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Individualized PEEP guided by electrical impedance tomography: physiological promise without clear clinical benefit

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Optimizing intraoperative ventilation remains a fundamental challenge in anesthetic practice, particularly in surgical settings characterized by significant alterations in respiratory mechanics. Laparoscopic procedures performed in the lateral decubitus position represent a complex physiological scenario, in which gravitational forces, pneumoperitoneum, and anesthesia collectively promote ventilation–perfusion mismatch and impaired oxygenation [1,2]. Kim et al. [3] conducted a randomized controlled trial evaluating whether individualized positive end-expiratory pressure (PEEP) titration guided by electrical impedance tomography (EIT) could improve oxygenation compared with the conventional fixed PEEP strategy.

In this prospective trial, 74 patients undergoing laparoscopic or robot-assisted urological surgery were randomized to either EIT-guided PEEP titration or the standard approach using a fixed PEEP of 5 cmH_2O. The intervention for the EIT-guided group consisted of a recruitment maneuver followed by a decremental PEEP trial, with the optimal PEEP defined by EIT-derived indices balancing alveolar collapse and over-distention. The primary outcome, the PaO_2/FiO_2 ratio at the end of surgery, was significantly higher in the EIT-guided group. Additionally, the intervention was associated with lower driving pressures and fewer intraoperative desaturation events, indicating improved respiratory mechanics and ventilation distribution. However, no significant differences in postoperative pulmonary complications (PPCs) were observed.

This study has several notable strengths. First, it addresses a clinically relevant question using a randomized design, thereby minimizing bias and enhancing internal validity. Second, the use of EIT as a real-time bedside tool represents an important advancement over traditional methods of PEEP titration. By providing regional information on lung ventilation, EIT allows clinicians to individualize PEEP settings based on physiological principles, thereby potentially reducing both atelectasis and overdistention [4]. This approach is consistent with contemporary concepts of lung-protective ventilation, which emphasize minimizing the driving pressure and mechanical power rather than applying uniform ventilatory settings [5,6]. Third, the authors demonstrated that relatively high levels of individualized PEEP could be applied without an apparent increase in intraoperative hypotension or vasopressor requirements, thereby addressing a key concern associated with higher airway pressures.

Despite these strengths, several limitations should be considered when interpreting the findings. Most importantly, the clinical relevance of the observed improvements in oxygenation is uncertain. Although the increase in PaO_2/FiO_2 was statistically significant, baseline oxygenation in the study population was already relatively preserved. Therefore, whether the observed physiological benefits translate into meaningful clinical outcomes is unclear. The absence of a reduction in PPCs reinforces this concern and highlights a persistent gap between intraoperative physiological optimization and postoperative outcomes. However, the study may have been underpowered to detect differences in clinical endpoints such as PPCs; therefore, firm conclusions regarding clinical benefits cannot be drawn. In addition, most participants were relatively healthy (predominantly American Society of Anesthesiologists physical status II), and patients with significant cardiopulmonary disease were excluded. Thus, the potential benefits of individualized PEEP in high-risk populations that are susceptible to perioperative pulmonary complications may have been underestimated. Future studies focusing on patients with impaired pulmonary reserve or higher surgical risk may provide clinically meaningful insights.

The potential risks associated with high PEEP levels warrant further investigation. Although the authors reported no significant differences in intraoperative hypotension or vasopressor use, more advanced hemodynamic parameters such as cardiac output or pulmonary arterial pressure were not assessed. Patients with limited cardiovascular reserves, particularly those with right ventricular dysfunction, may have an increased risk of adverse hemodynamic effects related to elevated PEEP. In addition, the application of higher airway pressures raises concerns regarding ventilator-induced lung injury, including the possibility of microscopic overdistention. These effects may not have been apparent within the limited follow-up period of this study, underscoring the need for more comprehensive hemodynamic and long-term outcome assessments.

Despite these limitations, this study provides valuable evidence of the physiological benefits of individualized ventilation strategies, reinforcing the concept that a "one-size-fits-all" approach to PEEP may be suboptimal, particularly in complex surgical conditions, such as the lateral decubitus position with pneumoperitoneum. The findings also highlight the potential role of advanced monitoring technologies such as EIT in enabling more personalized perioperative care. In conclusion, Kim et al. [3] demonstrated that EIT-guided individualized PEEP improved intraoperative oxygenation and respiratory mechanics in patients undergoing laparoscopic surgery in the lateral decubitus position. However, the absence of demonstrable improvements in clinical outcomes highlights the ongoing challenge of translating physiological optimization into meaningful patient benefits. Future research should focus on high-risk populations and long-term outcomes to determine the true clinical value of EIT-guided ventilation strategies.

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Conflicts of Interest

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