungs and cardio-respiratory development, organize digestive functions and facilitate improvement of respiratory status [16].

7. Conclusion

The present study showed that positioning of preterm neonates in the neonatal intensive care unit can be considered as an effective way of modifying the cardiorespiratory parameters. Likewise, the study results indicated that there were a significant improvement in both heart rate and respiratory rate of the studied neonates during the right lateral position followed by semi-prone positions while more than half of them and most of them had tachycardia and tachypnea during the supine position respectively. Accordingly, there was a highly significant increase in oxygen saturation in neonates placed in semi-prone position than during the supine and the right lateral positions. So, the study concluded that the semi-prone position was more effective safe, simple, and noninvasive method which can be helpful in improving oxygenation in neonates undergoing mechanical ventilation when they were being monitored and supervised carefully in NICUs. Also, the right lateral position was slightly effective while, the supine position was the least effective.

8. Recommendations

In the light of the findings of current study, the following are recommended:-

1-Use of semi-prone position in the routine pediatric care of ventilated neonates as it is a safe, simple, non-invasive method that can help in improving oxygenation of preterm neonates'.

2-Promotes awareness among neonatology nurses about the benefits and importance of positioning preterm neonates in the neonatal intensive care unit to improve cardio-respiratory function of ventilated neonates.

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