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Predictors of Postoperative Pulmonary Complications Following Major Abdominal Surgery: A Prospective Observational Cohort Study

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Abstract

Background: Postoperative pulmonary complications remain an important source of morbidity after major abdominal surgery, yet locally generated prospective data from Indian tertiary-care settings remain limited. ***Objectives***: To determine the incidence and pattern of postoperative pulmonary complications and identify perioperative factors associated with their occurrence following major abdominal surgery. ***Methods***: This prospective observational cohort study was conducted on 100 adults undergoing major abdominal surgery were enrolled. Demographic variables, smoking history, body mass index, pre-existing respiratory disease, operative details, anaesthetic technique, and postoperative intensive care unit admission were recorded. Postoperative pulmonary complications within seven days or during the same admission included atelectasis, pneumonia, pleural effusion, bronchospasm, and respiratory failure requiring ventilatory support. Associations were tested using chi-square analysis and independent determinants were assessed using multivariate logistic regression. ***Results***: Postoperative pulmonary complications occurred in 22% of patients. Atelectasis was the commonest event, followed by pneumonia and pleural effusion. Complications were significantly more frequent among patients aged above 60 years, smokers, those with pre-existing respiratory disease, those undergoing procedures lasting more than four hours, and those requiring postoperative intensive care unit admission. On multivariate analysis, postoperative intensive care unit admission, pre-existing lung disease, advanced age, smoking history, and operative duration greater than four hours remained independently associated with postoperative pulmonary complications. ***Conclusion***: Postoperative pulmonary complications were common after major abdominal surgery in this cohort. Advanced age, smoking, chronic respiratory disease, prolonged surgery, and postoperative intensive care requirement identified a subgroup at heightened risk. Focused perioperative risk stratification, pulmonary optimization, and vigilant postoperative monitoring are essential to reduce pulmonary morbidity.

Keywords: Postoperative pulmonary complications; abdominal surgery; risk factors; smoking; respiratory disease; cohort study.

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INTRODUCTION

Postoperative pulmonary complications (PPCs) are among the most clinically important adverse events after non-cardiothoracic surgery because they prolong recovery, increase resource utilization, and contribute substantially to early postoperative mortality [1,2]. The term encompasses a spectrum of respiratory problems, including atelectasis, pneumonia, pleural effusion, bronchospasm, and postoperative respiratory failure. Standardized perioperative definitions have improved reporting, but heterogeneity in diagnostic criteria across studies still affects comparison of incidence estimates between institutions and surgical populations [2]. Major abdominal procedures remain especially relevant because general anaesthesia, diaphragmatic dysfunction, postoperative pain, reduced cough effectiveness, splinting, and immobilization together promote impaired ventilation and secretion retention in the early postoperative period [1,3].

The burden of PPCs after abdominal surgery is influenced by both patient-related and procedure-related characteristics. Large cohort studies have identified advanced age, impaired baseline oxygenation, smoking, respiratory co-morbidity, upper abdominal procedures, emergency surgery, and longer operative duration as important determinants of pulmonary risk [3,4]. In abdominal surgical populations specifically, chronic obstructive pulmonary disease and other pre-existing

lung disorders have consistently been associated with higher rates of postoperative respiratory events [5,8]. Observational studies have further shown that prolonged anaesthesia, greater surgical stress, and emergency abdominal operations increase PPC frequency, while smoking remains a modifiable exposure of practical relevance in routine perioperative assessment [7,9].

Published incidence rates after abdominal surgery vary widely because of differences in surgical case-mix, definitions, surveillance periods, and perioperative practices. Cohort studies in major elective abdominal surgery have reported PPC rates around 11-12%, whereas broader abdominal cohorts and higher-risk populations have shown considerably greater event rates and worse downstream outcomes [5,6,11,14]. Delayed mobilisation and poor early postoperative functional recovery also appear to intensify pulmonary risk after major abdominal surgery [10]. More recent abdominal surgery studies continue to validate structured risk assessment approaches such as ARISCAT, particularly in elderly and emergency surgical populations, but local prospective evidence from many Indian centres remains limited [12-14]. In low-resource and mixed case-load settings, institution-level data are especially useful because they help clinicians identify preventable contributors, standardize perioperative respiratory surveillance, and prioritize postoperative monitoring in the patients most likely to deteriorate. Hospital-specific evidence is therefore important for contextualizing risk, improving counseling, and guiding preventive pathways tailored to local practice.

The objectives of the present study were to determine the incidence and pattern of postoperative pulmonary complications among patients undergoing major abdominal surgery at a tertiary-care hospital, and to identify the perioperative factors independently associated with their occurrence.

METHODOLOGY

Study design and setting

This prospective observational cohort study was carried out at Tirumala Medicover Hospital, Vizianagaram, Andhra Pradesh, from February 2025 to July 2025. The study evaluated the frequency of postoperative pulmonary complications after major abdominal surgery and identified perioperative factors associated with their development. Adult patients were followed from the preoperative period through the early postoperative hospital course. The final manuscript submitted to the journal should include the institutional ethics committee approval number and date as recorded in the study documents.

Study population

The study enrolled 100 consecutive adult patients undergoing major abdominal surgery during the study period. Major abdominal surgery was defined as a gastrointestinal, hepatobiliary, colorectal, or other major intra-abdominal procedure requiring general anaesthesia, with or without an additional regional technique, and postoperative in-hospital monitoring. Patients aged 18 years or older were eligible. Patients undergoing minor abdominal procedures, isolated day-care procedures, thoracic operations, or those with incomplete perioperative records were excluded. Written informed consent from participants or legally authorized attendants should be documented in the final submission according to source records.

Data collection

A structured proforma was used to record demographic and perioperative variables. Baseline characteristics included age, sex, smoking history, body mass index category, and pre-existing respiratory disease such as chronic obstructive pulmonary disease or bronchial asthma. Operative variables included type of abdominal surgery, duration of surgery, type of anaesthesia, and requirement for postoperative intensive care unit admission. Perioperative evaluation and surveillance were aligned with the clinical approach used in prior abdominal surgery cohorts and with contemporary perioperative pulmonary outcome frameworks [2,3]. All patients were reviewed clinically after surgery, and relevant radiological or laboratory findings were incorporated when respiratory complications were suspected.

Outcome definition and follow-up

The primary outcome was the occurrence of at least one postoperative pulmonary complication within the first seven postoperative days or during the index hospital stay, whichever occurred first. PPCs were classified using clinically relevant categories adapted from standardized perioperative pulmonary outcome definitions and major cohort studies [2,3]. The diagnostic categories included atelectasis, pneumonia, pleural effusion, bronchospasm, and respiratory failure requiring ventilatory support. Respiratory events were identified from daily clinical assessment, nursing records, imaging reports, oxygen requirement, and postoperative ventilatory support data.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS), version 25.0. Categorical variables were summarized as frequencies and percentages. The incidence of PPCs was calculated as the proportion of patients developing at least one complication. Associations between selected clinical factors and PPC

occurrence were examined using the chi-square test. Variables showing clinically meaningful associations were entered into a multivariate logistic regression model to estimate adjusted odds ratios with 95% confidence intervals. A two-sided p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 100 patients undergoing major abdominal surgery were included in the prospective observational cohort. The results describe demographic characteristics, surgical variables, incidence of postoperative pulmonary complications, and factors associated with their occurrence.

Table 1. Demographic characteristics of the study population (N = 100)

Variable	Category	n	%
Age group (years)	18-40	28	28.0
	41-60	42	42.0
	>60	30	30.0
Sex	Male	62	62.0
	Female	38	38.0
Smoking status	Current/Former smoker	36	36.0
	Non-smoker	64	64.0
BMI category	<18.5 kg/m²	8	8.0
	18.5-24.9 kg/m²	52	52.0
	≥25 kg/m²	40	40.0
Pre-existing respiratory disease	Present	18	18.0
	Absent	82	82.0

Most patients were aged 41–60 years (42.0%). Male patients constituted 62.0% of the cohort. A history of smoking was present in 36.0% of participants, while 18.0% had underlying respiratory diseases such as chronic obstructive pulmonary disease or bronchial asthma (Table 1).

Table 2. Surgical and perioperative characteristics (N = 100)

Variable	Category	n	%
Type of surgery	Gastrointestinal	48	48.0
	Hepatobiliary	24	24.0
	Colorectal	18	18.0
	Others	10	10.0
Duration of surgery	<2 hours	26	26.0
	2-4 hours	46	46.0
	>4 hours	28	28.0
Type of anesthesia	General anesthesia	84	84.0
	Combined regional + general	16	16.0
Postoperative ICU admission	Yes	32	32.0
	No	68	68.0

Gastrointestinal procedures formed the largest surgical group (48.0%), followed by hepatobiliary and colorectal surgeries. Nearly half of the procedures lasted 2–4 hours, whereas 28.0% exceeded four hours. General anaesthesia alone was used in the majority of patients, and 32.0% required postoperative intensive care unit admission (Table 2).

Table 3. Incidence and types of postoperative pulmonary complications (N = 100)

Pulmonary complication	n	%
Atelectasis	9	9.0
Pneumonia	7	7.0
Pleural effusion	5	5.0
Respiratory failure requiring ventilation	4	4.0
Bronchospasm	3	3.0
Total patients with PPCs	22	22.0

Note: Individual complication frequencies exceed the total number of affected patients because some patients experienced more than one pulmonary complication

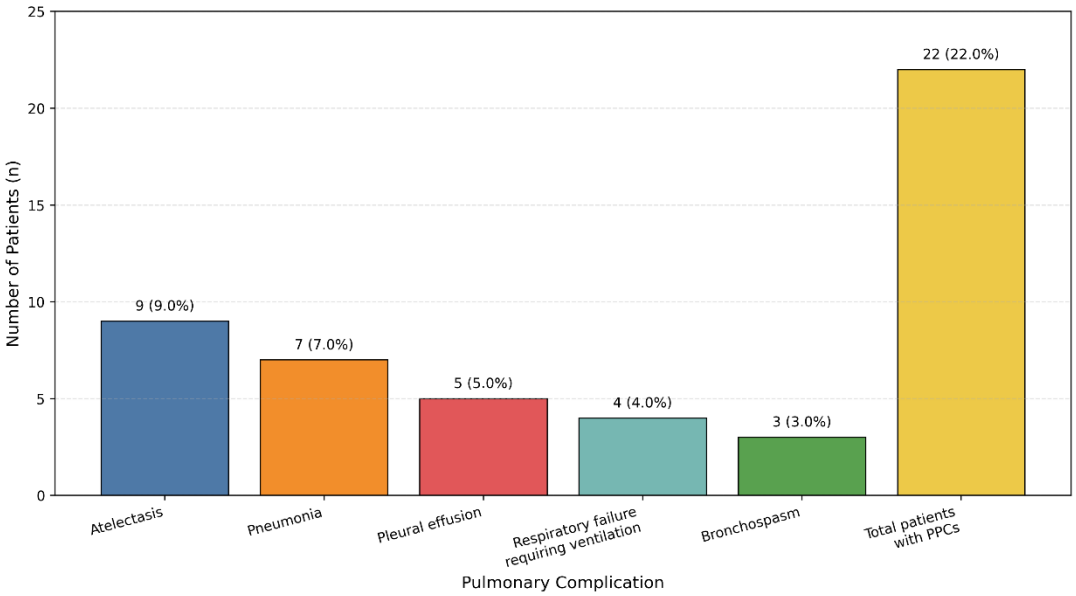

Figure 1. Incidence and types of postoperative pulmonary complications

Postoperative pulmonary complications were observed in 22 patients, giving an overall incidence of 22.0%. Atelectasis was the most frequent complication, followed by pneumonia, pleural effusion, respiratory failure requiring ventilatory support, and bronchospasm. Some patients developed more than one pulmonary event; therefore, the summed frequency of individual complications exceeded the total number of affected patients (Table 3).

Table 4. Association between clinical factors and postoperative pulmonary complications

Variable	PPC present (n = 22)	PPC absent (n = 78)	p-value
Age >60 years	12 (54.5%)	18 (23.1%)	0.006
Smoking history	13 (59.1%)	23 (29.5%)	0.012
Pre-existing lung disease	9 (40.9%)	9 (11.5%)	0.003
Surgery duration >4 hours	11 (50.0%)	17 (21.8%)	0.009
ICU admission	14 (63.6%)	18 (23.1%)	0.001

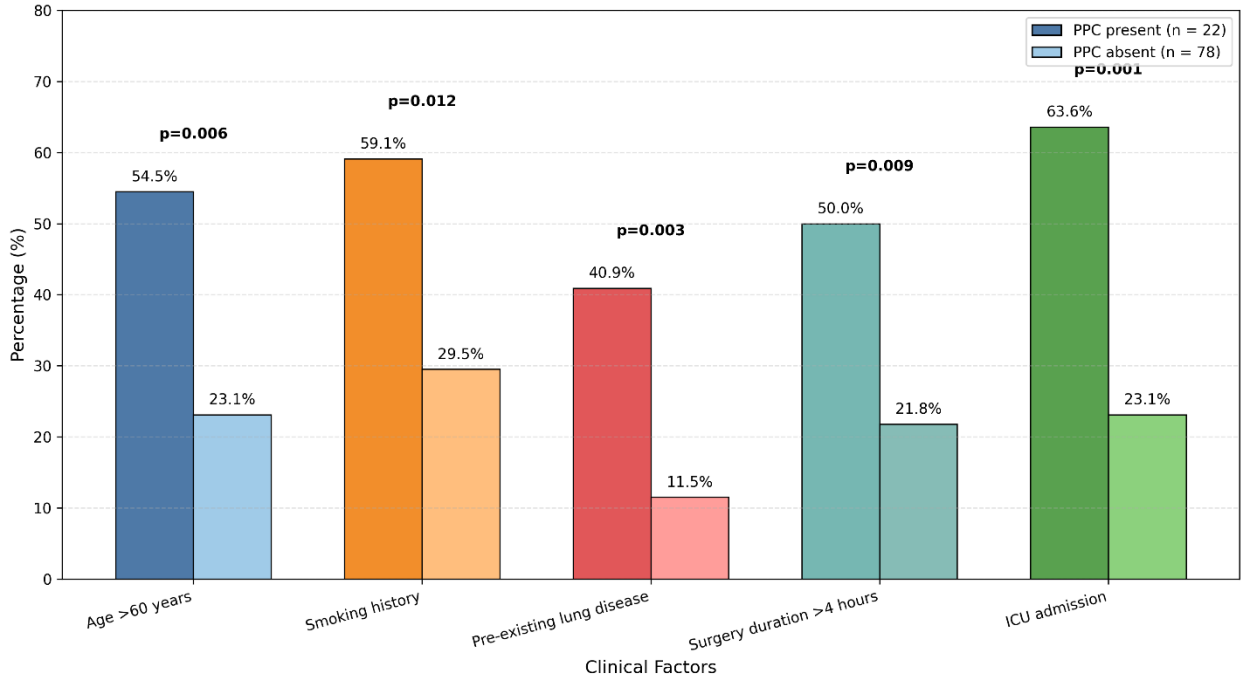

Figure 2: Association between clinical factors and postoperative pulmonary complications

On bivariate analysis, pulmonary complications were significantly more frequent among patients older than 60 years, those with smoking history, patients with pre-existing lung disease, those undergoing surgery lasting more than four hours, and those requiring postoperative intensive care unit admission (Table 4).

Table 5. Multivariate logistic regression analysis of factors associated with postoperative pulmonary complications

Predictor	Adjusted odds ratio	95% CI	p-value
Age >60 years	2.9	1.2-6.8	0.015
Smoking history	2.5	1.1-5.9	0.028
Pre-existing lung disease	3.6	1.4-9.2	0.006
Surgery duration >4 hours	2.7	1.1-6.4	0.021
ICU admission	3.9	1.6-9.5	0.003

Note: CI: confidence interval.

Multivariate logistic regression confirmed that postoperative intensive care unit admission and pre-existing respiratory disease were the strongest independent factors associated with PPCs. Advanced age, smoking history, and prolonged operative duration also remained independently associated with increased pulmonary risk after adjustment (Table 5).

DISCUSSION

The present prospective cohort study demonstrated that PPCs occurred in 22.0% of patients undergoing major abdominal surgery, with atelectasis emerging as the commonest respiratory event. This incidence is higher than the 5.8% reported in the NSQIP analysis by Yang et al. and the approximately 11-12% rates reported in the abdominal cohorts described by Patel et al. and de Ávila and Fenili [4-6]. However, the figure remains clinically plausible within the broader range documented in higher-risk abdominal populations, particularly when surveillance includes multiple clinically significant PPC categories and when the cohort contains older patients, smokers, and individuals with pre-existing respiratory disease [9,14]. Differences in case-mix, perioperative practices, and outcome definitions remain important reasons for variation between studies [1,2].

Advanced age was a significant determinant of PPCs in the present study, both on univariate comparison and in multivariate modelling. This finding is consistent with the ARISCAT derivation study and later abdominal surgery cohorts showing that increasing age reflects reduced physiological reserve, weaker cough, impaired mucociliary clearance, and greater vulnerability to postoperative hypoventilation and infection [3,12,13]. Smoking history was also independently associated with PPCs, which agrees with earlier observational work identifying smoking as a modifiable risk factor after upper abdominal and major abdominal procedures [4,7]. Similarly, pre-existing respiratory disease showed a strong association with PPCs in our cohort, mirroring studies demonstrating worse postoperative pulmonary outcomes in patients with chronic obstructive airway disease and other baseline respiratory disorders [5,8,9].

Operative duration greater than four hours was another independent factor associated with PPCs. This observation is in line with prior reports in which longer anaesthesia and more extensive surgery increased pulmonary morbidity through prolonged recumbency, higher anaesthetic exposure, fluid shifts, and a greater inflammatory burden [3,5,7]. In our series, postoperative intensive care unit admission was also strongly associated with PPCs. This variable should be interpreted primarily as a marker of greater perioperative severity rather than a purely antecedent causal factor. Studies from abdominal surgical cohorts have shown that PPCs are closely linked with increased ICU utilization, longer hospital stay, and worse short-term outcomes, supporting this interpretation [11,14]. Atelectasis being the commonest complication also aligns with the known early postoperative pathophysiology of abdominal surgery, where shallow breathing, pain-related splinting, and reduced lung expansion dominate the immediate recovery phase [1,12].

These findings have practical implications. Patients who are older, smoke, have chronic respiratory disease, or are expected to undergo prolonged abdominal procedures should be identified preoperatively as higher-risk individuals. Structured risk assessment tools such as ARISCAT, combined with respiratory evaluation, smoking cessation counselling, lung expansion measures, optimal analgesia, early mobilisation, and vigilant postoperative monitoring, can strengthen perioperative pulmonary care pathways [3,10,12,13]. The present study adds local prospective evidence from a tertiary-care hospital in Andhra Pradesh and supports the need for focused prevention bundles in major abdominal surgery. Larger multicentric studies that incorporate physiological variables such as oxygen saturation, albumin status, and frailty would further refine context-specific risk prediction.

Limitations

This single-center study included 100 patients, which restricted subgroup analyses and precision of effect estimates. Surgical categories were heterogeneous, and formal preoperative tools such as ARISCAT scoring, spirometry, frailty evaluation, and serum albumin assessment were not incorporated. Follow-up was limited to the early postoperative hospital

period, so late respiratory events after discharge were not captured. Postoperative ICU admission also reflected evolving clinical severity.

CONCLUSION

Postoperative pulmonary complications were common in this prospective cohort of patients undergoing major abdominal surgery, affecting more than one-fifth of the study population. Atelectasis was the predominant event. Advanced age, smoking history, pre-existing respiratory disease, prolonged operative duration, and postoperative intensive care requirement identified patients at substantially higher risk. These findings support routine perioperative pulmonary risk stratification and targeted preventive strategies, particularly in elderly and respiratory-vulnerable patients. Preoperative optimization, smoking cessation counselling, meticulous intraoperative management, aggressive pain control, lung expansion measures, early mobilisation, and close postoperative surveillance should form the core of institutional efforts to reduce pulmonary morbidity and improve surgical outcomes.

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