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Case Report

# A Successful Ventilatory Approach in a Severe Class 3 Obesity Patient Undergoing Robotic Gynecological Surgery

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## Abstract

**Background**: Robotic gynecologic surgery offers enhanced precision but requires Trendelenburg position and pneumoperitoneum, which can affect respiratory function, especially in patients suffering from obesity. Currently, there is limited evidence to establish the optimal ventilation strategy for severe Class 3 obesity patients undergoing robotic gynecologic surgery. **Case Presentation**: A 47-year-old woman with a body mass index of 60 kg/m$^2$ underwent a robotic-assisted hysterectomy and bilateral ovariectomy for endometrial cancer. Volume-controlled inverse ratio lung-protective mechanical ventilation with individualized positive end-expiratory pressure guided by driving pressure and mechanical power was used to manage the patient's ventilation. Her oxygenation remained stable throughout the surgery, and there was no evidence of postoperative pulmonary complications. **Conclusion**: Individualized positive end-expiratory pressure within the framework of volume-controlled inverse ratio lung-protective mechanical ventilation guided by driving pressure and mechanical power should be considered in severe Class 3 obesity patients undergoing robotic gynecologic surgery.

**Keywords**: Obesity; Ventilation; Positive-Pressure Respiration; Continuous Positive Airway Pressure; Robotic Surgical Procedures; Gynecologic Surgical Procedures; Complications.

## Introduction

Gynecologic robotic surgery enhances precision and outcomes, but involves steep Trendelenburg positioning and pneumoperitoneum, which can impair respiratory function and raise the risk of postoperative pulmonary complications (POPCs) [1]. Gynecologic robotic surgery is challenging in Class 3 obesity patients, who exhibit alterations in lung volumes and respiratory mechanical properties inversely correlated with BMI [2]. Under general anesthesia and pneumoperitoneum in a steep Trendelenburg position, a Class 3 obesity patient may experience a significant decrease in lung and chest wall compliance, worsening ventilation–perfusion mismatch, and increasing intrapulmonary shunting, which may result in intraoperative arterial hypoxemia and hypercapnia [1, 2]. Despite general suggestions to optimize ventilatory management during robotic surgery, the level of evidence to determine the optimal ventilation strategy is weak, and data are lacking in severe Class 3 obesity patients [1]. We contribute by reporting how individualized positive end-expiratory pressure (PEEP) within the framework of volume-controlled inverse ratio protective lung ventilation guided by driving pressure (DP) and mechanical power (MP), may play a pivotal role in the effective ventilation strategy for severe Class 3 obesity patients undergoing robotic gynecological surgery.

## Case Presentation

A 47-year-old woman (weight: 155 kg; height: 160 cm; BMI: 60 kg/m²) suffering from severe Class 3 obesity was scheduled for a robotic-assisted hysterectomy with a bilateral ovariectomy for endometrial cancer.

After overnight fasting, standard monitoring, including electrocardiogram, non-invasive blood pressure measurement, and pulse oximetry, was employed before placement of an intravenous line and premedication with dexamethasone 8 mg, cefazolin 3 g, and pantoprazole 40 mg.

After preoxygenation with the patient in the 20–30° reverse Trendelenburg position, anesthesia was sequentially induced using propofol 160 mg, fentanyl 0.2 mg, ketamine 30 mg, and rocuronium 80 mg.

After a video laryngoscopy-assisted tracheal intubation and a subsequent alveolar recruitment maneuver, consisting of manual inflation of the anesthesia reservoir bag to a peak inspiratory pressure of 40 cmH$_2$O sustained for 5 seconds, volume-controlled inverse ratio ventilation (FLOW-i® Ventilator, Getinge Group, Maquet Medical System, Milan, Italy) was instituted with a 40/60 oxygen/air mixture (see Figure 1 for ventilation settings). The FLOW-i® ventilator automatically displayed some ventilatory parameters (peak inspiratory pressure, inspiratory and expiratory minute volume, and tidal volume) and allowed us to calculate others (plateau pressure, static elastance, static compliance, total PEEP).

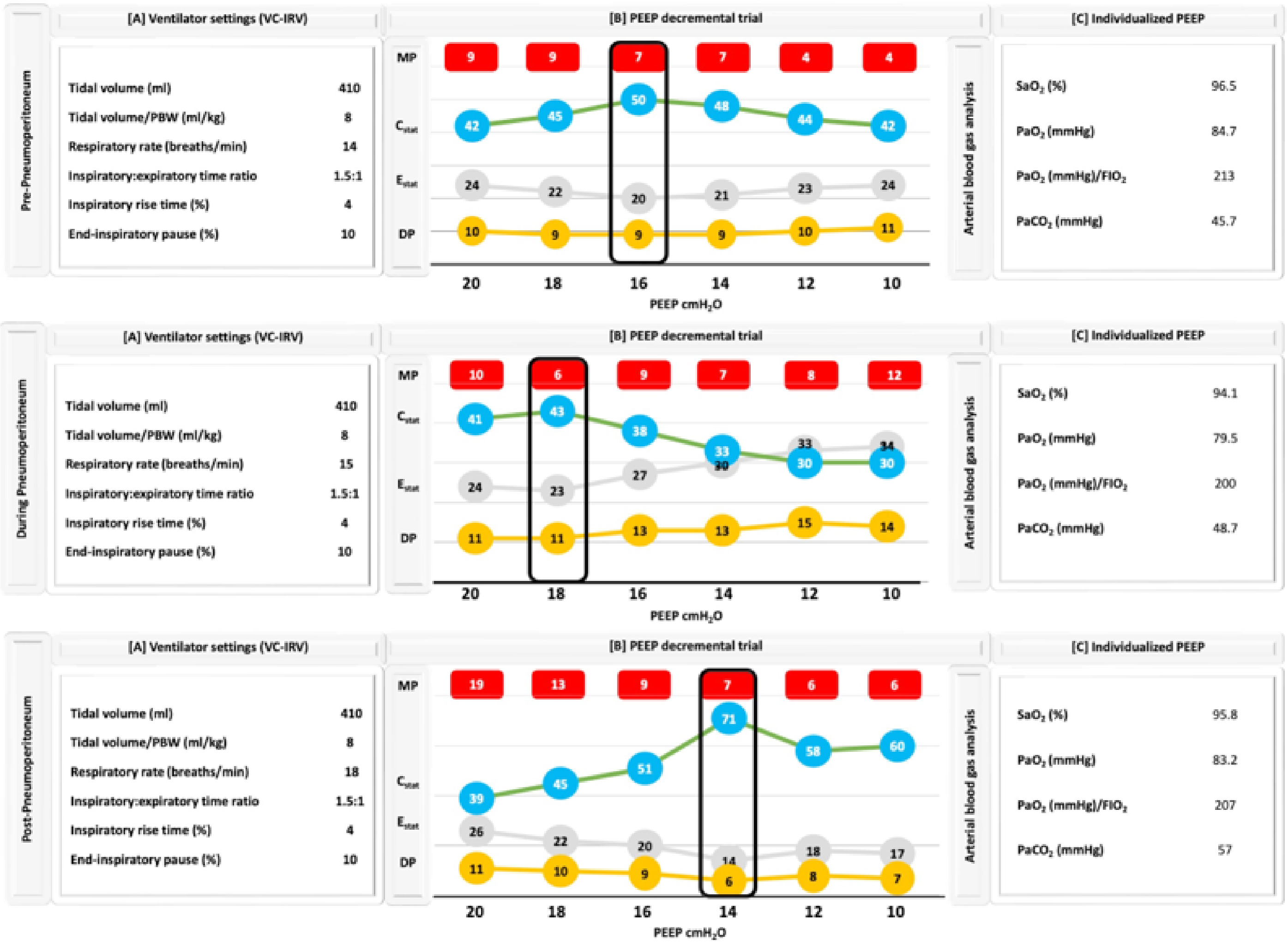


**Figure 1**: Intraoperative ventilation parameters, positive end-expiratory pressure decremental trials, and arterial blood gas analysis in a severe Class 3 obesity patient undergoing robotic-assisted hysterectomy with bilateral ovariectomy. Pre-pneumoperitoneum: 10 min before the institution of carbon dioxide pneumoperitoneum; during pneumoperitoneum: 10 min after the beginning of carbon dioxide pneumoperitoneum; post-pneumoperitoneum: 10 min after the end of carbon dioxide pneumoperitoneum. The patient was placed in the 20-30° reverse Trendelenburg position. (A) Ventilator settings. VC-IRV: volume-controlled inverse ratio ventilation with individualized positive end-expiratory pressure (PEEP) (black frame); PBW: predicted body weight. Before the first PEEP decremental trial, the starting PEEP was 10 cmH$_2$O. (B) PEEP decremental trial. To find the individualized PEEP (black frame), PEEP was set at 20 cmH$_2$O and then decreased in 2-cmH$_2$O steps to 10 cmH$_2$O after calculation of static elastance ($E_{stat}$, cmH$_2$O/l), static compliance (Cstat, ml/cmH$_2$O), driving pressure (DP, cmH$_2$O) measured as plateau pressure (cmH$_2$O) minus PEEP (cmH$_2$O), and mechanical power (MP, J/min), according to a simple equation proposed for volume-controlled ventilation. [3] The FLOW-i® ventilator required a 5-sec inspiratory hold and 5-sec expiratory hold to calculate plateau pressure, total PEEP, $E_{stat}$, and $C_{stat}$, as suggested by the manufacturer. (C) Individualized PEEP (black frame). Arterial blood gas analysis observed after 10 min of the choice of individualized PEEP, after the PEEP decremental trial.

Anesthesia was then maintained with sevoflurane and remifentanil titrated to ensure a bispectral index value of 40-50. As part of multimodal analgesia, ketamine 70 mg was administered (50 mg with clonidine 0.1 mg pre-pneumoperitoneum, and 20 mg post-pneumoperitoneum), accompanied by continuous infusions of magnesium 4 g and lidocaine 200 mg during anesthesia maintenance. A clinically validated electromyography neuromuscular function monitor (TwitchView® Monitor, Blink Device Company, Seattle, Washington, United States of America) was adopted, as per the manufacturer's recommendations, to ensure a deep block level (post-tetanic counts 1-5) during the surgery and a full recovery at the end.

Invasive blood pressure was adopted, and a central venous line was placed under ultrasound guidance.

Then, before starting surgery, with the patient placed in the 20–30° Trendelenburg position, a PEEP decremental trial was performed to find the individualized PEEP, as suggested by the best combination of static elastance, static compliance, and DP, measured as plateau pressure minus PEEP. PEEP was set at 20 cmH$_2$O and then decreased in 2-cmH$_2$O steps to 10 cmH$_2$O, registering all ventilatory and respiratory parameters at each PEEP level. A simple equation proposed for volume-controlled ventilation to estimate the MP [3] was used to support the choice of the individualized PEEP. The PEEP decremental trial was performed before, during, and after pneumoperitoneum (see Figure 1 for PEEP decremental trials). Intra-abdominal pressure was placed at 12 mmHg and maintained unaltered throughout the surgery, resulting in an adequate surgical view.

Arterial oxygenation remained substantially stable during surgery. An increased respiratory rate was sufficient to manage pneumoperitoneum-induced hypercapnia, effectively returning to baseline value by the end of the procedure (see Figure 1 for arterial blood gas analysis). The cardiovascular parameters were stable throughout the surgical procedure.

At the conclusion of the uneventful 2-hour surgery, remifentanil was discontinued. Ondansetron 8 mg and ketorolac 30 mg were given for postoperative nausea and vomiting, and pain prophylaxis, respectively. A bilateral ultrasound-guided transversus abdominis plane block was performed using a total of 40 ml of ropivacaine 0.25%. Sugammadex 620 mg was administered to reverse the deep rocuronium-induced neuromuscular block (from five post-tetanic counts to a train-of-four ratio of 1.0 in 80 seconds). Sevoflurane was then discontinued, the patient awakened, and the tracheal tube removed 10 minutes later. The patient had no pain, postoperative nausea and vomiting, or signs of respiratory failure in the post-anesthesia care unit. She was discharged home after four days without any complications.

## Discussion

Intraoperative lung-protective mechanical ventilation comprises low tidal volume (e.g., tidal volume 6-8 ml/kg), limited inspiratory pressure (e.g., plateau pressure <30 $cmH_2O$), and the application of PEEP [2]. It is a strategy utilized to mitigate the risk of ventilator-induced lung injury that arises from alveolar overdistention, repeated recruitment and collapse, or atelectasis [2, 4, 5], thereby diminishing the risk of POPCs [6].

Class 3 obesity patients often exhibit compromised intraoperative pulmonary mechanics resulting in elevated airway plateau and driving pressures, increased lung elastance, and reduced end-expiratory transpulmonary pressures [2,7]. Intraoperative lung-protective mechanical ventilation may benefit from higher PEEP levels [2], which showed to enhance intraoperative lung ventilation and oxygenation [7] and improve postoperative outcomes by significantly reducing the risk of acute hypoxic respiratory failure [8].

Pneumoperitoneum and Trendelenburg positioning further impact intraoperative pulmonary mechanics in Class 3 obesity patients undergoing robotic laparoscopic surgery [5]. However, the degree of impairment varies widely among patients suffering from obesity, despite using a lung-protective ventilation strategy [5].

So, monitoring tidal cycle mechanics is crucial for lung protection [9, 10]. Measuring respiratory compliance provides valuable insights into the respiratory system's mechanical properties [9]. Additionally, compliance determines the DP required to inflate the lungs with a specific tidal volume [9]. DP is an important mediator of ventilator-induced lung injury [2, 4, 9]. Adjusting PEEP and tidal volume can potentially reduce DP [4]. An inverse inspiratory-to-expiratory time ratio may further contribute by increasing functional residual capacity, reducing peak and plateau pressures, and improving respiratory mechanics, as observed in patients suffering from obesity undergoing gynecologic robotic surgery [10].

At a fixed tidal volume, the role of PEEP is crucial for DP [4]. While a moderate PEEP (4–8 $cmH_2O$) seems to be associated with better outcomes in patients undergoing robotic surgery [1], higher individualized PEEP is necessary in Class 3 obesity patients [5] to restore end-expiratory lung volume, regional ventilation distribution, and oxygenation during anesthesia [7]. However, increasing PEEP should not be accompanied by an increase in DP [2,4]. Changes in PEEP levels that lead to increased DP are associated with a significantly higher incidence of POPCs in adults undergoing noncardiac surgery [11].

Individualized PEEP settings can vary significantly among patients suffering from obesity. In cases of Class 3 obesity, a PEEP of 20 $cmH_2O$ or higher may be required to sustain optimal lung ventilation during procedures involving pneumoperitoneum or Trendelenburg positioning [5]. During robotic laparoscopic abdominal surgery, PEEP levels should be adjusted based on BMI and the specific surgical stage [5], but it is crucial to tailor intraoperative lung-protective mechanical ventilation individually, taking into account not only the patient's current physiological state but also their responses to treatment. DP should, then, be considered as a guide for the individualized PEEP [2, 4]. However, an individualized MP-based ventilation strategy may also be considered. MP is a novel concept that shows promise as an indicator of ventilator-induced lung injury. The MP, including tidal volume, respiratory rate, inspiratory flow, peak pressure, and PEEP in the equation, may help to estimate better than DP the contribution of the different ventilator-related causes of lung injury and their variations [3]. At the moment, a value of 18 J/min seems to discriminate the outcome [3]. In an experimental setting, mechanical ventilation is associated with lung injury even at low MP. The best compromise between severe histological injury and gas exchange was achieved at respiratory system MPs between 3 and 7 J/min [12].

Opioid-sparing anesthesia employing multimodal analgesia techniques, such as local anesthetics, should be utilized to minimize opioid-induced adverse respiratory effects in Class 3 obesity patients following surgery [2]. Deep neuromuscular blockade, compared to moderate, optimizes the view of the surgical field and has been shown to improve perioperative care [13]. A complete reversal of neuromuscular blockade, evaluated through quantitative monitoring of neuromuscular function, is recommended to enhance patient recovery [13]. Compared to neostigmine, sugammadex appears to further reduce the risk of POPCs (Relative Risk 0.31) [14].

## Conclusion

Adopting an intraoperative lung-protective mechanical ventilation combining a volume-controlled inverse ratio ventilation and individualized PEEP after the recruitment maneuvre may be an effective strategy to improve lung function and oxygenation

[2,10,15]. DP [4] and MP [3] should be adopted in the context of lung-protective mechanical ventilation [2] to optimize the ventilatory management of Class 3 obesity patients in any stage of robotic gynecological surgery.

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**Ethical Considerations:** This article adheres to the applicable Enhancing the Quality and Transparency of Health Research (EQUATOR) guidelines using the Case Reports (CARE) checklist. An Institutional Review Board approval was not required for this single-patient case report. Written informed consent from the patient was obtained for the publication of this case report.

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