New and Conventional Strategies for Lung Recruitment in Acute Respiratory Distress Syndrome

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Introduction

Mechanical ventilation is a supportive and life-saving therapy in patients with acute lung injury (ALI)/acute respiratory distress syndrome (ARDS). Despite advances in critical care, mortality remains high [1]. During the last decade, the fact that mechanical ventilation can produce morphologic and physiologic alterations in the lungs has been recognized [2]. In this context, the use of low tidal volumes ($V_T$) and limited inspiratory plateau pressure ($P_{plat}$) has been proposed when mechanically ventilating the lungs of patients with ALI/ARDS, to prevent lung as well as distal organ injury [3]. However, the reduction in $V_T$ may result in alveolar derecruitment, cyclic opening and closing of atelectatic alveoli and distal small airways leading to ventilator-induced lung injury (VILI) if inadequate low positive end-expiratory pressure (PEEP) is applied [4]. On the other hand, high PEEP levels may be associated with excessive lung parenchyma stress and strain [5] and negative hemodynamic effects, resulting in systemic organ injury [6]. Therefore, lung recruitment maneuvers have been proposed and used to open up collapsed lung, while PEEP counteracts alveolar derecruitment due to low $V_T$ ventilation [4]. Lung recruitment and stabilization through use of PEEP are illustrated in Figure 1. Nevertheless, the beneficial effects of recruitment maneuvers in ALI/ARDS have been questioned. Although Hodgson et al. [7] showed no evidence that recruitment maneuvers reduce mortality or the duration of mechanical ventilation in patients with ALI/ARDS, such maneuvers may be useful to reverse life-threatening hypoxemia [8] and to avoid derecruitment resulting from disconnection and/or airway suctioning procedures [9].

The success and/or failure of recruitment maneuvers are associated with various factors: 1) Different types of lung injury, mainly pulmonary and extra-pulmonary origin; 2) differences in the severity of lung injury; 3) the transpulmonary pressures reached during recruitment maneuvers; 4) the type of recruitment maneuver applied; 5) the PEEP levels used to stabilize the lungs after the recruitment maneuver; 6) differences in patient positioning (most notably supine vs prone); 7) use of different vasoactive drugs, which may affect cardiac output and the distribution of pulmonary blood flow, thus modifying gas-exchange.

Although numerous reviews have addressed the use of recruitment maneuvers to optimize ventilator settings in ALI/ARDS, this issue remains controversial. While some types of recruitment maneuver have been abandoned in clinical practice, new, potentially interesting strategies able to recruit the lungs have not been properly considered. In the present chapter we will describe and discuss: a) Definition and factors affecting recruitment; b) types of recruitment maneuvers; and c) the role of variable ventilation as a recruitment maneuver.
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Definition and Factors Affecting Recruitment Maneuvers

Recruitment maneuver denotes the dynamic process of an intentional transient increase in transpulmonary pressure aimed at opening unstable airless alveoli, which has also been termed alveolar recruitment maneuver. Although the existence of alveolar closure and opening in ALI/ARDS has been questioned [10], the rationale for recruitment maneuvers is to open the atelectatic alveoli, thus increasing end-expiratory lung volume, improving gas exchange, and attenuating VILI [11]. However, recruitment maneuvers may also contribute to VILI [11, 12], with translocation of pulmonary bacteria [13] and cytokines into the systemic circulation [14]. Furthermore, since recruitment maneuvers increase mean thoracic pressure, they may lead to a reduction in venous return with impairment of cardiac output [15].

Various factors may influence the response to a recruitment maneuver, namely: 1) The nature and extent of lung injury, and 2) patient positioning.