Short-term effects of prone positioning on oxygenation of pediatric patients submitted to mechanical ventilation

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Abstract

Objective: to analyze the short-term effects of prone positioning on the oxygenation of mechanically-ventilated children suffering from severe hypoxemia.

Materials and Methods: a prospective, nonrandomized trial (each patient as his/her own control) was conducted between July 1998 and July 1999. Mechanically-ventilated children with peak inspiratory pressure greater than or equal to 30 cm H2O, FiO2 greater than or equal to 0.5, and PaO2/FiO2 ratio less than or equal to 200 were included in the study. Each patient was kept in the prone position for two hours, returning to the supine position after this period. Oxygenation was assessed by means of PaO2/FiO2 in the supine position (one hour before prone positioning), one hour after prone positioning, and one hour after returning to the supine position. Patients who presented an increase of at least 20 in PaO2/FiO2 were considered responsive. The results were compared by Student t-test, Friedman test, chi-square test, Fisher’s exact test, and confidence interval.

Results: eighteen children (10 males), whose mean age was 11.5 ±11.5 months, with initial PaO2/FiO2 of 96.06 ± 41.78, participated in the study. After one hour in the prone position, 27.7% of the patients (5/18) improved their PaO2/FiO2 ratio (P=0.045). Six of these patients presented reduced lung compliance (four of them had acute respiratory distress syndrome); and twelve patients showed increased airway resistance (six of them presented bronchiolitis). No significant difference was observed between these two groups (reduced lung compliance x increased airway resistance) in terms of age, sex, duration of ventilation prior to change in position, peak inspiratory pressure, FiO2, severity of hypoxemia, and outcome.

Conclusion: prone positioning during mechanical ventilation of children with severe hypoxemia may improve the PaO2/FiO2 ratio in the first hour.


Introduction

The use of high ventilator settings in the treatment for hypoxemia is very common. This can result in secondary lesions to the lung.1 The use of additional resources in patients with severe hypoxemia and submitted to mechanical ventilation, in order to improve oxygenation, currently represents one of the main challenges in intensive care. Several lines of research have been developed in this sense for the past few years, such as in the areas of protective ventilation; oscillatory ventilation; liquid ventilation; use...
of surfactant, nitric oxide, and heliox; extra corporeal membrane oxygenation (ECMO); prone positioning; and so on.²

Lung damage caused by mechanical ventilation is related to alveolar overdistension and collapse. Maintenance of a positive end expiratory pressure (PEEP) has been suggested to avoid collapse of alveoli. This strategy was shown effective and is currently being used in mechanically ventilated patients, especially those who present restrictive disease.³ Alveolar recruitment maneuvers are also used in the prevention of alveolar collapse. This strategy involves the use of high levels of PEEP above alveolar opening pressure for a small period of time, and later maintaining the alveoli open with low pressures.⁴,⁵ Another alternative maneuver for pulmonary recruitment, which does not require changing respiratory settings, is prone positioning of the patient. Prone positioning allows for improvement of the ventilation-perfusion ratio (VA/Q) by reopening areas that were previously not aerated.⁶

When the patient is paralyzed in supine position, the diaphragm is shifted cranially. In this position, the abdominal content exerts a higher pressure (restriction) on the dorsal area. Similarly, mechanical ventilation with positive pressure promotes a prevalence in movement of the ventral diaphragm, and has a small impact on movement of the dorsal diaphragm, thus deteriorating alterations in the ventilation-perfusion ratio.⁶ Chest computed tomography (CT) examinations of patients with acute respiratory distress syndrome (ARDS) have allowed for the identification of normal (ventral), diseased (dorsal), and intermediate (recruitable) components of the lung. The diseased lung presents an inflation in the postero-basal region greater than normal due to inflammation and edema. This results from an increase in the vertical gradient in pleural pressure exceeding the alveolar opening pressure. Paralysis and sedation of patients, strategies commonly used in ARDS, can increase pleural pressure and atelectasia in the dorsal region of the lung.⁶,⁷ Chest CT scans, conversely to chest x-rays, in ARDS patients in prone position have indicated rapid redistribution of pulmonary opacities from dorsal to ventral regions;⁸⁻¹⁰ as a result, there is an improvement in oxygenation due to reduction in pulmonary shunt fraction and improvement in VA/Q to near normal values. This results from recruitment of nonaerated, though perfused, areas in the dorsal region of the lung.⁶,¹¹

Most patients can tolerate prone positioning without complications.¹²,¹³ There are few side-effects related to changing positions; the more common reports are of subcutaneous edema after a few hours (4h). There are also reports of facial edema, lesion to the cornea, accidental extubation, catheter removal, and supraventricular tachycardia.¹⁴⁻¹⁷

Several studies have shown long-term effects of prone positioning in patients with severe hypoxemia and on mechanical ventilation. However, in this study, it is our objective to assess the short-term effect of prone positioning in mechanically ventilated, severe hypoxemia patients.

Patients and methods

We carried out a prospective, nonrandomized clinical study in which each patient was considered his or her own control. Our study was carried out at the pediatric intensive care unit (ICU) of the Hospital São Lucas (HSL), Teaching Hospital of the Pontifícia Universidade Católica of Rio Grande do Sul (PUCRS), from July 1998 to July 1999.

Our population included all children with diagnosis of acute respiratory failure, on mechanical ventilation (with positive inspiratory pressure greater than or equal to 30 cm² H₂O and fraction of inspired oxygen greater than or equal to 0.5), and who presented refractory hypoxemia (ratio of arterial partial pressure of oxygen to fraction of inspired oxygen, or PaO₂/FiO₂, less than or equal to 200). Informed consent was obtained from the parents or guardians of all patients in the study population.

We excluded patients on mechanical ventilation with cardiac or neurologic diseases (cyanotic); patients in postoperative period following chest, abdominal, trauma, and neurologic surgeries; and patients with unstable circulatory system.

Patients were turned to prone position after a minimum interval of six hours from beginning of mechanical ventilation. This interval was observed in order to allow for initial stabilization of the patient. First, the monitoring electrodes placed on the chest were removed. Next, patients were moved first to one side (preferably to the side with more catheters) and then positioned prone or ventral decubitus leaning against the bed (Figure 1).

At least two nursing assistants were necessary to change positions of patients; one was responsible for maintaining catheters and endotracheal tube in place, while the other turned the patient. In cases of patients with weight greater than 10 kg, a third nurse was asked to assist in turning children. When patients were already in prone position, the face was turned to either the left or the right side, electrodes were fixed on the dorsal region, and children were propped against supports for better comfort. Patients remained in prone position for two hours and then were repositioned supine.

Data for evaluation of patients were collected by filling out a form containing information on patient identification; baseline disease; disease causing hypoxemia, required for inclusion in the study (classification in subgroups according to disease with increase in resistance or decrease in lung compliance by diagnosis of initial disease and radiological findings); duration of ventilation until turning position; sedation (COMFORT scale); chest x-ray results of the day;
oxygen saturation by pulse oximetry (SatO₂); arterial
gasometry; and ratio of PaO₂:FiO₂ at one hour before
turning position, at one hour in prone position, and at one
hour in supine position. We considered an increase of 20 in
PaO₂:FiO₂ for improvement in oxygenation.

We chose assessing oxygenation by the ratio PaO₂:FiO₂
because it is a simple, objective, and universally accepted
method for assessment of respiratory failure and for
indication of mechanical ventilation; this method can also
be used to predict the need for positive airway pressure and
as an important ally for the reduction (or not) of the
therapeutics employed.18

Oxygen saturation was used solely with the purpose of
monitoring patients during change in position; it was not
adopted as a parameter for assessing response to the
maneuver. The hemoglobin saturation curve is not linear in
relation to PaO₂, and there may be great variations in PO₂
at specific points on the curve as well as subtle changes in
hemoglobin saturation.

As to the pH, we considered that a) our population was
nonhomogeneous in relation to pulmonary pathologies
(obstructive diseases and diseases with decrease in lung
compliance), which can present different responses to these
maneuvers (separate analysis was not possible due to the
reduced number of patients in each group); b) prone
positioning, according to the literature, would have minimal
influence on ventilation and, thus, would not change PaCO₂
and pH. Consequently, these data were not assessed in our
study.

If increase in ventilator settings was necessary, the
change in decubitus would be considered unsuccessful
since the earlier would interfere in assessment of results.

Our study was approved by the Research Ethics
Committee of the Hospital São Lucas, teaching hospital of
the Pontifícia Universidade Católica do Rio Grande do Sul.

Study data were stored using Microsoft Excel software,
version 7.0 for Windows 98 in a spreadsheet specifically
designed for this purpose. Statistical analysis was carried
out using Excel (version 7.0), EPI INFO (version 6.0), and
SPSS (version 7.5) software. Continuous numerical variables
(quantitative) were expressed in the form of average ±
standard deviation, whereas categorical variables
.qualitative) were expressed in percentages (%) or in
descriptive form. Variables were analyzed using statistical
tests with P less than 0.05, and, if necessary, 95% confidence
interval for statistical significance. For comparison of
continuous variables, we used Student’s t test and the
Friedman test. For comparison of categorical variables, we
used the chi-square test, Fisher’s exact test, and confidence
interval.
Results

From July 1998 to July 1999, 18 children were indicated for participation in our study. Based on the COMFORT scale, six out of the 18 patients needed extra sedation before turning position. During the experiment, no patient was excluded from the study for presenting adverse effects to turning position.

Table 1 presents demographic characteristics of the study population, whose age average was 11.5 (± 11.5) months, for a median of 10.5 months. Out of the 18 patients, 10 were males. At the beginning of the study, the ratio of PaO₂/FiO₂ was 96 (± 41.8).

Six patients (33%) were classified as presenting disease characterized by decrease in lung compliance, out of which four were diagnosed with acute respiratory distress syndrome and two with interstitial pneumonia. Twelve patients (66%) were classified as presenting pulmonary disease related to increase in airway resistance, out of which six had bronchiolitis, two had severe acute asthma, and four had bronchopneumonia.

Comparison of the two groups of pulmonary diseases (decrease in compliance and increase in resistance groups), before prone positioning, indicated that there were no significant differences (Table 2).

Table 3 presents the comparison of average PaO₂:FiO₂ before turning prone (S), in prone position (P), and repositioned supine (PP). It is possible to observe that there were no statistically significant differences. However, considering the number of patients who present improvement of 20 in the ratio PaO₂:FiO₂, five out of the 18 patients (27.7%) responded to change in decubitus (P=0.045, Fisher’s exact test; 95% CI 9.6% to 53.4%).

Comparison of prone positioning in both groups indicated an improvement in PaO₂:FiO₂ in 33% (2/6) of patients in prone position and with decrease in lung compliance, and in 25% (3/12) of patients with increase in resistance. Differences were not statistically significant (P=0.57, Fisher’s exact test).

### Table 1  Demographic characteristics of mechanically-ventilated patients submitted to prone positioning

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (mo)</th>
<th>Sex (m:f)</th>
<th>PaO₂/FiO₂</th>
<th>PaCO₂</th>
<th>PaO₂</th>
<th>Days on MV</th>
<th>Disease</th>
<th>PIP/PEEP, FR, FiO₂</th>
<th>Evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>m</td>
<td>161</td>
<td>41</td>
<td>97</td>
<td>7</td>
<td>BCHLT</td>
<td>40/10,22,0.6</td>
<td>discharged</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>m</td>
<td>96</td>
<td>55</td>
<td>77</td>
<td>3</td>
<td>BCP</td>
<td>32/4,33,0.8</td>
<td>died</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>m</td>
<td>51</td>
<td>83</td>
<td>51</td>
<td>8</td>
<td>BCHLT</td>
<td>40/10,30,1.0</td>
<td>died</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>m</td>
<td>84</td>
<td>29</td>
<td>59</td>
<td>7</td>
<td>BCHLT</td>
<td>32/6,26,0.7</td>
<td>discharged</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>f</td>
<td>78</td>
<td>42</td>
<td>63</td>
<td>3</td>
<td>INT P</td>
<td>43/8,25,0.8</td>
<td>died</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>f</td>
<td>91</td>
<td>41</td>
<td>64</td>
<td>3</td>
<td>ARDS</td>
<td>35/10,22,0.7</td>
<td>died</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>m</td>
<td>59</td>
<td>41</td>
<td>59</td>
<td>12</td>
<td>BCHLT</td>
<td>38/9,28,1.0</td>
<td>discharged</td>
</tr>
<tr>
<td>8</td>
<td>24</td>
<td>f</td>
<td>157</td>
<td>28</td>
<td>112</td>
<td>7</td>
<td>ASTHMA</td>
<td>56/6,25,0.7</td>
<td>died</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>f</td>
<td>42</td>
<td>82</td>
<td>38</td>
<td>20</td>
<td>BCHLT</td>
<td>48/7,33,0.9</td>
<td>discharged</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>m</td>
<td>86</td>
<td>32</td>
<td>69</td>
<td>6</td>
<td>ARDS</td>
<td>45/18,25,0.7</td>
<td>died</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>f</td>
<td>75</td>
<td>70</td>
<td>60</td>
<td>9</td>
<td>ASTHMA</td>
<td>50/6,24,0.8</td>
<td>died</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
<td>f</td>
<td>99</td>
<td>47</td>
<td>89</td>
<td>5</td>
<td>ARDS</td>
<td>48/15,20,0.8</td>
<td>died</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>m</td>
<td>117</td>
<td>33</td>
<td>82</td>
<td>20</td>
<td>BCP</td>
<td>40/5,25,0.7</td>
<td>died</td>
</tr>
<tr>
<td>14</td>
<td>24</td>
<td>f</td>
<td>190</td>
<td>40</td>
<td>126</td>
<td>6</td>
<td>BCP</td>
<td>32/4,18,0.6</td>
<td>discharged</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>m</td>
<td>55</td>
<td>49</td>
<td>55</td>
<td>1</td>
<td>INT P</td>
<td>40/5,33,0.6</td>
<td>died</td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td>m</td>
<td>130</td>
<td>34</td>
<td>78</td>
<td>15</td>
<td>INT P</td>
<td>33/6,18,0.6</td>
<td>died</td>
</tr>
<tr>
<td>17</td>
<td>12</td>
<td>f</td>
<td>50</td>
<td>137</td>
<td>45</td>
<td>3</td>
<td>BCHLT</td>
<td>42/7,27,0.9</td>
<td>died</td>
</tr>
<tr>
<td>18</td>
<td>10</td>
<td>m</td>
<td>108</td>
<td>75</td>
<td>65</td>
<td>6</td>
<td>ARDS</td>
<td>39/9,20,0.6</td>
<td>died</td>
</tr>
</tbody>
</table>

Mo = months; m = male; f = female; PaO₂/FiO₂ = arterial partial pressure of oxygen x inspired oxygen fraction; PaCO₂ = arterial partial pressure of carbon dioxide in mmHg; PaO₂ = arterial partial pressure of oxygen in mmHg; MV = mechanical ventilation until position was changed; disease = disease that demanded change in position; PIP = peak inspiratory pressure; PEEP = positive end-expiratory pressure; RF = respiratory frequency; BCHLT, bronchiolitis; BCP, bronchopneumonia; INT P = interstitial pneumonia; ARDS = Acute respiratory distress syndrome; com = reduction in lung compliance; res = increase in pulmonary resistance; Fr = frequency of males and females; n = number of patients; SD = standard deviation
Table 2 - Comparison among the groups that presented lung disease with reduction in compliance, and those that had higher resistance

<table>
<thead>
<tr>
<th></th>
<th>Comp (n=6)</th>
<th>Obst (n=12)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mo)</td>
<td>12.50 (±7.40)</td>
<td>11.00 (±13.38)</td>
<td>0.803</td>
</tr>
<tr>
<td>Sext(m:f)</td>
<td>Fr: 3:3</td>
<td>Fr: 7:5</td>
<td>0.563</td>
</tr>
<tr>
<td>PaO2/FiO2</td>
<td>111.67 (±39.09)</td>
<td>88.25 (±42.47)</td>
<td>0.275</td>
</tr>
<tr>
<td>PaCO2</td>
<td>48.33 (±15.15)</td>
<td>55.75 (±32.17)</td>
<td>0.603</td>
</tr>
<tr>
<td>PaO2</td>
<td>81.67 (±23.63)</td>
<td>66.58 (±21.71)</td>
<td>0.196</td>
</tr>
<tr>
<td>Days on MV</td>
<td>4.83 (±1.47)</td>
<td>9.33 (±6.29)</td>
<td>0.107</td>
</tr>
<tr>
<td>PIP</td>
<td>38.50 (±6.77)</td>
<td>41.83 (±6.81)</td>
<td>0.341</td>
</tr>
<tr>
<td>FiO2</td>
<td>0.70 (±0.09)</td>
<td>0.78 (±0.15)</td>
<td>0.276</td>
</tr>
<tr>
<td>Evolution</td>
<td>Fr1: 5:1</td>
<td>Fr1: 5:7</td>
<td>0.119</td>
</tr>
</tbody>
</table>

Table 3 - Evolution of PaO2/FiO2 in 18 patients before, during, and after change in position

<table>
<thead>
<tr>
<th></th>
<th>Supine (S)</th>
<th>Prone (P)</th>
<th>Postprone (PP)</th>
<th>P</th>
<th>PaO2/FiO2 ≥20</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO2/FiO2</td>
<td>96.06</td>
<td>108.56</td>
<td>105.78</td>
<td>0.223</td>
<td>SxP:5 (27.7%)</td>
</tr>
<tr>
<td>mean (SD)</td>
<td>(±41.78)</td>
<td>(±62.38)</td>
<td>(±53.42)</td>
<td></td>
<td>SxPP:4 (22.2%)</td>
</tr>
</tbody>
</table>

Discussion

In our study, we were able to show that prone positioning is a simple, noninvasive procedure that, when applied to mechanically ventilated children with acute lung disease and refractory hypoxemia, promoted improvement in oxygenation in the first hour in a considerable number of patients. This method did not present an increase in risks nor in costs. There were no adverse effects to turning patients. Moreover, there were no differences in response of patients with pulmonary pathology presenting decrease in lung compliance nor in those with increase in pulmonary resistance.

One of the possible problems of our study is that it was not randomized nor double-masked, the most effective and safe form of assessing a clinical intervention, and the gold standard in terms of validation and efficacy. However, in certain occasions and due to technical difficulties, noncontrolled studies can be considered the best option and present a high impact. In these studies, in addition to other elements, it is important to make sure that measurements are not subjected to subjective assessment and, chiefly, that no other factors are related to the outcome. In our study, the main outcome measurement was impact of oxygenation in patients after change in decubitus, during mechanical ventilation. Establishing each patients as his or her own control is an accepted, safe practice if assessment of the phenomenon is carried out independently of the observer, and for a short period to avoid influence by other factors.

Another possible problem of our study may be related to the use of the ratio PaO2/FiO2 for assessment of turning prone in oxygenation of the patients. The ratio PaO2/FiO2 is adopted worldwide for assessment of oxygenation of patients; it is, also, used in definition of ARDS (American-European Consensus Conference). Despite its wide acceptance, the main criticism towards use of this ratio is that it does not account for pressure from the respirator in the calculation of the ratio, as in oxygenation rate (OR = PIP x FiO2/PaO2). We chose using the ratio PaO2/FiO2 for the assessment of the maneuver in order to compare our results with those of similar studies, in which PaO2/FiO2 was used almost as a consensus. This ratio can also be used to assess respiratory failure and to indicate mechanical ventilation in cases other than ARDS.

A question that is inevitably posited when studying this matter refers to the mechanism of turning prone involved in promoting improvement in oxygenation of ARDS patients. Examination of chest CT scans of ARDS patients indicated that the density of their lungs was threefold that of normal lungs. This increased density is probably due to the collection of fluids in the alveoli and interstitium. Increased weight of the lungs in ARDS promotes uneven distribution of fluid infiltration, which is subject to gravity in cases of increase
in vertical gradient of transpulmonary pressure; this results in collapse of dependent lung region (posterior region when in dorsal decubitus). 8,24

One way to explain regional differences in ARDS is by using the example of the wet sponge as an analog of the lung. The lung of ARDS patients is affected by an edema and contains more fluids than that of a normal person. If a wet sponge is sectioned from top to bottom, even if the fluid is distributed uniformly over the sponge, the pressure on the lower sections can be greater due to hydrostatic forces. Transposing this example back to the lung, this increased pressure can collapse the alveoli. 25

The literature on turning prone is restricted to few series of cases that have shown improvement in oxygenation. 2,6 The mechanism of prone positioning may be related to gravity-induced reexpansion of atelectasias, change in the ventilation-perfusion ratio, increase in residual capacity, and correction of venous stasis. Experiments animals with induced ARDS indicated that turning from supine to prone allowed for transpulmonary pressure that can exceed airway opening pressure on the dorsal region, thus improving ventilation without changing regional perfusion. Improvement in V A/Q also allowed for a decreased in shunt fraction (Qs/Qst). Dorsal region areas that are not well-aerated are recruited with few or no changes in ventilation on the ventral region of the lung. This provokes a more homogeneous V A/Q by decreasing the proportion of areas with reduced VA/Q. 11,26-30 Improvement in the V A/Q in prone positioning was also demonstrated by recruitment of previously atelectatic but nondiseased areas. 31

Prone positioning allows for reduction in positive pleural pressure on the dorsal region, which develops due to presence of lesion or of pulmonary edema. Consequently, the gradient of pleural pressure in relation to transpulmonary pressure is virtually eliminated. In addition to reopening the alveoli, this may also reduce ventilator-induced pulmonary lesions and, probably, suggests a protective effect against risk for ARDS. 26,30,32,33

Recruitment of alveolar space promoted by prone positioning also allows for enhanced effect of inhaled vasodilators, such as nitric oxide, and for more marked improvements in oxygenation than if they were used separately. Studies have reported the additive effects of nitric oxide and prone positioning as an alternative for ARDS and severely hypoxemic patients. 34-36

Prone positioning improves drainage of airway secretion by turning and moving the patient, this may explain the improvement of oxygenation in patients without restrictive disease. The simple fact that patients who are lying in bed are put in motion, due to the increase in drainage of secretions, can reduce the risk for respiratory infection. 30,37

The one-hour interval for examination of children in prone position allows for assessment of short-term effects. In this case, there should be no other factors with a positive effect on oxygenation of patients in such short period of time. Chest CT scans indicated that shortly after turning from supine to prone, the density will shift from the dorsal to the ventral areas, coincidentally with the improvement in oxygenation (dependent to nondependent areas). 7,8,11

Curley et al. studied the effect of prone positioning in children with acute lung injury (PaO2:FiO2 less than or equal to 300 mm Hg) and observed an improvement in 44% of patients. This finding is similar to our results (P=0.28). The authors also observed that after 19 hours, 80% of patients had improved, including those who were initially nonresponsive. These results corroborate the hypothesis that duration of prone positioning is important for the beneficial effects of this maneuver. 38

It is important not to forget mentioning sedation of our patients. The COMFORT scale was used so that we could assess the sedation of possible candidates to the study population and, also, the need for extra sedation when turning prone. Six patients required extra sedation before prone positioning. Criteria for prone positioning included appropriately sedated patients according to the COMFORT scale. In our opinion, the administration of extra sedation did not bias the assessment of oxygenation in our patients considering that it allowed for all children to be sedated to the same level.

We observed that our patients presented with prolonged mechanical ventilation upon inclusion in the study, for an average 7.83 (± 5.57) days. This finding suggests that patients had diseases refractory to standard treatment protocols (high inspiratory pressure and FiO2). However, the duration of ventilation in our study may still not cause definite pulmonary lesions. 26 In the specific case of ARDS, it is understood that there are two distinct phases: an initial phase followed by a fibroproliferative phase. The initial phase is characterized by pulmonary edema and atelectasias in dependent areas, in which alveolar recruitment is a fundamental therapeutic measure. In turn, during the latter phase (10 to 14 days), the lung is fibrotic and fragile, presenting cysts and emphysematous lesions in dependent areas. In this latter phase, moreover, PEEP and turning positions become deleterious and ineffective measures. 12,26

It is important to note that most of our population (12 patients) presented a ratio of PaO2:FiO2 less than 100 before turning prone. These patients had severe clinical status and presented unsuccessful to standard ventilatory strategies; in this sense, they were also subject to failure in prone positioning.

Turning positions of patients with different pulmonary diseases was not an original idea, considering that there are reports of positive effects of turning prone in obstructive diseases. 16,39 Despite the fact that most studies on turning prone in hypoxemic patients are related to ARDS, the benefits of the prone position were also shown in diseases with unilateral prevalence at X-ray (pneumonia, for example), acute or chronic respiratory failure, and cardiomegaly that collapses the lower left-side lobe. 16,40,41
The values for PaO$_2$:FiO$_2$ in our study (27.7% improvement in the total group) after one hour in prone position were not distant from those in the literature (44 to 75%). It is possible that our results were influenced by the mixed characteristic of our population (obstructive and restrictive diseases) and by lung involvement. Recently,Gattinoni and colleagues assessed differences in ARDS caused by pulmonary and extrapulmonary diseases; in ARDS originating from extrapulmonary diseases, the authors observed a secondary injury to the lung and extrapulmonary disease, such as, for example, trauma and sepsis with prevalence of interstitial edema and alveolar collapse. In this sense, these cases are all responsive to recruitment maneuvers. We understand that this is an important aspect in the response to prone positioning, since out of four patients with ARDS, three presented pneumonia; in other words, ARDS born from pulmonary disease. Thus, in this sense, these patients were poorly responsive to recruitment maneuvers.

In conclusion, it is clinically important to include prone positioning among the several alternatives for treatment of respiratory failure. Though mechanical ventilation is fundamental in treatment for ARDS, adjunct treatments are becoming more important with the objective of reducing the risk for iatrogenias caused by ventilators, which, in turn, can deteriorate pulmonary lesions. Prone positioning has one main objective: to improve V/AQ. The effect of this improvement can result in impacts on at least three important therapeutic aspects: reduction of oxygen toxicity, recruitment of alveolar space in order to reduce risk for barotrauma, and improvement of postural drainage of bronchial secretions with the consequent reduction in risk for infection.2,3,7

References
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