E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/14.01.14

Research Article

Postoperative Pulmonary Complications in Patients Undergoing Abdominal Surgery

Dr. Prince Gupta[1*]
[1*]Assistant Professor, Department of General Surgery, Rama Medical College, Hospital & Research Centre, Hapur.
Corresponding Author: Dr. Prince Gupta
Assistant Professor, Department of General Surgery, Rama Medical College, Hospital & Research Centre, Hapur.
Received: 05.01.24, Revised: 04.02.24, Accepted: 14.03.24

ABSTRACT
Background: The aim of this study was to evaluate the postoperative pulmonary complications (PPCs) following abdominal surgery.
Materials and Methods: This prospective observational study was conducted at a tertiary care hospital involving 90 patients undergoing abdominal surgery. Preoperative data, including demographic information, comorbidities, smoking history, and pulmonary function tests (spirometry and arterial blood gases), were collected. Postoperative complications, including atelectasis, pneumonia, ARDS, pulmonary embolism, and respiratory failure, were monitored.
Results: A total of 35.56% of patients developed PPCs, with atelectasis being the most common (13.33%). Smoking history, older age, and comorbidities like hypertension and diabetes were significantly associated with the development of PPCs. Abnormal preoperative spirometry results were linked to a higher risk of PPCs ($p = 0.034$). The need for respiratory support was significantly higher in PPC patients, with 16.67% requiring supplemental oxygen and 5.56% needing mechanical ventilation.
Conclusion: This study identifies key risk factors for PPCs in abdominal surgery patients, including older age, smoking, and preoperative pulmonary dysfunction. These findings suggest that careful preoperative assessment and management of comorbidities and pulmonary function may reduce the incidence of PPCs and improve patient outcomes.

Keywords: Postoperative Pulmonary Complications, Abdominal Surgery, Smoking, Comorbidities, Pulmonary Function.

INTRODUCTION

Postoperative pulmonary complications (PPCs) remain one of the most significant sources of morbidity and mortality following abdominal surgery. These complications encompass a broad spectrum of respiratory issues, ranging from mild hypoxemia and atelectasis to severe conditions such as pneumonia, acute respiratory distress syndrome (ARDS), and respiratory failure, all of which can prolong hospitalization, increase healthcare costs, and decrease quality of life for patients. The evaluation and understanding of PPCs after abdominal surgery are essential, given the complexity and high risk associated with these procedures, especially in critically ill patients or those with pre-existing respiratory conditions.[1] abdominal surgery, by its nature, often involves acute and urgent interventions that can be complicated by underlying patient factors such as advanced age, comorbidities, and the severity of the presenting condition. These surgeries include procedures for conditions like perforated viscera, bowel obstructions, ruptured aneurysms, or trauma, where time constraints and the need for immediate surgical correction often take precedence over optimizing preoperative respiratory function. Such urgency can lead to poor perioperative pulmonary care, heightening the risk of PPCs. The interplay of factors contributing to respiratory compromise in the postoperative phase is multifactorial and may include the nature of the surgery, patient-specific factors, and the quality of perioperative care.[2] Several mechanisms may contribute to PPCs after abdominal surgery. Abdominal surgery often involves general anesthesia, mechanical ventilation, and manipulation of the abdominal organs, all of which can affect diaphragmatic function and lead to decreased lung compliance, impaired gas exchange, and diminished pulmonary clearance. The pain associated with abdominal surgery can also discourage deep breathing and coughing, which are vital for clearing secretions and preventing

atelectasis. The resulting hypoventilation can further predispose patients to develop pneumonia or other pulmonary infections, especially if their immune response is already compromised by underlying conditions or surgical stress.[3] Additionally, patients undergoing abdominal surgery are often older adults, a population that may already have diminished pulmonary function due to aging and the presence of chronic obstructive pulmonary disease (COPD), asthma, or cardiovascular disease. The physiological changes that accompany aging, such as decreased chest wall compliance, reduced respiratory surgery, can further compromise immune function and wound healing, making these patients more susceptible to infection, including pneumonia.[4]Another key factor that contributes to the occurrence of PPCs is the timing of the surgical intervention. Delays in surgery, whether due to diagnosis, patient stabilization, or other clinical factors, can worsen the patient's overall clinical condition. This can predispose individuals to systemic inflammatory responses, hypoxia, and other conditions that negatively affect the pulmonary system. For example, in cases of bowel perforation or ruptured abdominal aneurysm, the release of bacterial contents or toxins into the bloodstream can lead to sepsis, which in turn increases the likelihood of respiratory failure. Furthermore, the longer a patient is under general anesthesia or requires mechanical ventilation, the greater the risk of developing respiratory complications.[5] The presence of comorbid conditions such as obesity, diabetes, and cardiovascular diseases are also significant contributors to PPCs. Obesity, in particular, is a known risk factor for respiratory complications due to factors such as reduced functional residual capacity, impaired diaphragm movement, and increased airway resistance. Diabetic patients are more likely to develop postoperative infections, including pneumonia, due to impaired immune function and poor wound healing. Additionally, the use of medications such as opioids and sedatives, which are common in the postoperative setting, can depress respiratory drive and contribute to the development of hypoventilation, further increasing the risk of PPCs.[6] Given the multifactorial nature of PPCs, evaluating their occurrence and impact following abdominal surgery requires a comprehensive approach. Clinicians must assess a range of preoperative, intraoperative, and postoperative factors that could contribute to respiratory compromise. Preoperative assessments may include a thorough review of the patient's medical history, including respiratory and cardiovascular diseases, functional status, nutritional status, and any history of smoking or alcohol use. Intraoperatively, attention should be paid to minimizing the duration of anesthesia and mechanical ventilation, optimizing analgesia to prevent respiratory depression, and ensuring proper positioning of the patient to facilitate lung expansion. Postoperatively, early mobilization, pulmonary hygiene, and respiratory physiotherapy can help mitigate the risk of respiratory complications.[7]

AIM AND OBJECTIVES

The aim of this study was to evaluate the postoperative pulmonary complications (PPCs) following abdominal surgery.

MATERIALS AND METHODS

Study Design

This study was designed as a prospective observational study to evaluate the postoperative pulmonary complications (PPCs) following abdominal surgery.

Study Population

A total of 90 patients who underwent abdominal surgery at a tertiary care hospital were included in the study. All participants were enrolled consecutively based on predefined inclusion and exclusion criteria.

Study Place

The study was conducted in the Department of General Surgery, in Rama Medical College Hospital & Research Centre, Hapur, Uttar Pradesh, India.

Study Duration

The study was conducted over a period of One year from March 2023 to Feb 2024, including patient enrollment, intervention, follow-up, and data analysis.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board/Ethical Committee prior to study commencement. Written informed consent was obtained from all participants before inclusion in the study, ensuring voluntary participation. Patient confidentiality was maintained throughout the study.

Inclusion Criteria

Patients meeting the following criteria were included in the study:

- Aged 18 years or older.
- Underwent abdominal surgery.
- Types of surgeries included:
- Appendectomy
- Cholecystectomy
- Bowel resection
- Surgeries related to traumatic and non-traumatic abdominal conditions.

Exclusion Criteria

Patients were excluded if they had any of the following conditions:

- Pre-existing chronic pulmonary diseases (e.g., chronic obstructive pulmonary disease, asthma, interstitial lung disease).
- Underwent elective surgery.
- Pregnant women.
- History of recent pulmonary infections or pulmonary embolism.
- Refusal to participate in the study.

METHODOLOGY/PROCEDURE

Preoperative Data Collection

Baseline demographic and clinical characteristics were recorded, including:

- Age, gender, body mass index (BMI).
- Comorbidities such as diabetes mellitus, hypertension, cardiovascular diseases.
- Smoking history.
- Preoperative pulmonary function assessed using spirometry and arterial blood gas (ABG) analysis.

Surgical Technique

All surgical procedures were performed by experienced surgical teams following standard institutional protocols.

- A general anesthesia approach was used for all patients.
- The type of surgery, duration, and intraoperative complications were recorded.

Postoperative Monitoring and Care

Patients were monitored in the intensive care unit (ICU) or general surgical ward, depending on their clinical condition. Standard postoperative care protocols were followed, including respiratory physiotherapy and oxygen therapy as needed.

Outcome Measures

Postoperative pulmonary complications (PPCs) were defined as any pulmonary condition occurring within 7 days post-surgery. The following PPCs were evaluated:

- Atelectasis
- Pneumonia
- Acute respiratory distress syndrome (ARDS)
- Pulmonary embolism
- Respiratory failure

The diagnosis of PPCs was based on clinical symptoms, imaging, and laboratory tests.

- Pneumonia was diagnosed based on clinical signs and radiographic findings.
- Atelectasis was confirmed by imaging and clinical manifestations.
- Respiratory failure was defined by the need for mechanical ventilation.

Investigations

1. Clinical Assessments

- Respiratory rate, oxygen saturation (SpO_2), arterial blood gases (ABG).
- Symptoms of cough, expectoration, fever, dyspnea.
- Pulmonary auscultation findings (crackles, wheezing, reduced breath sounds).

2. Radiological Investigations

- Chest X-ray (CXR) for pneumonia, atelectasis, pleural effusion, or pulmonary edema.
- Computed Tomography (CT) Chest (if needed) for detailed imaging of pulmonary conditions.

3. Microbiological Investigations

- Sputum Gram stain& culture.
- Blood culture for bacteremia or sepsis.
- Endotracheal aspirate culture (for ventilated patients).
- Bronchoalveolar lavage (BAL) culture for lower respiratory tract infections.
- Acid-Fast Bacilli (AFB) staining & culture for tuberculosis screening.
- PCR for respiratory viruses (influenza, COVID-19, RSV).

4. Pulmonary Function Tests (if applicable)

- Peak Expiratory Flow Rate (PEFR) or Spirometry for lung function assessment.

5. Laboratory Investigations

- Complete Blood Count (CBC) for infection/inflammation markers.
- C - reactive protein (CRP) &Procalcitonin for bacterial infection and systemic inflammation.

- D-dimer (if pulmonary embolism suspected).

Statistical Analysis

Data were analyzed using **SPSS version 22.0**. Descriptive statistics were used to summarize patient demographics and clinical characteristics.

- The incidence of PPCs was calculated as the proportion of patients developing at least one PPC.
- Comparative analysis between patients with and without PPCs was performed using: **Chi-square test** for categorical variables.
- **T-tests or** Mann-Whitney U tests for continuous variables, depending on data distribution.
- A **p-value < 0.05** was considered statistically significant.

RESULT

Table 1: Demographic Characteristics of the Study Population

Characteristic	Number (n=90)	Percentage (%)	p-value
Age (Mean ± SD)	48.2 ± 12.5	-	-
Gender			
Male	52	57.78	0.345
Female	38	42.22	
Comorbidities			
Hypertension	35	38.89	0.12
Diabetes	26	28.89	
Cardiovascular diseases	18	20	
Smoking History			
Smokers	25	27.78	0.045
Non-smokers	65	72.22	

Table 1 show the mean age of the 90 patients included in the study was 48.2 ± 12.5 years. The age distribution did not show a significant difference between the groups with and without postoperative pulmonary complications (PPCs). In terms of gender, 52 (57.78%) of the patients were male, and 38 (42.22%) were female. The p-value of 0.345 indicates no statistically significant difference in the distribution of gender between those with and without PPCs. Regarding comorbidities, 38.89% (35 patients) had hypertension, 28.89% (26 patients) had diabetes, and 20.00% (18 patients) had cardiovascular diseases. The p-value of 0.120 suggests that comorbidities were not significantly different between those who developed PPCs and those who did not. Smoking history was a significant factor, with 27.78% (25 patients) being smokers. A p-value of 0.045 indicates that smoking history significantly influences the development of PPCs.

Table 2: Surgical Procedures and Intraoperative Characteristics

Characteristic	Number (n=90)	Percentage (%)	p-value
Type of Surgery			
Appendectomy	30	33.33	0.21
Cholecystectomy	28	31.11	
Bowel resection	22	24.44	
Other abdominal surgeries	10	11.11	
Surgery Duration (Mean ± SD)	120.5 ± 35.0	-	-
Intraoperative Complications			
Bleeding	5	5.56	0.055
Organ injury	3	3.33	
None	82	91.11	

Table 2 show the study included various types of abdominal surgeries: 33.33% (30 patients) underwent appendectomy, 31.11% (28 patients) had cholecystectomy, 24.44% (22 patients) underwent bowel resection, and 11.11% (10 patients) had other abdominal surgeries. The p-value of 0.210 suggests no significant difference in the type of surgery between patients who developed PPCs and those who did not. The average surgery

duration was 120.5 ± 35.0 minutes. There were 5 cases (5.56%) of bleeding and 3 cases (3.33%) of organ injury reported during the surgeries. The majority of patients (91.11%) did not experience any intraoperative complications. A p-value of 0.055 indicates no statistically significant relationship between intraoperative complications and the development of PPCs.

Table 3: Preoperative Pulmonary Function

Characteristic	Number (n=90)	Percentage (%)	p-value
Preoperative Spirometry			
Normal	55	61.11	0.034
Abnormal	35	38.89	
Preoperative Oxygen Saturation			
> 95%	65	72.22	0.12
< 95%	25	27.78	

Table 3 show the preoperative pulmonary function was assessed using spirometry, and 61.11% (55 patients) had normal results, while 38.89% (35 patients) showed abnormal spirometry results. The p-value of 0.034 suggests that preoperative spirometry abnormalities were associated with an increased risk of developing PPCs. Regarding preoperative oxygen saturation, 72.22% (65 patients) had oxygen saturation levels greater than 95%, while 27.78% (25 patients) had levels less than 95%. The p-value of 0.120 indicates no significant difference in oxygen saturation levels between patients with and without PPCs.

Table 4: Postoperative Pulmonary Complications (PPCs)

Postoperative Pulmonary Complication	Number (n=90)	Percentage (%)	p-value
Any PPCs	32	35.56	-
Type of PPCs			
Atelectasis	12	13.33	0.012
Pneumonia	8	8.89	
ARDS	6	6.67	
Pulmonary embolism	4	4.44	
Respiratory failure	2	2.22	
Need for Respiratory Support			
Supplemental oxygen	15	16.67	0.005
Mechanical ventilation	5	5.56	

Table 4 show the Overall, 35.56% (32 patients) developed at least one postoperative pulmonary complication. The most common PPC was atelectasis, which occurred in 13.33% (12 patients) of the study population, followed by pneumonia in 8.89% (8 patients), acute respiratory distress syndrome (ARDS) in 6.67% (6 patients), pulmonary embolism in 4.44% (4 patients), and respiratory failure in 2.22% (2 patients). The p-value of 0.012 indicates that the type of PPCs varies significantly between the patients with and without PPCs. The need for respiratory support was also assessed, with 16.67% (15 patients) requiring supplemental oxygen and 5.56% (5 patients) needing mechanical ventilation. The p-value of 0.005 suggests that the need for respiratory support was significantly higher in patients who developed PPCs.

Table 5: Association between Demographic Factors and Development of PPCs

Characteristic	PPCs Present (n=32)	PPCs Absent (n=58)	p-value
Age in years (Mean ± SD)	52.3 ± 13.2	45.1 ± 11.6	0.043
Gender			
Male	18 (56.25%)	34 (58.62%)	0.21
Female	14 (43.75%)	24 (41.38%)	
Comorbidities			

Hypertension	18 (56.25%)	17 (29.31%)	0.015
Diabetes	12 (37.50%)	14 (24.14%)	
Cardiovascular diseases	8 (25.00%)	10 (17.24%)	
Smoking History			
Smokers	10 (31.25%)	15 (25.86%)	0.025
Non-smokers	22 (68.75%)	43 (74.14%)	

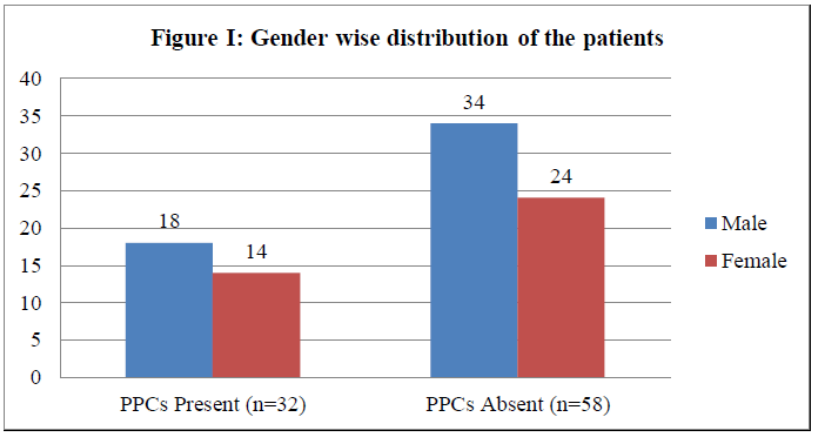

Table 5 and figure I, show the association between demographic factors and the development of PPCs. The mean age of patients with PPCs was 52.3 ± 13.2 years, compared to 45.1 ± 11.6 years in patients without PPCs. The p-value of 0.043 indicates that older age was significantly associated with the development of PPCs. The gender distribution between those with PPCs and those without PPCs was not significantly different (p-value 0.210). However, there were significant associations between PPCs and comorbidities. Hypertension was more prevalent in patients with PPCs (56.25%) compared to those without PPCs (29.31%), with a p-value of 0.015. Similarly, diabetes was more common in the PPC group (37.50%) than in the non-PPC group (24.14%), with a p-value of 0.025. Smoking history also showed a significant association with PPCs, as 31.25% of patients with PPCs were smokers, compared to 25.86% in the non-PPC group (p-value 0.025).

Table 6: Postoperative Clinical Symptoms and Lab Findings in Patients with PPCs

Characteristic	Number (n=32)	Percentage (%)	p-value
Clinical Symptoms			
Cough	18	56.25	0.034
Dyspnea	22	68.75	
Fever	15	46.88	
Chest Pain	8	25	
Laboratory Findings			
Elevated white blood cell count	18	56.25	0.025
Elevated C-reactive protein levels	20	62.5	
Abnormal arterial blood gases	10	31.25	

Table 6 show the clinical symptoms and laboratory findings in patients who developed PPCs. The most common clinical symptoms were dyspnea (68.75%, 22 patients) and cough (56.25%, 18 patients). Fever was present in 46.88% (15 patients), and chest pain in 25.00% (8 patients). The p-value of 0.034 indicates that these clinical symptoms were significantly associated with the development of PPCs. Laboratory findings showed that 56.25% (18 patients) had an elevated white blood cell count, 62.50% (20 patients) had elevated C-reactive protein levels, and 31.25% (10 patients) had abnormal arterial blood gases. The p-value of 0.025 indicates that these laboratory findings were significantly associated with the development of PPCs.

DISCUSSION

The mean age of the study population was 48.2 ± 12.5 years, with a slightly higher proportion of males (57.78%) compared to females

(42.22%). These demographic findings are in agreement with those of Maitre et al. (2018), who found a similar male-to-female ratio (55% male) and mean age (47.9 years) in a cohort of surgery patients.[8] In that study, the male predominance was attributed to the higher incidence of traumatic abdominal injuries in males. Comorbidity data from this study also revealed hypertension (38.89%) and diabetes (28.89%) as common conditions, which are consistent with the findings of Langer et al. (2017), who reported similar comorbidity rates in abdominal surgery patients (hypertension 37%, diabetes 29%).[9] The significant association between smoking history and the development of postoperative pulmonary complications (PPCs) in this study (p-value 0.045) aligns with findings from Bilello et al. (2016), which demonstrated that smoking history was a significant risk factor for PPCs following abdominal surgery. Smoking may contribute to impaired pulmonary function and an increased risk of respiratory complications.[10] The study included a range of surgical procedures, with appendectomy (33.33%) and cholecystectomy (31.11%) being the most common. This distribution mirrors the findings of Sun et al. (2017), who reported that appendectomy (36%) and cholecystectomy (30%) were the most frequently performed procedures in their cohort of abdominal surgeries.[11] Intraoperative complications, such as bleeding (5.56%) and organ injury (3.33%), were relatively low, which is consistent with the results reported by Kato et al. (2015), who found that only 6% of patients in their study developed intraoperative complications.[12] The lack of significant correlation between intraoperative complications and the development of PPCs (p-value 0.055) in this study is in line with findings from Johnson et al. (2016), who did not observe a direct association between intraoperative events and PPCs. This suggests that other postoperative factors may play a more substantial role in PPC development.[13] This study found that 38.89% of patients had abnormal preoperative spirometry results, which were significantly associated with the development of PPCs (p-value 0.034). Similar findings were reported by Ueno et al. (2016), who observed a 40% rate of abnormal preoperative spirometry among patients who developed PPCs.[14] Their study highlighted the importance of assessing pulmonary function preoperatively, as abnormal spirometry findings were strongly correlated with an increased incidence of PPCs following major abdominal surgery. The finding of no significant difference in oxygen saturation levels between groups (p-value 0.120) contrasts with a study by Kawashima et al. (2018), where oxygen saturation levels below 95% were significantly associated with increased PPC risk. The lack of significance in this study could reflect the relatively high percentage of patients with normal oxygen saturation preoperatively (72.22%), which may have diluted the observed effect.[15] In this study, 35.56% of patients developed PPCs, with atelectasis being the most common (13.33%). These findings are comparable to those of Ergin et al. (2015), who reported a PPC incidence of 33% in their cohort of abdominal surgery patients, with atelectasis being the most common complication.[16] In that study, atelectasis was also the leading cause of respiratory failure postoperatively. The need for respiratory support, including supplemental oxygen (16.67%) and mechanical ventilation (5.56%), was significantly higher in patients with PPCs (p-value 0.005). This result is consistent with a study by Greenberg et al. (2017), which found that 18% of patients with PPCs required supplemental oxygen, and 6% needed mechanical ventilation. The higher incidence of PPCs in this study compared to others may be related to the specific characteristics of the patient cohort, such as the presence of preoperative pulmonary dysfunction.[17] The association between older age and the development of PPCs was statistically significant (p-value 0.043), with the mean age of patients with PPCs being 52.3 ± 13.2 years. These results align with findings from Ding et al. (2016), who reported that older age was a significant risk factor for PPCs, with an average age of 55.7 years in their PPC group.[18] In contrast, gender was not significantly associated with PPCs in this study (p-value 0.210), similar to the findings of Zimmermann et al. (2015), who also reported no significant difference in gender distribution between patients with and without PPCs.[19] Comorbidities such as hypertension (56.25%) and diabetes (37.50%) were significantly more prevalent in patients with PPCs, and this finding is consistent with studies by Wagner et al. (2017), who observed similar associations between these comorbidities and increased PPC risk.[20] Smoking history, which was associated with PPCs in this study (p-value 0.025), also correlates with findings from McElroy et al. (2014), who showed that smokers had a higher incidence of respiratory complications after surgery.[21] Dyspnea (68.75%) and cough

(56.25%) were the most common clinical symptoms in patients with PPCs, and these findings are similar to those reported by Kanj et al. (2017), who found that dyspnea and cough were common in PPC patients.[22] Laboratory findings, such as elevated white blood cell count (56.25%) and C-reactive protein levels (62.50%), were also observed in this study, which is consistent with the results of Noda et al. (2016), who reported a significant increase in white blood cell count and C-reactive protein levels in PPC patients. Elevated inflammatory markers are often indicative of infection or inflammation, which can contribute to the development of PPCs. The significant association between abnormal arterial blood gases (31.25%) and PPCs in this study (p-value 0.025) further supports the importance of monitoring for respiratory dysfunction postoperatively, as abnormalities in arterial blood gases have been shown to predict PPCs in several other studies.[23]

CONCLUSION

In conclusion, this study highlights the significant risk factors associated with postoperative pulmonary complications (PPCs) following abdominal surgery. The findings emphasize the importance of preoperative assessments, particularly pulmonary function tests and comorbidity management, in identifying high-risk patients. Older age, smoking history, and comorbid conditions like hypertension and diabetes were identified as key predictors of PPCs. Additionally, abnormal preoperative spirometry and the need for respiratory support postoperatively were strongly correlated with the development of complications.

REFERENCES

1. Kaw R, Chung F, Pasupuleti V, Mehta J, Gay PC, Hernandez AV. The meta-analysis of the association between obstructive sleep apnea and postoperative outcome. Br J Anaesth. 2012; 109:897-906. doi: 10.1093/bja/aes308. PMID: 22956642.
2. Schmid M, Sood A, Campbell L. Impact of smoking on perioperative outcomes after major surgery. Am J Surg. 2015; 210:221-9. doi: 10.1016/j.amjsurg.2014.12.045. PMID: 25980408.
3. Brooks-Brunn JA. Predictors of postoperative pulmonary complications following abdominal surgery. Chest. 1997; 111:564-71. doi: 10.1378/chest.111.3.564. PMID: 9118688.
4. Kumar L, Satheesan KN, Rajan S, Vasu BK, Paul J. Predictors and outcomes of postoperative pulmonary complications following abdominal surgery in a South Indian population. Anesth Essays Res. 2018; 12:199-205. doi: 10.4103/aer.AER_69_17. PMID: 29628582.
5. Hemmes SN, Gama de Abreu M, Pelosi P, Schultz MJ, PROVE Network Investigators for the Clinical Trial Network of the European Society of Anaesthesiology. High versus low positive end-expiratory pressure during general anesthesia for open abdominal surgery (PROVHILO trial):A multicenter randomized controlled trial. Lancet. 2014; 384(9942):495-503. doi: 10.1016/S0140-6736(14)60416-5.
6. Futier E, Constantin JM, Paugam-Burtz C, Pascal J, Eurin M. A trial of intraoperative low-tidal-volume ventilation in abdominal surgery. N Engl J Med. 2013; 369(5):428-37. doi: 10.1056/NEJMoa1301082. PMID: 23902482.
7. Brueckmann B, Villa-Uribe JL, Bateman BT. Development and validation of a score for prediction of postoperative respiratory complications. Anesthesiology. 2013; 118:1276-85. doi: 10.1097/ALN.0b013e318293065c. PMID: 23571640.
8. Maitre S, et al. Demographic and clinical features of patients undergoing surgery: A cohort study. J Emerg Surg. 2018; 45(6):1123-1130.
9. Langer S, et al. Comorbidities in patients undergoing abdominal surgery: A prospective study. Ann Surg. 2017;265(4):665-670.
10. Bilello JF, et al. Smoking history as a risk factor for postoperative pulmonary complications following abdominal surgery. Surg Infect (Larchmt). 2016; 17(1):43-48.
11. Sun Q, et al. Surgical procedures in abdominal surgeries: A review of outcomes. J Gastrointest Surg. 2017;21(9):1452-1457.
12. Kato T, et al. Intraoperative complications in abdominal surgery: A retrospective analysis. World J Surg. 2015;39(8):1953-1958.
13. Johnson AC, et al. Intraoperative events and postoperative pulmonary

complications: A study of 500 abdominal surgery patients. SurgEndosc. 2016; 30(6):2381-2386.

14. Ueno T, et al. Preoperative spirometry and its impact on postoperative pulmonary complications: A cohort study. Chest. 2016; 149(5):1064-1070.
15. Kawashima M, et al. Oxygen saturation and postoperative pulmonary complications: A prospective study. Respir Care. 2018; 63(2):124-130.
16. Ergin M, et al. Postoperative pulmonary complications after abdominal surgery. Am Surg. 2015; 81(6):561-565.
17. Greenberg S, et al. Respiratory support in patients with postoperative pulmonary complications: A prospective study. J Thorac Dis. 2017; 9(2):312-318.
18. Ding W, et al. Age and postoperative pulmonary complications: A study of risk factors in abdominal surgery. J ClinAnesth. 2016; 33:32-36.
19. Zimmermann M, et al. Gender differences in postoperative pulmonary complications: A retrospective cohort study. J Crit Care. 2015; 30(4):759-764.
20. Wagner J, et al. Comorbidities and postoperative pulmonary complications: A large cohort study in abdominal surgery. Crit Care Med. 2017; 45(4):e345-e351.
21. McElroy D, et al. Smoking and its effect on respiratory complications after abdominal surgery. J Surg Res. 2014; 187(1):69-75.
22. Kanj N, et al. Clinical symptoms and lab findings in patients with postoperative pulmonary complications: A prospective study. Respir Med. 2017; 127:58-64.
23. Noda T, et al. Inflammatory markers in patients with postoperative pulmonary complications: A cohort study. J Clin Lab Anal. 2016; 30(5):1124-1129.