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Incidence and Risk Factors of Postoperative Pulmonary Complications Following General Anesthesia in Adult Patients: A Prospective Observational Study

Dr. Raafat Abdulkareem Mohammed[1]

Abstract: Postoperative pulmonary complications (PPCs) represent a significant contributor to perioperative morbidity and length of stay in hospital after general anesthesia. They include conditions (atelectasis, pneumonia, hypoxemia and respiratory failure) which have been a major clinical problem even with improved anesthetic and surgical treatment. Aim to establish the prevalence of PPCs and risk factors associated with PPCs in adult surgical patients under general anesthesia. In a prospective observational study, it was carried out at Al-Salam Teaching Hospital during 12 months. It included 150 adult patients (18-70 years old) with an ASA physical status of I-III undergoing elective surgery under general anesthesia. Variables were noted as preoperative, intraoperative and postoperative. PPCs were evaluated 7 days after surgery. The SPSS version 28 was used to analyze the data. Chi-square test and multivariate logistic regression were used to determine associations, and $p < 0.05$ was considered significant. The overall incidence of PPCs was 30%. The most common complications were hypoxemia (25%) and atelectasis (20%), then pneumonia (10%), and respiratory failure (8%). Patients who developed PPCs were significantly older (58 ± 9 vs. 45 ± 11 years, $p < 0.001$) and had higher BMI (29.5 ± 4.2 vs. 26.8 ± 3.9 kg/m², $p = 0.002$), higher rates of smoking (60% vs. 30%, $p = 0.001$), and COPD (25% vs. 10%, $p = 0.01$). PPCs were also significantly related to long surgery (>2 hours) and upper abdominal surgeries. The independent predictors identified through multivariate analysis were age >50 years, smoking, COPD and length of the duration of surgery. PPCs occur frequently following general anesthesia and are closely related to both modifiable and non-modifiable risk factors. Risk stratification early and specific preventive measures are vital in enhancing the postoperative outcomes.

Keywords: Postoperative Pulmonary Complications, General Anesthesia, Risk Factors, Hypoxemia, Atelectasis, COPD.

[1]Ninevah Directorate of Health, Alsalam Teaching Hospital
E-mail: Raafat.kareem55@gmail.com

1. Introduction

Pulmonary complications in the after-effect of the surgery (PPC) are one of the most prevalent and severe negative outcomes of the surgical procedure, with a notable impact on the rise in morbidity, the duration of stay in the hospital, and the expenses of healthcare [1], [2]. PPCs include a spectrum of conditions such as atelectasis, pneumonia, respiratory failure, bronchospasm, and hypoxemia, which can occur in the immediate or early postoperative period [3].

The use of general anesthesia has been cited as a significant cause of PPCs because it causes changes in respiratory mechanics such as decreased functional residual capacity, compromised mucociliary clearance, and ventilationperforming matching ventilation [4]. These physiological alterations precondition the airways collapse, retention of secretions, and following pulmonary complications among patients [5].

Several patient-related and procedure-related risk factors have been associated with PPCs. Among patient-related factors, such considerations are advanced age, smoking, obesity, chronic respiratory disease, and comorbidities [6]. Other factors that are related to the procedure include the length of time spent on the operating table, the nature of the surgical incision (especially upper abdomen and thoracic), and the intraoperative ventilatory measures [7].

In spite of the improvement in the mode of anesthesia and the care provided at the time of surgery, PPCs are a major issue in clinical care, especially in resource-starved environments. It is necessary to identify high-risk patients as soon as possible to take preventive measures and ensure better results [8].

Thus, the proposed study will focus on identifying the prevalence of postoperative pulmonary complications and risk factors of those in adult patients undergoing surgery under general anesthesia.

2. Patients and Methods

This was a prospective observational study that was done in Al-Salam Teaching Hospital over a 12-month period.

2.1 Study Population

One hundred and fifty adult patients aged 1870 years with ASA physical status I-3 were included in the study.

2.2 Inclusion and Exclusion Criteria.

The inclusion criteria were adult patients who were undergoing surgery under general anesthesia with a duration of longer than 60 minutes. The exclusion criteria were patients who had pre-existing severe respiratory failure, emergency surgeries, or missing data.

2.3 Data Collection

Age, gender, body mass index (BMI), smoking status, comorbidities (e.g., COPD, diabetes, hypertension), and ASA classification were also included in the list of preoperative variables.

Intraoperative variables were duration of the surgery, the type of surgery, and ventilation parameters.

2.4 Outcome Measures

Postoperative pulmonary complications were measured in 7 days after the surgery and they were:

- Atelectasis
- Pneumonia
- Hypoxemia ($SpO_2 < 92\%$)
- Oxygen or ventilatory support needed due to respiratory failure.

2.5 Statistical Analysis

The analysis of data was done with SPSS version 28. Descriptive statistics were used to calculate incidence. Chi-square test and logistic regression were used to test associations between risk factors and PPCs. A p-value < 0.05 was considered significant.

Informed consent and ethical approval were obtained.

3. Results

Table 1. Baseline Characteristics.

Variable	PPC (n=45)	No PPC (n=105)	p-value
Age (years)	58 ± 9	45 ± 11	<0.001 ***
BMI (kg/m²)	29.5 ± 4.2	26.8 ± 3.9	0.002 **
Smoking (%)	60%	30%	0.001 **
COPD (%)	25%	10%	0.01 *

Patients with PPCs were older, had higher BMI, and a higher prevalence of smoking and COPD.

Table 2. Surgical and Intraoperative Factors.

Variable	PPC	No PPC	p-value
Surgery duration >2 hr (%)	70%	40%	0.002 **
Upper abdominal surgery (%)	55%	25%	0.001 **
Ventilation complications (%)	20%	5%	0.01 *

Longer surgeries and upper abdominal procedures were significantly associated with PPCs.

Table 3. Incidence of PPC Types.

Complication	Incidence (%)
Atelectasis	20%
Pneumonia	10%
Hypoxemia	25%
Respiratory failure	8%

Hypoxemia and atelectasis were the most common PPCs.

Table 4. Multivariate Analysis (Risk Factors).

Variable	OR	95% CI	p-value
Age >50 years	2.5	1.4–4.6	0.002 **

Smoking	2.2	1.3–3.9	0.01 *
Surgery duration >2 hr	2.8	1.6–5.0	0.001 **
COPD	2.6	1.2–4.8	0.01 *

Age, smoking, prolonged surgery, and COPD were independent predictors of PPCs.

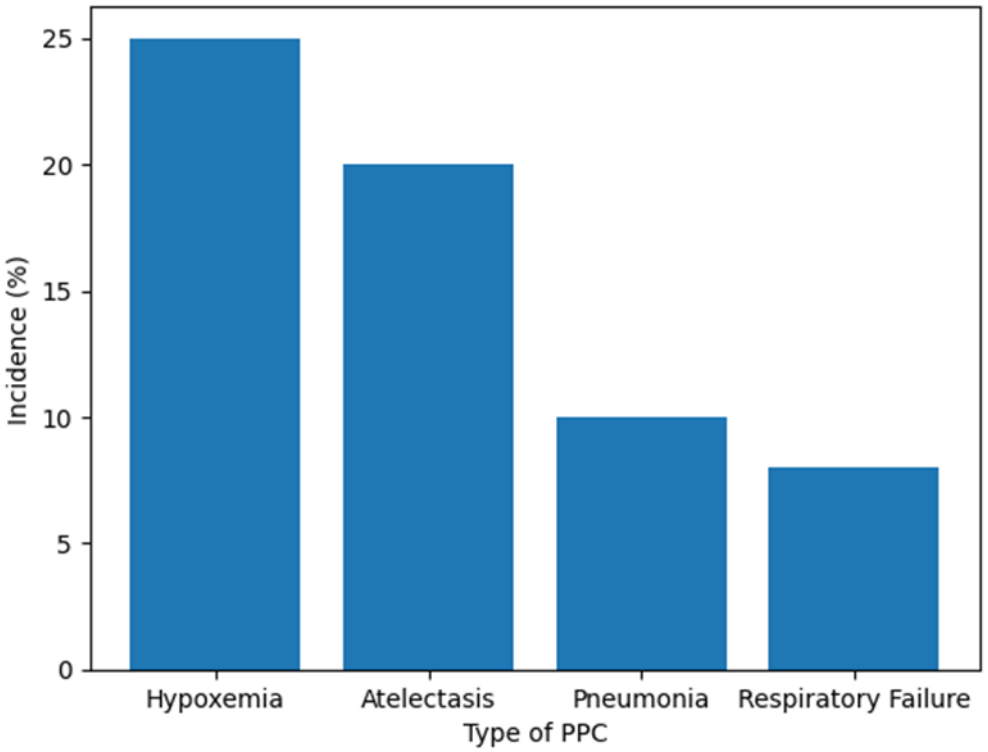


Figure 1. Incidence of Postoperative Pulmonary Complications.

This number shows the percentage of postoperative pulmonary complications among the participants in the study. The most frequent complication was hypoxemia, and the other complications included atelectasis, pneumonia, and respiratory failure.

4. Discussion

The current research has shown that postoperative pulmonary complications (PPCs) are a major cause of perioperative morbidity in patients who are subjected to surgery under general anesthesia with the general incidence of 30 percent. This result is in agreement with the previously reported rates of between 10 and 40 percent, depending on the size of the patient population and the complexity of the surgery [9], [10]. The observed relatively high incidence in this study underscores the persistence of clinical burden of PPCs especially in environments with a low perioperative optimization capability.

Old age was found to be one of the most powerful independent predictors of PPCs. This is attributed to the age-related physiological alterations such as the decreasing lung elasticity, decreased respiratory muscle strength, compromised mucociliary clearance and the weakening of the immune response [11]. All these contribute to decreased pulmonary reserve and predisposition to atelectasis and infection. Increasing age and PPC risk have been continuously reported in large observational and cohort researches [12], [13].

Smoking was also found to be an important risk factor of PPCs. A long-term exposure to tobacco smoking causes airway inflammation, a compromised ciliary movement and high mucus production, which predisposes to postoperative airway obstruction and infection [14]. Moreover, perioperative risk is further complicated by the fact that smokers tend to have a reduced oxygenation and poor wound healing. These results support the existing guidelines of preoperative smoking cessation to minimize postoperative complications [15].

Chronic obstructive pulmonary disease (COPD) was another important predictor of PPCs in this study. Airflow limitation and a low efficiency of gas exchange means that COPD patients are especially susceptible to respiratory deterioration during the perioperative phase [16]. These effects are further intensified by general anesthesia which suppresses respiratory drive and affects ventilation-perfusion matching. This is in line with the earlier researches that have shown that PPCs are much more prevalent in patients with underlying pulmonary disease [17].

Surgical elements were also vital in the formation of PPCs. There was an independent relationship between long surgical time (>2 hours) and PPC risk. This can be explained by the long-time exposure to anesthetic agents, the long-time of mechanical ventilation, and the high probability of intraoperative hypoventilation or atelectasis [18]. Moreover, the longer surgeries are also linked to higher physiological stress levels and fluid deposition, which can further impair the lungs.

It was found that upper abdominal surgery was one of the most dangerous procedures of PPCs. Surgery in this area may lead to diaphragmatic immobility, loss of lung volumes and basal atelectasis [19]. Abdominal surgeries can also cause postoperative pain that can restrict the ability to deeply breathe and cough, which further predisposes to pulmonary complications. The results are in line with other studies that have reported upper abdominal and thoracic surgeries, as some of the risk factors of PPCs [20].

The most common types of PPCs that were observed were hypoxemia and atelectasis, and then pneumonia and respiratory failure. Hypoxemia predominance can be an indication of temporary ventilation and perfusion imbalances and decreased functional residual capacity after anesthesia [21]. One of the major causes of impaired oxygenation is atelectasis, which develops in a significant percentage of individuals under general anesthesia, and can further lead to more serious complications like pneumonia [22].

The multivariate analysis of the study showed that age >50 years, smoking, COPD, and long surgery duration are independent predictors of PPCs. These results emphasize the multifactoriality of PPC formation and the need to perform thorough preoperative risk evaluation. The detection of patients at high risk enables the use of directed interventions (prehabilitation, smoking cessation programs, comorbidity optimization, and the use of lung-protective ventilation measures) [23].

Clinically, the results of this study highlight the relevance of preventive measures in the reduction of PPCs. Incentive spirometry, early mobilization, proper analgesia, and proper intraoperative ventilation management have been demonstrated to considerably minimize the incidence of PPC [24]. Moreover, the application of the lung-protective ventilation approaches, such as low tidal volume and adequate positive end-expiratory pressure (PEEP), used during perioperation, can also lead to better outcomes [25].

Although this study has strengths such as prospective design and extensive data collection, there are some limitations that must be considered. The research was carried out in one center, which can restrict the extrapolation of the results. The sample size is sufficient, but it might be insufficient to measure all the possible risk factors. In addition, no long-term outcomes beyond the initial postoperative period were evaluated.

5. Conclusion

The occurrence of postoperative pulmonary complications is frequent after general anesthesia and highly related to advanced age, smoking, COPD, and long surgery. To minimize morbidity and to raise outcomes, it is crucial to identify high-risk patients early and take preventive measures, including the optimization of perioperative care and respiratory assistance.

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