The oxygenation variations related to prone positioning during mechanical ventilation: a clinical comparison between ARDS and non-ARDS hypoxemic patients

Abstract Objectives: To compare, in clinical practice, the oxygenation variations related to prone positioning (PP) during mechanical ventilation in ARDS and non-ARDS hypoxemic patients. Design and setting: Prospective observational study of data on consecutive patients treated with the same protocol in the intensive care unit (ICU) of a university hospital. Patients: From May 1996 to December 1998, 226 PP periods without adjunction of nitric oxide (NO) inhalation and/or almitrine bimesylate infusion, performed in 59 mechanically ventilated hypoxemic patients (arterial oxygen tension/fractional inspired oxygen (PaO\textsubscript{2}/FIO\textsubscript{2}) ratio < 300 mmHg) with no evidence of left ventricular failure, were included in this study. Measurements: Arterial blood gas was measured before the PP, at 1 h from the beginning of the PP, at the end of the PP and 1 h after returning to the supine position. Results: We analyzed 136 PP periods in 34 non-ARDS patients (60.2 %) and 90 in 25 ARDS patients. The PP was repeated and the duration of the PP periods was: 10.6 ± 0.22 h. The PP during the mechanical ventilation appeared to be safe and well tolerated. A PaO\textsubscript{2}/FIO\textsubscript{2} ratio improvement at the end of the PP period, occurred for 196 periods (86.7 %) with a mean PaO\textsubscript{2}/FIO\textsubscript{2} ratio increase of +46.4 ± 0.03 % at the end of the PP periods compared to the baseline supine value. The PaO\textsubscript{2}/FIO\textsubscript{2} ratio variations at 1 h after the start of the PP, at the end of the PP period and at 1 h after the return to supine were not different in ARDS or non-ARDS hypoxemic patients. The PaO\textsubscript{2}/FIO\textsubscript{2} ratio improvement appeared to be more intense and more rapid in ARDS patients. Conclusions: In about 90 % of periods, PP improved the PaO\textsubscript{2}/FIO\textsubscript{2} ratio in patients with ARDS as well as in hypoxemic patients with non-ARDS. Studies are necessary to determine the impact of PP on survival and the mechanical ventilation duration in ARDS or non-ARDS hypoxemic patients.

Keywords ARDS · Prone position · Mechanical ventilation · Clinical study

Introduction

Although the positive effect on gas exchanges by prone positioning (PP) during mechanical ventilation has been known for about 20 years [1], literature regarding prone position mechanical ventilation include studies which enroll few patients, especially with ARDS [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. Therefore, the effect of PP on oxygenation in non-ARDS patients has actually not been clearly established. The aim of this observational prospective study of data on consecutive patients treated with the same protocol was to compare the ef-
ffects of the prone position on oxygenation in ARDS and non-ARDS hypoxemic mechanically ventilated patients. In clinical practice, therefore, we determined the arterial oxygen tension/fractional inspired oxygen (PaO_{2}/FiO_{2}) ratio variation at 1 h after the start of the PP, at the end of the PP period and at 1 h after the return to supine in these two groups of patients.

Methods

Patients

From May 1996 to December 1998 an observational prospective study of data on consecutive patients treated with the same protocol was undertaken to compare the oxygenation variations related to the prone position in hypoxemic patients according to the underlying respiratory disease, which was defined as ARDS or non-ARDS. All PP periods performed, without NO inhalation and/or almitrine bisulphate infusion, during mechanical ventilation to correct hypoxemia (PaO_{2}/FiO_{2} ratio of ≤300 mmHg) related to an ARDS or non-ARDS respiratory failure were included in this study. The ARDS was diagnosed according to the consensus conference [16]: sudden onset of respiratory failure; bilateral diffuse infiltrates on the chest radiograph; PaO_{2}/FiO_{2} ratio of 200 mmHg or less and pulmonary artery occlusion pressure of less than 18 mmHg when measured or no clinical evidence of left atrial hypertension. It could be primary or secondary ARDS. As in the ARDS group, the non-ARDS hypoxemic patients group included patients with an acute respiratory insufficiency requiring mechanical ventilation, with pulmonary artery occlusion pressure of less than 18 mmHg when measured and no clinical evidence of left atrial hypertension. These patients differed from those with ARDS because of a PaO_{2}/FiO_{2} ratio of 300 mmHg or less and/or because of unilateral lung infiltrates on chest radiograph (it was not only acute lung injury (ALI) but also unilateral pneumonia and/or unilateral chest trauma).

Criteria for turning to the prone position

All patients were mechanically ventilated. The ventilators used in our ICU were Servo 900C or 300 (Siemen-Elema, Solna, Sweden), Evita 2 or 4 (Drager Werk, Lubeck, Germany) and Cesar (Taema, Antony, France). To manage respiratory failure, the volume control mode with tidal volume at 8 ml/kg (weight measured at admission) was the usual ventilation. If the peak pressure was above 40 cmH_{2}O, the tidal volume was reduced or the pressure limitation used. The best positive end-expiratory pressure (PEEP) was selected by increase in steps of 2 cmH_{2}O in order to provide both the minimal peak pressure (in all the cases less than 40 cmH_{2}O) and the best PaO_{2}/FiO_{2} ratio without hemodynamic adverse effects. The FiO_{2} was adapted to the PaO_{2} in steps of 0.1: decreased when PaO_{2} was more than 120 mmHg or increased if it was less than 60 mmHg. The indication of PP in this study was to correct the hypoxemia, and the decision for turning to the prone position was at the discretion of the physicians in charge of the patients.

Two data interacted with this decision: respect for PP contraindications and hemodynamic stability before the PP turning. The contraindications to the prone position were: uncontrolled shock, uncontrolled supraventricular or ventricular arrhythmias, face injury, unstable fractures (rachis, chest, a limb or pelvis) without fixation or surgical advice. An elevated intracranial pressure (documented by intracranial pressure catheter or clinically suspected) was also considered as a contraindication to PP. A recent abdominal, thoracic or rachis surgery, hemodialysis or a tracheotomy were not considered as contraindications to the PP. Before placing a patient in the prone position, stable cardiac and blood pressure were required. Fluid-filling, anti-arrhythmic, inotropic and/or vasoactive agents were used to support hemodynamics when necessary. Before being turned prone, a patient should have at least mean arterial pressure above 65 mmHg and central venous pressure equal to PEEP.

Proyne positioning procedure

Patients were turned from supine to prone position according to Chatte and co-workers [9]. All patients in supine and during the prone position were monitored routinely in our ICU with: continuous electrocardiogram monitoring, non-invasive saturation monitoring by a pulse oximetry and a radial or femoral artery catheter for the invasive arterial systemic pressure monitoring and the arterial blood gas samples. A sedation by midazolam or propofol and fentanyl infusions with or without a neuromuscular blockade (pancuronium bromide, atracurium besylate or cisatracurium besylate) was used during the PP to adapt the patient fully to his ventilator. Air suspension beds were used in most patients (Kinetic Concept, San Antonio, Tex., USA). The ventilator settings were not modified while a patient was in the prone position, except for the FiO_{2}. The PP duration and its repetition to correct the hypoxemia were assessed by the physicians in charge of the patients according to the clinical or nursing need.

Measurement protocol

The study’s design is summarized in Fig. 1. To examine the oxygenation variations related to the PP, we examined the variation of the PaO_{2}/FiO_{2} ratio and its intensity. We determined the PaO_{2}/FiO_{2} ratio before PP (beforePP), at 1 h after the start of PP (H1PP), at the end of PP before returning to supine (endPP) and at 1 h after the return to the supine position (H1SP). To examine the intensity of the PaO_{2}/FiO_{2} ratio variations during a determined time, we used a delta percentage calculation. The formula used was Delta (%) = ( (R_{t}-R_{0}) / R_{0})x100 where R_{t} and R_{0} were the PaO_{2}/FiO_{2} ratio at the end and at the beginning, respectively, of the period analyzed. For example, the intensity of the PaO_{2}/FiO_{2} ratio variation during a PP period was called Delta (endPP–beforePP), and was calculated as follows: Delta (endPP–beforePP) = ([PaO_{2}/FiO_{2} ratio at the end of PP–PaO_{2}/FiO_{2} ratio beforePP]) / PaO_{2}/FiO_{2} ratio beforePP) x100. In the same way, we calculated Delta (H1PP–beforePP) and Delta (H1SP–endPP).

Statistical analysis

Our results were reported as mean ± SEM (standard error of the mean). The results we obtained and the analysis we made were based on PP periods and not on patients. A comparison between the ARDS and non-ARDS hypoxemic patient groups was performed. We appropriately used the Mann-Whitney test, Wilcoxon test and ANOVA in order to compare continuous values and the chi-square test or Fisher’s exact test when necessary, for categorical or qualitative data. Values of p less than 0.05 were considered significant.