CASE REPORT

Ventilatory Management Using Electrical Impedance Tomography in an Obese Patient Undergoing Robot-Assisted Laparoscopic Rectal Resection : A Case Report

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Abstract : This study focused on ventilatory management during robot-assisted laparoscopic rectal resection in an obese patient, using electrical impedance tomography (EIT) to evaluate lung conditions. The case involved a 40s male with a history of smoking, obesity (BMI : 31), and iodine allergy. General anesthesia was induced, and EIT was employed to assess positive end expiratory pressure (PEEP) during different surgical positions. The study found that the PEEP for supine positioning was 10-12 cmH_2O for ventilatory conditions in which the anterior and posterior impedance changes were equal in patients, but during pneumoperitoneum and head lowering, a higher PEEP of 20 cmH_2O was necessary to prevent lung collapse. This differed from conventional recommendations. Oxygenation was maintained, and the patient had no major complications. The study suggests that EIT may offer a noninvasive and bedside approach to evaluating ventilator settings, potentially changing perspectives on intraoperative ventilator management. J. Med. Invest. 72 : 447-450, August, 2025

Keywords **:** *Electrical impedance tomography, Obese patient, Robot-assisted laparoscopic surgery*

BACKGROUND

Ventilation is essential for general anesthesia, but the mode and setting of ventilation remains controversial and inconclusive (1, 2). While there is widespread agreement on the beneficial impact of establishing suitable positive end-expiratory pressure (PEEP) for patients to enhance outcomes, limited knowledge exists regarding the specific influence of PEEP on short-term ventilation, particularly during surgical procedures (3). Appropriate PEEP has benefits such as maintaining oxygenation and preventing end-expiratory alveolar collapse (4). On the other hand, excessive PEEP may result in hemodynamic compromise due to alveolar pressure damage from over-expansion and increased intrathoracic pressure (5). In Intensive Care Unit (ICU), transpulmonary pressure (TPP) measurements are commonly used to determine appropriate PEEP values. However, TPP refers to the compliance of the entire lung and cannot detect local atelectasis (6). Therefore, we attempted to monitor respiratory status during the brief period of surgery using electrical impedance tomography (EIT), which is noninvasive and easily measured, to evaluate ventilatory status from a different perspective than alveolar compliance or oxygenation. The ventilation state measured by EIT shifts from posterior side to anterior side by changing PEEP. Previous research has shown that conditions in which the ventral and dorsal ventilation ratios are similar are suitable for artificial respiration (7-9). In this case, the PEEP was used when the shift in ventilation progressed and the impedance change per breath in the posterior side and anterior side became equal. Additionally, PEEP was also varied and observed in obese patients undergoing robot-assisted laparoscopic rectal resection, whose ventilation state changed significantly.

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CASE PRESENTATION

A 40s male (174 cm tall, weighing 95 kg) was scheduled to undergo a robot-assisted laparoscopic rectal resection. Risk factors for anesthesia management included a history of smoking (40 cigarettes / day x 26 years), obesity with BMI : 31 (Obese class I), and iodine allergy, but no regular medications or other anesthesia-related complications. General anesthesia was induced with propofol TCI : 3 μg / ml, fentanyl 100 μg, remifentanil 0.2 μg/kg/min and rocuronium 70 mg after an epidural catheter was placed from Th11/12. Tracheal intubation was performed without problems, and anesthesia was maintained with desflurane. The patient was placed in a supine position and the use of EIT (Enlight 2100, Timpel Medical, Sao Paulo, Brazil) was started. The EIT belt was placed between the patient's fourth and fifth ribs and fixed in a position where the electrodes of the belt were closest to the skin. The surgeon verified this position and confirmed that no problems were encountered with the surgical procedure. First, alveolar recruitment was performed manually at a pressure of 30 cmH_2O for 30 seconds. Then, ventilation was started at inspiratory pressure : 10 cmH_2O, ventilation frequency : 12 times/min, PEEP : 20 cmH_2O, and PEEP was gradually decreased by 2 cmH_2O every minute while recording EIT electrical imaging diagrams. At high PEEP, ventilation was distributed more on the posterior side, but as PEEP was decreased, anterior ventilation improved, and posterior and anterior ventilation distributions were the same at PEEP 10-12 cmH_2O. As a result, the PEEP for this patient in the supine position with equal changes in impedance on the posterior and anterior sides was estimated to be 10-12 cmH_2O (Figure 1).

About 20 minutes after the start of surgery, pneumoperitoneum was established (10 mmHg) and the patient was in head down position (Trendelenburg position 15 degrees). At that time, the same manual alveolar recruitment was performed, and PEEP was gradually decreased from 20 cmH_2O again to search for a PEEP value for ventilatory conditions where the impedance changes were equal on the posterior and anterior sides. However, the PEEP was 20 cmH_2O and the ratio of anterior and posterior was 50%. When the pressure was lowered below 18 cmH_2O as a trial, the right and posterior lung collapsed markedly on the EIT images, so the ventilatory conditions were maintained at PEEP of 20 cmH_2O (Figure 2). Additionally, we have summarized the list of static lung compliance by ventilator setting and body position (Table 1) and intraoperative primary vital signs and static lung compliance are summarized (Figure 3). The patient had no major complications intraoperatively.

Table 1. The list of static lung compliance by ventilator setting and body position.

PEEP (cmH_2O)	Inspiratory driving pressure (cmH_2O)	Static lung compliance (mL / cmH_2O)	
		Supine position	Pneumoperitoneum and head-down posision
20	10	59.0	44.0
18	10	60.0	45.2
16	10	61.4	**45.9**
14	10	**66.7**	–
12	10	60.8	38.8
10	10	59.9	–
8	10	54.9	28.5
6	10	48.0	–

The arterial blood gas test (ABG) results 10 minutes after insufflation and head down position was pH : 7.407, pCO_2 : 36.6 mmHg, pO_2 : 167 mmHg (FiO_2 0.4). Anesthesia management was continued under the same ventilatory conditions, and ABG at 6 hours was pH : 7.304, pCO_2 : 51.3 mmHg, pO_2 : 172 mmHg. The patient was extubated with PEEP : 20 cmH_2O, and 5 minutes after extubation, ABG was pH : 7.295, pCO_2 : 53.5 mmHg, pO_2 : 104 mmHg under masked oxygen at 3L/min. Then the patient was returned to the general ward while receiving oxygen at 3L/min by mask. He was discharged on the 11th postoperative day without major complications.

DISCUSSION

The management of ventilation during general anesthesia is a critical aspect of patient care, and determining optimal ventilator settings, particularly PEEP, remains a subject of ongoing debate within the medical community (4). Conventionally, appropriate PEEP is believed to enhance patient outcomes by preserving oxygenation and preventing end-expiratory alveolar collapse (4, 5). However, the delicate balance between maintaining adequate PEEP and avoiding excessive levels is crucial, as elevated PEEP may lead to hemodynamic compromise due to alveolar pressure damage and increased intrathoracic pressure (5, 10).

In this case, the application of EIT provided a unique perspective

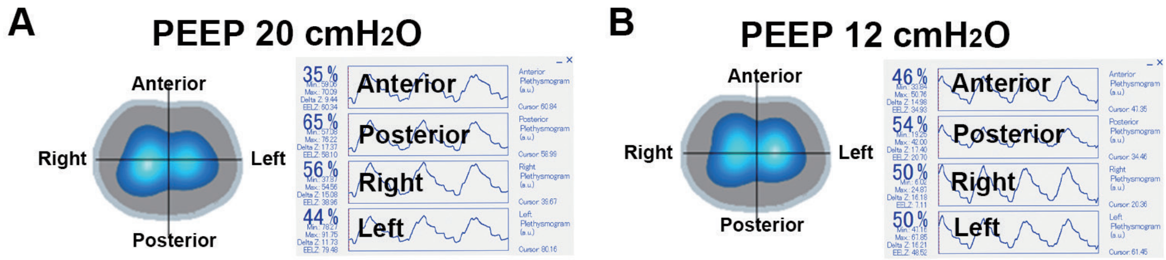

Figure 1. Electrical impedance tomography images for the optimal PEEP in the supine position.
(A) In the supine position, electrical impedance tomography (EIT) images revealed that ventilation was predominantly distributed on the posterior side (Anterior 35% vs Posterior 65%) when the positive end expiratory pressure (PEEP) was set at 20 cmH_2O. (B) As decreased PEEP, improvements in ventilation on the anterior side (35% to 46%). Ventilation distributions of both the anterior and posterior sides were the same in PEEP 10-12 cmH_2O.

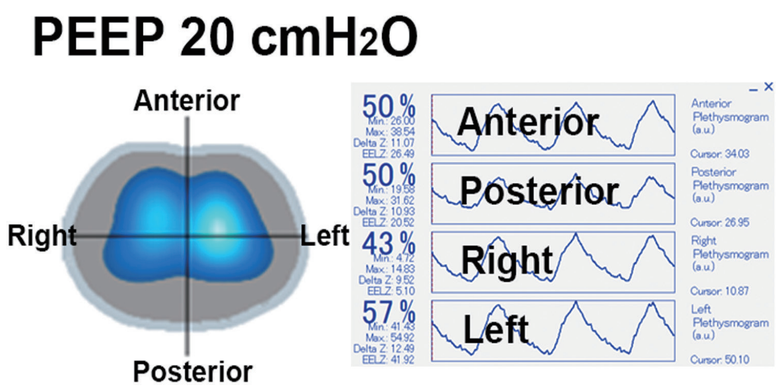

Figure 2. Electrical impedance tomography images during pneumoperitoneum and a head down position.
In conditions of pneumoperitoneum and a head down position, ventilation homogenization and equalization on both anterior (50%) and posterior (50%) sides were observed at a positive end expiratory pressure (PEEP) of 20 cmH_2O.

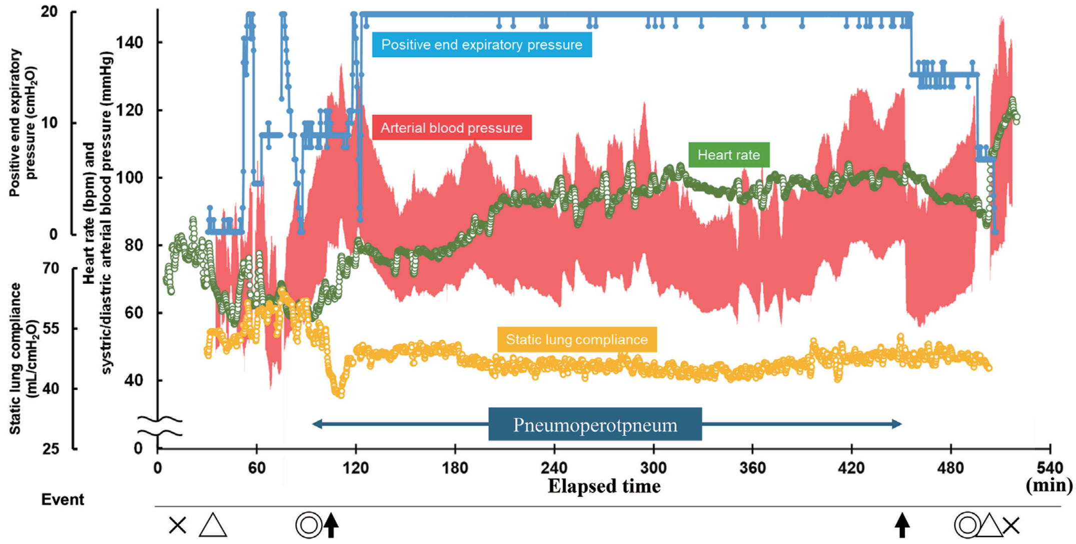

Figure 3. Intraoperative primary vital signs and static lung compliance.
× : Start of anesthesia / End of anesthesia, △ : Intubation / Extubation, ◎ : Start of surgery / End of surgery, ↑ : Start of head-down position (Trendelenburg position 15 degrees) / Supine position.

on ventilatory conditions during robot-assisted laparoscopic rectal resection in an obese patient (11). Unlike traditional approaches that focus on alveolar compliance or oxygenation, EIT offered real-time visualization of lung function. The technique involves applying a weak current to electrodes attached to the chest, producing an electrical tomographic image based on differences in electrical impedance (12). The findings from this case underscore the potential utility of EIT in evaluating and optimizing ventilatory settings. This patient in the supine position with equal changes in impedance on the posterior and anterior sides was estimated to be 10-12 cmH_2O, emphasizing the importance of individualized approaches. During pneumoperitoneum and a head-down position, the EIT-guided adjustment of PEEP to 20 cmH_2O differed significantly from conventional recommendations. Notably, attempts to lower PEEP below 18 cmH_2O resulted in marked not only anterior/posterior but also left/right ratio of impedance change, illustrating the value of EIT in dynamically assessing ventilatory conditions. For ethical concerns, we did not examine ABG at PEEP : 18 cmH_2O. However, ABG at PEEP : 18 cmH_2O was most likely worse than at PEEP : 20 cmH_2O because dorsal lung collapse and ventral lung hyperinflation are generally inappropriate respiratory conditions (13). This case challenges the existing paradigm of relying solely on arterial oxygen partial pressure, inspiratory oxygen fraction ratio (P/F ratio), CT scans and alveolar compliance for evaluating ventilator settings (14). Traditional dynamic lung compliance-based PEEP strategies may not provide optimal ventilation conditions for lung protection due to inappropriate PEEP values depending on the lung condition (15). EIT offers a noninvasive, real-time alternative that can be applied at the operating room, potentially transforming intraoperative ventilator management (16, 17). The ability to visualize and adapt ventilatory strategies based on local information about lung ventilation distribution is a promising aspect of EIT (18, 19).

The patient's successful outcome, with maintained oxygenation and the absence of major complications, suggests the feasibility and potential benefits of using EIT in clinical practice. However, accurate EIT data could not be obtained after the end of ventilation due to the large movement of the body in this case. Further studies are needed to validate the perioperative effects of EIT-guided intraoperative ventilatory management across a broader patient population and surgical scenario. Continued exploration of EIT in intraoperative ventilator management may contribute to a more nuanced understanding of optimal ventilatory strategies, ultimately improving patient outcomes during general anesthesia.

There are several limitations to this case report. The EIT indicates correct values only when the EIT belt is in the correct position, the EIT equipment has a suitable mesh for the patient's chest shape, and the software chooses the correct region to divide the image into ventral and dorsal. In the presence of pneumoperitoneum, the diaphragm moves cranially and invades the region in which the EIT monitor estimates the ventilation variation. Therefore, depending on the position of the belt, with the reduction in PEEP and elevation of the diaphragm, variation in ventilation distribution may occur due to the reduction of ventilation in the measurement field of the EIT monitor. Additionally, in some conditions, such as the presence of pneumonia, pulmonary cyst, lung resection, and others, this distribution will not always be the intended % for the ventral and dorsal regions. Therefore, this criterion for choosing PEEP may work in patients with healthy lungs, but it will not always work in patients with lung disease. Furthermore, the EIT only shows how much the electrical resistance of the area corresponding to the pixel (= lung) changes during one respiratory cycle based on the impedance change, which is an indirect estimation of ventilation volume, but not the same. These considerations suggest that more detailed prospective studies are needed in the future to clarify the optimal PEEP.

CONCLUSION

Utilizing EIT, the PEEP for supine positioning was 10-12 cmH_2O for ventilatory conditions in which the anterior and posterior impedance changes were equal in patients. However, during pneumoperitoneum and head down positioning, maintaining PEEP at 20 cmH_2O was necessary to prevent lung collapse. This case report highlights the potential of EIT in evaluating and optimizing ventilation parameters during general anesthesia, particularly in obese patients. From these results, a higher PEEP value during anesthesia may be advisable. Future larger trials are essential to confirm these findings in terms of both efficacy and safety.

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AVAILABILITY OF DATA AND MATERIALS

However, this is not applicable because of concerns about patient privacy.

DECLARATIONS

CONSENT FOR PUBLICATION

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images.

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

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