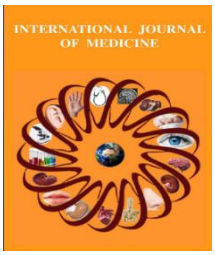

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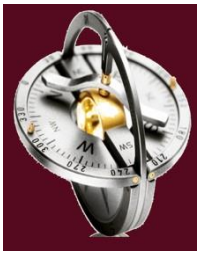

Original Research

Association Between Preoperative Pulmonary Function and Postoperative Pulmonary Complications in Patients Undergoing Elective Surgery Under General Anaesthesia: A Prospective Observational Study.

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Abstract

Background: Postoperative pulmonary complications substantially delay recovery after surgery under general anaesthesia. Although clinical risk scores are widely used, the value of preoperative spirometry in predicting these complications remains uncertain, particularly in heterogeneous elective surgical populations. *Objectives:* To evaluate the association between preoperative pulmonary function and postoperative pulmonary complications among patients undergoing elective surgery under general anaesthesia. *Methods:* This prospective observational study included 80 adults undergoing elective noncardiothoracic surgery at Government Medical College, Khammam, Telangana, India, from October 2024 to May 2025. Preoperative spirometry measured forced expiratory volume in the first second, forced vital capacity, and their ratio. Patients were followed for pulmonary complications during the first seven postoperative days or until discharge. Associations were assessed using group comparisons and multivariable logistic regression. *Results:* Abnormal spirometry was identified in 28 patients (35.0%). Nineteen patients developed postoperative pulmonary complications, giving an incidence of 23.8%. Complications occurred in 46.4% of patients with abnormal spirometry and 11.5% of those with normal spirometry. Patients with complications had lower mean predicted forced expiratory volume in the first second (64.8% versus 86.8%), predicted forced vital capacity (75.9% versus 88.2%), and forced expiratory volume in the first second/forced vital capacity ratio (70.9% versus 80.5%). After adjustment, abnormal pulmonary function remained independently associated with complications (adjusted odds ratio 5.12; 95% confidence interval 1.58-16.61). Median hospital stay was longer among affected patients (8 versus 5 days). *Conclusion:* Impaired preoperative pulmonary function was strongly associated with postoperative pulmonary complications and prolonged hospitalisation. Selective spirometry, combined with clinical and procedural risk assessment, can support perioperative risk stratification in elective surgical patients.

Keywords: *general anaesthesia; pulmonary function tests; postoperative pulmonary complications; preoperative assessment; spirometry*.

Introduction

Postoperative pulmonary complications (PPCs) comprise a clinically important group of respiratory events that arise after surgery, including atelectasis, pneumonia, bronchospasm, hypoxaemia, aspiration, and respiratory failure. Their reported frequency varies because surgical populations, observation periods, and diagnostic definitions differ. Even relatively mild events can interrupt mobilisation, increase oxygen requirements, prolong monitoring, and delay discharge. Severe complications are associated with unplanned intensive care admission, mechanical ventilation, and postoperative death. Contemporary evidence therefore regards PPCs as major determinants of perioperative morbidity and resource use rather than as isolated respiratory findings.[1,2]

General anaesthesia alters respiratory mechanics through reduced functional residual capacity, diaphragmatic displacement, ventilation-perfusion mismatch, and dependent-lung atelectasis. Surgical pain, residual neuromuscular blockade, opioid exposure, and impaired cough further compromise airway clearance after operation. The resulting risk is not uniform. Advanced age, cigarette smoking, chronic respiratory disease, poor functional status, higher American Society of Anesthesiologists (ASA) physical status, upper abdominal or thoracic incision, emergency surgery, and prolonged operating time have repeatedly been linked with PPCs.[3-6] Prediction tools such as the Assess Respiratory Risk in Surgical Patients in Catalonia score combine several of these factors and provide useful population-level risk estimates, although their performance varies across settings and geographical regions.[3,4]

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Spirometry provides objective measurements of expiratory airflow and ventilatory capacity. Forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio can identify obstructive patterns and suggest restrictive or mixed abnormalities when technically acceptable manoeuvres are obtained.[7] Nevertheless, routine pulmonary-function testing before all noncardiothoracic operations is not universally recommended. Earlier systematic reviews found insufficient evidence that spirometry adds substantial discrimination beyond history, examination, functional capacity, surgical site, and procedure duration.[5,6] A large 2024 cohort similarly found that preoperative FEV1 did not improve prediction of the severe composite of respiratory failure or death after adjustment for established risk factors.[13] These findings do not exclude a role for spirometry in selected patients or for broader PPC outcomes, particularly where undiagnosed airflow limitation is common.

Evidence from Indian tertiary-care surgical populations remains limited, and local case mix, smoking exposure, access to preoperative optimisation, and postoperative respiratory care can influence complication rates. Clarifying the relationship between measured pulmonary function and early postoperative respiratory morbidity could improve risk counselling and guide targeted surveillance. Accordingly, the present study aimed to determine the incidence and pattern of PPCs among adults undergoing elective surgery under general anaesthesia and to evaluate their association with preoperative spirometric abnormalities. Secondary objectives were to compare FEV1, FVC, and FEV1/FVC values between patients with and without PPCs; identify relevant clinical and procedural factors; and assess the relationship between PPCs and postoperative hospital stay.

METHODOLOGY

Study design and setting

This prospective, hospital-based observational study was conducted in the Department of Anaesthesiology, Government Medical College, Khammam, Telangana, India, from October 2024 to May 2025.

Ethical considerations

Necessary Permissions were obtained before starting the study. Written informed consent was obtained from every participant before enrolment.

Participants

Adults aged 18 years or older who were scheduled for elective noncardiothoracic surgery under general anaesthesia and were able to perform acceptable spirometry were eligible. Patients undergoing emergency or thoracic surgery, those requiring preoperative ventilatory support, patients with an acute respiratory infection, haemodynamic instability, severe neuromuscular disease affecting respiratory performance, or inability to understand or complete spirometry, and those with incomplete perioperative follow-up were excluded. Consecutive eligible patients were recruited. A minimum sample of 72 was estimated using an anticipated PPC proportion of 25%, 95% confidence, and 10% absolute precision. The target was increased to 80 to preserve analytical adequacy.

Preoperative assessment and spirometry

Demographic characteristics, body mass index, smoking status, respiratory comorbidity, ASA physical status, planned surgical category, and relevant clinical history were recorded. Spirometry was performed during the preanaesthetic evaluation by trained personnel using a calibrated spirometer and standard acceptability and repeatability procedures.[7] FEV1, FVC, FEV1 percentage predicted, FVC percentage predicted, and the FEV1/FVC ratio were documented. The best acceptable values were used. Results were classified as normal or abnormal. Abnormal patterns were categorised as obstructive, spirometric restrictive, or mixed. A restrictive pattern was considered suggestive because static lung-volume measurement was not undertaken.

Perioperative observation and outcome assessment

Anaesthesia and intraoperative care were provided according to institutional practice. Surgical site and duration were recorded. Participants were assessed daily during the first seven postoperative days or until hospital discharge, whichever occurred earlier. PPCs were identified using predefined clinical and radiological criteria informed by standard perioperative outcome definitions.[8] The composite included atelectasis, prolonged postoperative hypoxaemia requiring supplemental oxygen beyond routine recovery, pneumonia, clinically significant bronchospasm, and respiratory failure requiring noninvasive or invasive ventilatory support. Multiple events in the same patient were recorded, but each patient contributed once to the composite outcome. Unplanned intensive care admission, in-hospital death, and postoperative length of stay were also documented.

Statistical analysis

Continuous variables were summarised as mean ± standard deviation or median with interquartile range according to distribution, while categorical variables were presented as frequency and percentage. Patients with and without PPCs were compared using the independent-samples t-test or Mann-Whitney U test for continuous variables and the chi-square test or Fisher exact test for categorical variables. Unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Because only 19 participants developed PPCs, a parsimonious multivariable logistic-regression model was restricted to abnormal spirometry, age of at least 60 years, and surgical duration exceeding 120 minutes to reduce model overfitting. Adjusted ORs with 95% CIs were reported. A two-sided p-value below 0.05 indicated statistical significance. Analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA).

Results

During the study period, 86 patients scheduled for elective surgery under general anaesthesia were assessed for eligibility. Six were excluded: three did not meet the eligibility criteria, two declined participation, and one could not complete acceptable preoperative spirometry. The remaining 80 patients were enrolled and included in the final analysis. Complete preoperative pulmonary-function, intraoperative, and postoperative outcome data were available for all participants.

The mean age was 53.8 ± 13.1 years (range, 22-78 years), and 49 participants (61.3%) were male. The mean body mass index was 25.8 ± 3.9 kg/m². Current smoking was reported by 19 patients (23.8%), while 17 (21.3%) were former smokers. Twelve participants (15.0%) had a pre-existing respiratory disorder, predominantly chronic obstructive pulmonary disease or bronchial asthma. ASA physical status grade II was the most frequent category. Abdominal procedures accounted for 36.3% of operations, and the mean surgical duration was 128.4 ± 42.6 minutes (Table 1).

Table 1. Baseline demographic, perioperative, and pulmonary-function characteristics (n=80)

Characteristic	Overall value
Age, years	53.8 ± 13.1
Age range, years	22-78
Male sex	49 (61.3%)
Body mass index, kg/m²	25.8 ± 3.9
Current smoker	19 (23.8%)
Former smoker	17 (21.3%)
Pre-existing respiratory disease	12 (15.0%)

ASA physical status I	20 (25.0%)
ASA physical status II	44 (55.0%)
ASA physical status III	16 (20.0%)
Abdominal surgery	29 (36.3%)
Orthopaedic surgery	20 (25.0%)
Head-and-neck surgery	13 (16.3%)
Urological surgery	10 (12.5%)
Other elective surgery	8 (10.0%)
Surgical duration, minutes	128.4 ± 42.6
FEV1, L	2.24 ± 0.65
FEV1, percentage predicted	81.6 ± 16.4
FVC, L	2.86 ± 0.78
FVC, percentage predicted	85.3 ± 15.1
FEV1/FVC ratio, %	78.2 ± 9.8
Normal spirometry	52 (65.0%)
Obstructive pattern	15 (18.8%)
Spirometric restrictive pattern	10 (12.5%)
Mixed pattern	3 (3.8%)

Data are presented as mean ± standard deviation, range, or number (percentage). ASA, American Society of Anesthesiologists; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity.

The mean FEV1 was 2.24 ± 0.65 L and the mean FVC was 2.86 ± 0.78 L. Mean predicted FEV1 and FVC were 81.6 ± 16.4% and 85.3 ± 15.1%, respectively, while the mean FEV1/FVC ratio was 78.2 ± 9.8%. Normal spirometry was observed in 52 patients (65.0%). Twenty-eight patients (35.0%) had an abnormal pattern: obstructive in 15 (18.8%), spirometric restrictive in 10 (12.5%), and mixed in 3 (3.8%) (Table 1).

PPCs occurred in 19 of 80 patients, corresponding to an incidence of 23.8% (95% CI, 15.8-34.1%). Atelectasis was the most frequent event, followed by prolonged postoperative hypoxaemia and pneumonia. Several patients experienced more than one pulmonary event. Four participants (5.0%) required unplanned postoperative intensive care admission because of respiratory deterioration, and no in-hospital deaths occurred (Table 2).

Table 2. Incidence and pattern of postoperative pulmonary complications

Outcome	n	%
Any postoperative pulmonary complication	19	23.8
Atelectasis	9	11.3
Prolonged postoperative hypoxaemia	8	10.0
Pneumonia	5	6.3
Bronchospasm	4	5.0
Respiratory failure requiring ventilatory support	3	3.8
Unplanned postoperative intensive care admission	4	5.0
In-hospital mortality	0	0.0

Individual pulmonary complications are not mutually exclusive; some patients experienced more than one event.

PPCs developed in 13 of 28 patients with abnormal preoperative spirometry (46.4%) and in 6 of 52 patients with normal spirometry (11.5%; p<0.001). Abnormal spirometry was associated with an unadjusted OR of 6.64 (95% CI, 2.15-20.55). Patients with PPCs were older and had substantially lower predicted FEV1, predicted FVC, and FEV1/FVC ratios than those without PPCs. Current or former smoking, pre-existing respiratory disease, ASA physical status grade III, upper abdominal surgery, and surgical duration exceeding 120 minutes were also associated with PPC occurrence. Sex and body mass index were comparable between groups (Table 3).

Table 3. Characteristics according to postoperative pulmonary complication status

Characteristic	PPC present (n=19)	PPC absent (n=61)	p-value
Age, years	61.2 ± 10.5	51.5 ± 13.0	0.002
Age ≥60 years	12 (63.2%)	19 (31.1%)	0.013
Male sex	12 (63.2%)	37 (60.7%)	0.846
Body mass index, kg/m²	26.7 ± 4.2	25.5 ± 3.8	0.276
Current or former smoker	13 (68.4%)	23 (37.7%)	0.033
Pre-existing respiratory disease	7 (36.8%)	5 (8.2%)	0.005
ASA physical status grade III	8 (42.1%)	8 (13.1%)	0.017
Upper abdominal surgery	9 (47.4%)	10 (16.4%)	0.011
Surgical duration >120 minutes	14 (73.7%)	24 (39.3%)	0.016
Abnormal preoperative spirometry	13 (68.4%)	15 (24.6%)	<0.001
FEV1, percentage predicted	64.8 ± 13.7	86.8 ± 13.1	<0.001
FVC, percentage predicted	75.9 ± 15.6	88.2 ± 13.7	0.005
FEV1/FVC ratio, %	70.9 ± 9.6	80.5 ± 8.6	<0.001

Data are presented as mean ± standard deviation or number (percentage). ASA, American Society of Anesthesiologists; FEV1, forced expiratory volume in the first second; FVC, forced vital capacity; PPC, postoperative pulmonary complication.

A parsimonious multivariable logistic-regression model included abnormal preoperative pulmonary function, age of at least 60 years, and surgical duration exceeding 120 minutes. After adjustment, abnormal pulmonary function remained independently associated with PPCs (adjusted OR, 5.12; 95% CI, 1.58-16.61; p=0.006). Surgical duration exceeding 120 minutes showed a borderline association, whereas age of at least 60 years was not independently significant in the adjusted model (Table 4).

Table 4. Logistic-regression analysis of factors associated with postoperative pulmonary complications

Variable	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Abnormal preoperative pulmonary function	6.64 (2.15-20.55)	<0.001	5.12 (1.58-16.61)	0.006
Age ≥60 years	3.79 (1.29-11.13)	0.015	2.42 (0.76-7.72)	0.135
Surgical duration >120 minutes	4.32 (1.38-13.54)	0.012	3.14 (0.98-10.02)	0.054

CI, confidence interval; OR, odds ratio. The adjusted model included all three variables displayed.

Patients who developed PPCs had a longer postoperative hospital stay than those without complications. The median stay was 8 days (interquartile range, 7-11 days) in the PPC group and 5 days (interquartile range, 4-7 days) in the non-PPC group (p<0.001).

Discussion

This prospective study found that nearly one-quarter of patients undergoing elective surgery under general anaesthesia developed at least one PPC. Abnormal preoperative spirometry was present in 35.0% of participants and was strongly associated with postoperative respiratory morbidity. Patients with PPCs had lower predicted FEV1, lower predicted FVC, and a reduced FEV1/FVC ratio. After adjustment for age and prolonged surgical duration, abnormal pulmonary function remained an independent predictor. PPCs were also linked with a three-day increase in median postoperative hospital stay.

The observed PPC incidence of 23.8% lies within the broad range reported across surgical cohorts. Variation between studies reflects differences in case mix, procedure severity, surveillance intensity, and outcome definitions.[1,3] Fernandez-Bustamante and colleagues reported PPCs in 33.4% of a higher-risk cohort undergoing prolonged general anaesthesia, with prolonged oxygen therapy and atelectasis among the dominant events.[2] In contrast, the ARISCAT development and validation cohorts reported lower overall patient-level rates, but rates rose markedly among high-risk groups.[3,4] The present composite included clinically relevant hypoxaemia and radiologically supported atelectasis, which increased sensitivity for early morbidity.

The central finding was the association between impaired spirometry and PPCs. Abnormal results were followed by a complication rate of 46.4%, compared with 11.5% among patients with normal tests. This observation supports spirometry as an objective marker of reduced respiratory reserve in selected elective surgical patients. It should not be interpreted as evidence for universal testing. Systematic reviews and clinical guidance have questioned routine spirometry because established clinical and procedural variables often provide comparable risk information.[5,6] Moreover, Mizota and colleagues found no independent relationship between FEV1 and the narrower outcome of respiratory failure or death in a large 2024 cohort.[13] The difference from the present findings is plausibly related to outcome severity, patient selection, and the use of a broad PPC composite rather than severe respiratory failure alone.

Older age, smoking exposure, respiratory disease, ASA grade III, upper abdominal surgery, and prolonged operating time were associated with PPCs on unadjusted analysis. These factors agree with established indices for postoperative respiratory failure and pneumonia, which emphasise procedural category, functional and physiological reserve, smoking, chronic lung disease, and higher ASA status.[9-12] Age lost statistical significance after adjustment, indicating overlap between chronological age, pulmonary impairment, and procedural burden. The borderline estimate for prolonged surgery probably reflects limited event numbers rather than absence of clinical relevance.

The longer hospital stay among affected patients reinforces the practical importance of early respiratory morbidity. Preoperative spirometry should be integrated with symptom assessment, smoking history, functional status, ASA grade, oxygen saturation, surgical site, and expected duration rather than used as a solitary screening test. Patients with abnormal results warrant verification of respiratory diagnoses, optimisation of bronchodilator therapy when indicated, smoking cessation counselling, careful intraoperative ventilation, complete reversal of neuromuscular blockade, adequate analgesia, early mobilisation, and structured lung-expansion measures. Evidence for individual preventive interventions varies, but coordinated perioperative strategies remain central to risk reduction.[14]

LIMITATIONS

The single-centre design and modest sample limited external validity and the precision of adjusted estimates. Spirometry was performed before surgery, but lung-volume measurements were unavailable; therefore, restrictive patterns were based on spirometric criteria rather than confirmed total lung capacity. The heterogeneous operations and 19 pulmonary events required a parsimonious regression model. Residual confounding from analgesic techniques, ventilation settings, and postoperative physiotherapy remains possible.

Conclusion

Preoperative pulmonary impairment was strongly associated with postoperative pulmonary complications among adults undergoing elective surgery under general anaesthesia. Abnormal spirometry identified a subgroup with substantially greater respiratory morbidity, lower FEV1 and FVC values, and longer postoperative hospitalisation. Clinical factors, including smoking exposure, respiratory disease, higher ASA grade, upper abdominal surgery, and prolonged operating time, also contributed to risk. Spirometry should complement, rather than replace, structured clinical and procedural assessment. Selective testing in patients with respiratory symptoms, relevant comorbidity, smoking exposure, or higher-risk surgery can strengthen counselling, optimisation, postoperative surveillance, and resource planning. Larger multicentre studies should validate thresholds and determine whether spirometry-guided interventions reduce complications in comparable elective surgical populations.

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