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WHAT'S NEW IN INTENSIVE CARE

What's new in mechanical ventilation in patients without ARDS: lessons from the ARDS literature

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Introduction

The incidence of acute respiratory distress syndrome (ARDS) varies greatly across the world [1], and its impact on the outcome of critically ill patients remains significant [1]. The publication of the ARMA trial [2] demonstrated that a lung protective strategy of ventilation, using a tidal volume (V_T) of 6 ml/kg predicted body weight (PBW), decreased mortality in patients with ARDS, and led to the widespread, albeit not universal, use of lung protective strategies in this group of patients.

Recent studies suggest that the incidence of ARDS is decreasing [3, 4] and that this reduction is believed to be a result of advances in hospital practice and numerous quality improvement initiatives [4]. These advances included general quality improvement initiatives (i.e. infection control, timely antibiotics and resuscitation) and also specific critical care protocols such as the use of protective ventilation in critically ill patients without ARDS [5, 6].

Since the majority of the patients undergoing mechanical ventilation do not have ARDS, the number of studies focusing on strategies of ventilation in this group of patients has been increasing in recent years, both in surgical and non-surgical areas. The purpose of this paper is to review the recent evidence in mechanical ventilation in patients without ARDS.

Ventilator-induced lung injury

Several investigators have raised concerns that inflation of the lung with positive pressure ventilation could potentially damage the lungs and produce air leaks, and these lesions, termed 'barotrauma', were believed to be the most relevant in the pathogenesis of ventilator-induced lung injury (VILI) for several years [7]. More recently, some studies showed, in animals ventilated with various V_T but at similar airway pressures, that it was high V_T and not high airway pressures, that produced VILI. This was called 'volutrauma' and from then on researchers considered this more important than barotrauma [7]. Meanwhile, investigators started to take interest in the beneficial effects of positive end expiratory pressure (PEEP) in the prevention of VILI. Use of too low levels of PEEP, or no PEEP, was associated with lung injury, and this was thought to result from repetitive opening and closing of lung tissue that collapses at the end of expiration, a phenomenon called 'atelectrauma' 0 [7].

The results of the Landmark ARMA trial confirmed that VILI was not just an interesting experimental entity but was also an important clinical problem [2]. Indeed, VILI is not just a problem in patients with ARDS but also in critically ill patients receiving mechanical ventilation but without ARDS [4–7], and there has been a paradigm shift from treating ARDS to prevention of ARDS in response to this scenario [5, 6, 8].

Protective ventilation in patients without ARDS

Critically ill non-surgical patients without ARDS

The number of randomized controlled trials (RCT) that have focused on the effects of protective ventilation in critically ill patients without ARDS is limited. So far, only one RCT has tested the hypothesis whether V_T reduction would improve the outcome of ventilated critically ill patients [5]. A multi-center RCT in mixed ICU patients without ARDS showed that V_T reduction from

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10 to 6 ml/kg PBW at a same PEEP level was associated with a lower incidence of ARDS [5]. Two recent individual patient data meta-analyses confirmed the benefit of lower V_T ventilation in ICU patients without ARDS [9, 10]. Notably, the use of lower V_T did not increase sedation needs, which is cited as one of the main arguments against the use of lower V_T [10].

The use of lower V_T could promote atelectasis even more with longer duration of ventilation, which could be a reason to use higher levels of PEEP with the aim of maintaining closely similar end inspiratory pressure. Only two RCTs have tested the impact of PEEP in critically ill patients without ARDS. In one RCT in patients at risk for ARDS, mechanical ventilation with 8 cmH_2O of PEEP did not prevent the development of this syndrome compared to no PEEP [11]. The other RCT showed that the incidence of ventilator-associated pneumonia was lower in patients ventilated with higher levels of PEEP [12].

Surgical patients

Postoperative complications, especially postoperative pulmonary complications (PPC), are an important cause of morbidity in surgical patients [13]. Among several intra-operative factors that can influence the development of PPC, V_T size and level of PEEP are stronger predictors [13]. A RCT of intra-operative ventilation showed that the use of lower V_T prevents PPC, and all these RCT were summarized in a recent meta-analysis confirming that the use of lower V_T was consistently associated with reduced incidence of PPC [8–14].

The above-mentioned RCTs actually studied the effects of a bundle of "protective ventilation" settings which included low or limited V_T and moderate to high levels of PEEP with recruitment maneuvers. The rationale behind using a bundle of lower V_T and higher levels of PEEP with recruitment maneuvers was that V_T reduction would induce atelectasis and consequently could increase harm by tidal recruitment of those lung parts that collapse at the end of expiration. Moderate to high levels of PEEP with recruitment maneuvers could stabilize these parts during the respiratory cycle [7].

The Intraoperative PROtective VEntilation (IMPROVE) trial was the first RCT[8] in which a multifaceted strategy comprised of low V_T (6–8 ml/kg PBW) ventilation, moderate levels of PEEP (6-8 cmH2O), and repeated recruitment maneuvers aimed at keeping the lung open was compared with non-protective ventilation in 400 intermediate to high-risk patients undergoing major abdominal surgery. Consistent with previous findings in similar abdominal procedures, an overall postoperative respiratory failure rate of 12 % was found. Compared with non-protective ventilation, prophylactic lung-protective ventilation was associated with improved postoperative clinical outcomes, as suggested by a 69 % reduction in the patients requiring intubation or non-invasive ventilation for postoperative respiratory failure (relative risk 0.29; 95 % CI 0.14–0.61; $P = 0.001$). The European PROVHILO trial included 900 intermediate to high-risk patients undergoing major abdominal surgery. Contrary to the IMPROVE study which evaluated the effects of a multifaceted strategy (bundle of "lung protective ventilation"), the PROVHILO study focused mainly on the effect of low ($\leq$2 cmH_2O) versus high (10–12 cmH_2O) PEEP level at a same low V_T (8 ml/kg PBW). In the PROVHILO study, the incidence of PPC was not different in the patients receiving higher levels of PEEP [15]. However, the respective impact of moderate levels of PEEP and low V_T with or without recruitment maneuvers in abdominal surgical patients is still under debate. Finally, further studies on the role of recruitment maneuvers on the prevention of the occurrence on ARDS in patients with healthy lungs are needed.

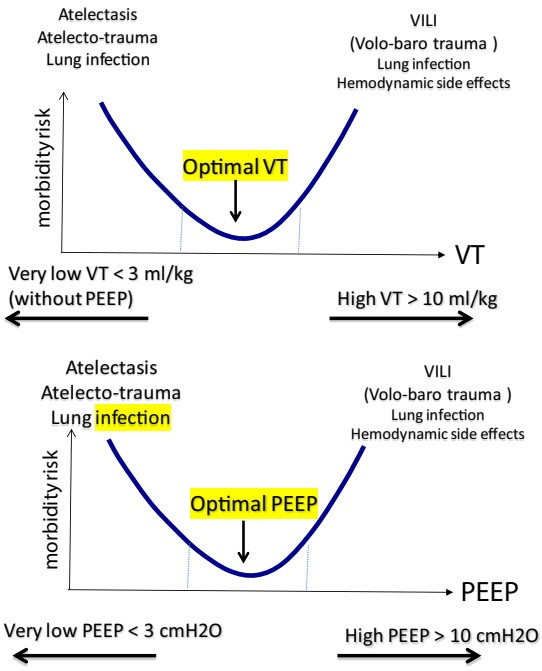

Fig. 1 Optimal tidal volume and PEEP level ranges and its related complications in patients with healthy non-ARDS lungs. V_T tidal volume, *PEEP* positive end expiratory pressure, *VILI* ventilator-induced lung injury

Conclusion

There is increasing and convincing evidence that the use of lower V_T (<8 ml/kg PBW) during intraoperative ventilation prevents PPC. Whether lower V_T should be

part of protective ventilation in ICU patients without ARDS is less certain, but the best available evidence so far suggests that these patients could also benefit from V_T reduction. The optimal levels of PEEP and/or driving pressure which should be associated with a low V_T, as part of a protective ventilation strategy for both surgical and non-surgical patients without ARDS, is still under debate (Fig. 1).

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