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Original Article

Effects of Positioning on Complications of Preterm Infants with Respiratory Distress Syndrome Treated with Nasal Continuous Positive Airway Pressure: A Randomized Clinical Trial

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ABSTRACT

Background: Nasal Continuous Positive Airway Pressure (N-CPAP) is the standard method of respiratory support in neonatal intensive care units, and this method is used for almost all infants with respiratory distress syndrome (RDS) for respiratory support. The position of infants under N-CPAP (prone and supine) affects the amount of blood supply. This study aimed to compare the prone \\and supine positions, followed by the investigation of their effects on various respiratory parameters and prematurity complications in premature infants with RDS treated with N-CPAP.

Methods: This randomized clinical trial was conducted on 127 premature infants under N-CPAP treatment in the neonatal intensive care units of Al-Zahra and Shahid Beheshti hospitals, Isfahan, Iran. Babies were placed in two groups of 68 and 59 cases with supine and prone positions, respectively. The duration of N-CPAP, the number of prescribed doses of surfactant, the need for mechanical ventilation, time to full feed, and positive end-expiratory pressure (PEEP) were investigated in this study. The obtained data were then analyzed using SPSS software (version 22).

Results: The mean±SD values of gestational age and birth weight of the neonates were 31.88±1.30 weeks and 1672.40±443.67 g, respectively. The frequency of using different modes of mechanical ventilation was significantly lower in the prone position group, compared to the supine position group ([17% vs. 32.4%], $X^2[3, N=127]=7.95$, $P<0.05$). There was a significant correlation between position and using mechanical ventilation during the first 72 hours (P=0.04, Correlation Coefficient=0.182). Multivariate analysis indicated a significant correlation between position and mean time of PEEP (P<0.001, F=13.67), mean of surfactant use (P=0.013, F=6.38), and time to full feed (P=0.002, F=10.29).

Conclusion: The results of this study showed that placing preterm infants with RDS who are treated with N-CPAP in the prone position reduces complications related to being preterm or using N-CPAP.

Keywords: N-CPAP, Prone position, Preterm newborn, RDS, Supine position

Introduction

Preterm birth is one of the most important reasons for hospitalization in the neonatal intensive care unit (NICU) due to several complications (long- or short-term) that affect a neonate's survival and quality of life (1, 2). One of these complications is respiratory distress syndrome (RDS), which is characterized by a decrease or lack of surfactant, and the first-line treatment is nasal continuous positive airway pressure (N-CPAP) (3, 4). It is effective in the

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treatment of RDS by improving alveolar function and increasing functional residual capacity (5).

The position of premature infants under N-CPAP is an important factor in their ventilation and oxygenation. They can be placed in prone and supine positions (6, 7). Since it is easier to monitor babies in the supine position, the majority of premature infants are placed in this position (8). However, the results of studies have shown that oxygenation is more improved in the prone position. Considering that the prone position is a therapeutic maneuver to improve the oxygen level of the arteries, the results of these studies can be justified (9). In addition to improving oxygen supply, the prone position also improves neural development, breathing control, and apnea. Moreover, reducing heart rate changes and gastric reflux are other benefits of this condition in premature infants (10, 11).

To our knowledge, although the majority of studies have found the prone position to be better for oxygenation (12-16), one study conducted on infants with chronic lung diseases reported no difference between these two positions (17). On the other hand, a study reported a higher percentage of oxygen saturation in infants with supine positions (18).

This study was conducted to compare the prone and supine positions, followed by the investigation of their effects on various respiratory parameters and prematurity complications in premature infants with RDS treated with N-CPAP.

Methods

Study population

This randomized clinical trial was conducted on 127 premature infants with a fetal age of 30-34 weeks suffering from RDS, hospitalized at the NICUs of Al-Zahra and Shahid Beheshti educational and treatment centers, Isfahan, Iran, from 2017 to 2018. This study was extracted from a research project conducted at Isfahan University of Medical Sciences, Isfahan, Iran (code: IR.MUI.REC.1396.1.142). Study Review Board of the university approved the written protocol, and informed consent was obtained from all the parents prior to the study. The IRCT code in this study is IRCT20150423021910N6.

Inclusion and exclusion criteria

The inclusion criteria were: 1) fetal age of 30-34 weeks; 2) suffering from RDS; 3) absence of congenital heart disease, any organ defect that prevents the change of position, asphyxia at birth (umbilical cord pH less than 7.2 and bicarbonate less than 12), blood circulation instability, and maternal chorioamnionitis; and 4) receiving at least one course of steroid therapy by the mother before delivery.

On the other hand, the neonates who required intubation, those who were unable to follow up, the babies who were placed in the supine position for more than 3 hours a day for any reason during the study (need to insert a bladder catheter and PICC) in the prone group, and the cases with the symptoms of infection during hospitalization were excluded from the study.

The diagnosis of RDS was made based on clinical symptoms, fetal age, and the findings of the X-ray. The diagnosis of Bronchopulmonary dysplasia (BPD) was made based on the National Heart, Lung, and Blood Institute Criteria.

Study procedure

Considering a 10% attrition rate, one would need to complete at least 60 patients per arm to be able to notice any degree of confidence in whether a difference exists between the two groups. Accordingly, for more accuracy and using a random number table, the infants were divided into two groups of supine (n=68) and prone (n=59). Age and gender were controlled and matched in both groups. A written consent form was obtained from all parents after providing the necessary explanations regarding the study.

Infants were kept in a supine or prone position throughout the hospitalization period and were placed under respiratory support with N-CPAP by BC161 Set (Bubble CPAP Infant Delivery System, Fisher & Paykel, Auckland, New Zealand). At first, continuous distending pressure (CDP)=6-8 cmH2O and the fraction of inspired oxygen (FiO2)=30% were meant (19). If the baby needs an inspiratory oxygen fraction of more than 40% to maintain the oxygen saturation percentage in the range of 90%-95%, the baby will receive CUROSURF at the rate of 200 mg/kg using the intubation-surfactant-extubation (INSURE) technique (20). After 12 hours of the previous dose of surfactant, CUROSURF was prescribed again (1.25 cc/kg). If necessary, the treatment course (maximum 3 doses) was completed (21). If the infant required inspiratory oxygen fraction remained at levels lower than 30%-40% for more than 4 hours, at CDP=4 cmH2O and Fio2<25%, the infant was separated from N-CPAP respiratory support (22).

In the prone group, the infants were placed in the supine position for a maximum of 15 minutes

at 2-hour intervals for feeding and routine nursing care. In this group, the surfactant administration method and separation from non-invasive respiratory support were the same as in the supine group.

For infants in both groups, non-invasive respiratory support was stopped and invasive intubation and ventilation started if any of the following indicators occurred:

1. By receiving CDP=8cmH2O and Fio2>70% for 2 hours, the inability to maintain oxygen saturation percentage in the range of 90%-95% in the right hand (22).
2. Gasometric indicators in CBG indicate respiratory failure (pH<7.2 & PCO2>60 mmHg) (21).
3. More than three apneas per hour requiring stimulation or one apnea requiring bag and mask ventilation.

CPAP failure and the need for different modes of mechanical ventilation, positive end-expiratory pressure (PEEP), time of PEEP, surfactant administration, air leak syndrome, BPD, and the time to reach full enteral feeding (at the rate of 150 cc/kg/day) were investigated and recorded in the questionnaire for both groups.

Statistical analysis

The ordinal proportional odds model was used to investigate the effect of the intervention on the interest outcomes using the generalized estimating equation method.

The obtained data were analyzed in SPSS software (version 22). Furthermore, the independent t-test was employed to compare the means, and McNemar's chi-squared test was utilized to compare the abundance between the two groups. A two-tailed statistical significance probability was considered less than 0.05 and a P-value less than 0.05 was considered statistically significant.

Ethical approval

The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (code: IR.MUI.REC.1396.1.142).

Results

A total of 136 infants were selected, of whom 127 infants were finally eligible to enter this study. The majority of the neonates (n=68, 53.5%) receiving N-CPAP were male. Of the selected neonates, 59(46.5%) and 68(53.5%) cases were allocated to the prone and supine position groups, respectively.

The characteristics of the studied infants in the two supine and prone positions are presented in Table 1. PEEP, surfactant administration, and full feed time were significantly lower in the prone position group, compared to the supine position group (P<0.05).

Furthermore, the frequency of using different modes of mechanical ventilation was significantly lower in the prone position group than in the supine position group ([17% vs. 32.4%], X^2[3, N=127]=7.95, P<0.05).

Figure 1 illustrates the frequency of different categories of acute lung injuries (Pneumothorax and Pneumomediastinum) and BPD in the two studied groups. The frequency of acute lung injuries was not significantly different between the two studied groups (P>0.05). BPD was significantly higher in the supine position group ([56.1% vs.39%], X^2[1, N=127]=3.64, P<0.05).

Table 1. Characteristics of preterm infants receiving nasal continuous positive airway pressure in the supine and prone position groups

Variables	Supine position n=68	Prone position n=59	P-value
Gestational age (weeks)	32.07(1.19)	31.65(1.40)	0.07
Birth weight (gr)	1763.32(436.311)	1598.73(444.31)	0.08
Gender [n (%)] Female/Male	28(41.2%)/40(58.8%)	31(52.5%)/28(47.5%)	0.13
Mechanical ventilation during the first 72 hours			
-No	46(67.6%)	49(83.1%)	
-NIMV	17(25%)	9(15.3%)	
-SIMV	5(7.4%)	0(0%)	0.04
-NIMV+SIMV	0(0%)	1(1.7%)	
PEEP	5.42(0.59)	5.32(0.70)	0.39
Time of PEEP	50.60(29.77)	38.82(23.66)	0.04
Surfactant administration	1.38(0.99)	0.97(0.89)	0.01
Time to full feed	10.16(4.36)	8.10(3.32)	0.004

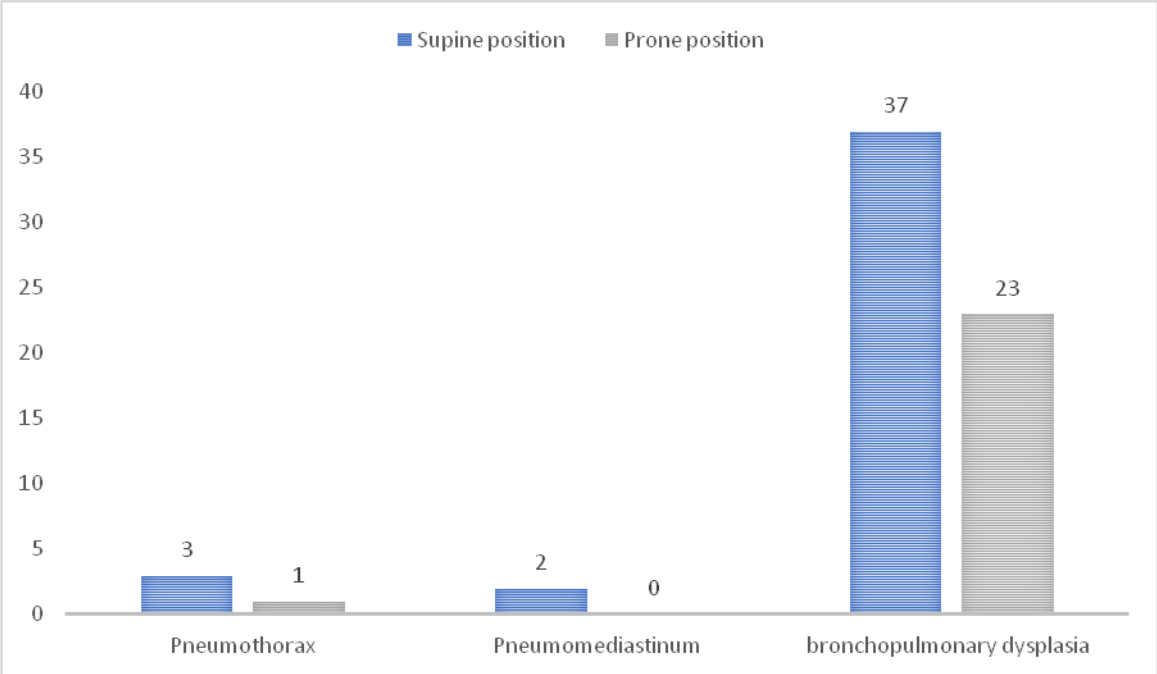

Figure 1. Frequency of different categories of acute lung injuries (Pneumothorax and Pneumomediastinum) and bronchopulmonary dysplasia in the supine and prone position groups

There was a significant correlation between position and using mechanical ventilation during the first 72 hours (P=0.04, Correlation Coefficient=0.182).

Multivariate analysis indicated a significant correlation between position and mean time of PEEP (P<0.001, F=13.67), mean of surfactant use (P=0.013, F=6.38), and time to full feed (P=0.002, F=10.29). In the supine and prone groups, 22 and 10 babies had CPAP failure, respectively (Table 2).

Table 2. Complications of preterm infants with respiratory distress syndrome and CPAP failure

Variable	Prone	Supine
CPAP failure	10	22
Pneumothorax	1	2
Pneumomediastinum	0	2
Bronchopulmonary dysplasia	4	15

Discussion

This study was conducted on 127 preterm infants (gestational age of 30-34 weeks) with RDS. Accordingly, 68 and 59 neonates were treated with N-CPAP in the supine and prone positions, respectively. The mean PEEP time, the frequency of different mechanical ventilation modes, the number of surfactant injections, and the time of complete feeding in the prone position group were significantly lower than those in the supine position group.

This study has provided evidence of improvement in infant feeding status, reduction in the number of surfactant injections, and PEEP reduction in high-risk infants with prone position. The results of this study also showed that the prone position can improve complications caused by RDS in preterm infants treated with N-CPAP. Baird et al. in line with the results of our study, by examining 70 children with lung diseases in the United States of America, showed that the amount of oxygen supply in the prone position is better than supine (23). Another study that examined the breathing pattern of preterm infants with RDS and treated with N-CPAP showed that arterial oxygen was higher in the prone position (14). Wells et al. also reported similar results (24). However, one study stated that the supine position provides better results and more arterial oxygen flow than the prone position (25).

On the other hand, two studies did not show a significant difference between prone and supine positions (26, 27). In one of these studies, the selected preterm babies weighed less than 1500 gr, which could be the reason for the difference in the results from our study. The mean weight of babies in our study was 1672.40±443.67 gr .On the other hand, the small sample size of both studies compared to our study can also explain the difference in the results (31 and 41 vs. 127).

Studies have shown that the prone position is associated with a decrease in breathing rate and an increase in tidal volume and functional residual capacity. These factors stabilize the chest wall (5).

In our study, mechanical ventilation during the first 72 hours in the prone position decreased significantly (P=0.04).

Contrary to the results of our study, one study did not find a significant difference in PEEP measured in the prone versus supine position. The mentioned study was done only on babies with severe bronchiolitis.

According to our knowledge, although animal and human studies in previous years have shown that different positions have no effects on surfactant injection (28, 29), our study showed a significant difference between prone and supine positions. The frequency of surfactant injection in the prone group was lower (P=0.01).

The use of N-CPAP also has many side effects. One of these important side effects is the delay in oral feeding (30). Our study showed that children under N-CPAP with prone position return to full nutrition in significantly less time (P=0.004).

Regarding the limitations of the study, baby crying and nursing routine care (e.g., IV-line) have changed the baby's position and created a bias in the study. In order to solve this problem to some extent, infants in the prone group who needed to be placed in the supine position for more than 3 hours were excluded from the study.

Conclusion

The results of this study showed that placing preterm infants with RDS who are treated with N-CPAP in the prone position reduces complications related to being preterm or using N-CPAP. This position can be considered an effective way to improve oxygenation in infants under N-CPAP. It is recommended to conduct studies with a larger sample size along with the measurement of physiological parameters to compare prone and supine positions in infants treated with N-CPAP.

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Conflicts of interest

The authors declare no conflict of interest regarding the publication of the study.

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