Commentary

Reducing ventilator-induced lung injury and other organ injury by the prone position

Peter M Suter

Vice-Rector, University of Geneva

Corresponding author: Peter M Suter, peter.suter@rectorat.unige.ch

Published: 6 April 2006
This article is online at http://ccforum.com/content/10/2/139

Critical Care 2006, **10:**139 (doi:10.1186/cc4898)

See related research by Nakos *et al*. in issue 10.1 [http://ccforum.com/content/10/1/R38]

Abstract

Mechanical ventilation can cause structural and functional disturbances in the lung, as well as other vital organ dysfunctions. Apoptosis is thought to be a histological sign of distant organ damage in ventilator-induced lung injury (VILI). Nakos and colleagues observed a protective effect of prone positioning against VILI in normal sheep. Less alteration in the lung architecture and function and in liver transaminases, and lower indices for apoptosis in the liver, the diaphragm and the lung were noted in the prone position compared with the supine position. If confirmed, these data open a new hypothesis for pathogenesis and prevention of VILI and its extrapulmonary complications.

In the previous issue of *Critical Care*, Nakos and colleagues presented interesting experimental research in sheep, reporting beneficial effects of the prone position on the damage of mechanical ventilation (MV) on lung tissue and apoptosis in several vital organs [1]. These observations are an interesting addition to a number of experimental and clinical studies showing that MV can initiate as well as exacerbate lung injury, and can worsen other vital organ function [2,3]. Ventilator-induced injury (VILI) can thereby contribute to an unfavourable outcome. At least two different basic mechanisms are involved in VILI and peripheral organ dysfunction: direct mechanical lung damage and enhancement of inflammatory changes in pulmonary tissue [4]. As a result, subsequent pathophysiological pathways contribute to clinical symptoms and morbidity, including translocation of inflammatory mediators, endotoxins and bacteria from the lung to the systemic circulation [4]. The clinical relevance of VILI in the intensive care unit is confirmed by the beneficial effects on outcome of protective ventilatory techniques [5,6], including the use of lower tidal volumes and plateau pressures, as well as higher levels of positive end-expiratory pressure.

The study of Nakos and colleagues [1] expands the findings of two recent publications on potentially beneficial effects of the prone position on VILI and its systemic complications [7,8]. In an experimental work on normal rats, Valenza and colleagues [7] observed a more homogeneous distribution of lung strain during MV in the prone position, assessed by computed tomography. These data suggest that a better distribution of alveolar ventilation in the prone position could be the cause of the delayed occurrence of VILI compared with the supine position [7]. In the other recent investigation, Mentzelopoulos and colleagues [8] examined the overall parenchymal lung stress and strain, estimated from the transpulmonary plateau pressure and the tidal volume to end-expiratory lung volume ratio, in 10 patients with severe ARDS. Both of these indexes were reduced in the prone position compared with the semirecumbant position. This suggests that lung tissue damage by VILI can be reduced by the prone position [9].

In the aforementioned study of VILI in normal sheep, Nakos and colleagues add information on function and apoptotic changes in other vital organs [1]. It is noteworthy that the type of MV used (tidal volume of 15 ml/kg body weight and positive end-expiratory pressure of 3 cmH_2O) for a duration of only 90 minutes did produce marked alterations in the lung and certain distal organs. The prone position made a significant difference only for the lung, the liver and the diaphragm. In contrast, apoptotic changes in the kidney, the brain and the intestine were no different between the supine and prone positions.

How could these findings be explained? First, the modifications of lung histology observed are in line with some earlier studies [7,9-12] and could be explained by differences in the distribution of ventilation, in tissular stress and strain as

MV = mechanical ventilation; VILI = ventilator-induced lung injury.

well as in changes of interactions between the weight of the heart and underlying lung tissue in the supine and prone positions. More novel approaches may be needed to explain the different intensities of apoptosis observed in different organs. Although such observations have been reported previously [13], little is known about the causes of programmed cell death in this situation. One of the suggested mechanisms could be the increased systemic plasma levels of inflammatory mediators and proaptotic soluble factors such as Fas ligand [5,6,13], but this does not explain the profound differences between some organs. Other factors such as different sensibility for these circulating proteins and/or differences in organ perfusion between the supine and prone positions may explain the more protective effect of the prone position for the liver and the diaphragm than for the kidney and the intestine epithelial cells.

These changes in cell biology induced by MV and the protective role of the body position seem an exciting area for further research. The optimal position in an intensive care unit patient in regard to VILI remains to be defined, and it could be different from the sheep model studied by Nakos and colleagues.

Competing interests

The author declares that they have no competing interests.

References

1. Nakos G, Batistatou A, Galiatsou E, Konstanti E, Koulouras V, Kanavaros P, Doulis A, Kitsakos A, Karachaliou A, Lekka ME, *et al.*: **Lung and 'end organ' injury due to mechanical ventilation in animals: comparison between the prone and supine positions.** *Crit Care* 2006, **10:**R38.
2. Pinhu L, Whitehead T, Evans T, Griffiths M: **Ventilator-associated lung injury.** *Lancet* 2003, **361:**332-340.
3. Ranieri M, Giunta F, Suter PM, Slutsky A: **Mechanical ventilation as a mediator of multisystem organ failure in acute respiratory distress syndrome.** *JAMA* 2000, **284:**43-44.
4. Tremblay LN, Slutsky AS: **Ventilator-induced lung injury: from the bench to the bedside.** *Intensive Care Med* 2006; **32:**24-33.
5. Ranieri VM, Suter PM, Tortorella C, De Tullio R, Dayer JM, Brienza A, Bruno F, Slutsky AS: **Effect of mechanical ventilation on inflammatory mediators in patients with acute respiratory distress syndrome. A randomized controlled trial.** *JAMA* 1999, **282:**54-61.
6. Anonymous: **The acute respiratory distress syndrome network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome.** *N Engl J Med* 2000; **342:**1301-1308.
7. Valenza F, Guglielmi M, Mafioletti M, Tedesco C, Maccagni P, Fossali T, Aletti G, Porro GA, Irace M, Carlesso E, *et al.*: **Prone position delays the progression of ventilator-induced lung injury in rats: does lung strain distribution play a role?** *Crit Care Med* 2005, **33:**361-367.
8. Mentzelopoulos SD, Roussos C, Zakynthinos E: **Prone position reduces lung stress and strain in severe acute respiratory distress syndrome.** *Eur Respir J* 2005, **25:**534-544.
9. Guérin C: **Ventilation in the prone position in patients with acute lung injury / acute respiratory distress syndrome.** *Curr Opin Crit Care* 2006, **12:**50-54.
10 Dreyfuss D, Soler P, Basset G, Saumon G: **High inflation pressure pulmonary edema. Respective effects of high airway pressure, high tidal volume, and positive end-expiratory pressure.** *Am Rev Respir Dis* 1988, **137:**1159-1164.
11. Muscedere JG, Muller JB, Gan K, Slutsky AS: **Tidal ventilation at low airway pressures can augment lung injury.** *Am J Respir Crit Care* 1994, **147:**1327-1334.
12. Albert RK, Hubmayr RD: **The prone position eliminates compression of the lungs by the heart.** *Am J Respir Crit Care* 2000, **161:**1660-1665.
13. Imai Y, Parodo J, Kajikawa O, De Perrot M, Fischer S, Edwards V, Cutz E, Liu M, Keshavjee S, Martin TR, *et al.*: **Injurious mechanical ventilation and end-organ epithelial cell apoptosis and organ dysfunction in an experimental model of acute respiratory distress syndrome.** *JAMA* 2003, **289:**2104-2112.