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Frequency and Risk Factors of Postoperative Pulmonary Complications after Major Abdominal Surgery: A Prospective Observational Study at Hayatabad Medical Complex Peshawar

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Abstract

Background: Postoperative pulmonary complications (PPCs) are among the most common and serious adverse events following major abdominal surgery, contributing to increased morbidity, prolonged hospital stay, and higher healthcare costs. Early identification of patients at risk is essential for implementing preventive strategies and improving postoperative outcomes. This study was conducted to determine the frequency of postoperative pulmonary complications and to identify the independent risk factors associated with their occurrence among patients undergoing major abdominal surgery at a tertiary care hospital. **Methodology:** A total of 384 adult patients undergoing elective or emergency major abdominal surgery under general anesthesia were enrolled consecutively.

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Demographic characteristics, comorbidities, smoking history, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status, and intraoperative variables were recorded using a structured proforma. Patients were followed for the first 30 postoperative days for development of PPCs (atelectasis, pneumonia, acute respiratory failure, pleural effusion, bronchospasm, prolonged mechanical ventilation, reintubation, pulmonary embolism, and ARDS). Data were analyzed using SPSS version 26. Chi-square and independent-samples t-tests assessed univariate associations; multivariable logistic regression identified independent predictors. A p-value <0.05 was considered statistically significant. **Results:** The mean age was 58.36 ± 14.63 years, and 218 (56.8%) patients were male. At least one PPC developed in 111 patients, giving an overall PPC frequency of 28.9%. Atelectasis was the most common complication (18.0%), followed by pneumonia (6.8%) and prolonged mechanical ventilation (5.5%). On multivariable logistic regression, independent predictors of PPC were advancing age (adjusted OR 1.04, 95% CI 1.01–1.06), higher BMI (OR 1.05, 95% CI 1.01–1.09), current smoking (OR 4.16, 95% CI 2.04–8.49), ex-smoking (OR 2.34, 95% CI 1.16–4.73), COPD (OR 6.48, 95% CI 2.55–16.43), bronchial asthma (OR 2.67, 95% CI 1.01–7.09), emergency surgery (OR 3.05, 95% CI 1.67–5.58), and upper abdominal or midline incisions (OR 5.20 and 4.93, respectively). Preoperative incentive spirometry was independently protective (OR 0.44, 95% CI 0.23–0.81). Patients who developed PPC had significantly longer hospital stay (11.32 ± 3.27 vs 6.32 ± 2.52 days, p<0.001), higher ICU admission (43.2% vs 5.1%, p<0.001), and higher 30-day mortality (6.3% vs 1.1%, p=0.011) than those without PPC.
Conclusion: Nearly three in ten patients undergoing major abdominal surgery developed a postoperative pulmonary complication, which was independently associated with substantially higher morbidity and mortality. Advanced age, elevated BMI, smoking, COPD, asthma, emergency surgery, and upper abdominal/midline incisions were independent risk factors, while preoperative incentive spirometry was protective. Targeted preoperative optimization and perioperative pulmonary care protocols in high-risk patients may reduce the burden of PPCs in this population.

Keywords: Postoperative pulmonary complications, major abdominal surgery, risk factors, atelectasis, pneumonia, ASA physical status, incentive spirometry, tertiary care hospital.

INTRODUCTION

Postoperative pulmonary complications (PPCs) remain among the most frequent and consequential adverse events following major abdominal surgery, contributing substantially to postoperative morbidity, prolonged hospitalization, escalated healthcare costs, and excess mortality.[1] PPCs encompass a heterogeneous group of respiratory

events including atelectasis, pneumonia, acute respiratory failure, pleural effusion, bronchospasm, prolonged mechanical ventilation, reintubation, pulmonary embolism, and acute respiratory distress syndrome (ARDS), each arising from the combined physiological insult of general anesthesia, surgical trauma, and impaired postoperative respiratory mechanics.[1] Changes in respiratory drive, diaphragmatic dysfunction, and reduced functional residual capacity begin at induction of anesthesia and may persist for several weeks after major surgery, predisposing patients to a cascade of complications that can markedly worsen surgical outcomes.[1]

Large multicentre cohorts have shown that the risk of PPC is not uniform across the surgical population but can be predicted from a combination of patient-related and procedure-related variables. The landmark ARISCAT study derived a validated risk index incorporating age, preoperative oxygen saturation, recent respiratory infection, anemia, surgical incision site, duration of surgery, and emergency status, demonstrating a graded increase in complication rates from low- to high-risk categories.[2] Similarly, a large North American multicentre analysis of noncardiothoracic surgical patients found that PPCs were independently associated with substantially higher 30-day mortality and prolonged hospital stay compared with patients who did not develop such complications.[3] Guidelines from the American College of Physicians have consistently identified advanced age, chronic obstructive pulmonary disease (COPD), poor functional status, and prolonged operative time as key predictors of pulmonary risk, and have highlighted evidence-based strategies — including preoperative incentive spirometry, lung-protective ventilation, and smoking cessation — that can mitigate this risk.[4,5]

Despite this substantial body of international literature, data specific to abdominal surgical cohorts in South Asian and Pakistani tertiary care settings remain comparatively limited, and the relative contribution of locally prevalent risk factors — such as high rates of tobacco use, delayed presentation for emergency surgery, and variable access to preoperative pulmonary optimization — is not well characterized.[6,7] Given the resource constraints and case-mix specific to tertiary care hospitals in this setting, a locally derived understanding of PPC frequency and its determinants is essential to inform targeted perioperative interventions.

We therefore conducted this prospective observational study to determine the frequency of postoperative pulmonary complications and to identify independent risk factors for their occurrence among patients undergoing major abdominal surgery at a tertiary care hospital, with the aim of informing perioperative risk stratification and targeted preventive strategies in this population.

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MATERIAL AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of General Surgery of Hayatabad Medical Complex over an 18-month period, from January 2024 to June 2025.

Sample Size and Sampling: A total of 384 adult patients undergoing elective or emergency major abdominal surgery under general anesthesia were enrolled by consecutive, non-probability sampling.

Inclusion Criteria: Adult patients aged 18 years and above undergoing major abdominal surgery (elective or emergency) under general anesthesia were included.

Exclusion Criteria: Patients with pre-existing ventilator dependence or incomplete clinical records were excluded.

Data Collection: After approval from the hospital's institutional ethical review committee and informed written consent, demographic characteristics (age, gender), anthropome tric data (height, weight, BMI), smoking history (status and pack-years), comorbidities (COPD, bronchial asthma, diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease, obstructive sleep apnea, anemia, malignancy), American Society of Anesthesiologists (ASA) physical status class, preoperative hemoglobin and serum albumin, preoperative oxygen saturation on room air, and receipt of preoperative incentive spirometry were recorded on a structured proforma. Intraoperative variables recorded included type of surgery (elective/emergency), surgical approach (open, laparoscopic, or laparoscopic converted to open), incision site (upper abdominal, lower abdominal, or midline), duration of surgery, type of anesthesia, intraoperative blood transfusion, and estimated blood loss.

Outcome Assessment: All patients were followed for the first 30 postoperative days for development of pulmonary complications, defined as atelectasis, pneumonia, acute respiratory failure, pleural effusion, bronchospasm, prolonged mechanical ventilation (>48 hours), reintubation, pulmonary embolism, or ARDS, diagnosed on the basis of standard clinical, radiological, and laboratory criteria by the attending surgical and anesthesia team. Secondary outcomes included ICU admission, total hospital length of stay, need for re-operation, and 30-day mortality.

Statistical Analysis: Data were entered and analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation and compared between patients with and without PPC using the independent-samples t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test. Variables significant on univariate analysis ($p<0.10$), together with clinically relevant covariates, were entered into a multivariable binary logistic regression model (Enter

method) with "any PPC" as the dependent variable, to identify independent predictors. Adjusted odds ratios (OR) with 95% confidence intervals (CI) were reported. A two-tailed p-value <0.05 was considered statistically significant.

RESULTS

A total of 384 patients undergoing major abdominal surgery were included in the analysis. The mean age of the study population was 58.36 ± 14.63 years (range 24–90 years), and 218 (56.8%) patients were male. The mean BMI was 27.34 ± 6.92 kg/m², with 98 (25.5%) patients classified as obese. Overall, 220 (57.3%) patients had a history of tobacco use (ex-smoker or current smoker). The most frequent comorbidities were hypertension (28.6%), diabetes mellitus (15.4%), COPD (10.9%), and malignancy (12.0%). The majority of patients were ASA class II (56.2%) or III (29.2%). Surgery was performed electively in 252 (65.6%) patients and on an emergency basis in 132 (34.4%). Detailed baseline demographic and clinical characteristics are presented in Table I.

Table I: *Baseline Demographic and Clinical Characteristics of the Study Population (N = 384)*

Variable	n (%) / Mean ± SD	Range
Age (years), mean ± SD	58.36 ± 14.63	24–90
Gender		
Male	218 (56.8%)	—
Female	166 (43.2%)	—
BMI (kg/m²), mean ± SD	27.34 ± 6.92	15.9–44.6
Underweight (<18.5)	22 (5.7%)	—
Normal (18.5–24.9)	136 (35.4%)	—
Overweight (25–29.9)	128 (33.3%)	—
Obese (⩾30)	98 (25.5%)	—
Smoking status		
Never smoker	164 (42.7%)	—
Ex-smoker	107 (27.9%)	—
Current smoker	113 (29.4%)	—
Comorbidities		

Variable	n (%) / Mean ± SD	Range
Hypertension	110 (28.6%)	—
Diabetes mellitus	59 (15.4%)	—
COPD	42 (10.9%)	—
Malignancy	46 (12.0%)	—
Bronchial asthma	32 (8.3%)	—
Anemia (Hb <10 g/dL)	32 (8.3%)	—
Chronic kidney disease	19 (4.9%)	—
Ischemic heart disease	18 (4.7%)	—
Obstructive sleep apnea	16 (4.2%)	—
ASA physical status		
Class II	216 (56.2%)	—
Class III	112 (29.2%)	—
Class IV	44 (11.5%)	—
Class V	12 (3.1%)	—
Preoperative hemoglobin (g/dL)	12.12 ± 1.87	6.6–16.7
Preoperative serum albumin (g/dL)	3.65 ± 0.53	2.2–5.1
Preoperative SpO_2 on room air (%)	96.09 ± 1.85	89.6–100
Preoperative incentive spirometry given	180 (46.9%)	—
Type of surgery		
Elective	252 (65.6%)	—
Emergency	132 (34.4%)	—
Surgical approach		
Open	205 (53.4%)	—
Laparoscopic	135 (35.2%)	—
Laparoscopic converted to open	44 (11.5%)	—

Variable	n (%) / Mean ± SD	Range
Incision site		
Upper abdominal	113 (29.4%)	—
Lower abdominal	135 (35.2%)	—
Midline (upper + lower)	136 (35.4%)	—
Duration of surgery (minutes)	184.74 ± 60.18	45–351
Intraoperative blood transfusion	111 (28.9%)	—
Estimated blood loss (mL)	367.18 ± 282.26	100–1853

At least one postoperative pulmonary complication occurred in 111 of 384 patients, giving an overall PPC frequency of 28.9%. Atelectasis was the most common complication, occurring in 69 patients (18.0%), followed by pneumonia (6.8%), prolonged mechanical ventilation >48 hours (5.5%), acute respiratory failure (3.9%), pleural effusion (2.6%), bronchospasm (1.8%), ARDS (1.0%), pulmonary embolism (1.0%), and reintubation (0.3%). Atelectasis and prolonged mechanical ventilation tended to develop earliest in the postoperative course (mean onset day 3.2 ± 1.4 and 2.1 ± 0.9, respectively), whereas pneumonia, pleural effusion, pulmonary embolism, and ARDS presented later, with mean onset between postoperative days 6 and 7 (Table II).

Table II: *Frequency and Onset of Individual Postoperative Pulmonary Complications (N = 384)*

Pulmonary Complication	n	% (of N=384)	Mean onset day ± SD
Atelectasis	69	18.0%	3.2 ± 1.4
Pneumonia	26	6.8%	6.3 ± 2.7
Acute respiratory failure	15	3.9%	3.7 ± 1.8
Prolonged mechanical ventilation (>48 h)	21	5.5%	2.1 ± 0.9
Pleural effusion	10	2.6%	6.5 ± 3.3
Bronchospasm	7	1.8%	2.7 ± 1.4
ARDS	4	1.0%	6.8 ± 1.3
Pulmonary embolism	4	1.0%	7.0 ± 2.9
Reintubation	1	0.3%	4.0

Pulmonary Complication	n	% (of N=384)	Mean onset day ± SD
Any PPC	111	28.9%	—
No PPC	273	71.1%	—

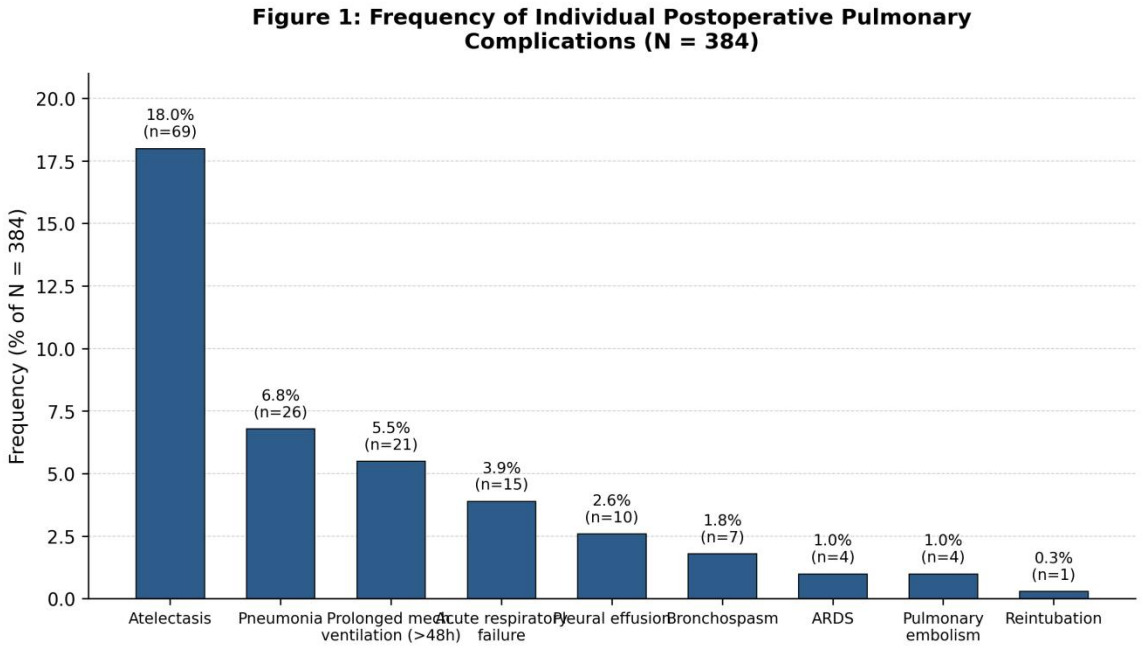

Figure 1: Frequency of individual postoperative pulmonary complications (N = 384).

On univariate analysis, patients who developed PPC were significantly older (63.25 ± 14.82 vs 56.38 ± 14.10 years, $p<0.001$), had lower preoperative SpO_2 (95.62 ± 2.00% vs 96.28 ± 1.76%, $p=0.003$), and underwent longer surgical procedures (204.11 ± 56.40 vs 176.86 ± 59.98 minutes, $p<0.001$) than those without PPC. Among categorical variables, smoking status, COPD, diabetes mellitus, ASA physical status class, type of surgery (emergency vs elective), surgical approach, incision site, and intraoperative blood transfusion were significantly associated with PPC occurrence (all $p<0.05$). Gender, BMI category, bronchial asthma, hypertension, ischemic heart disease, chronic kidney disease, obstructive sleep apnea, anemia, malignancy, type of anesthesia, and preoperative incentive spirometry were not significantly associated with PPC on univariate analysis (Table III).

Table III(a): *Univariate Association of Continuous Variables with PPC (Independent-Samples t-Test)*

Continuous Variable	PPC group (n=111)	No-PPC group (n=273)	p-value
Age (years), mean ± SD	63.25 ± 14.82	56.38 ± 14.10	**<0.001***
BMI (kg/m^2), mean ± SD	28.17 ± 7.20	27.00 ± 6.78	0.147
Preop. SpO_2 (%), mean ± SD	95.62 ± 2.00	96.28 ± 1.76	**0.003***
Duration of surgery (min), mean ± SD	204.11 ± 56.40	176.86 ± 59.98	**<0.001***
Estimated blood loss (mL), mean ± SD	402.75 ± 281.82	352.73 ± 281.66	0.116
Preop. hemoglobin (g/dL), mean ± SD	12.29 ± 1.89	12.06 ± 1.86	0.267
Preop. serum albumin (g/dL), mean ± SD	3.59 ± 0.52	3.68 ± 0.54	0.126

Table III(b): *Univariate Association of Categorical Variables with PPC (Chi-Square Test)*

Categorical Variable	PPC rate (category 1)	PPC rate (category 2)	p-value (χ^2)
Gender (Male vs Female)	—	—	0.736
BMI category	—	—	0.363
Smoking status (Never/Ex/Current)	22.0% / 30.8% / 37.2%	PPC rate by group	**0.020***
COPD (Yes vs No)	59.5%	25.1%	**<0.001***
Bronchial asthma (Yes vs No)	40.6%	27.8%	0.186
Diabetes mellitus (Yes vs No)	42.4%	26.5%	**0.020***
Hypertension (Yes vs No)	—	—	0.357
Ischemic heart disease (Yes vs No)	50.0%	27.9%	0.079
Chronic kidney disease (Yes vs No)	—	—	1.000

Categorical Variable	PPC rate (category 1)	PPC rate (category 2)	p-value (χ^2)
Obstructive sleep apnea (Yes vs No)	—	—	1.000
Anemia, Hb<10 (Yes vs No)	—	—	1.000
Malignancy (Yes vs No)	41.3%	27.2%	0.071
ASA class (II/III/IV/V)	19.9% / 34.8% / 47.7% / 66.7%	PPC rate by class	**<0.001***
Type of surgery (Emergency vs Elective)	43.2%	21.4%	**<0.001***
Surgical approach (Open/Lap/Lap conv.)	31.2% / 18.5% / 50.0%	PPC rate by group	**<0.001***
Incision site (Upper/Lower/Midline)	31.0% / 14.1% / 41.9%	PPC rate by group	**<0.001***
Type of anesthesia	—	—	0.346
Intraoperative blood transfusion (Yes vs No)	37.8%	25.3%	**0.019***
Preoperative incentive spirometry (Yes vs No)	27.2%	30.4%	0.568

**Statistically significant, p<0.05. For variables with more than two categories, PPC rates are presented in ascending category order (see text for category labels).*

On multivariable logistic regression analysis (pseudo R^2 = 0.304), independent predictors of postoperative pulmonary complications were advancing age (adjusted OR 1.04, 95% CI 1.01–1.06, p=0.006), higher BMI (adjusted OR 1.05, 95% CI 1.01–1.09, p=0.029), current smoking (adjusted OR 4.16, 95% CI 2.04–8.49, p<0.001), ex-smoking (adjusted OR 2.34, 95% CI 1.16–4.73, p=0.018), COPD (adjusted OR 6.48, 95% CI 2.55–16.43, p<0.001), bronchial asthma (adjusted OR 2.67, 95% CI 1.01–7.09, p=0.048), emergency surgery (adjusted OR 3.05, 95% CI 1.67–5.58, p<0.001), midline incision (adjusted OR 4.93, 95% CI 2.35–10.34, p<0.001), and upper abdominal incision (adjusted OR 5.20, 95% CI 2.38–11.37, p<0.001), each relative to lower abdominal incision. Preoperative incentive spirometry was independently protective against PPC (adjusted

OR 0.44, 95% CI 0.23–0.81, p=0.009). Laparoscopic approach showed a borderline protective trend relative to open surgery (adjusted OR 0.52, 95% CI 0.26–1.01, p=0.053), while intraoperative blood transfusion, preoperative hemoglobin, and preoperative serum albumin showed trends toward significance without reaching the conventional threshold (Table IV).

Table IV: *Independent Predictors of Postoperative Pulmonary Complications on Multivariable Logistic Regression*

Variable	Adjusted OR	95% CI	p-value
Age (per year)	**1.04**	1.01 – 1.06	**0.006***
BMI (per kg/m^2)	**1.05**	1.01 – 1.09	**0.029***
Current smoker (vs never)	**4.16**	2.04 – 8.49	**<0.001***
Ex-smoker (vs never)	**2.34**	1.16 – 4.73	**0.018***
COPD	**6.48**	2.55 – 16.43	**<0.001***
Bronchial asthma	**2.67**	1.01 – 7.09	**0.048***
Emergency surgery (vs elective)	**3.05**	1.67 – 5.58	**<0.001***
Midline incision (vs lower abdominal)	**4.93**	2.35 – 10.34	**<0.001***
Upper abdominal incision (vs lower abdominal)	**5.20**	2.38 – 11.37	**<0.001***
Preoperative incentive spirometry	**0.44**	0.23 – 0.81	**0.009***
Laparoscopic approach (vs open)	0.52	0.26 – 1.01	0.053
Intraoperative blood transfusion	1.80	0.98 – 3.30	0.057
Preoperative hemoglobin (per g/dL)	1.17	1.00 – 1.37	0.054
Preoperative serum albumin (per g/dL)	0.62	0.36 – 1.06	0.078
Diabetes mellitus	1.80	0.85 – 3.81	0.125
Duration of surgery (per minute)	1.005	0.999 – 1.010	0.082
Hypertension	1.45	0.73 – 2.86	0.288
Female gender (vs male)	0.65	0.37 – 1.17	0.149

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Statistically significant, p<0.05. OR = odds ratio; CI = confidence interval. Reference categories: never-smoker (smoking status), elective surgery (type of surgery), open approach (surgical approach), lower abdominal incision (incision site), male (gender).

Figure 2: Independent Predictors of Postoperative Pulmonary Complications on Multivariable Logistic Regression

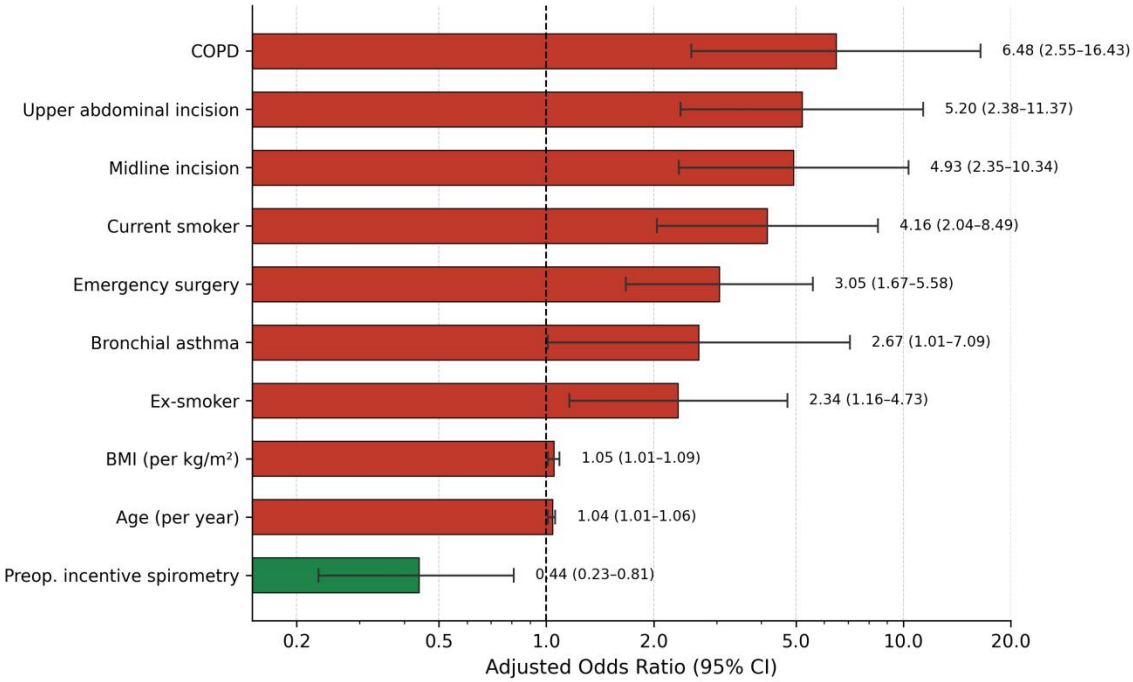

Figure 2: Independent predictors of postoperative pulmonary complications on multivariable logistic regression (adjusted odds ratios with 95% CI; log scale).

Patients who developed PPC experienced markedly worse postoperative outcomes than those who did not. ICU admission was required in 43.2% of patients with PPC compared with 5.1% of patients without PPC (p<0.001). Mean total hospital length of stay was nearly double in the PPC group (11.32 ± 3.27 days) compared with the no-PPC group (6.32 ± 2.52 days, p<0.001). Thirty-day mortality was significantly higher among patients with PPC (6.3%) than among those without (1.1%, p=0.011) (Table V).

Table V: *Impact of Postoperative Pulmonary Complications on Clinical Outcomes*

Outcome	PPC group (n=111)	No-PPC group (n=273)	p-value
ICU admission required	43.2% (48/111)	5.1% (14/273)	**<0.001***
Total hospital LOS (days), mean ±	11.32 ± 3.27	6.32 ± 2.52	**<0.001***

Outcome	PPC group (n=111)	No-PPC group (n=273)	p-value
SD			
30-day mortality	6.3% (7/111)	1.1% (3/273)	**0.011***

DISCUSSION

In this prospective study of 384 patients undergoing major abdominal surgery, nearly three in ten patients (28.9%) developed at least one postoperative pulmonary complication, with atelectasis and pneumonia being the most common. This frequency is consistent with the wide range of 2%–40% reported across the international literature, reflecting substantial variability in patient case-mix, surgical complexity, and diagnostic thresholds used to define PPC across studies.[6] Our observed frequency is considerably higher than the 5.8% reported in a large North American NSQIP-based cohort restricted to major abdominal oncologic resections,[6] but comparable to figures reported from other South Asian and regional tertiary care settings, where PPC rates in the range of 25%–30% have been described in similarly mixed elective and emergency abdominal surgical populations.[7] This discrepancy likely reflects differences in case complexity, the higher proportion of emergency surgery, and variable access to preoperative pulmonary optimization in resource-limited settings compared with high-volume Western surgical registries.

Advancing age, current and former smoking, COPD, and bronchial asthma emerged as independent predictors of PPC in our cohort, findings that closely mirror those of the ARISCAT risk model and subsequent validation studies, in which age and pre-existing respiratory disease consistently ranked among the strongest predictors of pulmonary risk.[2] The markedly elevated odds associated with COPD (adjusted OR 6.48) in our analysis is consistent with the well-established observation that chronic airway disease impairs mucociliary clearance and cough effectiveness, predisposing to atelectasis and secondary infection in the early postoperative period.[1] Similarly, the dose-dependent relationship we observed between smoking status and PPC risk — with current smokers at higher risk than ex-smokers, and both at higher risk than never-smokers — reinforces existing evidence that smoking cessation, even when incomplete, confers a measurable reduction in pulmonary risk and supports incorporating structured cessation counselling into preoperative pathways.[1,5]

Emergency surgery and upper abdominal or midline incision were also strong independent predictors of PPC in our cohort, consistent with prior evidence that

proximity of the surgical incision to the diaphragm impairs postoperative diaphragmatic excursion and cough mechanics, while the lack of opportunity for elective optimization in emergency settings compounds baseline risk.[1,2] The magnitude of risk associated with upper abdominal and midline incisions in our data (adjusted OR >5 relative to lower abdominal incision) underscores incision site as one of the more robust and consistently reproducible predictors of PPC across surgical populations, and supports continued emphasis on minimally invasive and laparoscopic approaches where oncologically and technically feasible; notably, laparoscopic surgery showed a borderline protective trend in our adjusted model.

Importantly, preoperative incentive spirometry was independently associated with a substantially lower risk of PPC in our cohort (adjusted OR 0.44), despite showing no significant association on univariate analysis alone — a pattern that likely reflects confounding by indication, whereby spirometry was preferentially offered to higher-risk patients, an effect only revealed once adjusted for other risk factors in the multivariable model. This finding is consistent with American College of Physicians guidance identifying preoperative lung expansion techniques, including incentive spirometry, as an evidence-based strategy to reduce postoperative pulmonary risk, and supports its wider and more consistent implementation as part of routine preoperative optimization pathways, particularly among patients with modifiable risk factors such as smoking or obstructive airway disease.[4,5]

Consistent with prior literature, PPC in our cohort was associated with markedly worse clinical outcomes: patients with PPC had nearly double the hospital length of stay, more than eight times the rate of ICU admission, and nearly six times the 30-day mortality of patients without PPC. These findings echo those of large multicentre cohorts demonstrating that PPCs are independently associated with early postoperative mortality and prolonged hospitalization even after adjustment for baseline surgical risk, reinforcing that PPC is not merely a marker of frailty but an outcome with substantial independent impact on recovery trajectory and resource utilization.[3]

Limitations: This study has several limitations. As a single-centre observational study, our findings may not be generalizable to institutions with different case-mix, staffing, or perioperative protocols. The non-probability consecutive sampling strategy, while pragmatic, may introduce selection bias. Diagnosis of individual PPCs relied on clinical and radiological criteria applied by the treating team rather than a single standardized adjudication protocol, which may introduce some heterogeneity in complication ascertainment. Additionally, although multivariable regression was used to adjust for

confounding, residual and unmeasured confounding (for example, detailed pulmonary function testing or frailty indices) cannot be excluded given the observational design.

CONCLUSION

Postoperative pulmonary complications occurred in nearly three in ten patients undergoing major abdominal surgery in this tertiary care cohort and were independently associated with substantially higher ICU admission, prolonged hospital stay, and 30-day mortality. Advanced age, elevated BMI, current and former smoking, COPD, bronchial asthma, emergency surgery, and upper abdominal or midline incisions were identified as independent risk factors, while preoperative incentive spirometry was independently protective. These findings support the implementation of structured preoperative risk stratification and targeted perioperative pulmonary optimization — including smoking cessation counselling, incentive spirometry, and judicious selection of minimally invasive approaches where feasible — to reduce the burden of postoperative pulmonary complications and improve surgical outcomes in similar tertiary care settings.

AUTHORS' CONTRIBUTION

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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ETHICAL APPROVAL

The study was approved by the Institutional Ethical Review Committee of Hayatabad Medical Complex Peshawar, and written informed consent was obtained from all participants prior to enrolment.

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