ORIGINAL ARTICLE

# RISK FACTORS FOR POSTOPERATIVE PULMONARY COMPLICATIONS AFTER MAJOR ABDOMINAL SURGERY IN PATIENTS AGED 65 YEARS AND OLDER: A RETROSPECTIVE OBSERVATIONAL STUDY

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## Abstract

**Introduction:** Postoperative pulmonary complications are among the most frequent and serious causes of morbidity and mortality in older surgical patients. Age-related physiological changes, reduced respiratory reserve, and comorbidities increase their vulnerability to adverse respiratory outcomes. The incidence and risk factors of postoperative pulmonary complications were evaluated in older adults undergoing major abdominal surgery.

**Materials and Method:** This retrospective study included 239 patients aged ≥65 years who underwent elective major abdominal surgery. Clinical and perioperative data were analyzed, and postoperative pulmonary complications—such as bronchospasm, infiltration, infection, atelectasis, pneumothorax, or acute respiratory distress syndrome—were assessed. Logistic regression identified independent predictors.

**Results:** The incidence of postoperative pulmonary complications was 22.2% (n=53). Patients with complications were older ($p < 0.001$) and slightly higher intraoperative positive end-expiratory pressure levels ($p = 0.007$), although other ventilatory parameters were not fully available. Multivariate analysis identified age (OR = 1.097; $p = 0.005$), positive end-expiratory pressure (OR = 1.452; $p = 0.014$), ASA ≥ 3 (OR = 30.532; $p < 0.001$), and upper abdominal surgery (OR = 2.322; $p = 0.022$) with the caveat that positive end-expiratory pressure evaluation was limited by the retrospective study design as independent risk factors.

**Conclusion:** Advanced age, high American Society of Anesthesiologists scores, upper abdominal surgery, and higher intraoperative PEEP were associated with increased postoperative pulmonary complication risk in elderly abdominal surgery patients. Due to limitations in available ventilatory data, the association of PEEP with complications should be interpreted cautiously. Optimizing preoperative status may help reduce complications and improve postoperative outcomes in this population.

***Keywords:*** Postoperative Complications; Pneumonia; Geriatrics; General Surgery.

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## INTRODUCTION

Approximately 300 million surgical procedures are performed worldwide each year, and this number continues to rise (1) . For older adult patients, postoperative pulmonary complications (PPCs) are among the major determinants of both morbidity and mortality, and the associated risk factors are emphasized in perioperative guidelines (2). The reported incidence of PPCs varies between 5% and 24%, and advanced age is a strong predictor (3,4). Advancements in surgical and anesthetic techniques will challenge the limits of safe perioperative care and may lead to a rise in the incidence of PPCs.

Although there is no universal consensus on the definition of PPCs, most definitions include postoperative pneumonia (POP), atelectasis, postoperative respiratory failure, pulmonary aspiration, and acute respiratory distress syndrome (ARDS) (5). Postoperative pneumonia is particularly noteworthy among these because it occurs frequently and is strongly associated with morbidity and mortality; the 30-day mortality rate for POP cases has been reported to be 21%, and it prolongs hospitalization by 7–9 days (6,7). Its annual cost to the United States healthcare system is approximately USD 11.9 billion (8).

The heightened risk of PPCs in older adult patients is closely linked to the physiological changes associated with aging. Between the ages of 25 and 80, lung function and aerobic capacity decline by approximately 40% (9). Pulmonary mechanics, cardiac output, muscle oxidative capacity, and ventilatory flexibility also decrease with age, and alveolar hypoventilation and impairments in bronchial secretion clearance become more common (10,11). Collectively, these alterations heighten older adults' risk of postoperative respiratory insufficiency and failure. Oncologic, cardiac, and thoracic surgeries as well as pulmonary comorbidities, such as chronic obstructive pulmonary disease (COPD), further increase the likelihood of PPCs (12–16).

The aim of this study was to determine the incidence rate and risk factors of postoperative pulmonary complications in older adults following major abdominal surgery. The study followed a retrospective design, and PPCs were defined based on the European Perioperative Clinical Outcome (EPCO) criteria, including bronchospasm, pulmonary infiltration, suspected pulmonary infection, atelectasis, pneumothorax, and ARDS. While advanced age, ASA score, and upper abdominal surgery are known risk factors, few studies have comprehensively evaluated intraoperative ventilation parameters and postoperative analgesia strategies in geriatric patients, highlighting the novelty of the present study.

## MATERIALS AND METHOD

This single-centre, retrospective, observational study included patients aged 65 years or older who underwent elective major abdominal surgery at a tertiary care hospital in Ankara, Türkiye between January 1, 2022, and December 31, 2024. A total of 507 patients who underwent major abdominal surgery during the study period were screened, of whom 272 were aged 65 years or older. After reviewing the medical records, 239 patients had complete essential perioperative and outcome data required for PPC assessment and were included in the final analysis. Patients were excluded if they were younger than 65 years, underwent emergency surgery, had incomplete core perioperative data, or had a pre-existing tracheostomy or chronic mechanical ventilation. Data were obtained from the hospital information system, anesthesia records, operating room forms, and postoperative follow-up notes. The demographic data included age, sex, height, weight, and body mass index (BMI). Preoperative clinical characteristics, such as The American Society of Anesthesiologists (ASA) score, smoking status, presence of COPD, history of cerebrovascular events, steroid use, and proton pump inhibitor use, were recorded. The type of

operation (upper or lower abdomen, open or laparoscopic), presence of bowel resection, use of nasogastric tube, and duration of surgery were the surgical variables considered, and the need for intensive care and type of postoperative analgesia were the postoperative variables. Intraoperative ventilation parameters, specifically the fraction of inspired oxygen ($FiO_2$) and positive end expiratory pressure (PEEP) levels, were documented. In addition, postoperative analgesia methods were systematically recorded and analysed, which, together with detailed ventilation parameters, provide a more comprehensive assessment of PPC risk factors in this underrepresented population.

All patients received a standardized anaesthetic protocol consisting of sevoflurane inhalation anaesthesia combined with remifentanil infusion. PEEP levels were recorded. Due to the retrospective nature of the study, PEEP settings were determined according to the attending anaesthesiologist's discretion. Other ventilatory parameters, such as tidal volume, minute ventilation, and driving pressure, were not available for all patients. Therefore, PEEP is presented descriptively, acknowledging that it cannot be fully interpreted in isolation. No other variations in anaesthetic management were applied.

The PPCs in this study were defined according to the EPCO criteria and included bronchospasm, pulmonary infiltration, suspected pulmonary infection, atelectasis, pneumothorax, and ARDS.

Statistical analyses were performed using Statistical Package for the Social Sciences software (IBM SPSS Statistics for Windows, Version 24.0). Categorical variables were expressed as counts and percentages, and continuous variables were presented as mean ± standard deviation values or medians (interquartile range [IQR]), depending on the data distribution. The chi-square test or Fisher's exact test was used to compare categorical variables, and an independent sample t-test or the Mann–Whitney U test was applied for continuous variables. Variables with $p < 0.10$ in a univariate analysis were included in multivariate logistic regression models to identify the independent risk factors of PPCs. The results of the multivariate regressions were reported as odds ratios (ORs) with 95% confidence intervals (CIs) and p-values. P-values < 0.05 were considered statistically significant.

This study was approved by the Local Ethics Committee (Decision No: 2025-10/154, Date: 02.10.2025). Individual informed consent was waived due to the retrospective design.

## RESULTS

A total of 239 geriatric surgical patients were included in the study. The baseline demographic, clinical, and surgical characteristics of the patients are summarized in Table 1. The incidence of PPCs was 22.2% (n=53). The mean age of the participants was 71.85 ± 5.21 years. Most patients (75.7%) had an ASA score ≥3, and 29.7% underwent upper abdominal surgery, 70.3% lower abdominal surgery.

The associations between the demographic and clinical variables and PPCs are summarized in Tables 2 and 3. No significant relationship was found between the PPCs and patient sex, smoking history, or BMI. In contrast, ASA score ($p < 0.001$), surgical incision site (p=0.013), and the presence of COPD (p=0.003) were significantly associated with PPCs. The continuous variables, including age and intraoperative PEEP, were significantly associated with PPC development. Patients who developed PPCs were older (74.4 ± 5.4 years vs. 71.1 ± 4.9 years; $p < 0.001$) and had higher PEEP levels (4.9 ± 1.2 $cmH_2O$ vs. 4.4 ± 1.6 $cmH_2O$; p=0.007) than those who did not develop PPCs. The median PEEP value was 5 $cmH_2O$ (IQR 4-5), and there was no significant difference between laparoscopic and open surgeries (Mann–Whitney U=5534.5; Z=–0.496; p=0.620). Continuous variables including age, $FiO_2$, PEEP, and BMI were not normally distributed; thus, median (interquartile range) values are reported in Table 1. For variables where median values were

**Table 1.** Patients' Demographic, Clinical, and Surgical Characteristics

| Characteristic | Category / Descriptive Statistics | n (%) / Value |
|---|---|---|
| Sex | Female | 104 (43.5) |
| | Male | 135 (56.5) |
| ASA Score | 2 | 58 (24.3) |
| | 3 | 169 (70.7) |
| | 4 | 12 (5.0) |
| Type of Surgery | Upper abdomen | 71 (29.7) |
| | Lower abdomen | 168 (70.3) |
| Surgical Approach | Open | 172 (72.0) |
| | Laparoscopic | 67 (28.0) |
| Duration of Surgery | >2 hours | 207 (86.6) |
| Postoperative Analgesia | Multimodal | 95 (39.7) |
| | IV PCA | 86 (36.0) |
| | Parenteral | 51 (21.3) |
| | Epidural PCA | 5 (2.1) |
| | Oral | 2 (0.8) |
| Postoperative Pulmonary Complications | - | 53 (22.2) |
| Smoking | - | 84 (35.1) |
| COPD | - | 30 (12.6) |
| CVA | - | 5 (2.1) |
| Preoperative Antibiotic Prophylaxis | - | 149 (62.3) |
| Bowel Resection | - | 124 (51.9) |
| Nasogastric Tube | - | 197 (82.4) |
| Age (years) | Median (Q1–Q3) | 71 (68–75) |
| FiO2 (%) | Median (Q1–Q3) | 40 (40–45) |
| PEEP (cmH2O) | Median (Q1–Q3) | 5 (4–5) |
| BMI (kg/m²) | Median (Q1–Q3) | 26.35 (23.75–29.38) |

ASA; American Society of Anesthesiologists physical status classification system, PCA; Patient-Controlled Analgesia, IV PCA; Intravenous Patient-Controlled Analgesia, COPD: Chronic Obstructive Pulmonary Disease, CVA; Cerebrovascular Accident (Stroke), FiO2; The fraction of inspired oxygen, PEEP; positive end expiratory pressure, BMI; body mass index

identical between groups (e.g., PEEP), mean ± SD is also presented to aid interpretation (Table 3). Recruitment manoeuvres were documented in only 74 patients, of whom 11 received manoeuvres; statistical analysis was not performed due to the small sample size.

Binary logistic regression analysis was conducted using age as a continuous variable (Table 4). The results showed that age (OR: 1.097; 95% CI: 1.028–1.171; p=0.005), PEEP (OR: 1.452; 95% CI: 1.080–1.951; p=0.014), ASA ≥ 3 (OR: 30.532; 95% CI: 5.293–176.132; p < 0.001), and upper abdominal surgery (OR: 2.322; 95% CI: 1.129–4.774; p=0.022) were independent risk factors for PPCs. BMI was not a statistically significant risk factor (p=0.512).

**Table 2.** Patient and Surgical Characteristics and Postoperative Pulmonary Complications

| Variable | | n | PPCs (%) | p value |
|---|---|---|---|---|
| Sex | Female | 104 | 23.1 | 0.768 |
| | Male | 135 | 21.5 | |
| ASA classification | II | 58 | 6.9 | **<0.001** |
| | III | 169 | 23.7 | |
| | IV | 12 | 75.0 | |
| Type of surgery | Upper abdomen | 71 | 32.4 | **0.013** |
| | Lower abdomen | 138 | 17.9 | |
| Surgical approach | Open | 172 | 25.0 | 0.092 |
| | Laparoscopic | 67 | 14.9 | |
| Smoking history | Yes | 84 | 26.2 | 0.271 |
| | No | 155 | 20.0 | |
| COPD | Yes | 30 | 43.3 | **0.003** |
| | No | 209 | 19.1 | |
| Preoperative antibiotic prophylaxis | Yes | 149 | 25.5 | 0.111 |
| | No | 90 | 16.7 | |
| Nasogastric tube | Present | 197 | 23.9 | 0.175 |
| | Absent | 42 | 14.3 | |
| Duration of surgery | <2 hours | 32 | 15.6 | 0.338 |
| | ≥2 hours | 207 | 23.2 | |
| Postoperative analgesia | IV PCA | 86 | 10.5 | **0.007** |
| | Parenteral | 51 | 29.4 | |
| | Multimodal | 95 | 0.5 | |
| | Other | 7 | 0 | |

Comparisons between categorical variables and the incidence of postoperative pulmonary complications were performed using Pearson's chi-square test or Fisher's exact test, as appropriate. ASA; American Society of Anesthesiologists physical status classification system, IV PCA; Intravenous Patient-Controlled Analgesia, COPD; Chronic Obstructive Pulmonary Disease, PPCs; Postoperative Pulmonary Complications

**Table 3.** Continuous perioperative variables according to the presence of postoperative pulmonary complications

| Variable | PPCs (+) (n=53) | PPCs (–) (n=186) | Mann–Whitney U | p-value |
|---|---|---|---|---|
| Age (years) | 74 (70.5–78) | 70 (67–74) | 3118.0 | **<0.001** |
| $FiO_2$ (%) | 40 (40–45), 43.8 ± 6.6 | 40 (40–43), 42.0 ± 3.6 | 4228.5 | 0.056 |
| PEEP ($cmH_2O$) | 5 (5–6), 4.9 ± 1.2 | 5 (4–5), 4.4 ± 1.6 | 3789.0 | **0.007** |
| BMI ($kg/m^2$) | 25.3 (24–29) | 26.9 (23–29) | 4420.5 | 0.252 |

Data are presented as median (interquartile range), mean ± standard deviation. Continuous variables were not normally distributed; therefore, comparisons between groups were performed using the Mann–Whitney U test. For variables where median values were identical between groups (e.g., PEEP), mean ± standard deviation is also provided to aid interpretation. PPCs; Postoperative Pulmonary Complications; $FiO_2$; The Fraction of Inspired Oxygen; PEEP; Positive End-Expiratory Pressure; BMI; Body Mass Index.

**Table 4.** Multivariate Logistic Regression Analysis of Independent Risk Factors for Postoperative Pulmonary Complications

| Variable | B | S.E. | Wald | p-value | Exp(B) | 95% CI Exp(B) |
|---|---|---|---|---|---|---|
| Age (years) | 0.093 | 0.033 | 7.814 | **0.005** | 1.097 | 1.028 – 1.171 |
| PEEP ($cmH_2O$) | 0.373 | 0.151 | 6.099 | **0.014** | 1.452 | 1.080 – 1.951 |
| BMI (kg/m²) | -0.027 | 0.042 | 0.431 | 0.512 | 0.973 | 0.897 – 1.056 |
| ASA (≥3 vs <3) | 3.419 | 0.894 | 14.620 | **<0.001** | 30.532 | 5.293 – 176.132 |
| Surgical site (upper vs lower abdomen) | 0.842 | 0.368 | 5.247 | **0.022** | 2.322 | 1.129 – 4.774 |
| Constant | -10.399 | 2.893 | 12.920 | 0.000 | 0.000 | – |

Binary logistic regression was performed using age as a continuous variable. Exp(B) represents the odds ratio for developing postoperative pulmonary complications. Reference categories: ASA <3, lower abdominal surgery. Model fit: -2 Log likelihood = 206.528, Cox & Snell $R^2$ = 0.176, Nagelkerke $R^2$ = 0.270. Hosmer-Lemeshow test: $\chi^2$ = 11.946, df = 8, p = 0.154, indicating good fit. PEEP; Positive End-Expiratory Pressure; BMI; Body Mass Index, ASA; American Society of Anesthesiologists

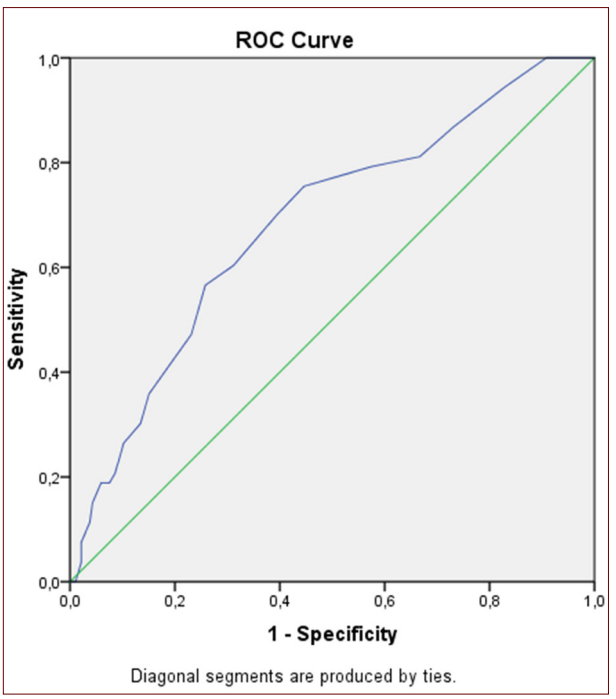


**Figure 1.** ROC Curve for Age Predicting PPCs. ROC curve illustrates the predictive ability of age for postoperative pulmonary complications. The area under the curve was 0.684 (95% CI, 0.602–0.765; p < 0.001). The optimal cut-off value for age was 70.5 years, which provided the best combination of sensitivity and specificity for identifying patients at risk of PPCs. ROC; The Receiver Operating Characteristic; PPCs; Postoperative Pulmonary Complications

The predictive performance of age was evaluated using receiver operating characteristic (ROC) analysis (Figure 1). The area under the curve (AUC) was 0.684 (95% CI: 0.602–0.765; p< 0.001), and the optimal cutoff value was determined to be 70.5 years. A second binary logistic regression analysis using this cutoff value showed that patients older than 70.5 years had a 3.3-fold increased risk of PPCs (OR: 3.325; 95% CI: 1.567–7.056; p=0.002). PEEP (OR: 1.531; 95% CI: 1.133–2.069; p=0.006), ASA ≥3 (OR: 32.180; 95% CI: 5.599–184.945; p< 0.001), and upper abdominal surgery (OR: 2.154; 95% CI: 1.053–4.407; p=0.036) remained independent risk factors, and BMI remained nonsignificant (p=0.384).

These findings indicate that advanced age (>70.5 years), high intraoperative PEEP levels, high ASA scores, and upper abdominal surgery significantly increase the risk of PPCs in geriatric surgical patients.

## DISCUSSION

Advanced age, high ASA scores, upper abdominal surgery, and increased intraoperative PEEP were identified as independent risk factors for PPCs in older adult patients who underwent abdominal surgery. Among these, ASA classification, comorbidities, and upper abdominal surgery showed the strongest associations with PPCs, while BMI and intraoperative $FiO_2$ did not have significant effects.

These findings indicate that patient- and surgery-related factors are important predictors of PPCs risk, but the role of intraoperative ventilation parameters is less clear.

Although age, ASA classification, and upper abdominal surgery are widely recognized PPCs risk factors, this study contributes to the literature by focusing specifically on a geriatric population undergoing major abdominal surgery and by incorporating detailed intraoperative ventilation parameters, which are not routinely evaluated in similar studies. Additionally, the use of standardized EPCO criteria and the assessment of postoperative analgesia methods (patient-controlled analgesia vs. parenteral analgesia) provide further practical insights for perioperative management in elderly surgical patients.

The patients who developed PPCs were older and had slightly higher intraoperative PEEP levels than those without any complications. The median PEEP value was 5 $cmH_2O$ in both groups, but the interquartile range was higher in the PPCs group. Considering that PEEP is generally a protective factor against alveolar collapse and is expected to reduce pulmonary complications, this finding seems surprising. However, this association can likely be explained by confounding by indication. Anesthesiologists may have applied higher PEEP to patients considered high risk due to advanced age, a high ASA score, or complex surgery. Thus, the observed relationship likely reflects a strategy applied to high-risk patients rather than a causal effect of PEEP on complications.

The literature shows that the use of a low tidal volume and low driving pressure reduces postoperative respiratory failure, ventilation requirement, and PPCs incidence (17–19). However, evidence regarding the additional benefits of high PEEP levels or recruitment maneuvers is inconsistent. A recent meta-analysis revealed that these interventions do not provide significant benefits (20). The present study's findings similarly suggest that PEEP may be a strategy adopted for high-risk patients rather than an independent risk factor.

Pulmonary comorbidities increase PPCs risk substantially. COPD affects more than 11.6% of the population over 65 years and is associated with reduced exercise tolerance, dyspnea, and limitations in daily activities (21). COPD has been reported to be an independent risk factor for PPCs (14). In our study, the incidence of PPCs was higher among patients with COPD.

Postoperative analgesia management is important for reducing PPCs. More specifically, patient-controlled analgesia (PCA) has been shown to reduce PPCs incidence. In a 2024 study by He et al., elderly patients who received intravenous or epidural PCA when undergoing major abdominal surgery had lower PPCs rates (OR: 0.208; 95% CI: 0.121–0.358; $p < 0.001$) (22). Our findings are consistent with previous reports, with lower PPCs rates seen in patients who received PCA (especially intravenous PCA) and higher complication rates seen in those who received parenteral analgesia. This indicates that appropriate postoperative analgesia selection may help prevent pulmonary complications in elderly patients.

In the literature, the PPCs incidence rates reported for older adult surgical patients vary. Peng et al. conducted a multicenter prospective study of 12,240 geriatric patients and found a PPCs incidence of 15.9% (23). Zhou et al. performed a nomogram study for elderly patients undergoing noncardiac thoracic surgery and reported PPCs incidence rates of 31.4–34.9% in a 30-day period (24). In our study, the incidence among patients aged ≥ 65 who underwent major abdominal surgery was 22.2%. These differences may be due to variations in surgical types, patient populations, risk prediction models, and PPCs definitions, which should be taken into account when comparing our findings with those of previous studies.

Surgical type also affects PPCs risk. Complication rates of around 18.8% have been reported for oncologic surgeries (15). Radical cystectomy is associated with a PPCs incidence of 5.6%, along with significantly increased 30-day mortality and hospital stays (25). POP rates of 3.3% and 25%, respectively, have been reported for cardiac and thoracic surgeries, with COPD and long surgical durations among the risk factors (12,13,16).

The present study's findings have important implications for anesthesia practice and perioperative care protocols. Patients of advanced age, with ASA ≥ 3, and undergoing upper abdominal surgery are at high risk for PPCs and require close perioperative monitoring. Analgesia choice plays a critical role in reducing PPCs risk. Our study findings as well as the literature show that PPCs rates reduce with PCA administration (22). This suggests that intravenous or epidural PCA may reduce complications in elderly surgical patients.

Preoperative optimization strategies are equally important. Smoking cessation, nutritional support, and treatment for pulmonary comorbidities such as COPD can improve patients' physiological reserves and reduce PPCs risk. Cardiopulmonary exercise testing, pulmonary function tests, and frailty assessments can facilitate the early identification of high-risk patients, allowing for targeted interventions. The selective monitoring of high-risk patients, appropriate analgesia management, and preoperative optimization can notably reduce PPCs.

The strengths of the present study include its focus on the elderly surgical population, which is underrepresented in the literature, and the use of detailed perioperative variables, especially intraoperative ventilation parameters, which allowed for a comprehensive and reliable analysis of PPCs risk factors. Further, the use of EPCO criteria provided standardized, objective definitions, which enhanced the reliability of findings. The study also has some limitations. Its retrospective design limited causal inference and may have introduced data issues such as missing records. The single-center setting limits the generalizability of the results. The impact of ventilation parameters may not have been fully captured because of the use of average PEEP values without assessing intraoperative dynamics. Lastly, imbalance between the analgesia subgroups (e.g., very few patients in the epidural PCA group) limited the statistical analysis of analgesia effects on PPCs. Postoperative pain scores (e.g., The visual analogue scale) were not systematically recorded due to the retrospective design. Therefore, the adequacy of pain control could not be directly assessed, and only the type of analgesic method (PCA vs. parenteral analgesia) could be evaluated. Finally, detailed ventilatory parameters such as tidal volume, minute ventilation, and driving pressure were not available for all patients. Consequently, PEEP is reported descriptively, and its isolated evaluation should be interpreted cautiously.

In the future, researchers should consider adopting prospective, multicenter, randomized controlled study designs to identify PPCs risk factors more reliably. Investigating various ventilation strategies (PEEP, tidal volume, and $FiO_2$) in a forward-looking manner could help clarify the impact of intraoperative management on complications. Research on the use of prehabilitation and analgesia

methods in elderly populations may also provide practical guidance for clinical care.

This study showed that advanced age, high ASA scores, upper abdominal surgery, and intraoperative PEEP are potential risk factors for PPCs in elderly patients who have undergone abdominal surgery. However, the findings related to PEEP do not exclude the possibility of confounding by indication. The appropriate selection of analgesia methods and preoperative optimization strategies may contribute to reducing PPCs risk in the older adult surgical population. Close perioperative monitoring of high-risk patients, tailored analgesia management, and prehabilitation interventions are practical measures that can meaningfully improve the outcomes of this vulnerable group. Overall, the results emphasize the importance of patient- and surgery-specific characteristics in PPCs development and highlight the need for prospective, large-scale, controlled studies to better understand the role of ventilation parameters.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

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