

Original Research Article

POST-OPERATIVE PULMONARY COMPLICATIONS FOLLOWING EXPLORATORY LAPAROTOMY: A SINGLE-CENTER STUDY

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Received : 04/04/2026
Received in revised form : 01/05/2026
Accepted : 15/05/2026

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DOI: 10.70034/ijmedph.2026.2.761

Source of Support: Nil,

Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (2); 4652-4657

ABSTRACT

Background: Postoperative pulmonary complications (PPCs) are a significant source of postoperative illness and death, encompassing various respiratory issues that heighten perioperative risks. This research sought to assess the frequency and risk factors of PPCs in patients who underwent exploratory laparotomy with general anesthesia at our facility.

Materials and Methods: A prospective longitudinal analytical study was carried out at the Department of General Surgery, Hamdard Institute of Medical Sciences and Research, New Delhi, over an 18-month period (2022–2025). The study included 92 patients over the age of 18 who underwent exploratory laparotomy under general anesthesia. PPCs were identified using established clinical criteria, and their occurrence was analyzed in relation to demographic, clinical, and perioperative factors to pinpoint potential risk factors.

Results: Among the 92 patients, 21 (22.8%) experienced postoperative pulmonary complications (PPCs). Key predictors included older age, higher body mass index (BMI), elevated American Society of Anesthesiologists (ASA) grade, and comorbidities such as chronic obstructive pulmonary disease (COPD), asthma, diabetes, and smoking ($p < 0.05$). Factors like surgical diagnosis, duration of surgery, and whether the surgery was elective or emergency did not show a significant association with PPCs.

Conclusion: PPCs are prevalent following exploratory laparotomy and have identifiable risk factors. Focusing on perioperative optimization for high-risk patients may help decrease the occurrence of PPCs. Larger multicenter studies are necessary to validate these findings and aid in developing preventive strategies.

Keywords: Exploratory Laparotomy, PPCs.

INTRODUCTION

Worldwide, over 300 million surgical procedures are conducted annually.^[1] Despite notable progress in surgical and anesthetic methods, postoperative complications continue to be a leading cause of adverse outcomes.^[2] Among these, postoperative pulmonary complications (PPCs) are particularly noteworthy. PPCs are defined as respiratory issues that arise within 48–72 hours after surgery and include conditions like atelectasis, pleural effusion, pneumonia, bronchospasm, and acute respiratory distress syndrome (ARDS). These complications are associated with increased morbidity, prolonged hospitalization, and higher healthcare costs.^[3,4]

The reported incidence of PPCs ranges from 9% to 40%, depending on the type of surgery and the population studied. The European Perioperative Clinical Outcome (EPCO) group has established standardized definitions and diagnostic criteria for each PPC.^[5]

Elective surgeries provide time for preoperative risk factor optimization, whereas emergency surgeries often proceed without such preparation, raising the risk of complications. Numerous studies in Western populations have examined PPC incidence in both elective and emergency contexts; however, similar research in Indian populations is limited. Existing Indian studies often encompass diverse surgical

procedures, making it difficult to isolate surgery-specific risk factors.

This study concentrated solely on adult patients undergoing exploratory laparotomy, aiming to determine PPC incidence and identify risk factors in both elective and emergency settings at a tertiary care hospital in North India.

MATERIALS AND METHODS

Study design: A prospective longitudinal analytical study was conducted at the Department of General Surgery, Hamdard Institute of Medical Sciences and Research, and the associated Hakeem Abdul Hameed Centenary Hospital, New Delhi, from January 2023 to June 2025.

After obtaining ethical approval from Institutional Ethics committee, ninety-two patients over the age of 18 who underwent exploratory laparotomy under general anesthesia were included. Patients with ASA grade IV or higher, those on long-term preoperative ventilatory support or oxygen dependence, and those who did not provide consent were excluded.

The study examined patient-related risk factors such as age, BMI, existing health conditions (including COPD, asthma, diabetes, hypertension, coronary artery disease, and cancer), American Society of Anesthesiologists (ASA) classification, the urgency of surgery (whether elective or emergency), surgical diagnosis, surgery duration, and intraoperative contamination. The postoperative pulmonary complications (PPCs) evaluated were atelectasis,

pneumonia, pleural effusion, bronchospasm, and ARDS, identified based on EPCO criteria [5] through clinical symptoms, lab tests, and imaging results. Preoperative assessment involved taking a medical history, conducting a physical examination, and performing a pre-anesthetic evaluation. Intraoperative data encompassed the surgical procedure, its duration, and findings. Postoperative monitoring continued until the patient was discharged.

Statistical analysis was conducted using SPSS version 25 (IBM Corp., Armonk, NY, USA). Continuous data are presented as mean $\pm$ standard deviation (SD), while categorical data are shown as frequency and percentage. The chi-square test, Fisher's exact test, t-test, and Mann-Whitney U test were utilized as needed. A p-value of less than 0.05 was considered statistically significant.

RESULTS

We recruited 92 patients who underwent exploratory laparotomy over one and a half years. All subjects were followed up for PPCs.

The mean age of the included subjects was 40.49 years, with the majority (57.6%) belonging to the younger age group of 18-40 years. 60 (65.2%) were male, and the majority belonged to the ASA II group. The mean BMI was 24.85 kg/m². Perforation peritonitis was the most common diagnosis, followed by intestinal obstruction. The basic details of the included cases are summarized in [Table 1].

Table 1: Summary of Basic Details

Basic Details	Mean $\pm$ SD
Age (Years)	40.49 $\pm$ 16.04
Age Group	
18-40 Years	53 (57.6%)
41-60 Years	24 (26.1%)
>60 Years	15 (16.3%)
Gender	
Male	60 (65.2%)
Female	32 (34.8%)
Height (cm)	168.14 $\pm$ 6.32
Weight (Kg)	70.40 $\pm$ 10.71
BMI (Kg/m ²)	24.85 $\pm$ 3.14
BMI	
18.5-22.9 Kg/m ²	27 (29.3%)
23.0-24.9 Kg/m ²	33 (35.9%)
25.0-29.9 Kg/m ²	23 (25.0%)
30.0-34.9 Kg/m ²	9 (9.8%)
ASA Grade	
I	3 (3.3%)
II	71 (77.2%)
III	18 (19.6%)
Diagnosis	
Perforation Peritonitis	43 (46.7%)
Intestinal Obstruction	27 (29.3%)
Intra-Abdominal Collection	13 (14.1%)
Trauma	5 (5.4%)
Malignancy	4 (4.3%)

The majority of cases belonged to the emergency category (92.4%). The mean surgical duration was

121 min. Contamination was present in 76 (82.6 %) cases, and 11 (12%) resulted in mortality. [Table 2].

Table 2: Summary of Procedure and Outcome

Procedure and Outcome	Mean ± SD
Nature	
Emergency	85 (92.4%)
Elective	7 (7.6%)
Duration Of Surgery (Minutes)	121.63 ± 28.26
Contamination (Yes)	76 (82.6%)
Mortality (Yes)	11 (12.0%)

The most common post-surgical complications were pleural effusion in 20 (21.7%) patients and atelectasis in 12 (13.0%). The least common postsurgical

complication was ARDS (3 (3.3%)). Overall, 21 (22.8%) patients experienced postsurgical complications [Table 3].

Table 3: Summary of PPC

PPC	Yes	No
Atelectasis	12 (13.0%)	80 (87.0%)
Pneumonia	5 (5.4%)	87 (94.6%)
Pleural Effusion	20 (21.7%)	72 (78.3%)
ARDS	3 (3.3%)	89 (96.7%)
Bronchospasm	6 (6.5%)	86 (93.5%)
Any	21 (22.8%)	71 (77.2%)

Factors that were found to be significantly correlated with the development of PPC included advancing age, higher BMI, presence of COPD, Asthma, Diabetes and Smoking ($p < 0.05$). Higher ASA Grade and the presence of cough, low oxygen saturation, and wheezing in the preoperative period were also significantly correlated with the development of PPC in postoperative period ($p < 0.05$). The details of the parameters studied and their association with PPC are presented in [Table 4].

There was a significant difference between the various groups in terms of Age Group distribution ($\chi^2 = 6.422$, $p = 0.040$), with patients over the age of 60 years having a higher incidence of PPC [Figure 1] as well as between the two groups in terms of BMI ($p < 0.001$), with the median BMI being highest in the group with PPCs [Figure 2 and 3].

PPCs were more commonly observed in smokers [Figure 4] and in higher ASA grade groups ($p < 0.001$), with most cases belonging to ASA III (Figure 5). There was no significant difference between the various groups in terms of the distribution of diagnoses ($\chi^2 = 6.079$, $p = 0.223$) [Figure 6].

Upon analyzing individual PPC with risk factors, various disease-specific risk factors were identified. Pleural effusion was associated with a higher BMI [Figure 7], atelectasis was commonly observed in those with preoperative cough (Figure 8), pneumonia was more common in patients with diabetes (Figure 9), and smokers frequently developed bronchospasm (Figure 10; $p < 0.05$).

Table 4: Summary Table for Association between PPC and Parameters

Parameters	PPC		Significance
	Yes (n = 21)	No (n = 71)	
Age (Years)	46.29 ± 17.67	38.77 ± 15.23	W = 929.500, $p = 0.088^m$
Age Group			
18-40 Years	11 (52.4%)	42 (59.2%)	$\chi^2 = 0.090$, $p = 0.622^f$
41-60 Years	3 (14.3%)	21 (29.6%)	$\chi^2 = 1.252$, $p = 0.257^f$
>60 Years***	7 (33.3%)	8 (11.3%)	$\chi^2 = 4.279$, $p = 0.038^f$
Gender			
Male	15 (71.4%)	45 (63.4%)	$\chi^2 = 0.176$, $p = 0.606^f$
Female	6 (28.6%)	26 (36.6%)	$\chi^2 = 0.176$, $p = 0.606^f$
BMI (Kg/m ²)***	29.47 ± 1.99	23.48 ± 1.83	W = 1430.000, $p = < 0.001^m$
BMI group***			
18.5-22.9 Kg/m ²	1 (4.8%)	26 (36.6%)	$\chi^2 = 6.471$, $p = 0.005^f$
23.0-24.9 Kg/m ²	0 (0.0%)	33 (46.5%)	$\chi^2 = 13.266$, $p = < 0.001^f$
25.0-29.9 Kg/m ²	11 (52.4%)	12 (16.9%)	$\chi^2 = 9.070$, $p = 0.003^f$
30.0-34.9 Kg/m ²	9 (42.9%)	0 (0.0%)	$\chi^2 = 29.047$, $p = < 0.001^f$
Hypertension	4 (19.0%)	10 (14.1%)	$\chi^2 = 0.044$, $p = 0.730^f$
Coronary Artery Disease	3 (14.3%)	5 (7.0%)	$\chi^2 = 0.353$, $p = 0.377^f$
COPD***	6 (28.6%)	5 (7.0%)	$\chi^2 = 5.237$, $p = 0.015^f$
Asthma ***	6 (28.6%)	1 (1.4%)	$\chi^2 = 13.365$, $p = < 0.001^f$
Diabetes***	11 (52.4%)	6 (8.5%)	$\chi^2 = 17.949$, $p = < 0.001^f$
Malignancy	0 (0.0%)	6 (8.5%)	$\chi^2 = 0.765$, $p = 0.330^f$
Smoking***	8 (38.1%)	8 (11.3%)	$\chi^2 = 6.359$, $p = 0.008^f$
Alcohol	4 (19.0%)	6 (8.5%)	$\chi^2 = 0.944$, $p = 0.228^f$
ASA Grade			
I	0 (0.0%)	3 (4.2%)	$\chi^2 = 0.067$, $p = 1.000^f$
II***	3 (14.3%)	68 (95.8%)	$\chi^2 = 56.554$, $p = < 0.001^f$

III***	18 (85.7%)	0 (0.0%)	$\chi^2 = 70.312, p = <0.001^f$
Cough (Baseline)***	10 (47.6%)	10 (14.1%)	$\chi^2 = 8.832, p = 0.002^f$
Respiratory Rate (CPM) (Baseline)	20.67 ± 3.62	20.34 ± 3.50	W = 743.500, p = 0.989 ^m
SpO2 (%) (Baseline)***	93.71 ± 3.16	96.24 ± 2.28	W = 391.000, p = <0.001 ^m
Crepts (Baseline)	4 (19.0%)	5 (7.0%)	$\chi^2 = 1.461, p = 0.202^f$
Wheeze (Baseline)***	6 (28.6%)	3 (4.2%)	$\chi^2 = 8.301, p = 0.004^f$
Diagnosis			
Perforation Peritonitis	9 (42.9%)	34 (47.9%)	$\chi^2 = 0.025, p = 0.805^f$
Intestinal Obstruction	10 (47.6%)	17 (23.9%)	$\chi^2 = 3.314, p = 0.055^f$
Intra-Abdominal Collection	1 (4.8%)	12 (16.9%)	$\chi^2 = 1.095, p = 0.285^f$
Trauma	1 (4.8%)	4 (5.6%)	$\chi^2 = 0.000, p = 1.000^f$
Malignancy	0 (0.0%)	4 (5.6%)	$\chi^2 = 0.253, p = 0.570^f$
Nature			
Emergency	21 (100.0%)	64 (90.1%)	$\chi^2 = 1.058, p = 0.345^f$
Elective	0 (0.0%)	7 (9.9%)	$\chi^2 = 1.058, p = 0.345^f$
Duration Of Surgery (Minutes)	125.71 ± 26.19	120.42 ± 28.91	W = 845.500, p = 0.326 ^m
Contamination	19 (90.5%)	57 (80.3%)	$\chi^2 = 0.570, p = 0.347^f$

***Significant at $p < 0.05$, ^m = Mann-Whitney U Test, ^f = Fisher's Exact Test

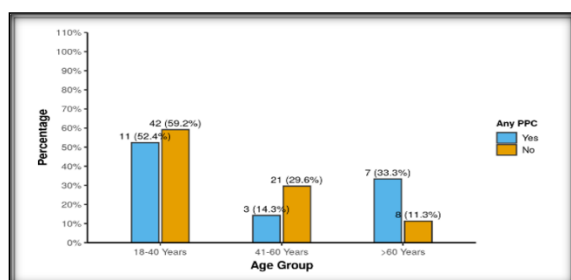


Figure 1: Association between PPC and Age Group

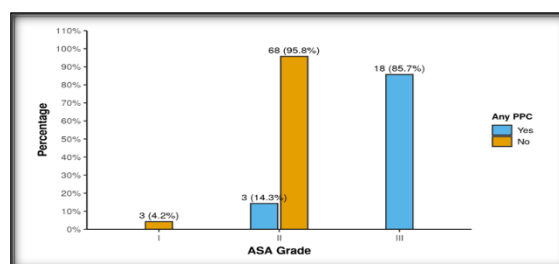


Figure 5: Association Between Any PPC and ASA category

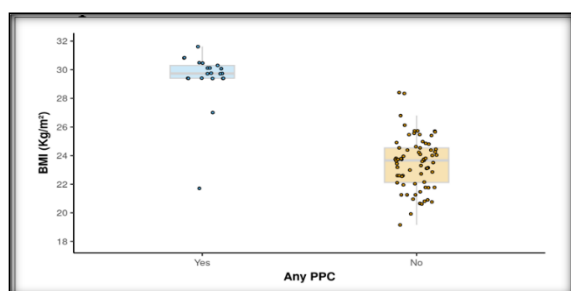


Figure 2: Association Between PPC and BMI

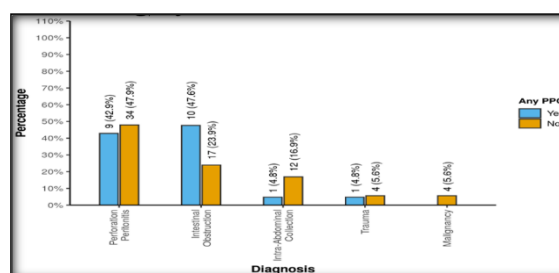


Figure 6: Association Between Any PPC and Diagnosis

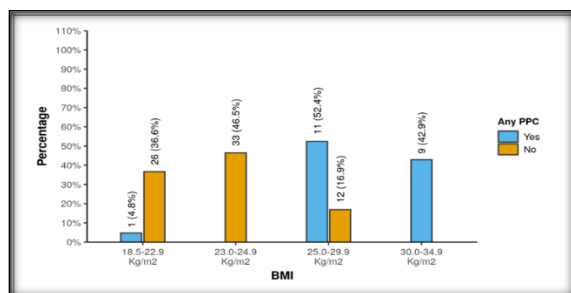


Figure 3: Association Between Any PPC and BMI group

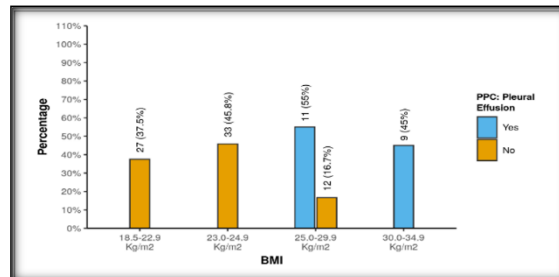


Figure 7: Association Between pleural effusion and BMI group

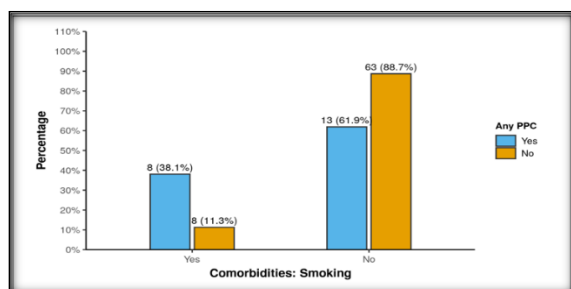


Figure 4: Association Between Any PPC and Smoking

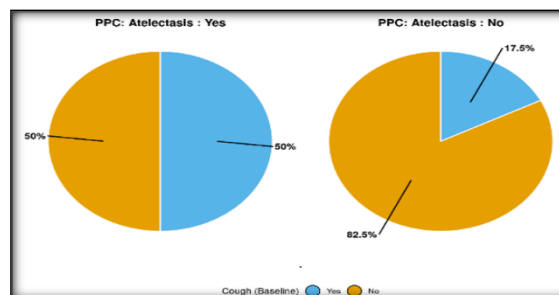


Figure 8: Association Between Atelectasis and Cough

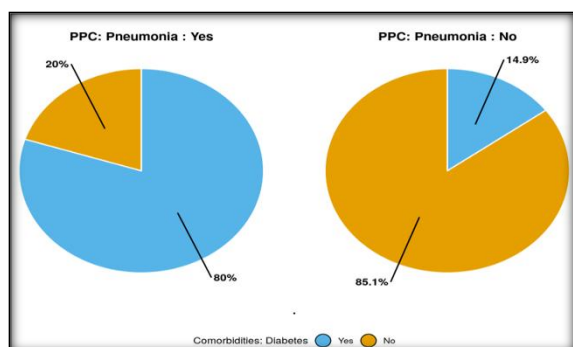


Figure 9: Association Between Pneumonia and Diabetes

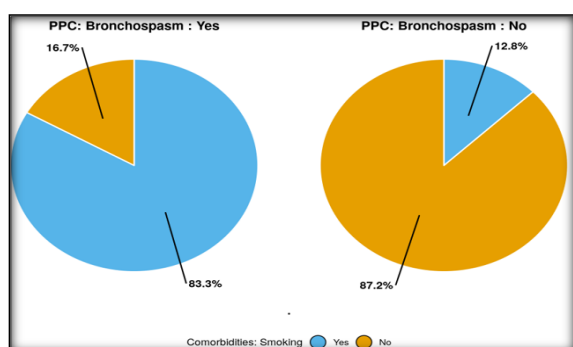


Figure 10: Association between Bronchospasm and Smoking

DISCUSSION

Postoperative pulmonary complications (PPC) affect up to 30% of patients in certain surgical groups [6], significantly contributing to postoperative morbidity and mortality. These complications lead to patient distress, extended hospitalizations, and increased healthcare expenses. This study examined the frequency and risk factors of PPC in adults who underwent exploratory laparotomy at a tertiary care hospital in North India.

The average age of participants was 40.49 (± 16.04) years, with ages ranging from 18 to 78 years, and a larger proportion of younger individuals (18-40 years). However, a positive correlation was observed between older age and the occurrence of PPCs post-laparotomy. Older adults are more prone to multiple and severe medical comorbidities, complicating both surgery and anesthesia. Although recent research and scoring systems indicate that many older patients recover well and regain function comparable to their peers,^[7,8] the increased risk of PPCs in elderly patients post-laparotomy remains notable.

The mean BMI in this study was 24.85 (± 3.14), with patients who developed PPCs having a higher mean BMI (29.47 ± 1.99). A higher BMI was linked to a greater likelihood of PPCs, with obese patients (BMI > 30) being particularly susceptible. Excess weight reduces lung function and raises intra-abdominal pressure. Our findings align with existing literature, identifying BMI as an independent risk factor for PPC in post-laparotomy patients. A separate analysis revealed that a high BMI was most strongly associated with pleural effusion and atelectasis.

Among the 92 patients studied, approximately 12% had chronic obstructive pulmonary disease (COPD) and about 7% had bronchial asthma. A significant difference in postsurgical complication rates was noted when patients were categorized by the presence or absence of presurgical complications. Patients with COPD faced a fivefold increased risk of PPC (OR: 5.28; 95%CI: 1.42 – 19.62). Impaired pulmonary function, a key feature of COPD, is a recognized risk factor for PPCs.^[9,10] Studies in Chinese populations reported that 13.7% of individuals over 40 had COPD, with a hospital stay rate of 1.6% in 2015.^[11,12] A respiratory infection in the preceding month increases the likelihood of PPC,^[13] thus, elective surgeries should be delayed until symptoms and lung function tests normalize,^[14] unless the surgery is urgent, in which case the decision should be made on an individual basis, weighing the risks of PPC against delaying the procedure.

Out of the 92 patients who had laparotomies, 14 (15.2%) were diagnosed with hypertension, 8 (8.7%) had coronary artery disease (CAD), 17 (18.5%) were diabetic, and 6 (6.5%) had cancer as their primary diagnosis. Among these conditions, only diabetes emerged as a predictor for developing postoperative pulmonary complications (PPCs). The compromised immune system in diabetics leads to extended sepsis and impaired cardiovascular function, necessitating a longer stay in the ICU. Upon individual analysis, pneumonia and atelectasis were more closely linked to diabetes, suggesting a higher prevalence of lower respiratory tract infections (LRTI) in diabetic patients. Previous research has indicated a higher occurrence of pulmonary edema and embolism in patients with hypertension and CAD, but our study did not observe these complications.

In our study, about 17% of patients who underwent laparotomy were smokers, and we identified a nearly fivefold increased risk (OR: 4.8; 95%CI: 1.54 – 15.27) of developing PPCs among those who had exploratory laparotomy. Consistent with our findings, a recent large retrospective cohort study involving 800 Korean patients found significant links between smoking status and postoperative complications.^[15] However, Kanat et al. did not find any association between smoking and PPCs in patients who underwent laparotomy.^[16]

Among all the patients in our study, a significant number were classified as ASA grade II, and after stratification, the incidence of post-surgical complications was higher in the ASA grade III group. It has been reported that a high ASA grade is a predictor of increased mortality 12 months post-laparotomy.

In our current study, 21 (22.8%) of the 92 patients experienced post-surgical complications. The most frequently observed complications were pleural effusion (21.7%) and atelectasis (13%). Serejo et al. found that approximately 21% of subjects developed post-operative atelectasis following emergency abdominal surgery.^[17] Atelectasis is induced during

surgery due to various factors, such as the induction of general anesthesia, neuromuscular (N-M) blocker-induced muscle paralysis, recumbent position, increased intra-abdominal pressure (as in laparoscopies), and different operative positions like Trendelenburg's position. The basal segment of the lung is most affected.

Our study also identified preoperative cough and higher BMI as independent risk factors for developing atelectasis. A higher BMI was also linked to an increased risk of pleural effusion, indicating that reduced lung expansion leading to impaired ventilation in obese patients is a significant risk factor for these PPCs.

Upon analyzing individual complications, bronchospasm was more frequently observed among smokers, likely due to underlying chronic obstructive pathology, which is rarely optimized in emergency situations. Diabetics were also found to have a relatively higher risk of pneumonia, implicating their immunocompromised status, which predisposes them to infection.

In our study, the most common surgical diagnosis was perforated peritonitis, followed by intestinal obstruction. However, we did not find a significant cumulative association between surgical diagnosis and post-surgical complications.

Our study also revealed a link between PPC and mortality. Out of the participants, 11 (12%) succumbed to various causes, and all of these individuals had pulmonary complications, indicating a significant occurrence of PPC among critically ill patients and those with extended ICU admissions. While not directly causing death, pulmonary complications likely play a role in the final outcome. Our study was limited by the small sample size, especially the fewer elective exploratory laparotomies as compared to their emergency counterparts. Another limitation was not including the length or the extent of incision made during surgery. Even though all the patients in the study received a vertical midline incision, one that extends till subxiphoid would impair respiration more than a lower midline incision.

Our research faced limitations due to the small number of participants, particularly the lower count of elective exploratory laparotomies compared to emergency ones. Additionally, we did not account for the length or extent of the surgical incision. Although all patients received a vertical midline incision, an incision extending to the subxiphoid area would hinder breathing more than a lower midline incision. Consequently, our research identified certain risk factors for PPCs. However, further studies with larger participant groups are necessary to validate these findings and develop future preventive measures for PPC in patients undergoing laparotomies.

CONCLUSION

PPCs are common after exploratory laparotomy, with an incidence of 22.8%. Significant risk factors included older age, high BMI, higher ASA grade, COPD, asthma, diabetes, smoking, and certain preoperative respiratory findings. Preventive strategies targeting high-risk patients may improve their outcomes.

REFERENCES

1. Canet J, et al.: Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology*. 2010;113(6):1338–50. 10.1097/ALN.0b013e3181fc6e0a
2. Fernandez-Bustamante A, et al.: Postoperative pulmonary complications, early mortality, and hospital stay following noncardiothoracic surgery: a multicenter study. *JAMA Surg*. 2017;152(2):157–66. 10.1001/jamasurg.2016.4065
3. Ephgrave KS, et al.: Postoperative pneumonia: a prospective study of risk factors and morbidity. *Surgery*. 1993;114(4):815–9.
4. Lawrence VA, et al.: Incidence and hospital stay for cardiac and pulmonary complications after abdominal surgery. *J Gen Intern Med*. 1995;10(12):671–8. 10.1007/BF02602761
5. Jammer I, et al.: Standards for definitions and use of outcome measures for clinical effectiveness research in perioperative medicine: EPCO definitions. *Eur J Anaesthesiol*. 2015;32(2):88–105. 10.1097/EJA.0000000000000118
6. Mayo NE, et al.: Impact of preoperative change in physical function on postoperative recovery: argument for prehabilitation. *Surgery*. 2011;150(3):505–14. 10.1016/j.surg.2011.07.045
7. Desserud KF, Veen T, Søreide K.: Emergency general surgery in the geriatric patient. *Br J Surg*. 2016;103(2):e52–61. 10.1002/bjs.10044. Epub 2015 Dec 1
8. Wilkinson K, et al.: An age-old problem: a review of the care of elderly surgical patients. National Confidential Enquiry into Patient Outcome and Death. 2010.
9. Saito H, et al.: Impact of pulmonary rehabilitation on postoperative complications in patients with lung cancer and COPD. *Thorac Cancer*. 2017;8(5):451–60.
10. Numata T, et al.: Risk factors of postoperative pulmonary complications in patients with asthma and COPD. *BMC Pulm Med*. 2018;18(1):1–8.
11. Wang C, et al.: Prevalence and risk factors of COPD in China. *Lancet*. 2018;391(10131):1706–17.
12. Huang K, et al.: Budesonide/formoterol plus ipratropium and theophylline in severe COPD. *Ther Adv Respir Dis*. 2019;13:1753466619853500.
13. Lumb A, Biercamp C.: COPD and anaesthesia. *Cont Educ Anaesth Crit Care Pain*. 2014;14(1):1–5.
14. Yong SL, Coulthard P, Wrzosek A.: Supplemental perioperative steroids for surgical patients with adrenal insufficiency. *Cochrane Database Syst Rev*. 2012;(12).
15. Kanat F, et al.: Risk factors for postoperative pulmonary complications in upper abdominal surgery. *ANZ J Surg*. 2007;77(3):135–41.
16. Baker CJ, et al.: Serum elastase and alpha-1-antitrypsin levels in cerebral aneurysms. *Neurosurgery*. 1995;37(1):56–62.
17. Serejo LGG, et al.: Risk factors for pulmonary complications after emergency abdominal surgery. *Respir Med*. 2007;101(4):808–13.