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Letter To the Editor

Influence of tidal volume on ventilation distribution and oxygenation during one-lung ventilation

Dear Editor,

Incorrect ventilator settings have the potential to induce lung injury. For this reason, the individualized setting of tidal volume (V_T) or variable V_T could be more physiology-oriented and thus improve patient outcomes [1]. In thoracic surgery, where one-lung ventilation (OLV) is performed, the setting of V_T is more challenging than during the ventilation of both lungs. V_T, which is regarded as low during a normal two-lung ventilation scenario, could be too high during OLV, potentially inducing barotraumas. However, simply reducing V_T to half during OLV may be insufficiently low to secure adequate gas exchange and result in hypoxemia [2]. We have conducted a study to explore the feasibility of titrating V_T during OLV at the bedside, based on ventilation distribution and oxygenation. The rationale was to monitor the regional ventilation distribution to avoid volutrauma with acceptable levels of blood gasses.

Nine consecutive patients with peripheral lung cancer requiring intubation with a double-lumen tube and subsequent OLV for thoracoscopic lobectomy were examined prospectively (2 male, 7 female; age 56 ± 7 yr (mean ± SD); body weight 63 ± 9 kg; height 163 ± 7 cm; ASA I–II). No emphysema, chronic obstructive pulmonary disease or restrictive pulmonary disease were present before surgery. The study was approved by the local ethics committee. Written informed consent was obtained from all patients before the study. After general anesthesia and tracheal intubation, mechanical ventilation was switched to OLV. FiO_2 was set to 100%, and V_T was gradually decreased from 8 ml/kg to 7 ml/kg, 6 ml/kg and 5 ml/kg ideal body weight, while ventilatory frequency was increased from 12/ml to 14/min, 16/min and 20/min, respectively. Each step lasted for 4 min. At the end of each step, PaO_2 and electrical impedance tomography (EIT) measurements were performed.

Fig. 1 summarizes the studied parameters at various V_T steps. All values were normalized to the corresponding step of 8 ml/kg during OLV for intra-patient comparison. During OLV, global respiratory system compliance (C_{rs}) measured with the ventilator was lower, since one of the lungs was not aerated. Significant differences in the global C_{rs} were found among different V_T steps during OLV (8 ml/kg vs. 6 ml/kg, $p < 0.01$; 8 ml/kg vs. 5 ml/kg, $p < 0.01$; Fig. 1 top-left). Maintaining V_T at the level of two-lung ventilation might prevent the drop in PaO_2 (Fig. 1 top-right); however, it would simultaneously induce a higher degree of ventilation inhomogeneity (EIT-based index [3]; Fig. 1 bottom-right). In fact, both high V_T and low V_T could result in high ventilation inhomogeneity (Fig. 1, bottom-right). Maximal regional C_{rs} (measured with EIT [4]) showed high variations, suggesting the need for individual titration (Fig. 1 bottom-left).

EIT was proposed to monitor ventilation distribution in the lungs to prevent tidal recruitment and overdistension [5]. Concerns were raised if EIT could be applied during thoracic surgery. Based on our experience, EIT can monitor ventilation during minimally invasive thoracic surgery without intrusion in the surgical field. When the electrotome is on, the EIT cable should be disconnected. Our study shows the feasibility of using EIT in combination with PaO_2 to identify suitable V_T with respect to ventilation distribution and gas exchange at the bedside during OLV. A suitable V_T should be selected (with a trade-off) by minimizing the decrease in the PaO_2 and maximizing the improvement in the regional C_{rs} and ventilation homogeneity.

Conflicts of interest: All authors declare no conflicts of interests.

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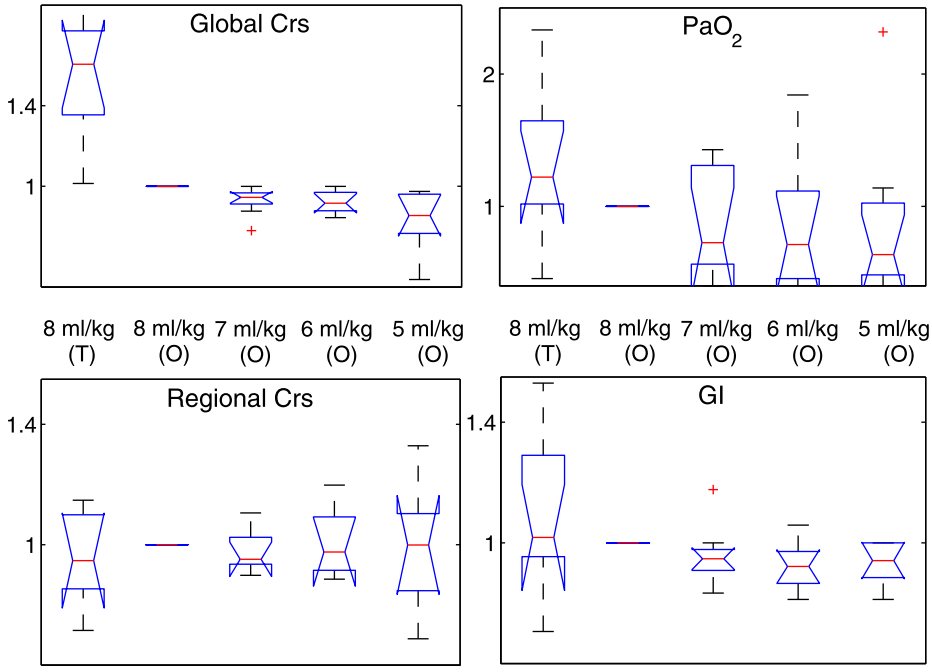

Figure 1. Studied parameter values at various tidal volume steps in nine patients. All values were normalized to the corresponding step of 8 ml/kg during one-lung ventilation. Global C_{rs}, global dynamic respiratory system compliance derived from the ventilator; PaO_2, partial pressure of oxygen in arterial blood; GI, the global inhomogeneity index derived from EIT; Regional C_{rs}, regional compliance derived from EIT. T: ventilation of two lungs; O: one-lung ventilation. The boxes mark the quartiles, while the whiskers extend from the box out to the most extreme data value within 1.5*the interquartile range of the sample; red + indicates an outlier.

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