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OUTCOME OF LOW TIDAL VOLUME PLUS HIGH PEEP VERSUS CONVENTIONAL VENTILATION IN OBESE PATIENTS UNDER GENERAL ANESTHESIA

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Abstract

Background: Obesity is a major global health concern associated with altered respiratory mechanics, increased airway resistance, and reduced lung compliance. These changes increase the risk of postoperative pulmonary complications (PPCs) in obese patients undergoing general anesthesia. Optimizing intraoperative ventilation strategies is critical to minimize lung injury and improve postoperative outcomes.**Aim**: To compare the outcomes of low tidal volume (V_T) ventilation combined with high positive end-expiratory pressure (PEEP) versus conventional ventilation in obese patients undergoing elective surgery under general anesthesia.**Methods**: This prospective randomized controlled study was conducted at the Department of Anesthesiology and Surgical ICU, Sher-e-Kashmir Institute of Medical Sciences (SKIMS), Soura, from January 2022 to December 2024. A total of 120 adult obese patients (BMI ≥30 kg/m²) scheduled for elective abdominal or laparoscopic surgery were enrolled. Patients were randomized into two groups: Group A (n=60) received low V_T (6–8 ml/kg predicted body weight) plus high PEEP (10–12 cm H_2O), and Group B (n=60) received conventional ventilation (10–12 ml/kg tidal volume, PEEP 4–6 cm H_2O). Primary outcomes included incidence of PPCs within 48 hours. Secondary outcomes were intraoperative oxygenation (PaO2/FiO2 ratio), peak and plateau airway pressures, hemodynamic stability, and duration of ICU stay. Data were analyzed using Student's t-test and Chi-square test; $p<0.05$ was considered significant. **Results**: Both groups were comparable in demographic and surgical characteristics. Group A demonstrated significantly lower peak (22 ± 3 vs 28 ± 4 cm H_2O, $p<0.001$) and plateau pressures (18 ± 2 vs 24 ± 3 cm H_2O, $p<0.001$). Postoperative oxygenation was superior in Group A at 1 hour (320 ± 25 vs 290 ± 30, $p<0.001$) and 6 hours (330 ± 28 vs 295 ± 35, $p<0.001$) post-extubation. The incidence of PPCs, including hypoxemia (10% vs 23.3%, p=0.04), atelectasis (8.3% vs 21.6%, p=0.03), and need for supplemental oxygen (13.3% vs 30%, p=0.02), was lower in Group A. Hemodynamic parameters were comparable between groups. **Conclusion**: Low tidal volume ventilation combined with high PEEP improves intraoperative oxygenation, reduces peak and plateau airway pressures, and decreases the incidence of postoperative pulmonary complications in obese patients undergoing general anesthesia. This strategy provides safe and effective lung-protective ventilation, supporting its use as the preferred approach in this high-risk population.

Keywords: Obesity, general anesthesia, low tidal volume ventilation, positive end-expiratory pressure, postoperative pulmonary complications, intraoperative oxygenation.

Introduction

Obesity has become a major global health challenge, with over 650 million adults worldwide classified as obese . In India, the prevalence of obesity is rising steadily in both urban and rural populations, and in the Kashmir region, approximately 20% of adults are obese [1]. This increase has significant implications for perioperative care, as obesity is associated with multiple comorbidities including type 2 diabetes mellitus, hypertension, and cardiovascular diseases [2].

Obesity induces profound changes in respiratory mechanics. Functional residual capacity (FRC) and expiratory reserve volume (ERV) are reduced, while chest wall and lung compliance decrease, predisposing patients to atelectasis and hypoxemia during general anesthesia [2,3]. Increased intra-abdominal pressure in obese individuals elevates the diaphragm, further reducing lung volumes. Additionally, airway resistance is increased and the prevalence of obstructive sleep apnea is higher, complicating both intraoperative ventilation and postoperative recovery [2,3].

Obese patients are at heightened risk for postoperative pulmonary complications (PPCs), such as atelectasis, pneumonia, and acute respiratory distress syndrome (ARDS). These complications contribute to increased morbidity, prolonged hospital stays, and higher healthcare costs [3]. The risk of PPCs is especially high in abdominal and thoracic surgeries due to combined effects of obesity-related respiratory changes and surgical stress [3].

Mechanical ventilation strategies are critical in reducing PPCs in obese surgical patients. Low tidal volume (V_T) ventilation, initially established in ARDS patients, minimizes alveolar overdistension and ventilator-induced lung injury [4]. High positive end-expiratory pressure (PEEP) is employed to prevent alveolar collapse and maintain oxygenation during surgery [4]. Conversely, conventional ventilation strategies, which often use higher tidal volumes and lower PEEP, may increase the risk of lung injury and postoperative complications [4].

A randomized controlled trial by Masud et al. (2025) evaluated the effect of higher PEEP (10 cm H_2O) versus lower PEEP (5 cm H_2O) in overweight patients (BMI 25–30) undergoing elective laparoscopic hernia surgery. The study found a significant reduction in postoperative pulmonary complications (PPCs) in the high PEEP group, with lower rates of atelectasis (6% vs 16%) and improved intraoperative oxygenation, although minor increases in mean arterial pressure were noted. These findings support the protective role of moderate to high PEEP levels in at-risk surgical populations and align with the present study's results that lung-protective ventilation reduces PPCs in obese patients [5].These findings highlight the importance of individualized ventilation strategies, taking into account patient-specific factors such as body mass index, intra-abdominal pressure, and respiratory mechanics [6].

Despite advances in understanding ventilatory strategies, the optimal approach for obese patients undergoing general anesthesia remains uncertain. Advanced monitoring techniques, such as esophageal pressure measurement and electrical impedance tomography, are being explored to optimize ventilator settings [6]. This study aims to compare low tidal volume plus high PEEP versus conventional ventilation in obese patients undergoing general anesthesia, evaluating postoperative pulmonary complications, intraoperative hemodynamic stability, and postoperative oxygenation parameters.

Materials and Methods

Study Design

This prospective randomized controlled study was conducted in the Department of Anesthesiology and Surgical ICU at Sher-e-Kashmir Institute of Medical Sciences (SKIMS), Soura. The study period extended from January 2022 to December 2024. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Sample Size and Patient Selection

A total of 120 adult patients with body mass index (BMI) ≥30 kg/m², scheduled for elective abdominal or laparoscopic surgery under general anesthesia, were enrolled.

Inclusion Criteria:
* Age 18–65 years
* BMI ≥30 kg/m²
* ASA physical status II–III
* Elective surgery requiring general anesthesia with endotracheal intubation

Exclusion Criteria:
* Severe pulmonary disease (COPD, pulmonary fibrosis)
* Cardiac failure (EF <40%)
* Pregnancy
* Emergency surgery
* Preoperative oxygen requirement

Patients were randomly assigned into two groups (n=60 each) using computer-generated random numbers:
* Group A (intervention group): Low tidal volume (6–8 ml/kg predicted body weight) plus high PEEP (10–12 cm H_2O)
* Group B (control group): Conventional ventilation (10–12 ml/kg tidal volume, PEEP 4–6 cm H_2O)

Anesthetic Protocol

All patients received standardized anesthetic management:
1. Premedication: Midazolam 0.02 mg/kg IV, Fentanyl 2 µg/kg IV
2. Induction: Propofol 2 mg/kg IV, Rocuronium 0.6 mg/kg IV
3. Maintenance: Sevoflurane 1–2% with 50% O_2/N_2O mixture
4. Ventilation: According to group allocation

In both groups, respiratory rate was adjusted to maintain end-tidal CO_2 between 35–45 mmHg. Peak inspiratory pressure and plateau pressures were monitored continuously.

Intraoperative Monitoring
* ECG, NIBP, SpO_2, and $EtCO_2$ were monitored continuously
* Arterial blood gas (ABG) analysis was performed at baseline, 30 min, 60 min, and at the end of surgery
* Hemodynamic parameters (heart rate, mean arterial pressure) were recorded at 5-min intervals

Outcome Measures

Primary Outcome:
* Incidence of postoperative pulmonary complications (PPCs) within 48 hours, including atelectasis, hypoxemia (PaO_2 <80 mmHg), and need for postoperative oxygen supplementation

Secondary Outcomes:
* Intraoperative oxygenation (PaO2/FiO2 ratio)
* Peak and plateau airway pressures
* Hemodynamic stability (MAP, HR)
* Duration of postoperative ICU stay

Data Collection and Statistical Analysis
Demographic data, surgical duration, and ventilatory parameters were recorded. Continuous variables were expressed as mean ± SD, and categorical variables as percentages. Student's t-test was used for continuous variables, and Chi-square test for categorical variables. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 25.0.

Results
The study included 120 obese patients undergoing elective surgery, randomized into Group A (low tidal volume + high PEEP, n=60) and Group B (conventional ventilation, n=60). Both groups were comparable with respect to age, gender, BMI, ASA status, and duration of surgery (Table 1). There were no statistically significant differences between the groups.

Table 1: Demographic Data of Study Participants (n=120)

Parameter	**Group A (Low V_T + High PEEP)**	**Group B (Conventional Ventilation)**	**p-value**
Number of patients	60	60	--
Age (years)	45.2 ± 10.1	46.0 ± 9.8	0.65
Gender (M/F)	32/28	34/26	0.68
BMI (kg/m²)	34.5 ± 3.2	34.8 ± 3.5	0.58
ASA II/III	38/22	36/24	0.72
Duration of surgery (min)	125 ± 30	128 ± 28	0.54

Intraoperative ventilatory parameters such as tidal volume, PEEP, peak airway pressure, and plateau pressure were recorded. Group A maintained lower tidal volumes with higher PEEP, resulting in lower peak pressures compared to Group B (Table 2).

Table 2: Intraoperative Ventilatory Parameters

Parameter	**Group A (Low V_T + High PEEP)**	**Group B (Conventional Ventilation)**	**p-value**
Tidal volume (ml/kg PBW)	7 ± 0.5	11 ± 0.8	<0.001
PEEP (cm H_2O)	11 ± 1	5 ± 0.5	<0.001
Peak airway pressure (cm H_2O)	22 ± 3	28 ± 4	<0.001
Plateau pressure (cm H_2O)	18 ± 2	24 ± 3	<0.001

The incidence of postoperative pulmonary complications within 48 hours, including hypoxemia, atelectasis, and requirement for supplemental oxygen, was lower in Group A compared to Group B (Table 3).

Table 3: Postoperative Pulmonary Complications

Complication	**GroupA (n=60)**	**Group B (n=60)**	**p-value**
Hypoxemia (PaO_2 <80 mmHg)	6 (10%)	14 (23.3%)	0.04
Atelectasis (clinically/radiologic)	5 (8.3%)	13 (21.6%)	0.03
Need for supplemental oxygen	8 (13.3%)	18 (30%)	0.02
ICU stay >24 h	4 (6.6%)	10 (16.6%)	0.08

Postoperative arterial oxygenation was assessed using PaO_2/FiO_2 ratio at 1 hour and 6 hours post-extubation. Group A showed higher oxygenation levels than Group B (Table 4).

Table 4: Postoperative Oxygenation Parameters

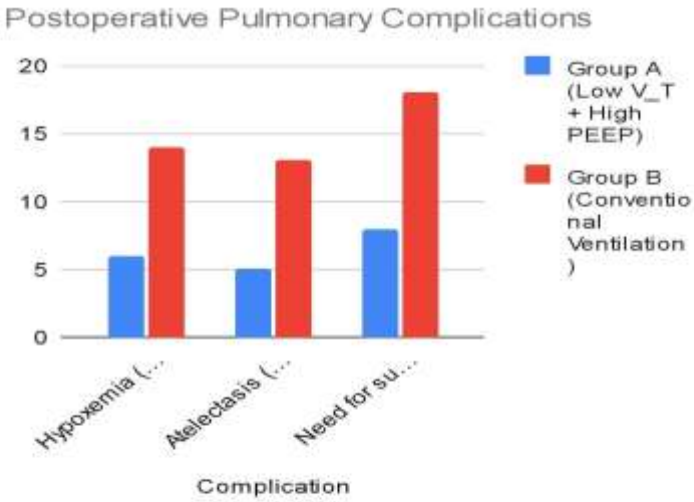
Time Point	Group A (Low V_T + High PEEP)	Group B (Conventional Ventilation)	p-value
PaO_2/FiO_2 ratio at 1 h	320 ± 25	290 ± 30	<0.001
PaO_2/FiO_2 ratio at 6 h	330 ± 28	295 ± 35	<0.001

Hemodynamic parameters including mean arterial pressure (MAP) and heart rate (HR) were recorded at 5-min intervals. Both groups maintained stable hemodynamics, though minor transient decreases in MAP were observed in Group A due to higher PEEP (Table 5).

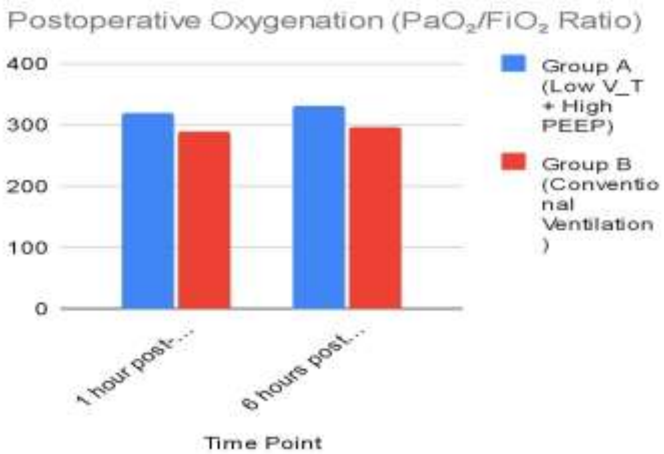
Table 5: Intraoperative Hemodynamic Parameters

Parameter	Group A (Low V_T + High PEEP)	Group B (Conventional Ventilation)	p-value
Mean arterial pressure (mmHg)	82 ± 6	85 ± 7	0.08
Heart rate (beats/min)	78 ± 8	80 ± 9	0.30
Episodes of hypotension (<65 mmHg)	5 (8.3%)	3 (5%)	0.45

Bar graph 1: Postoperative Pulmonary Complications.



Bar graph 2 : Postoperative Oxygenation (PaO_2/FiO_2) Ratio.



Discussion

This prospective randomized controlled trial compared the effects of low tidal volume ventilation with high positive end-expiratory pressure (PEEP) versus conventional ventilation in obese patients undergoing elective surgery under general anesthesia. The findings clearly demonstrated that the

lung-protective strategy (Group A) was associated with improved oxygenation, lower peak and plateau airway pressures, and a reduced incidence of postoperative pulmonary complications (PPCs) compared to conventional ventilation (Group B).
The lower peak and plateau pressures observed in Group A highlight the protective effect of smaller tidal volumes combined with higher PEEP. Obese patients are particularly vulnerable to increased airway pressures and atelectasis due to reduced lung compliance and elevated intra-abdominal pressure. By lowering tidal volumes and maintaining alveolar recruitment with higher PEEP, Group A achieved more favorable ventilatory mechanics. Similar results have been reported by Futier et al., who showed that low tidal volume ventilation significantly reduced pulmonary stress and strain during surgery [3]. Oxygenation outcomes further support the efficacy of the intervention strategy. Group A demonstrated significantly higher PaO_2/FiO_2 ratios both at 1 hour and 6 hours post-extubation, indicating sustained improvement in postoperative pulmonary gas exchange. Nestler et al. Also found that individualized PEEP levels in obese patients enhanced oxygenation and prevented alveolar collapse during anesthesia [7]. These findings confirm that adequate PEEP titration plays a crucial role in optimizing oxygenation in this high-risk population.
The incidence of PPCs, including hypoxemia, atelectasis, and the need for supplemental oxygen, was notably lower in Group A in our study. These findings are consistent with the randomized trial by Vijayakumar et al., which demonstrated that higher PEEP (10 cm H_2O) significantly reduced the incidence of postoperative pulmonary complications compared to lower PEEP (5 cm H_2O) in overweight patients undergoing laparoscopic hernia surgery [9]. This supports the role of protective ventilation strategies in improving oxygenation and reducing pulmonary morbidity, particularly in patients at increased risk. This suggests that while our findings support the benefit of lung-protective strategies, larger multicenter studies are needed to confirm their generalizability.Importantly, the current study reinforces the clinical applicability of lung-protective strategies not only in critically ill patients but also in obese surgical candidates who face elevated risks for perioperative respiratory compromise. Hemodynamic parameters remained stable in both groups, although minor, transient decreases in mean arterial pressure were more frequent in the high PEEP group. These changes were not statistically significant and did not translate into adverse clinical outcomes. Ferrando et al. Reported similar observations, noting that while higher PEEP can mildly influence preload and cardiac output, the effects are generally well tolerated in anesthetized patients [8]. Thus, the use of high PEEP in the obese surgical population appears to be safe when applied within moderate limits and under vigilant monitoring. The present study contributes important evidence in favor of using lung-protective ventilation strategies in obese patients, a group often underrepresented in randomized trials. However, certain limitations must be acknowledged. First, this was a single-center trial with a modest sample size, which may limit generalizability. Second, the follow-up was restricted to the immediate 48-hour postoperative period, and longer-term outcomes such as hospital length of stay, readmission rates, or pulmonary function recovery were not assessed. Finally, recruitment maneuvers were not standardized, which may have influenced the degree of alveolar recruitment achieved in some patients.
Despite these limitations, the study provides strong evidence that low tidal volume ventilation combined with higher PEEP is both safe and beneficial in obese surgical patients. By improving oxygenation, minimizing airway pressures, and reducing the incidence of PPCs without compromising hemodynamic stability, this approach represents a rational, evidence-based ventilatory strategy for this vulnerable population.

Conclusion

In this prospective randomized study of obese patients undergoing elective surgery under general anesthesia, low tidal volume ventilation combined with high positive end-expiratory pressure (PEEP) was associated with improved intraoperative oxygenation, lower peak and plateau airway pressures, and a reduced incidence of postoperative pulmonary complications compared to conventional ventilation.

Group A (low V_T + high PEEP) demonstrated significantly higher PaO2/FiO2 ratios postoperatively, fewer cases of hypoxemia and atelectasis, and a reduced requirement for supplemental oxygen, without clinically significant hemodynamic compromise. These findings support the application of lung-protective ventilation strategies in obese surgical patients to minimize ventilator-induced lung injury and improve postoperative pulmonary outcomes.
Despite these encouraging results, individualized ventilatory strategies considering patient-specific factors such as body mass index, intra-abdominal pressure, and respiratory mechanics may further optimize outcomes. Multicenter studies with larger sample sizes and long-term follow-up are warranted to validate these findings and determine the impact on postoperative recovery and overall morbidity.
In conclusion, low tidal volume ventilation with appropriately titrated high PEEP represents an effective and safe ventilatory approach in obese patients undergoing general anesthesia, offering improved pulmonary protection and better postoperative respiratory outcomes compared to conventional ventilation strategies.

Conflict of interest: Nil
Funding: Nil

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