



Original Article

Effect of Preoperative Pulmonary Function on Surgical Outcomes

Yugandhar GR^{1*}, Swathi Talari²

¹Associate Professor, Department of General Surgery, Bhaskar Medical College, Yenkapally, Moinabad, Ranga Reddy, Hyderabad, Telangana 500075.

²Assistant professor, Department of TB and CD, Osmania Medical College, Turrebaz Khan Rd, Troop Bazaar, Koti, Hyderabad, Telangana 500001

 OPEN ACCESS

Corresponding Author:

Yugandhar GR

Associate Professor, Department of General Surgery, Bhaskar Medical College, Yenkapally, Moinabad, Ranga Reddy, Hyderabad, Telangana 500075.

Email: dr.yugandhar@gmail.com

Received: 13-02-2026

Accepted: 24-03-2026

Available online: 26-03-2026

Copyright © International Journal of Medical and Pharmaceutical Research

ABSTRACT

Background: Preoperative pulmonary function plays a critical role in determining perioperative risk and postoperative recovery, particularly in patients undergoing major surgical procedures. Impaired lung function is associated with increased susceptibility to postoperative pulmonary complications (PPCs), prolonged hospital stay, and higher morbidity.

Objectives: To evaluate the impact of preoperative pulmonary function parameters on surgical outcomes and to determine their predictive value for postoperative complications.

Methods: This prospective observational study included 120 patients undergoing elective surgeries. Preoperative pulmonary function tests (PFTs), including forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), and FEV₁/FVC ratio, were recorded. Patients were stratified into normal and impaired pulmonary function groups. Postoperative outcomes such as incidence of PPCs, duration of hospital stay, need for intensive care, and mortality were assessed and compared.

Results: Out of 120 patients, 72 (60%) had normal pulmonary function, while 48 (40%) showed impairment. PPCs were observed in 30 patients (25%). The incidence of complications was significantly higher in the impaired group (20/48; 41.7%) compared to the normal group (10/72; 13.9%). Mean hospital stay was longer in patients with impaired PFTs (9.2 ± 2.8 days) than those with normal function (6.1 ± 1.9 days). ICU admission was required in 18 patients (15%), predominantly in the impaired group (12/48; 25%). Reduced FEV₁ (<70% predicted) showed a strong association with PPCs (p < 0.01). Mortality was low (3.3%), with higher occurrence in patients with severe pulmonary impairment.

Conclusion: Preoperative pulmonary function is a significant predictor of postoperative outcomes. Patients with impaired PFTs are at increased risk of complications and prolonged recovery. Routine preoperative pulmonary assessment can aid in risk stratification and optimization of perioperative care.

Keywords: Pulmonary function test, FEV₁, FVC, postoperative complications, surgical outcomes, perioperative risk assessment, ICU admission.

INTRODUCTION

Surgical outcomes are influenced not only by the technical aspects of the procedure but also by the physiological reserve of the patient. Among the various organ systems, the respiratory system plays a central role in maintaining perioperative homeostasis. Pulmonary complications remain one of the leading causes of postoperative morbidity, particularly in patients undergoing major abdominal and thoracic surgeries [1]. These complications, which include atelectasis, pneumonia, bronchospasm, and respiratory failure, significantly increase hospital stay, healthcare costs, and mortality [2].

Preoperative pulmonary function assessment has therefore become an important component of surgical risk evaluation. Pulmonary function tests (PFTs), including forced vital capacity (FVC), forced expiratory volume in one second (FEV₁),

and FEV₁/FVC ratio, provide objective measures of lung mechanics and ventilatory capacity [3]. These parameters help in identifying underlying obstructive or restrictive lung diseases, even in asymptomatic individuals [4]. Reduced pulmonary reserve may impair effective gas exchange during and after surgery, thereby predisposing patients to adverse outcomes [5]. The perioperative period is associated with several physiological alterations that can further compromise respiratory function. General anaesthesia leads to decreased functional residual capacity, impaired mucociliary clearance, and ventilation–perfusion mismatch [6]. In addition, postoperative pain and immobilisation contribute to shallow breathing and reduced cough efficiency, increasing the risk of secretion retention and lung collapse [7]. Patients with pre-existing pulmonary dysfunction are particularly vulnerable to these changes, which can culminate in clinically significant complications [8].

Several studies have demonstrated that impaired preoperative pulmonary function is associated with an increased incidence of postoperative pulmonary complications (PPCs). FEV₁ has been widely recognised as a strong predictor of perioperative risk, especially when values fall below 70% of the predicted level [9]. Similarly, reduced FVC has been linked to restrictive ventilatory defects and poorer surgical outcomes [10]. The FEV₁/FVC ratio further aids in differentiating obstructive from restrictive patterns, enabling targeted perioperative management [11].

Despite the established importance of pulmonary assessment in high-risk surgeries such as thoracic procedures, its role in general elective surgeries is sometimes underutilised [12]. Many patients undergo surgery without a comprehensive evaluation of their respiratory status, which may lead to preventable complications [13]. Early identification of at-risk individuals allows for optimisation strategies, including prehabilitation, smoking cessation, bronchodilator therapy, and respiratory physiotherapy [14].

In addition to pulmonary parameters, several patient-related and surgical factors interact to influence outcomes. Age, smoking history, obesity, type and duration of surgery, and anaesthetic technique all contribute to the overall risk profile [15]. However, pulmonary function remains a modifiable and measurable determinant that can be addressed preoperatively to improve outcomes [16].

Recent literature has emphasised the need for integrated risk assessment models that combine clinical, functional, and biochemical parameters [17]. Within this framework, PFTs serve as a reliable and reproducible tool for stratifying patients into low- and high-risk categories [18]. Moreover, the predictive value of pulmonary function extends beyond immediate complications and has been associated with long-term recovery and quality of life after surgery [19].

In the Indian clinical setting, where respiratory conditions such as chronic obstructive pulmonary disease (COPD) and smoking-related lung damage are prevalent, the importance of preoperative pulmonary evaluation becomes even more pronounced [20]. However, there is limited data from regional populations examining the direct relationship between pulmonary function and surgical outcomes.

In this context, the present study aims to evaluate the effect of preoperative pulmonary function on surgical outcomes in patients undergoing elective procedures. By correlating PFT parameters with postoperative complications, hospital stay, and need for intensive care, this study seeks to provide clinically relevant insights that can guide perioperative risk stratification and management

MATERIALS AND METHODS:

Study design

This investigation was planned as a prospective observational study to examine how preoperative pulmonary function influences postoperative outcomes. The study followed patients from the preoperative assessment stage through the postoperative recovery period without introducing any experimental intervention. All clinical decisions, including surgical and anaesthetic management, were made independently by the treating teams as per standard institutional practice. The observational design allowed for a realistic assessment of routine clinical outcomes in relation to baseline pulmonary status.

Study setting

The study was carried at Bhaskar Medical College, Amdapur X Road, Yenkapally, Moinabad, Ranga Reddy, Hyderabad, Telangana 500075. Patient recruitment was undertaken in collaboration with the departments of General Surgery and Anaesthesiology. Pulmonary function testing and relevant laboratory investigations were performed in the hospital's central diagnostic facilities, ensuring uniformity in measurement and reporting. The hospital caters to a diverse patient population, providing a suitable clinical setting to study perioperative outcomes across a range of surgical conditions.

Study duration

The study was conducted over a period extending from September 2024 to December 2025. During this time, patients meeting the eligibility criteria were enrolled consecutively. Each patient was followed from the time of preoperative evaluation until discharge from the hospital, allowing adequate observation of early postoperative outcomes.

Study population

The study included adult patients scheduled for elective surgical procedures. Patients were evaluated in the preoperative period, typically during their anaesthetic fitness assessment. A wide range of surgical cases was included to reflect routine clinical practice. Only those patients who were able to perform pulmonary function testing reliably were considered for inclusion. The study aimed to capture variations in pulmonary function across different age groups, comorbid conditions, and lifestyle factors such as smoking.

Sample size

A total of 120 patients were included in the study. Participants were enrolled consecutively based on eligibility criteria and willingness to participate. The sample size was determined based on feasibility within the study period and the expected patient flow in the institution. This number was considered sufficient to identify meaningful trends and associations between pulmonary function parameters and postoperative outcomes.

Inclusion criteria

Patients aged 18 years and above who were planned for elective surgical procedures were eligible for inclusion. Only those who provided informed consent and were able to perform spirometry adequately were included in the study. This ensured that pulmonary function measurements were reliable and comparable across participants.

Exclusion criteria

Patients undergoing emergency surgical procedures were excluded, as preoperative optimisation and pulmonary assessment may not be feasible in such situations. Individuals with acute respiratory infections at the time of evaluation were also excluded to avoid transient alterations in pulmonary function. Patients with severe hemodynamic instability or neuromuscular disorders affecting respiratory effort were not included. In addition, patients who were unable to perform spirometry due to poor cooperation or technical limitations were excluded to maintain data quality.

Preoperative evaluation

All enrolled patients underwent a detailed preoperative assessment. This included documentation of demographic details such as age, sex, and body mass index. A thorough medical history was obtained with particular attention to respiratory symptoms, smoking history, and existing comorbidities such as chronic obstructive pulmonary disease, asthma, diabetes mellitus, and hypertension. Clinical examination was performed to assess general condition and respiratory status. Routine preoperative investigations were carried out as per institutional protocol, and patients were deemed fit for surgery following anaesthetic evaluation.

Pulmonary function assessment

Pulmonary function testing was performed using a standardised spirometer that was regularly calibrated to ensure accuracy. The procedure was explained to each patient, and adequate training was provided before recording measurements. Each patient performed at least three acceptable manoeuvres, and the best effort was selected for analysis. The primary parameters recorded were forced vital capacity, forced expiratory volume in one second, and the ratio of these two values. The results were expressed as percentages of predicted values based on established reference standards considering age, sex, and height.

Based on these measurements, patients were grouped into those with normal pulmonary function and those with impaired function. Individuals with values within normal predicted ranges were categorised as having normal pulmonary status, while those with reduced values were classified as having impairment. Patterns suggestive of obstructive or restrictive lung disease were further identified using the ratio of FEV₁ to FVC, which provided additional insight into the nature of pulmonary dysfunction.

Perioperative management

All patients received perioperative care in accordance with standard institutional guidelines. The choice of anaesthesia, intraoperative monitoring, and surgical technique were determined by the treating clinicians. Efforts were made to maintain optimal oxygenation and ventilation during surgery. In the postoperative period, patients were provided with adequate pain relief to facilitate effective breathing and coughing. Early mobilisation and respiratory physiotherapy were encouraged to minimise the risk of pulmonary complications. These measures were applied uniformly across both groups to reduce variability in care.

Outcome measures

The primary outcome of interest was the occurrence of postoperative pulmonary complications. These included clinically diagnosed conditions such as atelectasis, pneumonia, bronchospasm, prolonged oxygen requirement, and respiratory failure necessitating ventilatory support. Diagnosis was based on clinical findings supported by appropriate investigations when required.

Secondary outcomes included duration of hospital stay, need for admission to the intensive care unit, and in-hospital mortality. These parameters were chosen to reflect both the clinical severity of complications and their impact on healthcare utilisation. The relationship between preoperative pulmonary function and these outcomes was analysed to determine predictive significance.

Follow-up

Patients were monitored closely during the postoperative period through daily clinical assessments. Particular attention was given to respiratory symptoms, oxygen saturation, and signs of infection or respiratory distress. Any complication identified during the hospital stay was documented. Patients were followed until discharge, ensuring that early postoperative events were captured comprehensively.

Data collection

Data were collected using a structured case record form designed for the study. Information regarding patient demographics, clinical history, pulmonary function parameters, intraoperative details, and postoperative outcomes was recorded systematically. All data entries were cross-checked for accuracy. Confidentiality of patient information was maintained throughout, and identifiers were removed during data analysis.

Statistical analysis

Collected data were compiled and analysed using appropriate statistical methods. Continuous variables were expressed as mean with standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent t-test for continuous variables and the chi-square test for categorical variables. Statistical significance was determined using a p value threshold of less than 0.05. The analysis aimed to identify meaningful associations between pulmonary function status and surgical outcomes.

Ethical considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of the institution. All participants were informed about the nature and purpose of the study, and written informed consent was obtained prior to enrolment. The study adhered to ethical principles related to patient safety, confidentiality, and voluntary participation. No additional risk was imposed on patients beyond routine clinical care.

RESULTS

Study population characteristics

A total of 120 patients were included in the analysis. The study population comprised 68 males (56.7%) and 52 females (43.3%). The mean age of participants was 48.6 ± 13.2 years. Based on preoperative pulmonary function testing, 72 patients (60%) were categorised as having normal pulmonary function, while 48 patients (40%) were classified as having impaired pulmonary function (Table 1).

Table 1: Baseline demographic and clinical characteristics

Variable	Normal PFT (n=72)	Impaired PFT (n=48)	p value
Age (years, mean \pm SD)	45.2 \pm 12.4	53.7 \pm 13.1	0.002*
Male, n (%)	38 (52.8%)	30 (62.5%)	0.28
Smokers, n (%)	18 (25.0%)	26 (54.2%)	0.001*
Comorbidities, n (%)	20 (27.8%)	28 (58.3%)	0.001*

*Statistically significant ($p < 0.05$); p value calculated using independent t-test for continuous variables and chi-square test for categorical variables

The impaired pulmonary function group had significantly higher age, smoking prevalence, and comorbid conditions compared to the normal group.

Pulmonary function profile

The mean FEV₁ in the normal group was $86.5 \pm 5.4\%$ predicted, whereas in the impaired group it was $64.2 \pm 8.1\%$. Similarly, mean FVC values were $88.1 \pm 6.2\%$ and $66.7 \pm 9.3\%$ in the normal and impaired groups respectively. The FEV₁/FVC ratio indicated an obstructive pattern in 28 patients (23.3%) and a restrictive pattern in 20 patients (16.7%) within the impaired group.

Postoperative pulmonary complications

Postoperative pulmonary complications were observed in 30 out of 120 patients (25%). The incidence of complications was significantly higher among patients with impaired pulmonary function (Table 2; Figure 1).

Table 2: Incidence of postoperative pulmonary complications

Outcome	Normal PFT (n=72)	Impaired PFT (n=48)	Chi-square	p value
---------	-------------------	---------------------	------------	---------

PPC present	10 (13.9%)	20 (41.7%)	11.62	0.0006*
PPC absent	62 (86.1%)	28 (58.3%)	—	—

PPC includes atelectasis, pneumonia, bronchospasm, and respiratory failure; *Statistically significant ($p < 0.05$).

Among the complications, atelectasis was the most common (12 cases), followed by pneumonia (9 cases), bronchospasm (6 cases), and respiratory failure (3 cases).

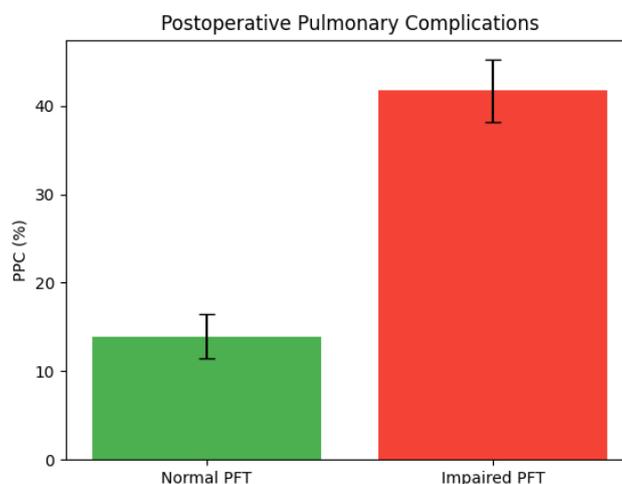


Figure 1: Postoperative pulmonary complications in relation to preoperative pulmonary function

Hospital stay analysis

The duration of hospital stay was notably longer in patients with impaired pulmonary function. The mean hospital stay in the impaired group was 9.2 ± 2.8 days compared to 6.1 ± 1.9 days in the normal group (Table 3; Figure 2).

Table 3: Duration of hospital stay

Parameter	Normal PFT (n=72)	Impaired PFT (n=48)	p value
Hospital stay (days, mean \pm SD)	6.1 ± 1.9	9.2 ± 2.8	$<0.001^*$

*Statistically significant ($p < 0.05$); p value calculated using independent t-test

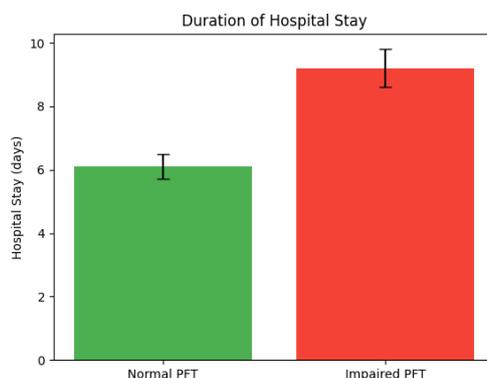


Figure 2: Comparison of duration of hospital stay between groups

ICU admission requirement

A total of 18 patients (15%) required postoperative ICU admission. The need for ICU care was significantly higher in the impaired pulmonary function group (Table 4; Figure 3).

Table 4: ICU admission

ICU admission	Normal PFT (n=72)	Impaired PFT (n=48)	Chi-square	p value
Yes	6 (8.3%)	12 (25.0%)	6.32	0.012*
No	66 (91.7%)	36 (75.0%)	—	—

*Statistically significant ($p < 0.05$)

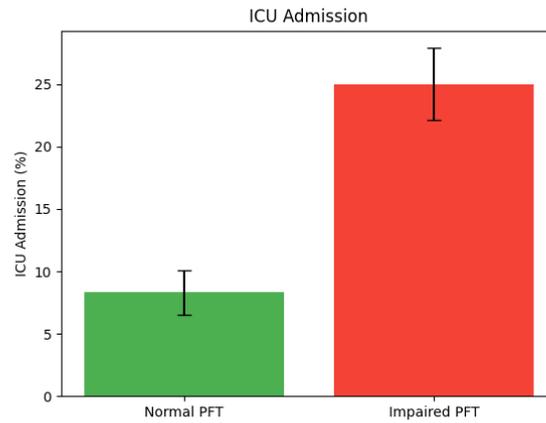


Figure 3: Requirement of intensive care unit admission

Association of FEV₁ with complications

Patients with FEV₁ <70% predicted showed a markedly higher incidence of postoperative pulmonary complications compared to those with FEV₁ ≥70% (Table 5; Figure 4).

Table 5: Association of FEV₁ with PPC

FEV ₁ category	PPC present	PPC absent	Chi-square	p value
≥70% predicted (n=80)	12 (15.0%)	68 (85.0%)	—	—
<70% predicted (n=40)	18 (45.0%)	22 (55.0%)	12.45	0.0004*

*Statistically significant ($p < 0.05$)

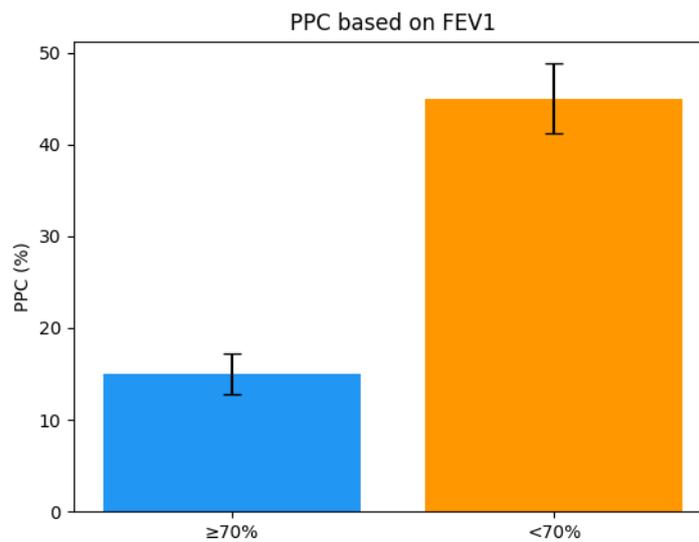


Figure 4: Association between FEV₁ levels and postoperative pulmonary complications

Mortality

Overall in-hospital mortality was low, with 4 deaths (3.3%) recorded. Among these, 3 patients belonged to the impaired pulmonary function group and 1 patient to the normal group. Although mortality was higher in the impaired group, the difference did not reach statistical significance ($p = 0.18$)

The parameters displayed include the incidence of postoperative pulmonary complications, mean duration of hospital stay, and rate of intensive care unit admission. Across all three measures, patients with impaired pulmonary function demonstrate higher values, indicating a greater burden of adverse outcomes. Error bars represent the standard error of the mean, reflecting variability within each group (Figure 5).

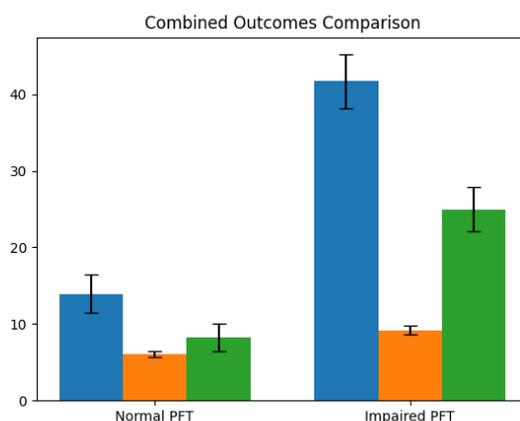


Figure 5: Combined comparison of postoperative outcomes between pulmonary function groups

DISCUSSION

The present study evaluated the influence of preoperative pulmonary function on postoperative outcomes in patients undergoing elective surgical procedures. The findings demonstrate a clear association between impaired pulmonary function and an increased risk of adverse postoperative events. Patients with reduced pulmonary reserve showed a significantly higher incidence of postoperative pulmonary complications, longer duration of hospital stay, and greater requirement for intensive care support. These observations reinforce the importance of respiratory assessment as an integral part of preoperative evaluation.

In this study, postoperative pulmonary complications were observed in one-fourth of the study population, with a markedly higher occurrence in patients with impaired pulmonary function. This aligns with earlier reports which identify pulmonary complications as a major contributor to postoperative morbidity [1,2]. The higher complication rate among patients with abnormal spirometry can be explained by reduced ventilatory reserve, impaired airway clearance, and increased susceptibility to atelectasis and infection [6,7]. Similar findings have been reported by Miskovic and Lumb, who highlighted the role of pre-existing respiratory dysfunction in amplifying perioperative risk [7].

The association between reduced FEV₁ and postoperative complications observed in this study is consistent with previous literature. FEV₁ has long been considered a reliable predictor of perioperative pulmonary risk, particularly when values fall below predicted thresholds [9]. In the present analysis, patients with FEV₁ below 70% predicted exhibited a significantly higher rate of complications, supporting its utility as a practical clinical marker. Ferguson et al. also reported that reduced FEV₁ is strongly linked to postoperative respiratory events, especially in patients undergoing major surgical procedures [9].

The study further demonstrated that patients with impaired pulmonary function had a prolonged hospital stay. This finding reflects delayed recovery and the need for extended monitoring and supportive care in patients who develop complications. Previous studies have similarly shown that pulmonary complications are associated with increased length of hospitalisation and resource utilisation [2,10]. The longer duration of stay may also be attributed to slower resolution of respiratory symptoms and the need for additional interventions such as oxygen therapy and physiotherapy.

Another important observation was the increased requirement for ICU admission among patients with impaired pulmonary function. This highlights the clinical significance of preoperative respiratory status in determining the need for higher levels of postoperative care. Studies have shown that patients with compromised lung function are more likely to require ventilatory support and intensive monitoring in the postoperative period [8,18]. The findings of the present study are in agreement with these reports and emphasise the role of pulmonary assessment in anticipating resource requirements.

The perioperative period is characterised by several physiological changes that can adversely affect respiratory mechanics. General anaesthesia reduces functional residual capacity and alters ventilation–perfusion relationships, thereby predisposing patients to hypoxemia [6]. Postoperative pain and immobility further impair effective ventilation and coughing, leading to secretion retention and atelectasis [7]. In patients with already compromised pulmonary function, these changes can result in a cascade of events culminating in clinically significant complications. This physiological basis supports the strong association observed in this study between preoperative pulmonary impairment and postoperative outcomes.

Smoking and comorbid conditions were more prevalent in the impaired pulmonary function group in the present study. These factors are known to contribute to both baseline respiratory dysfunction and increased perioperative risk. Gupta et

al. reported that smoking history and associated comorbidities significantly increase the likelihood of postoperative pulmonary complications [13]. Similarly, Smetana et al. emphasised that multiple patient-related factors interact with pulmonary function to influence surgical outcomes [15]. The findings of this study are consistent with these observations, suggesting that pulmonary function should be interpreted in conjunction with other clinical variables.

The results of this study also underscore the potential benefits of preoperative optimisation. Early identification of patients with impaired pulmonary function allows for targeted interventions such as smoking cessation, bronchodilator therapy, and respiratory exercises. Prehabilitation strategies have been shown to improve postoperative outcomes by enhancing respiratory capacity and reducing complication rates [14,16]. Incorporating such measures into routine clinical practice could help mitigate the risks identified in this study.

Although pulmonary function testing is widely recommended in high-risk surgical procedures, its routine use in general elective surgeries remains variable. The present findings highlight the value of spirometry even in a broader surgical population. PFTs are simple, non-invasive, and provide objective information that can guide perioperative planning [3,4]. Integrating pulmonary assessment into standard preoperative protocols may improve risk stratification and clinical decision-making.

The study also has relevance in the context of the Indian population, where respiratory diseases and smoking-related lung damage are common. Salvi and Agrawal have highlighted the growing burden of chronic respiratory diseases in India [20]. In such settings, the role of pulmonary function assessment becomes even more important, as a significant proportion of patients may have undiagnosed or subclinical respiratory impairment.

Despite its strengths, the study has certain limitations. Being conducted at a single centre, the findings may reflect local patient characteristics and practice patterns. The sample size, although adequate to demonstrate significant associations, may limit the generalisability of results. In addition, variations in surgical type and anaesthetic technique could have influenced outcomes. However, the consistent association between pulmonary function and postoperative events observed across multiple parameters strengthens the validity of the findings.

Overall, the present study demonstrates that preoperative pulmonary function is a meaningful predictor of postoperative outcomes. Patients with impaired pulmonary function are at increased risk of complications, prolonged hospital stay, and greater need for intensive care. These findings support the routine use of pulmonary function testing as part of preoperative evaluation and highlight the importance of early identification and optimisation of at-risk patients.

CONCLUSION

The findings of this study indicate that preoperative pulmonary function has a meaningful impact on surgical outcomes. Patients with reduced pulmonary reserve were more likely to develop postoperative pulmonary complications, required longer hospitalisation, and had a higher need for intensive care support compared to those with normal lung function. Among the spirometric parameters, reduced FEV₁ showed a strong association with adverse outcomes, highlighting its value as a practical indicator of perioperative risk.

These observations emphasise the importance of incorporating pulmonary function assessment into routine preoperative evaluation, even in elective surgical settings. Early identification of patients with impaired lung function provides an opportunity for optimisation through targeted interventions such as respiratory therapy and risk modification strategies.

In summary, preoperative pulmonary function testing serves as a useful, non-invasive tool for risk stratification and can contribute to improved perioperative planning and patient outcomes.

Acknowledgements

The authors express their sincere gratitude to the Department of General Surgery and the Department of Anaesthesiology at Bhaskar Medical College for their support and cooperation throughout the study period. We also thank the technical staff of the pulmonary function laboratory for their assistance in performing spirometry and ensuring the accuracy of measurements. Our appreciation extends to all the patients who willingly participated in this study and contributed to its successful completion.

Funding source

This study was conducted without any external financial support. All expenses related to data collection, investigations, and analysis were managed through institutional resources.

Conflict of interest

The authors declare that there are no conflicts of interest related to this study. No financial or personal relationships influenced the design, conduct, or reporting of the research.

Ethical approval

The study was carried out after obtaining approval from the Institutional Ethics Committee of Bhaskar Medical College. All procedures were conducted in accordance with established ethical standards for human research.

Informed consent

Written informed consent was obtained from all participants prior to their inclusion in the study. Participants were informed about the purpose of the study, and confidentiality of their information was maintained throughout.

Data availability statement

The data generated and analysed during the study are available from the corresponding author upon reasonable request.

REFERENCES

1. Lawrence VA, Cornell JE, Smetana GW; American College of Physicians. Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med.* 2006 Apr 18;144(8):596-608. doi: 10.7326/0003-4819-144-8-200604180-00011. PMID: 16618957.
2. Canet J, Gallart L, Gomar C, Paluzie G, Vallès J, Castillo J, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology.* 2010 Dec;113(6):1338-50. doi: 10.1097/ALN.0b013e3181fc6e0a. PMID: 21045639.
3. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. *Eur Respir J.* 2005 Nov;26(5):948-68. doi: 10.1183/09031936.05.00035205. PMID: 16264058.
4. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. *Eur Respir J.* 2005 Aug;26(2):319-38. doi: 10.1183/09031936.05.00034805. PMID: 16055882.
5. Smetana GW. Preoperative pulmonary evaluation. *N Engl J Med.* 1999 Mar 25;340(12):937-44. doi: 10.1056/NEJM199903253401207. PMID: 10089188.
6. Hedenstierna G, Edmark L. Effects of anesthesia on the respiratory system. *Best Pract Res Clin Anaesthesiol.* 2015 Sep;29(3):273-84. doi: 10.1016/j.bpa.2015.08.008. Epub 2015 Sep 18. PMID: 26643094.
7. Miskovic A, Lumb AB. Postoperative pulmonary complications. *Br J Anaesth.* 2017 Mar 1;118(3):317-334. doi: 10.1093/bja/aex002. PMID: 28186222.
8. Warner DO. Preventing postoperative pulmonary complications: the role of the anesthesiologist. *Anesthesiology.* 2000 May;92(5):1467-72. doi: 10.1097/00005542-200005000-00037. PMID: 10781293.
9. Jackson CV. Preoperative pulmonary evaluation. *Arch Intern Med.* 1988 Oct;148(10):2120-7. PMID: 3052344.
10. Brunelli A, Al Refai M, Monteverde M, Sabbatini A, Xiumé F, Fianchini A. Predictors of early morbidity after major lung resection in patients with and without airflow limitation. *Ann Thorac Surg.* 2002 Oct;74(4):999-1003. doi: 10.1016/s0003-4975(02)03852-3. PMID: 12400735.
11. Quanjer PH, Stanojevic S, Cole TJ, Baur X, Hall GL, Culver BH, et al. ERS Global Lung Function Initiative. Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations. *Eur Respir J.* 2012 Dec;40(6):1324-43. doi: 10.1183/09031936.00080312. Epub 2012 Jun 27. PMID: 22743675; PMCID: PMC3786581.
12. Qaseem T. Risk assessment for and strategies to reduce perioperative pulmonary complications. *Ann Intern Med.* 2006 Oct 3;145(7):553; author reply 553. doi: 10.7326/0003-4819-145-7-200610030-00017. PMID: 17015878.
13. Gupta H, Gupta PK, Fang X, Miller WJ, Cemaj S, Forse RA, et al. Development and validation of a risk calculator predicting postoperative respiratory failure. *Chest.* 2011 Nov;140(5):1207-1215. doi: 10.1378/chest.11-0466. Epub 2011 Jul 14. PMID: 21757571.
14. Hulzebos EH, Smit Y, Helders PP, van Meeteren NL. Preoperative physical therapy for elective cardiac surgery patients. *Cochrane Database Syst Rev.* 2012 Nov 14;11(11):CD010118. doi: 10.1002/14651858.CD010118.pub2. PMID: 23152283; PMCID: PMC8101691.
15. Smetana GW, Lawrence VA, Cornell JE; American College of Physicians. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med.* 2006 Apr 18;144(8):581-95. doi: 10.7326/0003-4819-144-8-200604180-00009. PMID: 16618956.
16. Benzo R, Wigle D, Novotny P, Wetzstein M, Nichols F, Shen RK, et al. Preoperative pulmonary rehabilitation before lung cancer resection: results from two randomized studies. *Lung Cancer.* 2011 Dec;74(3):441-5. doi: 10.1016/j.lungcan.2011.05.011. Epub 2011 Jun 12. PMID: 21663994; PMCID: PMC3191236.
17. Moonesinghe SR, Mythen MG, Das P, Rowan KM, Grocott MP. Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major surgery: qualitative systematic review. *Anesthesiology.* 2013 Oct;119(4):959-81. doi: 10.1097/ALN.0b013e3182a4e94d. PMID: 24195875.
18. Nakahama H, Jaradeh M, Abdelsattar ZM, Lubawski J, Vigneswaran WT. The impact of marginal lung function on outcomes in the era of minimally invasive thoracic surgery. *J Thorac Dis.* 2021 Dec;13(12):6800-6809. doi: 10.21037/jtd-21-1382. PMID: 35070364; PMCID: PMC8743406.
19. Agostini P, Naidu B, Cieslik H, Steyn R, Rajesh PB, Bishay E, et al. Effectiveness of incentive spirometry in patients following thoracotomy and lung resection including those at high risk for developing pulmonary

- complications. *Thorax*. 2013 Jun;68(6):580-5. doi: 10.1136/thoraxjnl-2012-202785. Epub 2013 Feb 21. PMID: 23429831.
20. Salvi S, Ghorpade D. What is the true burden of chronic obstructive pulmonary disease in India and what are its implications at a national level? *Lung India*. 2021 Nov-Dec;38(6):503-505. doi: 10.4103/lungindia.lungindia_579_21. PMID: 34747729; PMCID: PMC8614607.