Prone Positioning in Cardiac Surgery: For Many, But Not for Everyone

Che von Wardenburg, MD,[*] Martin Wenzl, MD,[†] Angelo M. Dell'Aquila, MD,[‡] Axel Junger, MD,[†] Theodor Fischlein, MD,[*] and Giuseppe Santarpino, MD[*]

Prone positioning is a therapeutic maneuver to improve arterial oxygenation in patients with acute lung injury that is not implemented in most centers performing adult cardiac surgery. The aim of this study was to review our experience with prone positioning to assess the effects of this maneuver in patients with postoperative acute respiratory failure. From 2010-2014, 127 adult patients with postoperative acute respiratory failure were treated with prone positioning in addition to specific therapy. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors associated with in-hospital mortality. In-hospital mortality was 22.8% ($n = 29$). No significant differences were observed in preoperative risk factors between patients who survived (S) and those who died (D), except for age (62.7 ± 11.2 vs 70.2 ± 11.3; $P = 0.007$—at multivariate analysis $P = 0.03$, odds ratio [OR] = 1.1/year). Preproning values of PaO_2/FiO_2 were significantly different between groups (D vs S: 115 ± 46 vs 150 ± 56; $P = 0.006$), but only preproning FiO_2 remained highly significant at multivariate analysis (D vs S: 0.82 ± 0.18 vs 0.67 ± 0.16; $P = 0.001$, OR = 1.07; with $FiO_2 > 0.75$ vs < 75, OR = 19.6). D showed a higher improvement of PaO_2/FiO_2 immediately after prone positioning (207 ± 100 vs 219 ± 90, $P = 0.56$; within-group analysis between preproning and 1 hour after proning: S—$P = 0.49$, D—$P = 0.019$; at 12 hours: 286 ± 123 vs 240 ± 120, $P = 0.06$; within-group analysis between 1 hour and 12 hours after proning: S—$P = 0.15$; D—$P = 0.17$; between groups —$P = 0.05$). D had higher peak WBC count (26 ± 9.8 vs 17.7 ± 5.9×10^3/mL; $P = 0.0001$) and a higher rate of low output syndrome (15 vs 9 patients—51.7% vs 9.2%; $P = 0.0001$). At multivariate analysis, white blood cell count: $P = 0.005$, OR = $1.11/10^3$ white blood cell; low output syndrome: $P = 0.0002$, OR = 20.5. In conclusion, our results show that prone positioning, if performed early, is a safe and effective adjunct measure for patients with postoperative acute hypoxemic respiratory failure of noncardiogenic origin.

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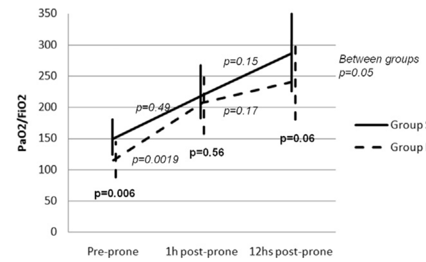

Univariate, within, and between-group analysis comparing PaO2/FiO2 before and after proning.

Central Message

Prone-positioning efficacy seems to be related to the optimal timing and a noncardiogenic etiology as the cause of low PaO_2/FiO_2.

Perspective Statement

Prone positioning, if performed early, is a safe and effective adjunct measure for patients with postoperative acute hypoxemic respiratory failure of noncardiogenic origin. It may be speculated that a more invasive approach (ie, arteriovenous or vvECMO) should be considered for patients with severe hypoxemia and cardiogenic respiratory failure to achieve better results.

See Editorial Commentary pages 288-289.

INTRODUCTION

Prone positioning was first introduced more than 2 decades ago as a strategy for improving arterial oxygenation in patients with acute lung injury and acute respiratory distress syndrome (ARDS).[1]

In a multicenter randomized controlled trial, Guérin et al.[2] showed that early application of prolonged prone-positioning sessions significantly decreased 28-day and 90-day mortality in patients with severe ARDS. The effectiveness of this intervention on outcome of patients suffering from ARDS was confirmed by a recent systematic review and meta-analysis.[3]

However, this treatment modality has not yet entered into routine clinical practice in most centers performing adult

[*]Department of Cardiac Surgery, Paracelsus Medical University Nuremberg, Nuremberg, Germany
[†]Department of Anesthesiology, Paracelsus Medical University Nuremberg, Nuremberg, Germany
[‡]Department of Cardiac Surgery, University Hospital Münster, Münster, Germany

Address reprint requests to Giuseppe Santarpino, MD, Department of Cardiac Surgery, Paracelsus Medical University, Klinikum Nürnberg, Breslauerstraße 201-90471 Nuremberg, Germany. E-mail: g.santarpino@libero.it

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cardiac surgery. Consequently, the question "Should we prone cardiac surgery patients with acute respiratory distress syndrome?" is still open.[4] A PubMed search for the keywords "prone position" AND "cardiac surgery" yielded only 2 studies in Chinese and Russian language, respectively,[5,6] the former conducted in neonates. Also, 2 other studies conducted in cardiac surgery patients involved a total of 26 patients.[7,8] In clinical practice, prone positioning is often used as a last chance option, when perhaps lung injury already reaches an advanced stage. The aim of this study was to review our experience with prone positioning that has become widely employed at our cardiac surgery center over the past years, and to identify independent predictors of in-hospital mortality and lack of effect of this adjunct intervention.

METHODS

From 2010-2014, 4763 cardiac surgery procedures requiring cardiopulmonary bypass were performed. After retrospective review of medical records, 127 patients were identified who underwent prone positioning as an adjunct measure for the treatment of "postoperative acute respiratory failure"; not necessarily based on ARDS criteria.[1] In this retrospective evaluation, there was no clear distinction between patients with ARDS or acute lung failure. Complete preoperative and intraoperative characteristics and postoperative outcomes—including complications—were retrospectively extracted for all patients. Intraoperative and postoperative ventilatory strategies did not change during the whole study period. The indication for prone positioning was established by the attending medical team (experienced intensivists, surgeons, and nurses) based on clinical, radiographic, and arterial blood gas analysis findings in response to ventilator settings. Criteria for prone positioning and the applied strategy (continuous vs intermittent mode), along with ventilator and arterial blood gas values, were recorded both before and after proning, with measurements taken at time intervals. The primary end point was in-hospital mortality, and the efficacy end point was the change in the partial pressure of arterial oxygen to inspired fraction of oxygen (PaO_2/FiO_2) ratio after 1 and 12 hours of proning. A search for complications related to the prone position was also conducted (pressure ulcers, endotracheal tube obstruction, unplanned extubations, central venous catheter dislodgement, accidental removal of chest drains, pneumothorax, need for cardiopulmonary resuscitation, or defibrillation). In addition, preoperative, intraoperative, and postoperative risk factors were evaluated both in patients who survived (group S) and in patients who died (group D). Institutional review and ethical board approval was obtained for the study.

Statistical Analysis

Any variable that was significant in univariate analysis was entered into a multivariate logistic regression model to identify independent predictors of in-hospital mortality. The discrimination achieved was assessed with the C statistic, which is equivalent to the area under the receiver operating characteristic (ROC) curve. C statistic values of 1.0 indicate perfect discrimination between survivors and deceased, whereas values of 0.5 indicate equal probability. A P value <0.05 was considered statistically significant. All significant continuous variables of the univariate analysis were additionally dichotomized using ROC curves to define cutoff values. This dichotomization was also meant to additionally provide clinical information. The change in the PaO_2/FiO_2 ratio after 1 and 12 hours of proning within group and between groups S and D was analyzed by general linear model for repeated measures. Differences in mortality between patients with severe ($PaO_2/FiO_2 < 100$ mm Hg) or mild-to-moderate hypoxemia (PaO_2/FiO_2 100-300 mm Hg) before prone positioning were also assessed.

RESULTS

In-hospital mortality was 22.8% ($n = 29$) mainly caused by complications associated with postoperative acute respiratory failure. The primary cause of death was cardiogenic shock in 15 patients (left or right ventricular failure, or both), septic shock of pulmonary origin in 8, intestinal ischemia in 2, cerebral ischemia in 2, and postoperative acute renal failure with multiorgan involvement in 2. Preoperative characteristics of the study population are reported in Table 1. Group D patients were significantly older (70 vs 62 years) and had a higher prevalence of severe renal dysfunction (27% vs 10%) compared to group S patients (Table 1).

Intraoperative Results

No significant differences were evidenced regarding the type of surgical intervention (eg, aortic valve surgery), indications, urgency (Table 1), and procedure time (cross-clamp time, overall population: 78 ± 50 minutes; group D vs S: 77 ± 54 vs 78 ± 50 minutes, $P = 0.89$; cardiopulmonary bypass time, overall population: 136 ± 76 minutes; group D vs S: 142 ± 92 vs 134±72 minutes, $P = 0.66$; surgical time, overall population: 259 ± 115 minutes; group D vs S: 264 ± 107 vs 257 ± 119 minutes, $P = 0.78$). In group D, intraoperative complications occurred in