Original Article

Effect of preterm infant position on weaning from mechanical ventilation

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Abstract

Objective: the purpose of this study was to determine the effects of prone positioning on cardiorespiratory stability and weaning outcome of preterm infants during weaning from mechanical ventilation.

Methods: from January to December 1999, a sample of 42 preterm infants, with birthweight < 2,000 g, mechanically ventilated in the first week of life, were randomly divided, in the beginning of the weaning process, in two groups according to the position: supine position (n = 21) or prone position (n = 21). Heart rate, respiratory rate, transcutaneous oxygen saturation and ventilatory parameters were recorded every one hour. Length of the weaning process and complications were also assessed.

Results: in both groups the mean gestational age was 29 weeks, most of the patients presented very low birthweight and respiratory distress syndrome. The mean length of the weaning process was 2 days. There were no differences between the groups regarding respiratory rate, heart rate and transcutaneous oxygen saturation, however, oxygen desaturation episodes were more frequent in supine position (p = 0.009). Ventilatory parameters decreased faster and reintubation was less frequent in the prone group (4% versus 33%). No adverse effects of prone positioning were observed.

Conclusion: these results suggest that prone position is a safe and beneficial procedure during the weaning from mechanical ventilation and may contribute to weaning success in preterm infants.


Introduction

There is a great deal of discussion in extant literature on the subject of supine and prone positioning of newborns. For healthy, full term newborns the American Academy of Pediatrics (1992) recommends that the prone position should not be adopted due to the association, observed in a number of different epidemiological studies, between the prone position when sleeping and sudden infant death syndrome.1-3 Indeed, based on current knowledge, the prone position is considered inadequate and unsafe for healthy, full term newborns and should be avoided.

Notwithstanding there are certain benefits of the prone position in terms of pulmonary mechanics, such as: a greater tidal volume, improved diaphragm function and greater thorax-abdomen coordination.4,5 For healthy, or even sick, premature infants the prone position can offer a number of benefits to respiratory function. It can promote increased oxygenation, a decrease in expired CO2, an improvement in compliance and function of the diaphragm and a reduction in thorax-abdomen asynchronicity.6-9

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The effects of positioning on newborns have been investigated under a variety of neonatal circumstances, but there is one critical period, which is during weaning off from mechanical ventilation, during which the effects of position have not been evaluated. Therefore, this study was proposed into premature infants during the discontinuation of mechanical ventilation, with the objective of determining the effects of the prone position on oxygen saturation (SaO₂), respiratory rate and cardiac rate, on the reduction of the ventilator parameters during the weaning process and on the frequency of success or complications during that process.

Methods

This prospective, randomized, clinical study was performed at the Neonatal Intensive Care Unit (ICU), of the Hospital das Clínicas da Faculdade de Medicina de Botucatu-UNESP, in the year 1999, after approval by the Committee for Ethics in Research of the HC-FMB-UNESP, hearing number 302/98. Premature newborn infants on mechanical ventilation were studied. Their parents signed an informed free consent form. The babies fulfilled the following inclusion criteria:

- Gestational age less than 37 weeks and birth weight less than 2,000g.
- The need for mechanical ventilation during the first week of life for a period of more than 48 hours.
- The absence of congenital malformations and of clinical or surgical conditions which make the prone position impossible.
- Ventilator weaning started during the period of the day in which the researcher was present at the ICU.

The exclusion criteria were:

- Clinical or surgical intercurrent conditions which make the randomized position at the start of the study impossible to maintain or which interrupt the ventilator weaning process.
- The failure to obtain all of the information contained in the research protocol.
- The inadvertent violation of the research protocol or the newborn remaining in a position other than that prescribed by the study for more than an hour per day.

Of the infants included initially, only one was excluded due to failure to complete the study protocol. None of the newborn infants died during the study period.

Gestational age was calculated based on the last certain date of menstruation or by the New Ballard method.¹⁰

The start of the mechanical ventilation weaning process was decided upon by the medical team at a point when, due to clinical radiological and gasometric improvements, ventilator parameters were below: 0.5 for O₂ inspired fraction (FiO₂), 20 cm H₂O for positive inspiratory pressure (PIP) and 40 bpm respiratory rate, with the infant remaining stable and with adequate gasometric values: PaO₂ = 50-70mmHg and PaCO₂ = 35-45 mmHg. At this point a progressive reduction of these three ventilator parameters was begun. At this point the patient was also randomized by means of drawing lots in the form of sealed envelopes defining the infant’s position: supine or prone, to be adopted until extubation. The two study groups were composed thus: Prone n = 21 and Supine n = 21. After extubation all of the infants were laid in the supine position for the application of 5 cmH₂O continuous positive air pressure on the respiratory system, nasally (NCPAP) and were assessed in terms of the success of ventilation weaning for 48 hours after extubation, which is the critical period for extubation failure.¹¹ Aminophylline was not used either during or after weaning and physical respiratory therapy was not performed as a matter of course, but only when required. Physiotherapy techniques were performed by a physiotherapist who was unaware both of the study objectives and the position in which the child reclined; sessions had a maximum duration of twenty minutes and consisted of airway clearance: postural drainage, manual percussion and tracheobronchial aspiration. Physical therapy was requested by the doctor for five infants from the supine group and six from the prone group.

The newborns allocated to the supine group were maintained in this position throughout the study. The prone group infants were placed in a supine position between 7 and 10am for hygiene, physical examination, sampling for laboratory examinations and thoracic radiography. Data recorded during this period was not considered in the analysis of the results.

The newborn infants were continuously monitored for O₂ saturation and cardiac rate. Respiratory rate, cardiac rate, O₂ saturation, ventilator parameters and each patient’s intercurrent conditions were evaluated and recorded by the nursing staff every hour, on the research protocol. For the ventilator parameters (FiO₂, PIP and respiratory rate of the ventilator), the average values for each day were used and for the remaining variables the occurrence, measured at least two monitoring times during the day, of any of the following alterations was considered:

- SaO₂ values of less than 90% requiring a temporary increase in FiO₂.
- Respiratory rate greater than 60 bpm.
- Cardiac rate greater than 160 bpm.

The presence of atelectasis was decided upon based on the thorax radiography findings, performed for difficult to wean patients and during the first 12 hours post-extubation for all infants. Apnea was defined as an inspiration pause of more than 20 seconds duration or of lesser duration, but associated with bradycardia and/or cyanosis.

The success of weaning was allowed when the newborn remained extubated for 48 hours post-extubation.
For the comparison between the Supine and Prone groups the Student t test or the Mann Witney test were used for quantitative variables and the $\chi^2$ test or Fisher’s exact test for categorical variables, with a significance level of 5%.\textsuperscript{12}

**Results**

The demographic characteristics and the morbidity of the sample studied are to be found in Table 1.

The median for age at the start of weaning for the supine group was within the first week of life (4 days) and in the Prone group within the second week (11 days), with no statistical difference. In both cases the period of weaning was brief, giving a median of 2 days (Table 2).

During the first 24 hours of weaning only one patient in each group could be extubated, between 24 and 48 hours 57% of the patients in each group were extubated, and at the end of the third day of the ventilator weaning process only three infants in the supine group and one from the prone group remained intubated. For this reason the effects of the position on the newborn babies was analyzed based on the first 3 days of weaning.

There was no difference between the Supine and Prone groups in terms of the average values for $\text{SaO}_2$ (95% x 96%), respiratory rate (48x49) and cardiac rate (144x147, respectively).

The number of patients who presented $\text{SaO}_2 < 90\%$ was significantly greater in the Supine group, as is shown in Figure 1.

On the first day of weaning three patients from the supine group and five from the prone group presented tachycardia ($p = 0.697$); tachypnea episodes occurred in two patients from the supine group and from the prone group ($p = 0.251$). There was a reduction in the numbers of these intercurrent events on the second day (only two patients in each group had tachypnea) and a disappearance on the third day of weaning.

### Table 1 - Demographic characteristics and morbidity of newborns of supine and prone groups

<table>
<thead>
<tr>
<th></th>
<th>Supine (n=21)</th>
<th>Prone (n=21)</th>
<th>Total (n=42)</th>
<th>Statistical analysis of p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA (s)</td>
<td>x ± s</td>
<td>x ± s</td>
<td>x ± s</td>
<td>0.537 *</td>
</tr>
<tr>
<td>(min-max)</td>
<td>(25 s 1d – 33 s 3d)</td>
<td>(24 s 1d – 33 s 4d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW (g)</td>
<td>x ± s</td>
<td>x ± s</td>
<td>x ± s</td>
<td>0.918 *</td>
</tr>
<tr>
<td></td>
<td>(1,213 ± 323.2)</td>
<td>(1,201 ± 385.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13 (62)</td>
<td>11 (52)</td>
<td>24 (57)</td>
<td>0.755 †</td>
</tr>
<tr>
<td>1st-min Apgar ≤ 3</td>
<td>16 (84)</td>
<td>12 (57)</td>
<td>28 (70)</td>
<td>0.326 †</td>
</tr>
<tr>
<td>SRT</td>
<td>10 (48)</td>
<td>7 (33)</td>
<td>17 (40)</td>
<td>0.53 †</td>
</tr>
<tr>
<td>Vaginal delivery</td>
<td>14 (67)</td>
<td>10 (48)</td>
<td>24 (57)</td>
<td>0.35 †</td>
</tr>
<tr>
<td>Initial diseases</td>
<td>RDS</td>
<td>14 (67)</td>
<td>12 (57)</td>
<td>0.751 †</td>
</tr>
<tr>
<td></td>
<td>BCP and/or sepsis</td>
<td>4 (19)</td>
<td>6 (29)</td>
<td>0.717 †</td>
</tr>
<tr>
<td></td>
<td>TTRN</td>
<td>4 (19)</td>
<td>2 (09)</td>
<td>0.663 †</td>
</tr>
<tr>
<td>Associated diseases</td>
<td>PDA</td>
<td>9 (43)</td>
<td>10 (48)</td>
<td>1.0 ‡</td>
</tr>
<tr>
<td></td>
<td>Late BCP</td>
<td>5 (24)</td>
<td>6 (29)</td>
<td>1.0 ‡</td>
</tr>
<tr>
<td></td>
<td>Late sepsis</td>
<td>3 (14)</td>
<td>3 (14)</td>
<td>1.0 ‡</td>
</tr>
</tbody>
</table>

IQ= gestational age, BW= birthweight, SRT= surfactant replacement therapy, RDS= respiratory distress syndrome, BCP= bronchopneumonia, TTRN= transient tachypnea of the NB, PDA= Patent ductus arteriosus, s= weeks, d= days, g= grams.
Table 3 shows that the infant’s position had no significant influence over FiO₂ usage over the first three days of weaning, but the prone position favors the reduction of PIP and of ventilator respiratory rate with significant differences between the two groups.

In Table 4 we observe that the predominant weaning complication for both groups was atelectasis which showed no significant difference between the groups. The need for reintubation, however, was more frequent in the supine group (p = 0.049). The main reason for reintubation was atelectasis in five cases and apnea in two. Within this sample accidental extubation did not occur and neither did any undesirable positioning effects.

**Discussion**

The demographic characteristics of the two groups reveal them to be homogenous.

The sample was made up, basically, of very low weight premature babies with an average gestational age of 29 weeks, which reflects the profile of patients cared for at the neonatal ICU of this institution. This is an important feature of the sample as these infants present elevated neonatal morbidity and mortality and are greatly limited in terms of respiratory function, which may be limits of central respiratory control, anatomical and biochemical immaturity or respiratory mechanics.¹³

The age at start of weaning did not differ between the groups, but individually there was a large variation as a result of the high levels of morbidity presented by these premature babies during their first week of life. It can be stated that weaning was started at the opportune moment since the weaning period was relatively short, with a median of 2 days. Weaning duration is little referred to in literature, but there is a consensus that mechanical ventilation should be continued for the minimum period necessary until the patient is capable of adequately maintaining their own spontaneous respiration. With the patient stable and gas exchange improving, the doctor should be considering every day whether the patient is capable of breathing spontaneously, thus avoiding hours or days of unnecessary ventilation along with its traditional complications.¹⁴

The less frequent occurrence of decreased SaO₂ among the prone group on the first day of weaning could be due to improved respiratory mechanics since in the prone position thorax-abdomen asynchrony is reduced.⁸,¹⁵

We found no evidence that position affected the cardiac rate and respiratory rate of the premature infants studied. In relation to these aspects there is no consensus in literature.

**Table 3**

<table>
<thead>
<tr>
<th></th>
<th>1st day n = 21</th>
<th>2nd day n = 20</th>
<th>3rd day n = 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>P</td>
<td>p</td>
</tr>
<tr>
<td>FiO₂ * md</td>
<td>0.36</td>
<td>0.31</td>
<td>0.159</td>
</tr>
<tr>
<td>(Q₁ Q₃)</td>
<td>(0.30 0.41)</td>
<td>(0.28 0.35)</td>
<td>(0.28 0.40)</td>
</tr>
<tr>
<td>RR * md</td>
<td>25</td>
<td>20</td>
<td>0.048</td>
</tr>
<tr>
<td>(Q₁ Q₃)</td>
<td>(20 33)</td>
<td>(20 24)</td>
<td>(18 29)</td>
</tr>
<tr>
<td>PIP x ± s</td>
<td>14.6 ± 2.19</td>
<td>13.8 ± 2.74</td>
<td>0.307</td>
</tr>
</tbody>
</table>

md= median, x s= mean standard deviation, * Mann Withney, † t test.
Table 4 - Complications of weaning in supine and prone groups

<table>
<thead>
<tr>
<th></th>
<th>Supine (n=21)</th>
<th>Prone (n=21)</th>
<th>Total (n=42)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>p</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>9 (43)</td>
<td>4 (19)</td>
<td>13 (31)</td>
<td>0.182</td>
</tr>
<tr>
<td>PE atelectasis*</td>
<td>4 (19)</td>
<td>2 (9)</td>
<td>6 (14)</td>
<td>0.659</td>
</tr>
<tr>
<td>Reintubation</td>
<td>7 (33)</td>
<td>1 (4)</td>
<td>8 (19)</td>
<td>0.049</td>
</tr>
</tbody>
</table>

* post-extubation atelectasis.

In a study by Mendonza et al. (1991), cardiac rate values were lower in the prone position whilst Sahni et al. (1999) encountered the opposite and Lioy & Manginelo, (1988) recount a reduction in the respiratory rate of prone infants. These variations may be due to the differences between samples and study methods.7,16,17

The prone position favored a more rapid reduction of some of the ventilator parameters, such as PIP and respiratory rate, which can be attributed to the improvement of respiratory mechanics in the prone position. This is an important result which has not been investigated in the literature before.

The success of extubation depends upon the patient’s capacity to perform spontaneous respiration and to maintain adequate gas exchange. It is known that newborn infants, particularly those which are premature, the high thoracic compliance can reduce the efficiency of ventilation, and that there is a greater risk of extubation failure when the respiratory force results in an insufficient tidal volume, when there is an increased load on the respiratory muscles or when central respiratory control is insufficient. Extubation is temporarily associated with an increased load on the diaphragm, increased activity of auxiliary muscles and increased respiratory rate, which are important mechanical changes to sustain minute ventilation and maintain pulmonary volume. When the newborn is incapable of making these adaptations, apnea occurs, which is an important cause of the failure of extubation.11

The presence of atelectasis is another worry during weaning and after extubation and is a relatively frequent cause of prolongation and/or failure of mechanical ventilation weaning. In this study the frequency of atelectasis in the supine group was twice that of the prone, both during weaning and after extubation. Atelectasis occurred most frequently in the superior lobe of the right lung, and could be related to the mobilization and poor positioning of the orotracheal tube causing selective intubation to the right, and also an ever-present risk of secretions accumulating in intubated patients. Taking into account the fact that the accumulation of secretions in the airways is directly related to the length of time for which the tracheal tube remains in place, it would be expected that atelectasis occurrence was more common among the patients in the prone group the median of whose ages at extubation was 11 days while in the supine group it was 4 days; nevertheless the prone position may have been conducive to reduced movement of the patient and consequently of the tracheal tube.18-20

After extubation, the newborn infants of this study were maintained with a nasal continuous positive airway pressure, which has been recommended, primarily for very low weight newborns, to prevent the appearance of atelectasis and apnea thereby favoring the success of extubation.21 Despite the expected benefits, nasal CPAP did not guarantee the success of extubation in all of the patients studied and 19% of the sample needed reintubation during the first 48 hours post-extubation.

A recent study with 30 extremely premature babies investigating predictive factors for the failure of extubation, showed that 1/3 of premature infants required reintubation and that a low gestational age was the best predictor of extubation failure.22

Our extubation failure percentage (19%) is in agreement with that referred to in extant literature, where figures varying from 3 to 19% in adults and from 22 to 33% in premature newborns are found.11,22,23 It can be stated that the prone position was of benefit in relation to this outcome, since only one patient in the prone group was reintubated, while 7 (33%) of the supine group required reintubation, which is a statistically significant difference.

Concern over the failure of extubation is justified by the association with increased morbidity and mortality and a protraction of the ICU period and of hospitalization.24

In this study there were no occurrences of accidental extubation, or other rarer complications associated with prone positioning for prolonged periods such as: subcutaneous positional edema, facial edema, corneal lesions, loss of vascular access, pressure sores.25,26
The results of this clinical study, performed with simple methodology and inexpensive resources, reveal that the prone position was beneficial to premature infants during the process of mechanical ventilation weaning since it favored successful extubation without affecting physiological parameters and with no undesirable effects. We therefore consider that the prone position can be a good option for premature babies during the mechanical ventilation weaning process. Further studies should evaluate the efficacy and safety of this position with premature newborns since data currently available are not yet sufficient to recommend the routine use of this position.

References

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