Iran J Pediatr. 2017 October; 27(5):e12405. doi: 10.5812/ijp.12405.
Published online 2017 October 20. **Research Article**

# Cerebral Tissue Oxygenation in Postural Changes in Mechanically Ventilated Preterm Newborns Less than 72 Hours after Birth

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**Received** 2017 May 01; **Revised** 2017 August 01; **Accepted** 2017 August 14.

## Abstract

**Background:** Positioning is a part of routine neonatal care in most neonatal intensive care units. Optimal positioning has been controversially advocated as a practice for providing better neuro-developmental outcomes in prematures.
**Objectives:** To evaluate by near-infrared spectroscopy (NIRS) the effect of changing posture on regional saturation of oxygen (rSO2) in the brain in mechanically ventilated preterm newborns during first 3 days after delivery.
**Methods:** Twenty stable ventilated preterm newborns were studied by NIRS in four different positions sequentially including supine, right-side-lying, prone, and left-side-lying, as well as in 3 intermediate periods between the four main positions.
**Results:** About 45 percent of the sample of 20 neonates was under 30 weeks with a mean gestational age of $30.985 \pm 6.459$. Also, 50 percent were less than 1500 grams, with a mean weight of $1638.75 \pm 623.04$ grams. No statistically significant changes in rSO2 were found in the 4 main positions but we found significant difference between the rSO2 values of the "intermediate period between the right-side-lying and the prone position" with all other main positions and intermediate periods.
**Conclusions:** The four main postures utilized in the practice of positioning infants, do not differ in terms of cerebral oxygenation. However, it seems that wide ranges of spatial mobilization in ventilated preterm neonates may be a potential cause of fall in brain oxygenation.

*Keywords:* Near Infrared Spectroscopy, Cerebral Oxygenation, rSO2, Preterm, Positioning

## 1. Background

Positioning is known as an important practice in early developmental care and intervention for preterm neonates who are at high risk of developing neurodevelopmental delay, and is a part of routine neonatal care in most neonatal intensive care units (NICUs) (1). It is easy to perform and has no economic costs. Early developmental care and interventions generally aim at reducing the risks of prematurity and providing better neuro-developmental outcomes (1, 2). Developmental positioning is in fact the periodic change of the baby's position to the prone, side-lying and supine positions, along with flexion of the trunk and keeping the limbs in midline (3). Use of developmental positioning compared with the dominant use of one position has been recommended to prevent motor abnormalities and improve developmental outcomes in the preterm infant (4).

Nevertheless, there is a traditional preference towards maintaining infants, especially mechanically-ventilated ones, in a supine position, in which observation and handling is easier (5). On the other hand, some studies suggest that other positions, especially the prone position, have some benefits in comparison to the supine position. For example, it is reported that the prone position helps improve motor development (6), may have positive effects on feeding (7), sleep (8) and increase some features of development during neonatal period (6, 9, 10).

Some studies on ventilated premature infants have shown that the prone position is beneficial for oxygenation in comparison to supine or lateral positions (11-13). Also, some other studies in neonates without assisted ventilation have recorded advantages for positions other than supine such as reduction of obstructive apnea (8) and improvement in oxygenation (14).

Regardless of all studies carried out to date on this issue, positioning of the head and body with the aim of preserving cerebral oxygenation reserve in the neonate is still one of the critical challenges in the care of NICU-admitted infants (15, 16), because studies have shown conflicting outcomes about the effect of head and body positioning on cerebral hemodynamics (17-21) and controversy is still prominent in this field. Arriving at a consensus regarding this issue is important in that some studies have demonstrated that fluctuations in cerebral oxygenation are associated with brain hemorrhage (22) and lower levels of cerebral oxygenation have been related to poor brain outcomes (23). However, there is currently no consensus on which position is suitable for very preterm neonates in the early days of life. For example, some studies evaluating alterations of cerebral oxygenation with head positioning and/or bed tilting on non-mechanically ventilated infants (24-26), or others assessing the effects of supine or prone positioning on ventilated and spontaneous breathing of premature newborns have reported that cerebral oxygenation was not significantly affected by changes in positioning (24, 27).

Near-infrared spectroscopy (NIRS) is a new and non-invasive technology that helps evaluate alterations in oxygenated and deoxygenated hemoglobin levels in the brain tissue of the newborn at bedside (19, 26, 27). A clinical trial reported that the burden of hypoxia was decreased in NIRS visible groups (28). In contrast to pulse-oximetry (also based on light spectroscopy) which estimates the arterial oxygen saturation, NIRS estimates venous elements (29). Accordingly, NIRS is the suggested method for discovering any potential venous drainage disturbances due to positioning and has been used in several relevant studies (17, 24, 26, 30). The safe BoosC-II trial reported that for decreasing the risk of cerebral hypoxia in extremely preterm infants during the first 3 days of life we can add cerebral oximetry to the routine care in NICUs (31).

Actually, NIRS is available only at a few NICUs in Iran and provides a new and promising opportunity for better care for NICU care-givers in the country.

Overall, it is still of great universal interest to know whether placing infants in different positions could cause any benefit or harm to the oxygenation and thus health of the brain. This is even truer for premature neonates, especially those under mechanical ventilation, for which there is scarce evidence. Knowing this can help provide a less aggressive and less harmful care in the NICU and further prevent undesired negative outcomes for the delicate brain of the high-risk newborn.

## 2. Objectives

In this study we aimed to evaluate the changes of cerebral tissue oxygenation by using NIRS, in four different positions (supine, right-side-lying, prone and left-side-lying) as well as three different "intermediate periods", among clinically stable, mechanically ventilated preterm infants in the first 72 hours of their life. The ultimate goal was to determine whether positioning could be a factor in fluctuation of cerebral oxygenation, the results of which could help NICU therapists and nurses in providing less harmful and more effective care.

This is a rather genuine study in its type because, to our knowledge, rarely have studies addressed the topic of cerebral oxygenation with regard to positioning in four different positions, in mechanically-ventilated premature neonates.

## 3. Methods

This prospective observational study which was carried out from November to March 2017, was performed on a cohort of mechanically ventilated preterm newborns with a gestational age of less than 37 weeks who had been admitted to the NICU of Arash Women's Hospital in Tehran city during the first 72 hours of their life. The inclusion criteria were being stable under mechanical ventilation, in general terms and in terms of vital signs and parental written consent. Exclusion criteria included infants, whose parents could not be accessed for consent prior to 24 hours of age; who had severe and gross congenital dysmorphology or abnormalities; who were very ill so the medical team did not allow them to participate in the study.

Regional saturation $O_2$ ($rSO_2$) of the brain was measured by NIRS device (INVOS 5100) at the bedside. Cerebral $rSO_2$ was recorded sequentially in each of the following four main positions that changed sequentially and each lasted for 30-minutes: body in supine and head in the midline position (position 1); head and body turned 80-90 degrees from midline toward the right-side and nested in this position (RSL) (position 2); body turned prone and head turned to right-side while supporting the abdomen with a pad and maintaining a flexed position in prone (position 3); and body turned from prone toward the left-side (80 - 90 degrees from the midline) and nested in this position (LSL) (position 4). Between each position and the next, a 5 - 10 minute "intermediate period" was considered, the first few seconds of which consisted of the time during which changing of position took place (which we called "changing time") and the rest consisted of the time which we considered for the baby to stabilize in his new position (which we called "stabilization time"). Thus we had three "intermediate periods", one between the supine and the RSL position, another between the RSL and the prone position and finally one between the prone and the LSL position.

The NIRS device automatically registered and recorded the $rSO_2$ throughout this process, that is, through all the four main positions, as well as through all the three "intermediate periods' named above. However, for convenience of calculation and comparison, $rSO_2$ values were calculated as an average of all the $rSO_2$s recorded during the first 10 minutes, the second 10 minutes, and the third 10 minutes, as well as the average of the entire 30 minute period, for each case in each main position.

The heart rate, pulse oximetry and mean arterial blood pressure were also recorded every 30 minutes throughout this process in order to keep track of the vital signs. It is noteworthy that the head of the bed was elevated 30 degrees in all of the four positions named above, according to references which consider this beneficial to reduce cerebral venous pressure by increasing hydrostatic brain drainage (32, 33).

All these positionings were performed by 2 persons, a neonatal occupational therapist for changing the positions and an NICU nurse for supporting the ventilation devices and the NIRS probes, and for keeping an eye on the vital signs. The neonatal occupational therapist stayed at the bedside throughout the process of the study to intervene in case of physiologic instabilities and to ensure correct positioning. If an infant required changes in fraction of inspiratory oxygen ($FiO_2$) following decrease in arterial saturation (according to the pulse oximetry) after positioning, the therapist had to start the positioning process from the beginning again (body in supine and head in the midline position (position 1)) and then keep on with the current $FiO_2$.

Differences between means of the first, second and third ten minutes were calculated subtracting the means. General linear model, repeated-measure analysis of variance (ANOVA), was performed to evaluate the influence of different positions on NIRS parameters. We reported the point estimate and 95% confidence interval (CI95%) as the effect measure. All data were analyzed using the statistical package SPSS16.

## 4. Results

All infants tolerated the position changes without apnea, bradycardia, or desaturation episodes. None of the infants required inotropic agents during the study period.

45 percent of the final sample of 20 neonates were under 30 weeks and 55 percent were over 30 weeks gestational age with a total mean gestational age of 30.985 ± 6.459 (Table 1). The youngest and oldest participants had a gestational age of 27and 36 weeks, respectively. Table 1 also shows that 50 percent of the participating neonates were less than 1500 grams and 50 percent were over 1500 grams, with a total mean weight of 1638.75 ± 623.04 grams. The minimum and maximum weight of the sample was 640 and 2770 grams, respectively.

It is noteworthy that the results of Independent t test analysis, showed no significant differences in the results of $rSO_2$ values between the under 30 and over 30 weeks gestational age groups, as well as between the under 1500 and over 1500 gram weight groups of neonates.

Table 2 shows the total mean values of $rSO_2$s registered for all the 20 participating neonates in the first, second and third ten minutes of each of the four main positions and the difference between them. As can be seen in this table, no significant differences existed between the mean $rSO_2$ of the first, second and third ten minutes, which is an indicator of stability of $rSO_2$ throughout the time interval of each main position.

As Table 3 demonstrates, repeated measure ANOVA showed no statistically significant differences in mean $rSO_2$ values between each of the four main positions with the other main positions or with the three intermediate periods, with the exception of the "intermediate period between the RSL position and the prone position", which showed significant differences in rSO2 values with all other main positions and intermediate periods.

## 5. Discussion

Positioning is a routine practice for premature infants in the NICU. In the present study we aimed to evaluate the correlation of 4 different main positions (supine, right-side- lying, prone and left-side-lying), as well as three different "intermediate periods" on cerebral oxygenation, by NIRS device, in clinically stable, intubated preterm newborns. The ultimate goal was to determine whether positioning could be a factor in fluctuation of cerebral oxygenation, the results of which could help NICU therapists and nurses in providing less harmful and more effective care.

No statistically significant differences in rSO2 were found between any of the 4 main positions. This means that ventilated premature infants may be able to maintain stable cerebral oxygenations in different positions and unlike what may be the more popular notion, no position seems to be better or worse than the other, at least in terms of cerebral oxygenation .Some other studies have reported similar findings.

Ancora studied cerebral tissue oxygenation in 24 non-mechanically ventilated newborns with rotation of the

**Table 1.** Frequency of Gestational Age and Weight in Participating Neonates

| Variable | Category | No. (%) | Mean (Sd) | Min | Max |
|---|---|---|---|---|---|
| **GA, w** | ≤ 30 | 9 (45) | 28.57 (1.420 | 27.0 | 30.0 |
| | > 30 | 11 (55) | 33.71 (1.79) | 31.3 | 36.0 |
| | Total | 20 (100) | 30.985 (6.459) | 27.0 | 36.0 |
| **Weight, g** | ≤ 1500 | 10 (50) | 1333020 (364.1) | 640 | 1350 |
| | > 1500 | 10 (50) | 2129.61 (452.9) | 1660 | 2770 |
| | Total | 20 (100) | 1638.75 ± 623.04 | 640 | 2770 |

Abbreviations: g, gram; GA, gestational age.

**Table 2.** Mean $rSO_2$ Values in the First, Second and Third Ten Minutes of Each Main Position

| Positions | Time | n | Mean (SD) | P Value |
|---|---|---|---|---|
| **Supine** | The first 10 min | 20 | 84.1430 (7.84663) | 0.2 |
| | The second 10 min | | 83.3260 (7.54040) | |
| | The third 10 min | | 82.7330 (7.08908) | |
| **RSL** | The first 10 min | 20 | 8.97346 (8.97346) | 0.3 |
| | The second 10 min | | 82.1120 (8.65197) | |
| | The third 10 min | | 81.5615 (9.00120) | |
| **Prone** | The first 10 min | 20 | 84.0770 (7.02319) | 0.4 |
| | The second 10 min | | 84.5965 (6.87740) | |
| | The third 10 min | | 84.0520 (7.45574) | |
| **LSL** | The first 10 min | 20 | 83.2150 (8.03468) | 0.5 |
| | The second 10 min | | 83.3570 (7.61337) | |
| | The third 10 min | | 82.7475 (6.63444) | |

Abbreviations: LS L, left side lying position; prone, prone position; RSL, right side lying position; Sup, supine position.

head and elevation of the bed and they did not find significant differences in oxygenation of cerebral tissue in these changes of position (24).

Liao studied cerebral hemodynamics in 20 preterm infants during the early postnatal period. They reported that stable preterm neonates tolerate short-period head positioning changes in the first 3 days of life with no significant changes in regional cerebral saturations. In this study head turning took 30 minutes long in each position (26).

However, unlike our study, Bembich who studied the effect of body positioning on cerebral oxygenation using NIRS in 20 preterm infants of 25 to 34 weeks gestational age in the first 2 days of life, reported cerebral oxygenation was higher in the prone position with the head turned laterally than the supine position with the head in midline (34)). We have no explanations for the difference in the findings of our study and that of Bembich.

Another important result in the present study was that we found statistically significant difference between the $rSO_2$ values of the "intermediate period between the RSL position and the prone position", with all other main positions and intermediate periods. It is unsure what factors affect the brain tissue oxygenation during this intermediate period which is different from all other main positions and intermediate periods. It is possible that the decrease in cerebral oxygenation is somehow related to the fact that unlike the change in other positions which normally does not require any further maneuvers than rolling from one position to the other on the bed, the change from the RSL to the prone position requires mobilization of the baby in a wider spatial range. This in-turn may interfere with the hemodynamics and auto-regulation of cerebral tissue in premature infants (35-37). Schrod and Walter also observed changes of the $rSO_2$ during kangarooing of neonates. They reported a mild and clinically insignificant decrease of $rSO_2$ during kangarooing in premature

**Table 3.** Differences in rSO2 Values Between Each of the Four Main Positions with the Other main Positions and with the Three Intermediate Positions

| Reference Positions | Positions | Mean Difference | Std. Error | P Value | 95%Confidence Interval for Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Supine | Sup to RSL | 0.96 | 0.77 | 0.22 | -0.65 | 2.58 |
| | RSL | 1.66 | 1.79 | 0.36 | -2.09 | 5.42 |
| | RSL to prone* | 3.67 | 1.43 | 0.01* | 0.67 | 6.67 |
| | Prone | -0.82 | 0.91 | 0.37 | -2.74 | 1.08 |
| | Prone to LSL | -0.38 | 0.93 | 0.68 | -2.34 | 1.57 |
| | LSL | 0.29 | 0.99 | 0.77 | -1.78 | 2.37 |
| Intermediate from Sup to RSL | Sup | -0.96 | 0.77 | 0.22 | -2.58 | 0.65 |
| | RSL | 0.70 | 1.36 | 0.61 | -2.14 | 3.55 |
| | RSL to prone* | 2.70 | 1.05 | 0.01* | 0.503 | 4.91 |
| | Prone* | -1.79 | 0.65 | 0.01* | -3.17 | -0.41 |
| | Prone to LSL | -1.34 | 1.08 | 0.22 | -3.61 | 0.91 |
| | LSL | -0.67 | 0.91 | 0.47 | -2.58 | 1.25 |
| RSL | Sup | -1.66 | 1.79 | 0.36 | -5.42 | 2.09 |
| | Sup to RSL | -0.70 | 1.36 | 0.61 | -3.55 | 2.14 |
| | RSL to prone* | 2.00 | 0.86 | 0.03* | 0.19 | 3.81 |
| | Prone | -2.49 | 1.68 | 0.15 | -6.01 | 1.02 |
| | Prone to LSL | -2.05 | 1.80 | 0.27 | -5.83 | 1.72 |
| | LSL | -1.37 | 1.61 | 0.40 | -4.76 | 2.01 |
| Intermediate from RSL to prone* | Sup* | -3.67 | 1.43 | 0.01* | -6.67 | -0.67 |
| | Sup to RSL* | -2.70 | 1.05 | 0.01* | -4.91 | -0.50 |
| | RSL* | -2.00 | 0.86 | 0.03* | -3.81 | -0.19 |
| | Prone* | -4.50 | 1.28 | 0.00* | -7.19 | -1.81 |
| | Prone to LSL* | -4.05 | 1.41 | 0.01* | -7.01 | -1.09 |
| | LSL* | -3.37 | 1.31 | 0.01* | -6.12 | -0.62 |
| Prone | Sup | .82 | 0.91 | 0.37 | -1.08 | 2.74 |
| | Sup to RSL* | 1.79 | 0.65 | 0.01* | 0.41 | 3.17 |
| | RS | 2.49 | 1.68 | 0.15 | -1.02 | 6.01 |
| | RSL to prone* | 4.50 | 1.28 | 0.00* | 1.81 | 7.19 |
| | Prone to LSL | .44 | 1.02 | 0.67 | -1.70 | 2.59 |
| | LSL | 1.12 | 0.87 | 0.21 | -0.69 | 2.94 |
| Intermediate from Pron to LSL | Sup | .38 | 0.93 | 0.68 | -1.57 | 2.34 |
| | Sup to RSL | 1.34 | 1.08 | 0.22 | -0.91 | 3.61 |
| | RSL | 2.05 | 1.80 | 0.27 | -1.72 | 5.83 |
| | RSL to prone* | 4.05 | 1.41 | 0.01* | 1.09 | 7.01 |
| | Prone | -0.44 | 1.02 | 0.67 | -2.59 | 1.70 |
| | LSL | 0.68 | 1.01 | 0.51 | -1.44 | 2.80 |
| LSL | Sup | -0.29 | 0.99 | 0.77 | -2.37 | 1.78 |
| | Sup to RSL | 0.67 | 0.91 | 0.47 | -1.25 | 2.58 |
| | RSL | 1.37 | 1.61 | 0.40 | -2.01 | 4.76 |
| | RSL to prone* | 3.37* | 1.31 | 0.01* | 0.627 | 6.12 |
| | Prone | -1.12 | 0.87 | 0.21 | -2.94 | 0.69 |
| | Prone to LSL | -0.68 | 1.01 | 0.51 | -2.80 | 1.44 |

Abbreviations: LSL, left side lying position; Prone, prone position; RSL, right side lying position; Supine, supine position.

neonates with a birth weight $\leq$ 1500 g (38). Petrova and Mehta reported the alteration in cerebral and renal tissue oxygenation during re-positioning to the semi-upright position from the supine position in 15 stable infants of gestational age 25 - 36 w, birth weight 800 - 2,250 g. They showed clinically insignificant alteration of cerebral and renal tissue oxygen saturation in the majority of the stable preterm infants. However, they referred to the reduction in cerebral tissue oxygenation that was seen in approximately 30% of the participating neonates, as an important finding, because it could be a base for neurocognitive deficits seen in preterm born infants (39). The common point in our finding and what Schrod and Walter, as well as Petrova and Mehta found could be the mobilization of the baby in a wider spatial range. This issue needs further attention and consideration in future studies.

In conclusion, the use of NIRS device demonstrated no significant cerebral oxygenation differences between positional changes in stable ventilated premature infants. All four positions seem to be equally safe for this group of patients in the NICU.

However, our finding regarding the significant difference in cerebral oxygenation during the intermediate time between the left side and prone positions warrants attention of researchers and clinicians as to the possibility that wide ranges of spatial mobilization in ventilated preterm neonates may be a potential cause of fall in brain oxygenation. We suggest that this issue be addressed in future studies.

### 5.1. Limitation

Because of limitation in number of samples we could not categorize infants according to their age, weight and cause of prematurity and their hospitalization that, investigation of which would be a task for other research teams.

## Acknowledgments

Special thanks to parents, NICU nurses and staff of Arash Women's Hospital who are the real angels on earth .Without their suport, it was impossible to achieve this goal.

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