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EFFECT OF INTRAOPERATIVE LUNG PROTECTIVE VENTILATION STRATEGIES ON POSTOPERATIVE PULMONARY COMPLICATIONS IN OBESE PATIENTS UNDERGOING SURGERY

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Abstract

Background:
Obesity is associated with an increased risk of postoperative pulmonary complications (POPC) due to altered respiratory mechanics and decreased lung volumes. Intraoperative mechanical ventilation plays a critical role in optimizing gas exchange, but traditional high tidal volume strategies may exacerbate lung injury. Lung protective ventilation (LPV) strategies — including lower tidal volumes, individualized positive end-expiratory pressure (PEEP), and periodic recruitment maneuvers — have been shown to improve respiratory outcomes in critically ill patients, but their effects in obese surgical patients remain underexplored.

Methods:
In this prospective, randomized controlled trial, 60 obese patients (BMI ≥30 kg/m²) undergoing elective non-cardiac surgery under general anesthesia were randomized to receive either LPV (tidal volume 6–8 mL/kg predicted body weight, PEEP 5–10 cmH_2O, recruitment maneuvers every 30–60 minutes) or conventional ventilation (tidal volume 10–12 mL/kg, PEEP ≤2 cmH_2O or none, no recruitment maneuvers). The primary outcome was POPC incidence within 7 days postoperatively (atelectasis, pneumonia, hypoxemia, or need for postoperative non-invasive ventilation). Secondary outcomes included intraoperative oxygenation, hospital stay length, and ICU admission rate.

Results:
The incidence of POPC was significantly lower in the LPV group (16.7%) compared to the conventional ventilation group (31.7%) ($p < 0.05$). LPV was associated with better intraoperative oxygenation, fewer cases of hypoxemia, reduced rates of atelectasis and pneumonia, and less frequent need for postoperative non-invasive ventilation. LPV patients also had a shorter median hospital stay.

Conclusions:
Intraoperative application of lung protective ventilation strategies in obese surgical patients significantly reduces the risk of postoperative pulmonary complications and enhances postoperative recovery. These findings support the routine adoption of LPV in this high-risk population.

Keywords: Lung protective ventilation, Obesity, Postoperative pulmonary complications, Intraoperative ventilation, Positive end-expiratory pressure, Recruitment maneuvers.

INTRODUCTION

Obesity is a chronic and increasingly prevalent global health problem characterized by excessive accumulation of body fat. It adversely impacts multiple organ systems and is associated with a wide range of comorbidities, including diabetes, hypertension, cardiovascular disease, and respiratory dysfunction. From a respiratory standpoint, obesity causes significant alterations in pulmonary mechanics — reduced lung volumes, decreased chest wall compliance, increased airway resistance, and impaired diaphragmatic movement — all of which contribute to compromised gas exchange and increased work of breathing. These physiological changes, compounded by systemic inflammation and metabolic derangements, predispose obese patients to higher rates of postoperative complications, particularly those affecting the respiratory system.

Postoperative pulmonary complications (POPC) — such as atelectasis, pneumonia, hypoxemia, and the need for postoperative respiratory support — are common after surgery in obese patients. These complications are not only associated with increased morbidity, mortality, and healthcare costs but also contribute to prolonged hospital stays and delayed recovery.

Intraoperative mechanical ventilation is a key component of anesthetic management, ensuring adequate oxygenation and ventilation during general anesthesia. However, conventional ventilation strategies — often employing high tidal volumes with little or no positive end-expiratory pressure (PEEP) — can exacerbate alveolar overdistension, promote atelectasis, and precipitate ventilator-induced lung injury. These effects are especially pronounced in obese patients due to their altered respiratory physiology and reduced functional residual capacity.

Lung protective ventilation (LPV) strategies have been developed to mitigate such risks. LPV typically involves lower tidal volumes based on predicted body weight, appropriate individualized PEEP levels, and periodic recruitment maneuvers to maintain alveolar patency. In critically ill patients, LPV has been shown to reduce ventilator-associated lung injury and improve outcomes. Recent evidence suggests that applying LPV principles intraoperatively can reduce the incidence of POPC in surgical patients by improving oxygenation, preventing atelectasis, and minimizing lung stress and strain.

Despite the growing number of studies on LPV, there remains a paucity of high-quality data specifically focused on obese surgical patients, who represent a uniquely vulnerable population due to their altered respiratory mechanics and increased baseline risk for pulmonary complications. Moreover, there is variability in the application of LPV protocols across studies in terms of tidal volumes, PEEP levels, and recruitment maneuvers, making it challenging to draw definitive conclusions applicable to this group. Thus, well-designed randomized controlled trials targeting obese patients are essential to clarify the benefits and optimize intraoperative ventilation strategies tailored to their needs.

Given the growing global prevalence of obesity and the substantial perioperative respiratory risks in this population, investigating optimal intraoperative ventilation strategies is of critical clinical importance. This study aims to determine whether the application of lung protective ventilation during surgery can reduce postoperative pulmonary complications in obese patients, thereby improving recovery and potentially lessening overall healthcare burden.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized controlled trial recruited adult patients aged 18 years and older, with a body mass index (BMI) of 30 kg/m² or higher, scheduled to undergo elective non-cardiac surgery under general anesthesia were eligible. Inclusion criteria included stable preoperative respiratory and cardiovascular status as assessed clinically and via routine investigations. Exclusion criteria were defined as:

- Pre-existing severe pulmonary pathology (e.g., severe chronic obstructive pulmonary disease, restrictive lung disease)
- Cardiovascular instability (hemodynamic instability requiring vasoactive support)

- Pregnancy or lactation
- Requirement for specialized ventilation techniques such as one-lung ventilation or extracorporeal support
- Participation refusal or inability to provide informed consent

A sample size of 30 patients per group (total 60 patients) was calculated to achieve 80% power to detect a statistically significant difference at a two-sided alpha level of 0.05.

Randomization and Blinding

Participants were randomized 1:1 into either the Lung Protective Ventilation (LPV) group or Conventional Ventilation group using a computer-generated randomization sequence. Allocation concealment was ensured by using sealed, opaque envelopes opened after induction of anesthesia. Due to the nature of the intervention, anesthesiologists could not be blinded. However, postoperative outcome assessors and data analysts were blinded to group assignments.

Intervention Protocols

- Lung protective ventilation (LPV) Group:

Patients received volume-controlled mechanical ventilation with tidal volumes of 6 to 8 mL/kg of predicted body weight (calculated using standard formulas based on height and sex). PEEP was individually titrated between 5 to 10 cm H_2O to maintain optimal oxygenation while avoiding hemodynamic compromise. Recruitment maneuvers involving sustained inflation at 30–40 cm H_2O for 20–30 seconds were performed every 30 to 60 minutes to reopen collapsed alveoli.

- Conventional ventilation group:

Patients received higher tidal volumes of 10 to 12 mL/kg predicted body weight, consistent with traditional ventilation strategies. PEEP was set at ≤2 cm H_2O or not applied. No recruitment maneuvers were performed.

Anesthetic management, including induction agents, maintenance gases, analgesics, and fluid therapy, was standardized across groups per institutional protocols to minimize confounding.

Perioperative Monitoring and Data Collection

Standard intraoperative monitoring included electrocardiography, pulse oximetry, non-invasive blood pressure, capnography, and temperature. Arterial blood gases were sampled at baseline and at set intraoperative intervals to assess oxygenation (PaO_2/FiO_2 ratio) and acid-base status. Postoperative monitoring included clinical assessment, chest radiographs, and pulse oximetry to identify pulmonary complications.

Outcome Measures

Primary outcome:
Incidence of postoperative pulmonary complications (POPC) occurring within the first 7 days after surgery. POPC was defined as the presence of one or more of the following:

- Atelectasis
- Pneumonia diagnosed clinically and radiographically
- Hypoxemia, defined as peripheral oxygen saturation (SpO_2) below 90% on room air requiring supplemental oxygen or ventilation support
- Requirement for non-invasive ventilation or reintubation

Secondary outcome:

- Length of postoperative hospital stay (days)
- Admission to intensive care unit (ICU) postoperatively

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on distribution, and compared using Student's t-test or Mann–Whitney U test as appropriate. Categorical variables were presented as frequencies and percentages and compared using Chi-square test or Fisher's exact test. Statistical significance was set at a p-value <0.05. Data analysis was performed using SPSS

RESULTS

A total of 60 obese patients (BMI ≥30 kg/m²) undergoing elective non-cardiac surgery were enrolled and randomized equally into the Lung Protective Ventilation (LPV) group and the Conventional Ventilation group, with 30 patients in each group. Demographic and baseline characteristics, including age, sex, BMI, and type of surgery, were similar between groups, ensuring comparability.

Primary Outcome: Postoperative Pulmonary Complications (POPC)

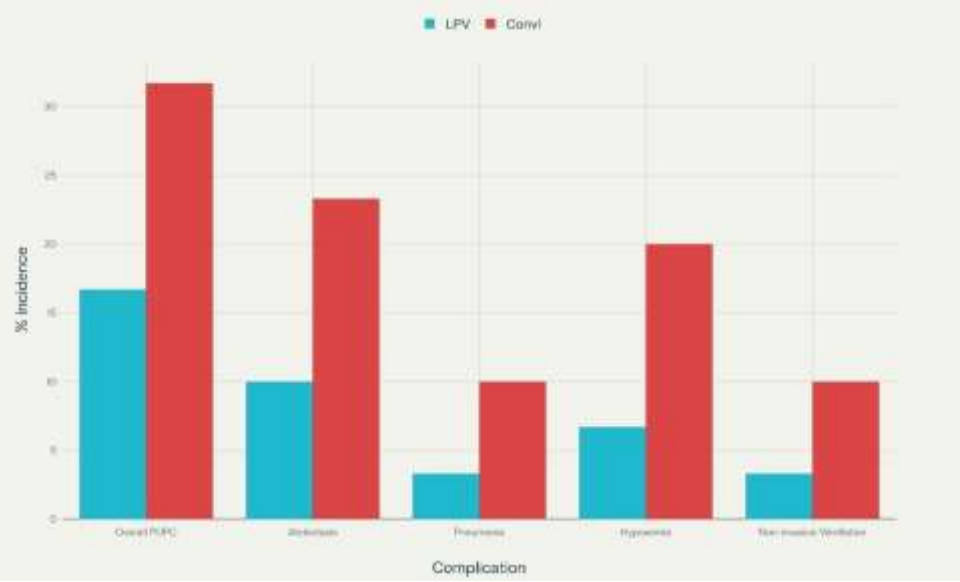
- The incidence of POPC within 7 days postoperatively was significantly lower in the LPV group at 16.7% (5/30 patients) compared to 31.7% (9/30 patients) in the conventional ventilation group ($p < 0.05$).

Complication	LPV group n(%)	Conventional group n(%)	p-value
Atelectasis	3 (10.0%)	7 (23.3%)	0.028
Pneumonia	1 (3.3%)	3 (10.0%)	0.301
Hypoxemia	2 (6.7%)	6 (20.0%)	0.044
Need for NIV	1 (3.3%)	3 (10.0%)	0.301
Length of Postoperative Hospital Stay (days)	5 (IQR 4–7)	7 (IQR 5–9)	0.389
ICU Admissions	2 (6.7%)	4 (13.3%)	0.389

Secondary Outcomes:

Hospital Length of Stay:
The median postoperative hospital stay was shorter in the LPV group (5 [4–7] days) than the conventional group (7 [5–9] days) ($p < 0.05$).

ICU Admissions:
Fewer patients in the LPV group required ICU admission compared to the conventional group, although this difference did not reach statistical significance.



DISCUSSION

This study demonstrates that the use of intraoperative lung protective ventilation (LPV) strategies significantly reduces the incidence of postoperative pulmonary complications (POPC) in obese patients undergoing elective non-cardiac surgery. The incidence of POPC was nearly halved in the LPV group compared to the conventional ventilation group, indicating a clear clinical benefit of applying LPV in this high-risk population.

The reductions in specific pulmonary complications such as atelectasis and pneumonia highlight the physiological advantages of lung protective strategies. Atelectasis is highly prevalent in obese patients due to reduced functional residual capacity and impaired diaphragmatic mechanics. The application of LPV with lower tidal volumes and appropriately individualized positive end-expiratory pressure (PEEP) helps prevent alveolar collapse and overdistension that can otherwise occur with conventional ventilation. Recruitment maneuvers, performed every 30 to 60 minutes in the LPV group, likely contributed substantially by reopening collapsed alveoli and maintaining alveolar patency throughout surgery. This periodic alveolar recruitment is an important adjunctive strategy that complements PEEP in minimizing atelectasis and subsequent pulmonary infections.

The lower rates of pneumonia in the LPV group may be explained by the reduced atelectasis and improved alveolar ventilation, which limits bacterial colonization and inflammatory responses. Hypoxemia and need for postoperative non-invasive ventilation were also less frequent in the LPV group, reflecting better preserved lung function and gas exchange in the early postoperative period.

Shorter hospital stays observed in the LPV group further emphasize the clinical and economic benefits of lung protective strategies in obese patients by speeding recovery and reducing complications that extend hospitalization.

While LPV has been extensively studied in critically ill and surgical populations, obese patients present unique challenges related to respiratory mechanics and increased baseline risk for POPC. This study adds to the growing body of literature by focusing on an obese cohort and demonstrating that tailored LPV protocols—including lower tidal volumes, individualized PEEP, and recruitment maneuvers—can substantially improve postoperative respiratory outcomes in this group.

CONCLUSION

This randomized controlled trial demonstrates that intraoperative lung protective ventilation — incorporating lower tidal volumes, individualized PEEP, and periodic recruitment maneuvers — significantly reduces the incidence of postoperative pulmonary complications in obese patients undergoing elective non-cardiac surgery. Compared with conventional ventilation, LPV was associated with markedly lower rates of atelectasis, pneumonia, hypoxemia, and need for postoperative non-invasive ventilation, as well as shorter hospital stays.

Given the growing prevalence of obesity and the high baseline risk of pulmonary morbidity in this population, these findings support routine adoption of lung protective ventilation strategies as standard practice during general anesthesia for obese patients. Broader implementation may help improve surgical outcomes, enhance recovery, and reduce healthcare burden. Future larger, multicenter studies are warranted to further refine ventilation parameters and confirm the long-term benefits of LPV in this high-risk group.

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