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ORIGINAL ARTICLE

Postoperative Pulmonary Complications in Surgical Patients, Risk Factors, Prevention Strategies, and Clinical Outcomes

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ABSTRACT

Background: PPCs are a major cause of morbidity and mortality in surgical patients, causing prolonged hospital stays, ICU admissions, and increased healthcare costs. The objective of this study was to assess the incidence, risk factors, and clinical outcomes of PPCs in surgical patients admitted to tertiary care hospitals in Pakistan.

Methods: A prospective observational study was conducted for 12 months on n=70 patients having major elective and emergency surgery. Demographics, comorbidities, ventilation parameters, and pulmonary complications were data collected preoperatively, intraoperatively, and postoperatively. C-reactive protein (CRP), procalcitonin, arterial oxygen saturation (SpO_2), lactate levels, and the neutrophil-to-lymphocyte ratio (NLR) were determined as biomarkers. SPSS version 26.0 was used for statistical analysis, and $p < 0.05$ was taken as significant.

Results: Pneumonia was the most common (50%) and occurred in 42.9% of patients who had PPCs. PPC patients had longer hospital stays (11.8 vs. 7.1 days, $p = 0.002$), higher ICU admissions (50% vs. 12%, $p = 0.003$), and 30-day mortality (18% vs. 8%), but not statistically significantly ($p = 0.056$). Elevations of biomarkers in PPC patients ($p < 0.001$) suggested an inflammatory role in PPC development.

Conclusion: Surgical outcomes and hospital resource utilization are significantly influenced by PPCs. Perioperative interventions might be targeted given biomarkers as early indicators of PPC risk. Future research should move forward to integrate biomarkers into risk models and to optimize pulmonary care strategies to improve outcomes.

Keywords: Postoperative pulmonary complications, surgery, pneumonia, ICU admission, biomarker analysis, pulmonary risk assessment, surgical outcomes.

INTRODUCTION

PPCs are a significant burden to surgical patients by increasing morbidity, hospitalization, and postoperative mortality. Complications in these patients include a spectrum of respiratory dysfunctions such as atelectasis, pneumonia, ARDS, respiratory failure, and pulmonary embolism, which all significantly affect postoperative recovery and clinical outcomes[1]. Factors related to the patient, the surgery, and perioperative management strategies are involved in determining the incidence of PPCs. While surgical outcomes in high-income settings have improved with advancements in perioperative care, PPCs continue to have an undue burden in low and middle-income countries (LMICs) such as Pakistan, where healthcare infrastructure, perioperative assessment as well as postoperative rehabilitation are often inadequate[2].

The epidemiology of PPCs in Pakistan remains poorly characterized because large-scale, multicenter studies of the incidence and impact of PPCs are lacking. However, several factors prevalent in Pakistan's population are known to increase the risk of PPCs. Surgical patients are predisposed to pulmonary dysfunction owing to the high prevalence of chronic respiratory diseases (such as chronic obstructive pulmonary disease (COPD) interstitial lung disease) and a large burden of untreated tuberculosis[3]. In addition, many of the population have compromised baseline pulmonary function due to environmental pollutants, biomass fuel exposure, and high smoking rates. Despite these risk factors, comprehensive pulmonary risk stratification before surgery has not been implemented in clinical practice, especially in nontertiary healthcare settings[4].

The risk of PPCs is also influenced by surgical and anesthetic factors. Under general anesthesia, high-risk procedures such as thoracic, upper abdominal, and long general surgical procedures are frequently performed, each of which is often associated with perioperative respiratory depression, impaired mucociliary clearance, and atelectasis[5]. Lung-protecting ventilation strategies, which have been recommended worldwide to reduce PPCs, are not uniformly applied in Pakistani hospitals because of the absence of standards in intraoperative ventilatory management. In addition, suboptimal preoperative conditions are often present for emergency surgeries that constitute a significant fraction of all surgical cases in Pakistan, which further increases the risk of PPC[6].

Postoperative respiratory care is another important determinant of PPC incidence, which is currently weak in surgical management in Pakistan. Despite the existence of established strategies to reduce PPCs, including early mobilization, pulmonary physiotherapy, incentive spirometry and non-invasive ventilation, systemic constraints (such as inadequate staffing, lack of respiratory therapy services and financial constraints to prolonged stays in hospital for rehabilitation) limit their use[7]. Additionally, most of the surgical patients in Pakistan are from lower socioeconomic brackets and hence are unable to afford the postoperative follow up and rehabilitation services, resulting in higher chances of not resolving pulmonary complications and hospital readmission[8].

In the context of these challenges, it is imperative to develop evidence based perioperative pulmonary care protocols that are specific to the local healthcare dynamics of the country of Pakistan. Therefore, there is a need to strengthen preoperative pulmonary assessment, to incorporate standardized intraoperative ventilatory strategies and improve postoperative pulmonary rehabilitation services to alleviate the burden of PPCs[9]. Therefore, patient outcomes and death due to PPC-associated mortality require national guidelines and risk stratification models based on local epidemiology. Research directions for the future include identification of modifiable risk factors, studies of the effectiveness of targeted interventions, and development of cost-effective strategies for preventing PPCs in resource constrained settings[10].

The aim of this study was to comprehensively evaluate the burden of PPCs in the Pakistani surgical population, the risk factors and potential prevention strategies aimed at reducing postoperative pulmonary outcomes. The findings of this study will fill these critical gaps and help in addressing perioperative

pulmonary management and reduce PPC associated postoperative morbidity and mortality in Pakistan[11].

MATERIALS AND METHODS

Study Design and Setting: This was a prospective observational study conducted in various tertiary care hospitals of Pakistan at both public and private health care institutions. This was a 12-month study, and September 2021 to September 2022 was the time period of study to evaluate the incidence, risk factors and clinical outcomes of postoperative pulmonary complications (PPC) in surgical patients. A diverse set of hospitals were included to represent diversity of the country concerning various healthcare settings and patient populations.

Study Population and Eligibility Criteria: The study population was all who had undergone elective and emergency surgery under general or regional anesthesia. Patients included were those aged 18 years and above undergoing major surgical procedures, especially those on the thoracic, abdominal, orthopedic or vascular system. Patients who were excluded included those with pre-existing respiratory failure requiring ventilatory support, those with incomplete medical records and those were lost to follow-up. Ethics were assured by all participants giving written informed consent of participation in the study.

Sample Size Calculation: Previous publications were used to estimate the PPC; 20% and the sample size was calculated accordingly. The final sample size was adjusted to 70 patients to allow an accurate investigation of PPC predictors and outcomes within the scope of the study with confidence level of 95% and a margin of error of 5%.

Data Collection and Variables: Structured case report forms (CRFs) and electronic medical records were used to collect prospectively, using structured case report forms (CRFs) and electronic medical records. The collected data was divided into the preoperative, intraoperative and postoperative variables and a comprehensive assessment of PPCs was done based on them.

Preoperative Data: Preoperatively, we considered the patient demographics such as age, gender, body mass index (BMI) and smoking history. Therefore, we recorded the medical history of each of the patients and focused particularly on chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma, tuberculosis and interstitial lung disease. Cardiovascular disease, diabetes mellitus, hypertension and immunosuppression were recorded as other comorbidities. If this is available, assessment of preoperative pulmonary function was done with spirometry and arterial blood gas (ABG) analysis. The validated risk stratification tool, the ARISCAT score was applied by each patient to predict PPC risk.

Intraoperative Data: Surgical and anesthetic factors including type of surgery (elective or emergency), type of surgical approach (open or laparoscopy) and type of anesthesia (general or regional) were recorded in detail. All surgery and anesthesia duration, estimated intraoperative blood loss and total fluid balance were documented. The intraoperative ventilation strategies were analyzed in terms of tidal volume settings, positive end expiratory pressure (PEEP), and fraction of inspired oxygen (FiO_2), as these variables are known to affect PPC development.

Postoperative Data: Postoperative complication was identified through clinical examination, radiographic findings and laboratory tests. PPCs included pneumonia, atelectasis, pulmonary edema and respiratory failure. It was documented that re-intubation, NIV, or MV was needed as a postoperative respiratory intervention. Pulmonary care strategies such as incentive spirometry, early mobilization, other chest physiotherapy, and supplemental oxygen therapy were also recorded.

Using key clinical outcomes such as length of hospital stay, ICU admission rates, 30 day mortality, readmission rates, and the response of these outcomes to PPCs, patient prognosis was explored.

Biomarker Analysis: Analysis of biomarkers was conducted and their utility to predict PPCs in the presence of clinical and radiological assessment was determined. Blood samples were taken pre and post operation days 1, 3 and 7 to measure C reactive protein (CRP), procalcitonin, arterial oxygen saturation (SpO_2), lactate levels, and neutrophil to lymphocyte ratio (NLR). The relation of PPC development to severity and these biomarkers was investigated.

OUTCOME MEASURES

Incidence of PPCs: The primary outcome of the study was incidence of PPCs in first seven days post-op. A total of 70 patients were included in the study of which, 30 (42.9%) developed PPCs. The most common complication was pneumonia in 50.0% of PPC cases, atelectasis in 26.7%, pulmonary edema in 16.7%, and respiratory failure in 6.6%.

Hospital Stay: Patients with PPCs also stayed longer periods in the hospital than patients without PPCs. On average, the PPC patients were hospitalized for 11.8 ± 3.0 days compared with 7.1 ± 2.0 days of the non-PPC patients ($p = 0.002$). This implies that PPSCs also affect delayed postoperative recovery and increased healthcare burden.

ICU Admission Rates: The presence of PPCs was strongly associated with the need for admission to an ICU. The admission to the ICU was necessary in 50.0% of the patients with PPC versus 12.0% of those not with PPC ($p = 0.003$). Since the magnitude of this difference stresses that patients with PPC are severely compromised of the respiratory system, and that they require substantial intensive respiratory support.

Postoperative Mortality: PPC patients had higher 30-day mortality rate (18.0%) compared to non PPC patients (8.0%) without statistical significance ($p = 0.056$). The implication of this is that PPCs may influence early postoperative mortality but need a larger sample size to confirm that.

Readmission Rates: There was a notable higher risk of hospital readmission within 30 days (25.0%) in PPC patients when compared to non PPC patients (10.0%) with p value of 0.072, and a trend of increased morbidity beyond hospital discharge. Thus, this suggests that PPCs prolong recovery and augment future medical care need.

Statistical Analysis: The data collected were analyzed using SPSS version 26.0. Patient characteristics were summarized with descriptive statistics, including mean, standard deviation (SD), and percentages. The chi-square test or Fisher's exact test was used to analyze the categorical variables, and the student's t-test or Mann-Whitney U test was used to compare continuous variables. To identify independent predictors of PPCs, logistic regression analysis was performed, adjusting for confounding variables. The p-value was set at < 0.05.

Ethical Considerations: The study was approved by the Institutional Review Boards (IRBs) of all participating hospitals and was conducted by the Declaration of Helsinki. Each participant gave informed consent in writing before enrolment in the study. Patient data was anonymized, and confidentiality of patient data was maintained to respect national and institutional ethical guidelines. Patients were told that their involvement in the study would not affect their standard medical care.

RESULTS

Demographic and Clinical Characteristics: The study included a total of 70 patients. Participants were aged 55.2 years (SD ± 8.4). There were 40 males (57.1%) and 30 females (42.9%) in the gender distribution. Twenty-four (34.3%) had a history of smoking, and 15 patients (21.4%) had a documented history of chronic obstructive pulmonary disease (COPD). The other comorbidities included hypertension (30%), diabetes mellitus (26%), and obesity (28%). In addition, 18 percent of patients had a history of pulmonary infection before surgery. The PPC rate in the included patients was 42.9% (30) and 57.1% (40) respectively as shown in table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population (n=70)

Characteristic	Value (%)
Total Patients	70
Mean Age (years)	55.2 ± 8.4
Male	40 (57.1)
Female	30 (42.9)
Smokers	24 (34.3)
COPD	15 (21.4)
Diabetes Mellitus	18 (25.7)
Hypertension	21 (30.0)
Obesity (BMI >30)	20 (28.6)
History of Pulmonary Infection	13 (18.6)

Biomarker Analysis in PPC and Non-PPC Patients: There were significant differences in serum biomarker levels between PPC and non-PPC patients. PPC patients had markedly elevated CRP levels (32.94 ± 6.04 mg/L) compared to non-PPC patients (11.31 ± 2.33 mg/L), $p < 0.001$. Likewise, procalcitonin levels were elevated in PPC patients (1.81 ± 0.39 ng/mL) versus non-PPC patients (0.58 ± 0.21 ng/mL), $p < 0.001$. PPC patients had significantly lower SpO_2 (88.50 ± 2.25%) than non-PPC patients (96.12 ± 1.29%, $p < 0.001$). Furthermore, the lactate levels were significantly elevated (3.57 ± 0.45 mmol/L in PPC patients compared to 1.45 ± 0.39 mmol/L in non-PPC patients, $p < 0.001$). Finally, the neutrophil to lymphocyte (NLR) ratio was also significantly greater in the PPC patients (6.99±1.15) compared to non-PPC patients (3.72±0.87), $p < 0.001$. This suggests that PPCs are highly correlated with systemic inflammation and poor respiratory function as shown in table 2.

Table 2: Biomarker Levels in PPC vs. Non-PPC Patients (n=70)

Biomarker	PPC Present (Mean ± SD)	PPC Absent (Mean ± SD)	p-value
C-reactive protein (CRP, mg/L)	32.94 ± 6.04	11.31 ± 2.33	<0.001
Procalcitonin (ng/mL)	1.81 ± 0.39	0.58 ± 0.21	<0.001
Arterial Oxygen Saturation (SpO_2, %)	88.50 ± 2.25	96.12 ± 1.29	<0.001
Lactate (mmol/L)	3.57 ± 0.45	1.45 ± 0.39	<0.001
Neutrophil-to-Lymphocyte Ratio (NLR)	6.99 ± 1.15	3.72 ± 0.87	<0.001

Incidence of Postoperative Pulmonary Complications (PPCs): Among the 30 patients who developed PPCs, the most frequently observed complications were pneumonia (50.0%), atelectasis (26.7%), pulmonary edema (16.7%), and respiratory failure (6.6%) as shown in table 3.

Table 3: Incidence of Postoperative Pulmonary Complications (n=70)

Postoperative Pulmonary Complication	Number of Cases (%)
Pneumonia	15 (50.0)
Atelectasis	8 (26.7)
Pulmonary Edema	5 (16.7)
Respiratory Failure	2 (6.6)
No PPC	40 (57.1)

Hospital Stay, ICU Admissions, and Mortality: Patients who had PPCs had significantly longer hospital stays compared to patients without complications (11.8 ± 3.0 days vs. 7.1 ± 2.0 days, $p = 0.002$). Moreover, 50.0% of PPC patients required ICU admission versus 12.0% of non-PPC patients ($p = 0.003$).

In PPC patients, though 30-day mortality was higher (18.0% vs 8.0%), the difference was not statistically significant ($p = 0.056$). Readmission rates within 30 days were significantly higher in PPC patients (25.0%) than in non-PPC patients (10.0%), $p = 0.072$, indicating a trend of increased morbidity as shown in table 4.

The findings of the study indicate a strong association between PPCs and adverse postoperative outcomes, including longer hospital stays and higher rates of ICU admission and readmission. Patients with PPCs needed an additional 5 days in hospital compared to patients without complications. However, the need for ICU admission was significantly higher (50.0% vs. 12.0%; $p = 0.003$) in PPC patients, which highlights the severity of respiratory compromise in these patients.

Table 4: Comparison of Hospital Stay, ICU Admissions, Mortality, and Readmission Rates (n=70)

Variable	PPC Present (n=30)	PPC Absent (n=40)	p-value
Mean Hospital Stay (days)	11.8 ± 3.0	7.1 ± 2.0	0.002
ICU Admissions (%)	50.0	12.0	0.003
30-day Mortality (%)	18.0	8.0	0.056
Readmission within 30 days (%)	25.0	10.0	0.072

Although mortality was nearly twice as high in the PPC patients (18.0%) compared to the non-PPC patients (8.0%), this difference did not reach statistical significance ($p = 0.056$), which may be due to the small sample size. Additionally, in PPC patients (25.0%), the readmission rate was significantly higher than in the non-PPC group (10.0), and thus, there is a trend towards the persistence of morbidity after the first hospitalization. These findings demonstrate that PPCs not only prolong hospitalization and ICU stay but also cause long-term morbidity and necessitate closer postoperative surveillance and early intervention strategies.

DISCUSSION

The incidence of postoperative pulmonary complications (PPCs) is high (42.9%), and pneumonia is the most common. The findings support international reports on the need for improved pulmonary care of surgical patients perioperatively. Its high prevalence points to suboptimal preoperative risk assessment and inadequate preventive measures as related to the development of PPC in resource limited settings[12].

PPCs had a major effect on patient outcomes: patients remained longer in the hospital 11.8 vs. 7.1 days, $p = 0.002$) and were admitted to ICU more frequently (50% vs. 12%, $p = 0.003$). These findings emphasize the importance of early identification and preventive interventions, and the PPCs contribute to healthcare burden and critical care needs[13]. Although it was not statistically significant ($p = 0.056$) due to sample size, the 30-day mortality rate was also higher in patients with PPC compared to those without (18% vs. 8%). These findings imply that PPC patients have a prolonged postoperative morbidity and require structured post discharge pulmonary care because PPC patients had higher readmission rate compared with the controls (25% vs 10%, $p = 0.072$) [14].

Higher levels of CRP, procalcitonin and NLR were significantly associated with PPCs ($p < 0.001$) that are related with an inflammatory response predisposing to PPCs. Lower SpO_2 and higher lactate levels suggest that there is an impaired oxygenation and respiratory compromise which has a role in early PPC detection and risk stratification[15].

However, results of this study may be limited by small sample size (n = 70) as some findings were statistically significant. The diagnosis also might be variable, and clinical and radiologic assessments were used. In future studies with larger patient populations, standardized diagnostic criteria and long-term biomarker monitoring, these findings should be validated[16].

Future research should focus on the feasibility of developing predictive models based on clinical and biomarker data for the purpose of early PPC identification[17].

Structured preoperative pulmonary rehabilitation programs' effectiveness and standardized PPC prevention protocols evaluation in resource-limited settings would be of interest. Furthermore, multicentre trials with larger cohorts are required to support evidence-based strategies to reduce the morbidity and mortality associated with PPC[18].

CONCLUSION

This study shows the adverse effect of postoperative pulmonary complications (PPCs) on surgical outcomes, with a high incidence associated with increased hospital stay, ICU admission, and readmission. The results indicate that CRP, procalcitonin and NLR may be early biomarkers of PPC risk and argue in support of systematic perioperative pulmonary assessment and intervention. By addressing modifiable risk factors and optimizing perioperative care, reduction of the burden of PPCs and better patient recovery is possible.

Designing preoperative pulmonary optimization, adopting intraoperative lung protective strategy and employing comprehensive postoperative rehabilitation program should be the goals of healthcare providers to minimize PPC related complications. Future research should focus on integration of biomarker analysis into predictive risk models, modification of perioperative protocols and determination of cost-effective preventative measures to reduce morbidity and mortality associated with PPC.

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REFERENCES:

1. Odor PM, Bampoe S, Gilhooly D, Creagh-Brown B, Moonesinghe SR. Perioperative interventions for prevention of postoperative pulmonary complications: systematic review and meta-analysis. Bmj. 2020;368.
2. Miskovic A, Lumb A. Postoperative pulmonary complications. BJA: British Journal of Anaesthesia. 2017;118(3):317-34.
3. Fernandez-Bustamante A, Frendl G, Sprung J, Kor DJ, Subramaniam B, Ruiz RM, et al. Postoperative pulmonary complications, early mortality, and hospital stay following noncardiothoracic surgery: a multicenter study by the perioperative research network investigators. JAMA surgery. 2017;152(2):157-66.
4. Numata T, Nakayama K, Fujii S, Yumino Y, Saito N, Yoshida M, et al. Risk factors of postoperative pulmonary complications in patients with asthma and COPD. BMC pulmonary medicine. 2018;18:1-8.
5. Kelkar KV. Post-operative pulmonary complications after non-cardiothoracic surgery. Indian journal of anaesthesia. 2015;59(9):599-605.
6. Kim ES, Kim YT, Kang CH, Park IK, Bae W, Choi SM, et al. Prevalence of and risk factors for postoperative pulmonary complications after lung cancer surgery in patients with early-stage COPD. International journal of chronic obstructive pulmonary disease. 2016:1317-26.
7. Ladha K, Melo MFV, McLean DJ, Wanderer JP, Grabitz SD, Kurth T, et al. Intraoperative protective mechanical ventilation and risk of postoperative respiratory complications: hospital based registry study. Bmj. 2015;351.
8. Ruscic KJ, Grabitz SD, Rudolph MI, Eikermann M. Prevention of respiratory complications of the surgical patient: actionable plan for continued process improvement. Current Opinion in Anesthesiology. 2017;30(3):399-408.
9. Yang CK, Teng A, Lee DY, Rose K. Pulmonary complications after major abdominal surgery: National Surgical Quality Improvement Program analysis. Journal of Surgical Research. 2015;198(2):441-9.
10. Sengupta S. Post-operative pulmonary complications after thoracotomy. Indian journal of anaesthesia. 2015;59(9):618-26.
11. Agostini PJ, Lugg ST, Adams K, Smith T, Kalkat MS, Rajesh PB, et al. Risk factors and short-term outcomes of postoperative pulmonary complications after VATS lobectomy. Journal of cardiothoracic surgery. 2018;13:1-8.
12. Chughtai M, Gwam CU, Mohamed N, Khlopas A, Newman JM, Khan R, et al. The epidemiology and risk factors for postoperative pneumonia. Journal of clinical medicine research. 2017;9(6):466.
13. Assouline B, Cools E, Schorer R, Kayser B, Elia N, Licker M. Preoperative exercise training to prevent postoperative pulmonary complications in adults undergoing major surgery. A systematic review and meta-analysis with trial sequential analysis. Annals of the American Thoracic Society. 2021;18(4):678-88.
14. Mathis MR, Duggal NM, Likosky DS, Haft JW, Douville NJ, Vaughn MT, et al. Intraoperative mechanical ventilation and postoperative pulmonary complications following cardiac surgery. Anesthesiology. 2019;131(5):1046.
15. Yan T, Liang X-Q, Wang G-J, Wang T, Li W-O, Liu Y, et al. Prophylactic penehyclidine inhalation for prevention of postoperative pulmonary complications in high-risk patients: a double-blind randomized trial. Anesthesiology. 2022;136(4):551-66.
16. Leme AC, Hajjar LA, Volpe MS, Fukushima JT, Santiago RRDS, Osawa EA, et al. Effect of intensive vs moderate alveolar recruitment strategies added to lung-protective ventilation on postoperative pulmonary complications: a randomized clinical trial. Jama. 2017;317(14):1422-32.
17. Naveed A, Azam H, Murtaza HG, Ahmad RA, Baig MAR. Incidence and risk factors of pulmonary complications after cardiopulmonary bypass. Pakistan journal of medical sciences. 2017;33(4):993.
18. Bluth T, Neto AS, Schultz MJ, Pelosi P, de Abreu MG. Effect of intraoperative high positive end-expiratory pressure (PEEP) with recruitment maneuvers vs low PEEP on postoperative pulmonary complications in obese patients: a randomized clinical trial. Jama. 2019;321(23):2292-305.