Original Article

Effects of preoperative pulmonary function on short-term outcomes and overall survival after video-assisted thoracic surgery lobectomy

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Background: Preoperative pulmonary function tests are a necessary preoperative assessment tool for non-small cell lung cancer (NSCLC) patients awaiting surgery. We studied the effects of preoperative pulmonary function on short-term outcomes and overall survival (OS).

Methods: A retrospective cohort study was undertaken with adult NSCLC patients undergoing video-assisted thoracoscopic surgery (VATS) lobectomy between May 2016 and April 2017. The primary exposure variables were the percentage of predicted peak expiratory flow (PEF%), the percentage of predicted forced vital capacity (FVC%), and the percentage of predicted forced expiratory volume in 1 s. The observation outcomes were postoperative pulmonary complications (PPCs), acute kidney injury (AKI), in-hospital mortality, readmission within 30 days, and OS. Univariate and multivariate analyses were performed.

Results: Of the 548 patients, postoperative pneumonia was observed in 206 (37.6%). The results of the binary logistics regression analysis showed that relative to the moderate PEF% group, the risk of postoperative pneumonia was significantly increased in the marginal PEF% [odds ratio (OR) 2.076; 95% confidence interval (CI): 1.211–3.558; P=0.008] and excellent PEF% (OR 1.962; 95% CI: 1.129–3.411; P=0.017) groups. Relative to the good FVC% group, the risk of postoperative pneumonia was significantly increased in the marginal FVC% (OR 2.125; 95% CI: 1.226–3.683; P=0.007) and moderate FVC% (OR 2.230; 95% CI: 1.298–3.832; P=0.004) groups. The OS analysis did not reveal any correlations among the pulmonary function parameters and OS in this cohort.

Conclusions: Preoperative PEF% and FVC% are associated with postoperative pneumonia in NSCLC patients undergoing VATS lobectomy. Preoperative PEF% is as important as FVC% in pulmonary function assessment before lung surgery.

Keywords: Pulmonary function; video-assisted thoracoscopic surgery (VATS); lobectomy; postoperative pneumonia

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Introduction

Lung cancer is the most common cause of cancer-related death worldwide (1). About 80% of lung cancers are Non-small cell lung cancer (NSCLC) (2). Lobectomy with systematic mediastinal lymph node dissection is the gold standard surgical treatment for early NSCLC (3). Preoperative pulmonary function assessment is the most basic assessment method for preoperative assessment of surgical tolerance, lung reserve, and risk of perioperative complications (2). Forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) are the most commonly used clinical pulmonary function parameters, which are useful for predicting perioperative complications, short-term mortality, and long-term survival in NSCLC (3-6). However, research findings are controversial, and a unified consensus has yet to be reached (2,7). Peak expiratory flow (PEF), which is defined as the maximum flow achieved during a forced expiration starting from the level of maximal lung inflation, is also an important pulmonary function parameter (8). However, apart from studies on FEV1 and FVC, few studies have analysed the effects of PEF on NSCLC patients following lobectomy.

In the past 30 years, video-assisted thoracoscopic surgery (VATS) has been widely used in thoracic surgery and is the standard surgical method for the treatment of lung cancer (9). Unlike traditional surgery, VATS can be performed through small incisions and results in less postoperative pain, a shorter hospital stay, and a more rapid recovery (1). However, evaluations of the relationship between preoperative pulmonary function and postoperative short- and long-term outcomes following VATS lobectomy in patients with NSCLC are limited. Thus, this retrospective study aimed to determine whether preoperative pulmonary functions are associated with postoperative outcomes in patients with NSCLC.

We focused on the effect of preoperative pulmonary functions including preoperative PEF, FVC, and FEV1 on the immediate and long-term post-surgical outcomes of patients with NSCLC undergoing VATS lobectomy to provide guidelines for the preoperative physiologic assessment of patients being considered for surgical resection of lung cancer.

We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/atm-21-5244).

Methods

Patients

This study is an observational retrospective study, including 592 consecutive NSCLC patients who underwent VATS lobectomy at The First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou, China from May 1, 2016 to April 30, 2017. Patients were considered eligible for inclusion in the study if they were aged over 18 years and were underwent VATS lobectomy under general anaesthesia. The patients fasted for 8 h before surgery. A lung protective strategy (with low tidal volume) was adopted. The VATS lobectomy was performed through three ports. Systematic mediastinal lymph node dissection was performed. Patients with preoperative renal dysfunction, a history of thoracic surgery, congestive heart failure, or who required a sleeve lobectomy, a simultaneous resection of more than two lobes, or a second surgery were excluded from this study. The exclusion criteria for this study are detailed in *Figure 1*. Patients with missing pulmonary function data were also excluded. Ultimately, 548 patients were enrolled in the study (see *Figure 1*).

Demographics, intraoperative and postoperative data were all extracted from the patients' medical record system as described in Tables S1,S2. All patients received prophylactic first-generation/second-generation cephalosporins after surgery until the chest tubes were removed, but if the patient developed a postoperative lung infection, they were treated with sulbactam ampicillin or ciprofloxacin. In addition, if there was no risk of aspiration, patients usually started oral feedings 6–8 hours after the tracheal intubation is extubated. The tumour-node-metastasis classification (7th edition) proposed by the International Union Against Cancer was applied in this cohort.

The study was approved by the Medical Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine (No. 2017–58). As the data were recorded retrospectively and without any specific intervention, the Medical Ethics Committee waived informed consent. The study was conducted in accordance with Declaration of Helsinki (as revised in 2013).

Exposure variables

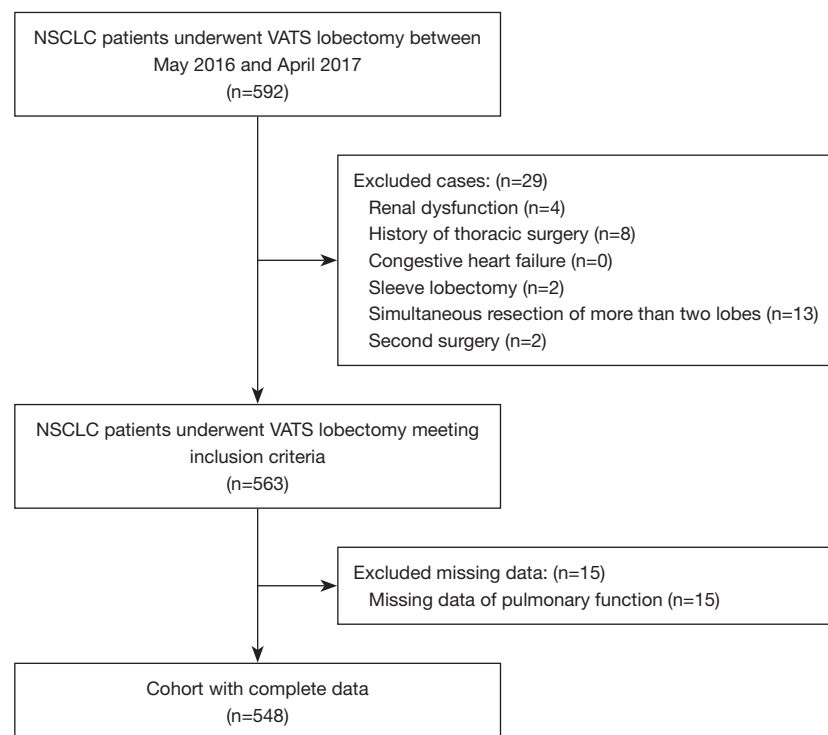The exposure variables included the percentage of predicted

Figure 1 Study enrolment flow chart. NSCLC, non-small cell lung cancer; VATS, video-assisted thoracoscopic surgery.

PEF (PEF%), the percentage of predicted FVC (FVC%), and the percentage of predicted FEV1 (FEV1%). To analyse the effect of these pulmonary function parameters on postoperative short-term outcomes and overall survival (OS), patients were classified into the following four groups representing incremental quartiles of the exposure variables of PEF%, FVC%, and FEV1%: (I) marginal [quartile 1 (Q1)]; (II) moderate [quartile 2 (Q2)]; (III) good [quartile 3 (Q3)]; and (IV) excellent [quartile 4 (Q4)] (10).

Short-term outcome measures

The observation short-term outcome measures were postoperative pulmonary complications (PPCs), (including acute respiratory distress syndrome, reintubation, pulmonary embolism, the need for bedside bronchoscopy, prolonged air leak, failure to expand, atelectasis, and pneumonia during the period of postoperative hospitalisation), acute kidney injury (AKI), in-hospital mortality, and readmission within 30 days (10,11). Pulmonary embolism needs to be diagnosed by computed tomography angiography of the pulmonary artery (12). Prolonged air leak was defined as the postoperative lung leakage time greater than 7 days

(11,12). Failure to expand was defined as a pneumothorax with or without air leakage, which required chest X-ray diagnosis (11,12). Atelectasis was diagnosed by chest radiograph documentation. The diagnosis of postoperative pneumonia needs to meet the following 3 conditions: a new pulmonary infiltrate on a chest X-ray, leucocytosis and fever (ear temperature >37.5 ℃) (11,12). AKI was defined as the increase of serum creatinine level by more than 50% or 0.3 mg/dL compared with preoperative level within 48 h postoperatively or the existence of an AKI diagnostic code within 1 week postoperatively (10).

OS measures

All patients were followed up for OS, and the cause of death was extracted from patients' death certificate or medical records. We classified deaths into four categories, including deaths caused by postoperative complication during the initial hospital admission period or within 30 days after surgery, cancer-related deaths due to tumor progression/recurrence, non-cancer-related deaths, and deaths with uncertain cause for those for whom records were not available.

Statistical analysis

Data are expressed as mean ± standard deviation for the continuous variables, and as a percentage for the categorical variables. The continuous data were compared using 1-way variance analysis. When the variance was not homogeneous, a non-parametric test (Kruskal-Wallis H test for multiple independent samples) was selected. R × C chi-square test was used for comparison of categorical variables. Fisher's exact test was used when the theoretical frequency was <5. Binary logistic regression analyses were conducted to determine the relationships between preoperative pulmonary function (PEF%, FVC%, and FEV1%) and PPCs, AKI, in-hospital mortality, and readmission within 30 days. Potential confounders were included based on *a priori* knowledge of predictors of PPCs, AKI, and OS (10). The assignment of the variables in the multivariate analysis is shown in Table S3. Odds ratios (ORs) with their 95% confidence intervals (CIs) were calculated from these models. Kaplan-Meier plots and log-rank tests were used to assess the effects of preoperative pulmonary function on survival. A multivariate Cox regression analysis was undertaken to estimate the hazard ratios and the 95% CIs for OS. A 2-tailed P≤0.05 was considered statistically significant for all tests. All analyses were performed using SPSS 25.0 (SPSS, Inc., Chicago, IL, USA) (10,12,13).

Results

Patient selection and comparative univariate analysis

Of the 548 patients who met the inclusion criteria (see *Figure 1*), 206 (37.6%) cases of postoperative pneumonia were observed (see Table S2). No patient died during postoperative hospitalisation (see Table S2). The baseline characteristics and comparative univariate results of the cohort are set out in Tables S1,S2, and Tables S4-S7.

Comparative multivariate analysis of 4 different PEF% groups

All potential confounders were included in our multivariate regression model to determine the degree of contribution of the preoperative PEF% on postoperative outcomes (see Table S8). Body mass index, instead of weight, was included in the regression model. Due to possible interactions among the various pulmonary function parameters, only the grouping variable PEF% was included in the regression model. The binary logistics regression results revealed that

the incidence of postoperative pneumonia was lowest in the moderate PEF% (Q2) group (see *Table 1* and Table S8). Conversely, the risk for postoperative pneumonia was significantly increased in the marginal PEF% (Q1: OR 2.076; 95% CI: 1.211–3.558; P=0.008) and excellent PEF% (Q4: OR 1.962; 95% CI: 1.129–3.411; P=0.017) groups (see *Table 1*). The incidences of other PPCs (including acute respiratory distress syndrome, reintubation, pulmonary embolism, the need for bedside bronchoscopy, prolonged air leak, failure to expand, and atelectasis) were similar among the four groups (see *Table 1*). The incidence of AKI was also similar among the four groups (P=0.168; see *Table 1*). No deaths occurred among patients in the four groups during hospitalisation. There were also no statistical differences in readmission within 30 days among the four groups (P=0.648; see *Table 1*).

Comparative multivariate analysis of 4 different FVC% groups

All potential confounders were included in our multivariate regression model to determine the degree of contribution of preoperative FVC% on postoperative outcomes (see Table S9). Patient weight and other pulmonary function parameters, including the PEF%, FEV1%, PEF (L/s), FVC (L), and FEV1 (L), were excluded from the regression model for the reason stated above. The binary logistics regression results affirmed that the incidence of postoperative pneumonia was lowest in the good (Q3) FVC% group (see *Table 2* and Table S9). Conversely, the postoperative risk of pneumonia was significantly increased in the marginal FVC% (Q1: OR 2.125; 95% CI: 1.226–3.683; P=0.007) and moderate FVC% (Q2: OR 2.230; 95% CI: 1.298–3.832; P=0.004) groups (see *Table 2*). The incidence of other PPCs (including acute respiratory distress syndrome, reintubation, pulmonary embolism, the need for bedside bronchoscopy, prolonged air leak, failure to expand, and atelectasis) were similar among the four groups (see *Table 2*). The incidence of AKI was also similar among the four groups (P=0.439; see *Table 2*). No deaths occurred among patients in the four groups during hospitalisation. Readmission within 30 days was also comparable among the four groups (P=0.802; see *Table 2*).

Comparative multivariate analysis of 4 different FEV1% groups

All potential confounders were included in our multivariate regression model to determine the degree of contribution

Table 1 Effects of the PEF% on postoperative outcomes

Postoperative outcome	PEF%				Total P value
	Quartile 1 (n=139), ≤49.0%	Quartile 2 (n=135), >49.0–65.6%	Quartile 3 (n=146), >65.6–84.0%	Quartile 4 (n=128), >84.0%	
Postoperative pulmonary complications, n (%)					
Acute respiratory distress syndrome	1 (0.7)	0 (0.0)	2 (1.4)	1 (0.8)	0.991
Reintubation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Pulmonary embolism	1 (0.7)	0 (0.0)	2 (1.4)	0 (0.0)	0.999
Need for bedside bronchoscopy	0 (0.0)	2 (1.5)	1 (0.7)	1 (0.8)	1.000
Prolonged air leak	1 (0.7)	3 (2.2)	4 (2.7)	2 (1.6)	0.493
Failure to expand	5 (3.6)	5 (3.7)	1 (0.7)	2 (1.6)	0.288
Atelectasis	0 (0.0)	6 (4.4)	4 (2.7)	3 (2.3)	0.525
Pneumonia	64 (46.0)	41 (30.4)	49 (33.6)	52 (40.6)	0.013
OR (95% CI)	2.076 (1.211–3.558)	1	1.157 (0.677–1.978)	1.962 (1.129–3.411)	
P value	0.008	–	0.595	0.017	
Acute kidney injury, n (%)	2 (1.4)	4 (3.0)	0 (0.0)	6 (4.7)	0.168
In-hospital mortality, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Readmission within 30 days, n (%)	2 (1.4)	0 (0.0)	3 (2.1)	1 (0.8)	0.648

The results of the binary logistics regression are presented as the adjusted OR, 95% CI, and P value. The best-performing quartile 2 served as the reference group. CI, confidence interval; OR, odds ratio; PEF%, peak expiratory flow as a percentage of predicted.

of the preoperative FEV1% on postoperative outcomes (see Table S10). The binary logistics regression results showed that the incidence of all PPCs (including acute respiratory distress syndrome, reintubation, pulmonary embolism, the need for bedside bronchoscopy, prolonged air leak, failure to expand, atelectasis, and pneumonia) were similar among the four different FEV1% groups (see *Table 3* and Table S10). The incidence of AKI was also similar among the four groups (P=0.964; see *Table 3*). No deaths occurred among patients in the four groups during hospitalisation. There were also no statistical differences in readmission within 30 days among the four groups (P=0.812; see *Table 3*).

OS analysis

The median follow-up period for all patients was 28.7 months. Nine (1.7%) deaths had occurred at the median follow-up period of 13.6 months. Causes of death included early postoperative complications (0.0%), cancer-related deaths (55.6%), non-cancer-related deaths (0.0%), and cause of death uncertain (44.4%) (see *Table 4* and Tables S11,S12).

There were no statistical differences in OS among the 4 different PEF%, FVC%, and FEV1% groups (see *Figure 2*), and these findings were further confirmed by the multivariate Cox regression results (see Tables S13-S15).

In addition, we grouped the patients using the absolute values of preoperative PEF, FVC, and FEV1 as grouping variables. Patients were also classified into 4 groups representing incremental quartiles of the exposure variables of PEF (L/s), FVC (L), and FEV1 (L). The baseline characteristics and comparative univariate results of the cohort are presented in Tables S16-S21. The results of the multivariate analysis and OS analysis are presented in Tables S22-S33, and Figure S1.

Discussion

In the analysis of the 548 NSCLC patients who underwent VATS lobectomy, a robust association between preoperative pulmonary functions (PEF% and FVC%) and postoperative pneumonia was observed (see *Tables 1,2*). However, this association did not lead to differences in OS (see *Figure 2*).

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Table 2 Effects of the FVC% on postoperative outcomes

Postoperative outcome	FVC%				Total P value
	Quartile 1 (n=145), ≤80.0%	Quartile 2 (n=136), >80.0–92.0%	Quartile 3 (n=133), >92.0–101.0%	Quartile 4 (n=134), >101.0%	
Postoperative pulmonary complications, n (%)					
Acute respiratory distress syndrome	2 (1.4)	0 (0.0)	1 (0.8)	1 (0.7)	0.959
Reintubation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Pulmonary embolism	2 (1.4)	0 (0.0)	1 (0.8)	0 (0.0)	0.941
Need for bedside bronchoscopy	0 (0.0)	2 (1.5)	2 (1.5)	0 (0.0)	0.842
Prolonged air leak	2 (1.4)	1 (0.7)	3(2.3)	4 (3.0)	0.755
Failure to expand	2 (1.4)	6(4.4)	0 (0.0)	5 (3.7)	0.616
Atelectasis	4 (2.8)	4 (2.9)	2 (1.5)	3 (2.2)	0.893
Pneumonia	64 (44.1)	62 (45.6)	36 (27.1)	44 (32.8)	0.012
OR (95% CI)	2.125 (1.226–3.683)	2.230 (1.298–3.832)	1	1.399 (0.802–2.440)	
P value	0.007	0.004	–	0.237	
Acute kidney injury, n (%)	4 (2.8)	3 (2.2)	0 (0.0)	5 (3.7)	0.439
In-hospital mortality, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Readmission within 30 days, n (%)	1 (0.7)	0 (0.0)	2 (1.5)	3 (2.2)	0.802

The results of the binary logistics regression are presented as the adjusted OR, 95% CI, and P value. The best-performing quartile 3 served as the reference group. CI, confidence interval; FVC%, forced vital capacity as percentage of predicted; OR, odds ratio.

Neither postoperative pneumonia nor OS was significantly associated with the FEV1%. The major finding of this study is that for NSCLC patients who underwent VATS lobectomy, a preoperative PEF% value that was too low (≤49.0%) or too high (>84.0%) led to an increased incidence of postoperative pneumonia (see *Table 1*). Conversely, only a preoperative FVC% value that was too low (≤92.0%) led to an increased incidence of postoperative pneumonia (see *Table 2*). Thus, preoperative PEF% is as important as FVC% in pulmonary function assessment before lung surgery.

To estimate the risk of complications, including pneumonia and atelectasis, FEV1 and FVC have been studied in the last quarter of the 1900s (14-17). FEV1 and FVC have traditionally been considered the two critical pulmonary function parameters for lung cancer candidates awaiting surgery (8,18,19). FEV1 is a measure of how much air can be exhaled in 1 s following a deep inhalation. No significant association was found between FEV1% and postoperative pneumonia in the current study. FVC is a measurement of lung size (in litres) and represents the volume of air in the lungs that can be exhaled following a deep inhalation. Historically, research has focused on the lower threshold of a FVC% for curative lung resection, but the upper threshold of a FVC% of 60% has not received much attention (20). Under the conventional practice specification at our hospital, only patients with a FVC% >60% can undergo a lobectomy. The average value of FVC% in this group was 91.3%±15.7% (see Table S1). However, while the FVC% was screened before surgery, patients with a marginal and moderate FVC% (≤92.0%) had an increased incidence of postoperative pneumonia. The main cause of postoperative pneumonia is the decrease of cough ability and sputum excretion ability caused by surgical trauma and postoperative decline of pulmonary function (18). After lobectomy, a fall in the FEV1% from 12% to 23%, and a fall in the FVC% from 10% to 30% has been reported (21). The lower the preoperative lung function, the more significant the decline in postoperative lung function (21). For patients with an impaired preoperative FVC%, combinations of bronchodilators, physical therapy, smoking cessation, and corticosteroids might be needed to reduce the risk of postoperative respiratory complications (22).

PEF refers to a person's maximum speed of expiration.

Table 3 Effects of the FEV1% on postoperative outcomes

Postoperative outcome	FEV1%				Total P value
	Quartile 1 (n=138), ≤78.4%	Quartile 2 (n=148), >78.4–92.0%	Quartile 3 (n=130), >92.0–103.0%	Quartile 4 (n=132), >103.0%	
Postoperative pulmonary complications, n (%)					
Acute respiratory distress syndrome	0 (0.0)	2 (1.4)	1 (0.8)	1 (0.8)	0.981
Reintubation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Pulmonary embolism	0 (0.0)	2 (1.4)	1 (0.8)	0 (0.0)	0.971
Need for bedside bronchoscopy	0 (0.0)	2 (1.4)	2 (1.5)	0 (0.0)	0.941
Prolonged air leak	0 (0.0)	6 (4.1)	2 (1.5)	2 (1.5)	0.222
Failure to expand	4 (2.9)	4 (2.7)	4 (3.1)	1 (0.8)	0.555
Atelectasis	2 (1.4)	3 (2.0)	3 (2.3)	5 (3.8)	0.363
Pneumonia	56 (40.6)	64 (43.2)	43 (33.1)	43 (32.6)	0.349
OR (95% CI)	1.309 (0.755–2.269)	1.465 (0.876–2.448)	0.979 (0.564–1.700)	1	
P value	0.338	0.146	0.940	–	
Acute kidney injury, n (%)	2 (1.4)	6 (4.1)	0 (0.0)	4 (3.0)	0.964
In-hospital mortality, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–
Readmission within 30 days, n (%)	0 (0.0)	1 (0.7)	2 (1.5)	3 (2.3)	0.812

The results of the binary logistics regression are presented as adjusted the OR, 95% CI, and P value. The best-performing quartile 4 served as the reference group. CI, confidence interval; FEV1%, forced expiratory volume in 1 s as percentage of predicted; OR, odds ratio.

Table 4 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on PEF%

Variable	PEF%					P value
	Total (n=548)	Quartile 1 (n=139), ≤49.0%	Quartile 2 (n=135), >49.0–65.6%	Quartile 3 (n=146), >65.6–84.0%	Quartile 4 (n=128), >84.0%	
Number of deaths, n (%)	9 (1.7)	2 (1.5)	1 (0.7)	1 (0.7)	5 (3.9)	0.181
Cause of death, n (%)						0.205
Postoperative complication	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Cancer related	5 (55.6)	1 (50.0)	0 (0.0)	0 (0.0)	4 (80.0)	
Non-cancer related	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Uncertain	4 (44.4)	1 (50.0)	1 (100.0)	1 (100.0)	1 (20.0)	

Values are presented as n (%). PEF%, peak expiratory flow as a percentage of predicted.

It measures the airflow through the bronchi and thus the degree of obstruction in the airways. In clinical practice, PEF is rarely used to assess the risk of complications associated with lung resection. In recent years, several studies have found that PEF is closely related to cardiovascular events and lung cancer mortality, and is an important indicator of physical functioning and health status in the elderly population (8,23-26). PEF reflects airway patency and resistance, and respiratory muscle strength and thus reflects a patient's cough and expectoration ability, which is especially important for patients undergoing lung resection (8). In our study, we observed that a preoperative
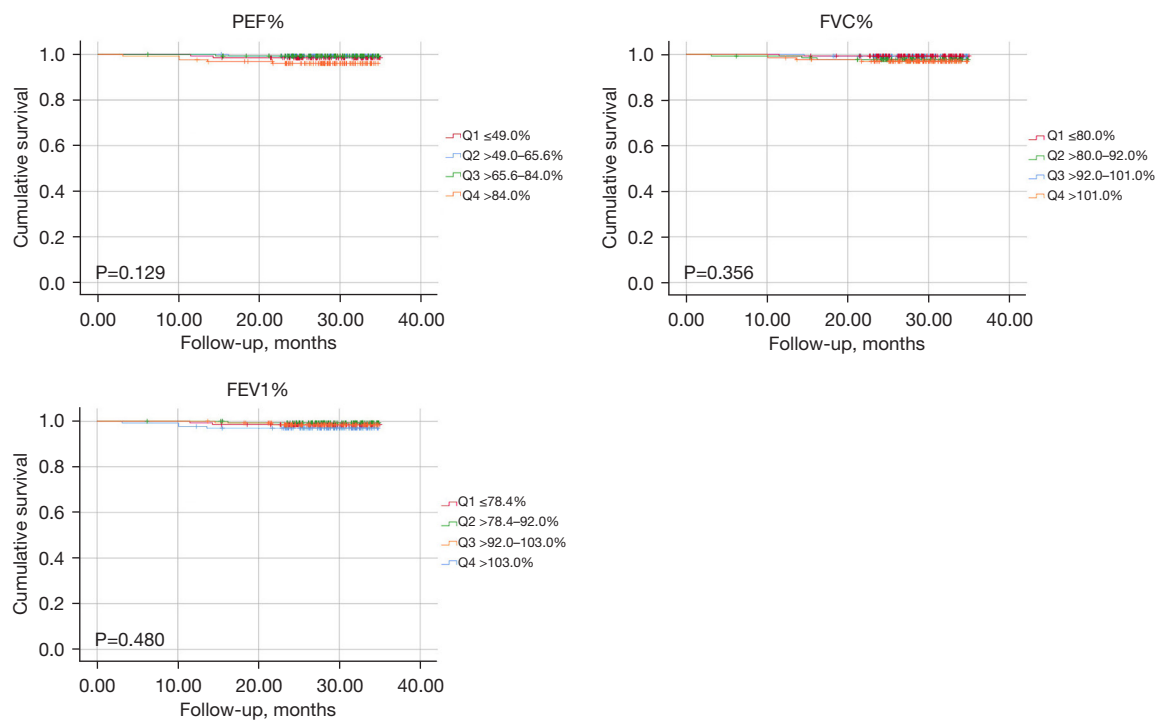
Figure 2 Overall survival curves in 548 patients among the 4 different groups according to the predicted pulmonary function values of PEF%, FVC%, and FEV1%. FEV1%, forced expiratory volume in 1 s as a percentage of predicted; FVC%, forced vital capacity as a percentage of predicted; PEF%, peak expiratory flow as a percentage of predicted; Q1–Q4, quartiles 1 to 4.

PEF% that was too low (≤49.0%) or too high (>84.0%) led to an increased incidence of postoperative pneumonia in NSCLC patients undergoing VATS lobectomy (see *Table 1*). A PEF% that was too low caused an increase in the incidence of postoperative pneumonia due to the poor cough and expectoration ability of the patients. However, the reasons for the increase in the incidence of postoperative pneumonia in patients with a PEF% that was too high are difficult to reasonably explain, and currently, no other studies appear to have examined this issue. Thus, further research is required. There is good evidence that PEF, which can be measured rapidly and easily with an inexpensive and hand-held device, is both reliable and reproducible (27). Further, PEF is more reproducible than FEV1 (27). Thus, the PEF% should be considered as a primary pulmonary function parameter for the preoperative assessment of NSCLC patients awaiting surgery.

In relation to the other PPCs (including acute respiratory distress syndrome, reintubation, pulmonary embolism, the need for bedside bronchoscopy, prolonged air leak, failure to expand, and atelectasis), we did not find any associations among the various parameters of pulmonary function examined. In addition, other short-term outcomes (including AKI, in-hospital mortality, and readmission within 30 days) were also not associated with the pulmonary function parameters. The OS analysis (for which there was a median follow-up period of 28.7 months) showed no correlation between the pulmonary function parameters and OS in this cohort of NSCLC patients. Similarly, Almquist *et al.* noted that after a median follow-up period of 53.2 months, preoperative pulmonary function did not predict survival in resected early-stage NSCLC patients (4).

Limitations

The present study had several limitations. First, as a single-centre retrospective study (the study population predominantly comprised patients who were deemed good surgical candidates), it carries the inherent possibility of selection bias. Second, due to its retrospective nature, any diagnosis of postoperative pneumonia lacked pathogenic evidence. However, our diagnostic criteria for postoperative pneumonia (a new pulmonary infiltrate on a chest X-ray

with leucocytosis and fever) are objective and reproducible. Third, because the proportion of IA-stage NSCLC patients in this cohort was as high as 81.6%, the median follow-up period of 28.7 months was slightly insufficient, and the evaluation of OS was slightly inefficient. Fourth, our study did not include the diffusion capacity of carbon monoxide (DLCO) of pulmonary function in the analysis. As the preoperative DLCO assessment at our centre is not mandatory and is usually replaced by arterial oxygen pressure, DLCO data were only available for 145 of 548 patients in this cohort. However, despite these limitations, a relatively homogeneous population, treated uniformly at a single centre, was analysed. Thus, we believe that our data are valid.

Conclusions

In summary, the preoperative PEF% and FVC% are associated with postoperative pneumonia in NSCLC patients undergoing VATS lobectomy, but this association does not necessarily lead to differences in OS. We found that a preoperative PEF% that was too low (≤49.0%) or too high (>84.0%) led to an increased incidence of postoperative pneumonia; however, only a preoperative FVC% that was too low (≤92.0%) led to an increased incidence of postoperative pneumonia. An increase in the application of the PEF% in preoperative assessment in NSCLC patients awaiting surgery might prevent postoperative pneumonia.

Acknowledgments

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/atm-21-5244

Data Sharing Statement: Available at https://dx.doi.org/10.21037/atm-21-5244

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dx.doi.org/10.21037/atm-21-5244). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Medical Ethics Committee of the First Affiliated Hospital, Zhejiang University School of Medicine (No. 2017–58). As the data were recorded retrospectively and without any specific intervention, the Medical Ethics Committee waived informed consent. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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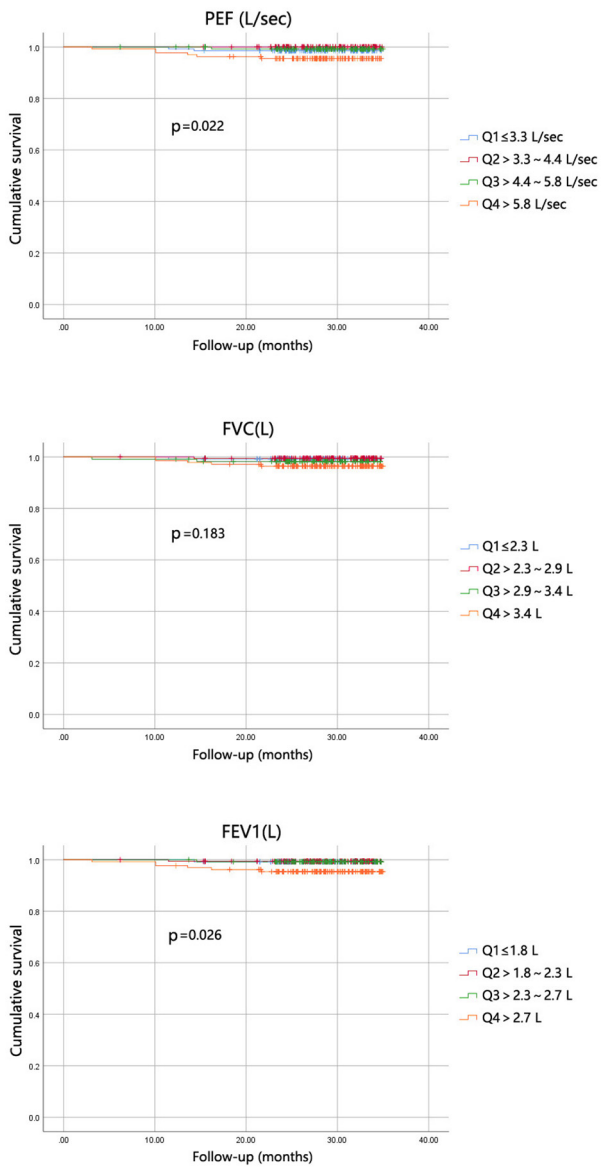
Figure S1 Overall survival curves in 548 patients among the 4 different groups according to the absolute pulmonary function values of PEF (L/s), FVC (L), and FEV1 (L). FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; PEF, peak expiratory flow; Q1–Q4, quartiles 1 to 4.

Table S1 Clinical characteristics of patients based on PEF%

Characteristic	Total (n=548)	PEF%				P value
		Quartile 1 (n=139), ≤49.0%	Quartile 2 (n=135), >49.0–65.6%	Quartile 3 (n=146), >65.6–84.0%	Quartile 4 (n=128), >84.0%	
ASA score						0.084
I	459 (83.8%)	110 (79.1%)	118 (87.4%)	126 (86.3%)	105 (82.0%)	
II	66 (12.0%)	18 (12.9%)	11 (8.1%)	17(11.6%)	20 (15.6%)	
III	23 (4.2%)	11 (7.9%)	6 (4.4%)	3 (2.1%)	3 (2.3%)	
Age	63.0±10.6	65.0±9.7	63.5±10.4	63.5±10.3	59.6±11.4	0.000
Gender (female/male)	331/217	71/68	85/50	92/54	83/45	0.075
Weight, kg	61.4±9.8	62.8±10.4	61.4±9.8	61.5±9.6	59.7±9.1	0.081
BMI, kg/m^2	23.2±2.8	23.5±2.7	23.3±3.2	23.2±2.9	22.6±2.5	0.043
Smoking	146 (26.6%)	56 (40.3%)	30 (22.2%)	33 (22.6%)	27 (21.1%)	0.000
Diabetes mellitus	48 (8.8%)	17 (12.2%)	7 (5.2%)	12 (8.2%)	12 (9.4%)	0.224
Coronary heart disease	9 (1.6%)	4 (2.9%)	2 (1.5%)	2 (1.4%)	1 (0.8%)	0.594
FEV1, L	2.3±0.6	2.0±0.5	2.2±0.6	2.4±0.6	2.6±0.6	0.000
FVC, L	2.9±0.7	2.7±0.7	2.8±0.7	3.0±0.8	3.2±0.7	0.000
PEF, L/s	4.7 ±1.9	2.7 ±0.7	3.9 ±0.8	5.2 ±1.1	7.0 ±1.5	0.000
FEV1%	(91.1±17.2)%	(76.5±12.8)%	(87.4±14.7)%	(97.3±15.7)%	(103.6±11.9)%	0.000
FVC%	(91.3±15.7)%	(83.1±13.2)%	(87.5±15.0)%	(94.8±15.6)%	(100.1±13.2)%	0.000
PEF%	(67.6±24.0)%	(39.8±6.4)%	(57.2±4.9)%	(74.5±5.4)%	(101.1±15.0)%	0.000
Intraoperative bleeding, mL	47.2±32.0	53.6±43.3	42.7±25.8	50.0±32.2	41.7±19.4	0.097
Intraoperative blood transfusion, mL	0	0	0	0	0	–
Length of operation, min	132.6±35.6	131.3±38.6	130.5±33.2	135.8±36.4	132.5±33.9	0.618
NSCLC staging						0.042
IA	447 (81.6%)	115 (82.7%)	103 (76.3%)	120 (82.2%)	109 (85.2%)	
IB	37 (6.8%)	6 (4.3%)	13 (9.6%)	12 (8.2%)	6 (4.7%)	
IIA	29 (5.3%)	10 (7.2%)	7 (5.2%)	10 (6.8%)	2 (1.6%)	
IIB	2 (0.4%)	0 (0.0%)	2 (1.5%)	0 (0.0%)	0 (0.0%)	
IIIA	33 (6.0%)	8(5.8%)	10 (7.4%)	4 (2.7%)	11 (8.6%)	
Postoperative pathology						0.009
Adenocarcinoma	504 (92.0%)	122 (87.8%)	128 (94.8%)	132 (90.4%)	122 (95.3%)	
Squamous cell carcinoma	37 (6.8%)	17 (12.2%)	4 (3.0%)	12 (8.2%)	4 (3.1%)	
Adenosquamous carcinoma	7 (1.3%)	0 (0.0%)	3 (2.2%)	2 (1.4%)	2 (1.6%)	
Postoperative length of stay, days	5.8±2.1	5.7±1.7	5.5±1.7	6.3±2.8	5.8±1.9	0.093
Total hospital care costs (Renminbi)	58351.3±9687.7	60533.3±10223.6	57968.9±8391.9	58067.5±11048.8	56708.7±8294.2	0.006

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S2 Univariate results of postoperative outcomes based on PEF%

Postoperative outcome	PEF%					
	Total (n=548)	Quartile 1 (n=139), ≤49.0%	Quartile 2 (n=135), >49.0–65.6%	Quartile 3 (n=146), >65.6–84.0%	Quartile 4 (n=128), >84.0%	P value
Postoperative pulmonary complications						
Acute respiratory distress syndrome	4 (0.7%)	1 (0.7%)	0 (0.0%)	2 (1.4%)	1 (0.8%)	0.451
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Pulmonary embolism	3 (0.5%)	1 (0.7%)	0 (0.0%)	2 (1.4%)	0 (0.0%)	0.237
Need for bedside bronchoscopy	4 (0.7%)	0 (0.0%)	2 (1.5%)	1 (0.7%)	1 (0.8%)	0.414
Prolonged air leak	10 (1.8%)	1 (0.7%)	3 (2.2%)	4 (2.7%)	2 (1.6%)	0.576
Failure to expand	13 (2.4%)	5 (3.6%)	5 (3.7%)	1 (0.7%)	2 (1.6%)	0.207
Atelectasis	13 (2.4%)	0 (0.0%)	6 (4.4%)	4 (2.7%)	3 (2.3%)	0.033
Pneumonia	206 (37.6%)	64 (46.0%)	41 (30.4%)	49 (33.6%)	52 (40.6%)	0.033
Acute kidney injury	12 (2.2%)	2 (1.4%)	4 (3.0%)	0 (0.0%)	6 (4.7%)	0.018
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Readmission within 30 days	6 (1.1%)	2 (1.4%)	0 (0.0%)	3 (2.1%)	1 (0.8%)	0.238

Values are presented as n (%).

Table S3 Assignment of variables in multivariate analysis

Variables	Assignment instruction
ASA score	ASA I =1, ASA II =2, ASA III =3
Age	<60 =1, 60– =2
Gender	Male =1, Female =2
BMI, kg/m^2	<24.0 kg/m^2=1, ≥24.0 kg/m^2=2
Smoking	No=0, Yes=1
Diabetes mellitus	No=0, Yes=1
Coronary heart disease	No=0, Yes=1
Intraoperative bleeding, mL	<50 mL =1, 50 mL–=2
Length of operation, h	<2 h=1, 2 h–=2
NSCLC staging	IA =1, IB =2, IIA =3, IIB =4, IIIA =5
Postoperative pathology	Adenocarcinoma =1; Squamous cell carcinoma =2; Adenosquamous carcinoma =3
PEF%	≤49.0%=1, >49.0–65.6%=2, >65.6–84.0%=3, >84.0%=4
FVC%	≤80.0%=1, >80.0–92.0%=2, >92.0–101.0%=3, >101.0%=4
FEV1%	≤78.4%=1, >78.4–92.0%=2, >92.0–103.0%=3, >103.0%=4
PEF, L/s	≤3.3 L/s =1, >3.3–4.4 L/s =2, >4.4–5.8 L/s =3, >5.8 L/s =4
FVC, L	≤2.3 L =1, >2.3–2.9 L =2, >2.9–3.4 L =3, >3.4 L =4
FEV1, L	≤1.8 L =1, >1.8–2.3 L =2, >2.3–2.7 L =3, >2.7 L =4

ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S4 Clinical characteristics of patients based on FVC%

Characteristic	FVC %				
	Quartile 1 (n=145), ≤80.0%	Quartile 2 (n=136), >80.0–92.0%	Quartile 3 (n=133), >92.0–101.0%	Quartile 4 (n=134), >101.0%	P value
ASA score					0.343
I	115 (79.3%)	113 (83.1%)	113 (85.0%)	118 (88.1%)	
II	20 (13.8%)	18 (13.2%)	17 (12.8%)	11 (8.2%)	
III	10 (6.9%)	5 (3.7%)	3 (2.3%)	5 (3.7%)	
Age	66.7±9.5	63.2±10.8	61.2±10.5	60.4±10.5	0.000
Gender (female/male)	81/64	96/40	74/59	80/54	0.038
Weight, kg	64.6±9.7	60.7±10.3	61.0±8.8	58.9±9.5	0.000
BMI, kg/m^2	24.2±2.9	23.1±2.9	22.9±2.4	22.4±2.8	0.000
Smoking	45 (31.0%)	28 (20.6%)	36 (27.1%)	37 (27.6%)	0.255
Diabetes mellitus	17 (11.7%)	10 (7.4%)	11 (8.3%)	10 (7.5%)	0.522
Coronary heart disease	6 (4.1%)	0 (0.0%)	1 (0.8%)	2 (1.5%)	0.026
FEV1, L	1.9±0.4	2.2±0.5	2.5±0.5	2.8±0.5	0.000
FVC, L	2.3±0.5	2.7±0.6	3.2±0.6	3.5±0.7	0.000
PEF, L/s	3.9±1.5	4.1±1.6	5.0±1.8	5.8±1.9	0.000
FEV1%	(73.8±10.9) %	(86.7±10.2) %	(95.9±10.6) %	(109.3±13.1) %	0.000
FVC%	(72.0±6.4) %	(86.7±3.2) %	(96.5±2.7) %	(111.6±9.0) %	0.000
PEF%	(55.9±20.0) %	(62.1±20.9) %	(71.4±24.0) %	(82.2±22.5) %	0.000
Intraoperative bleeding, mL	53.8±45.1	45.7±23.8	48.0±25.6	40.8±26.1	0.021
Intraoperative blood transfusion, mL	0	0	0	0	–
Length of operation, min	136.0±42.8	135.0±34.8	127.6±30.0	131.4±32.6	0.259
NSCLC staging					0.003
IA	124 (85.5%)	105 (77.2%)	111 (83.5%)	107 (79.9%)	
IB	15 (10.3%)	12 (8.8%)	6 (4.5%)	4 (3.0%)	
IIA	4 (2.8%)	7 (5.1%)	7 (5.3%)	11 (8.2%)	
IIB	1 (0.7%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	
IIIA	1 (0.7%)	12 (8.8%)	8 (6.0%)	12 (9.0%)	
Postoperative pathology					0.577
Adenocarcinoma, n	130 (89.7%)	125 (91.9%)	122 (91.7%)	127 (94.8%)	
Squamous cell carcinoma, n	14 (9.7%)	8 (5.9%)	9 (6.8%)	6 (4.5%)	
Adenosquamous carcinoma, n	1 (0.7%)	3 (2.2%)	2 (1.5%)	1 (0.7%)	
Postoperative length of stay, days	5.9±2.4	5.7±1.9	5.8±2.2	5.9±2.0	0.735
Total hospital care costs (Renminbi)	59940.6±10768.4	58222.5±9788.9	58621.0±9679.4	56494.4±7992.4	0.120

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S5 Univariate results of postoperative outcomes based on FVC%

Postoperative outcome	FVC %				
	Quartile 1 (n=145), ≤80.0%	Quartile 2 (n=136), >80.0–92.0%	Quartile 3 (n=133), >92.0–101.0%	Quartile 4 (n=134), >101.0%	P value
Postoperative pulmonary complications					
Acute respiratory distress syndrome	2 (1.4%)	0 (0.0%)	1 (0.8%)	1 (0.7%)	0.447
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Pulmonary embolism	2 (1.4%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	0.226
Need for bedside bronchoscopy	0 (0.0%)	2 (1.5%)	2 (1.5%)	0 (0.0%)	0.126
Prolonged air leak	2 (1.4%)	1 (0.7%)	3(2.3%)	4 (3.0%)	0.510
Failure to expand	2 (1.4%)	6(4.4%)	0 (0.0%)	5 (3.7%)	0.019
Atelectasis	4 (2.8%)	4 (2.9%)	2 (1.5%)	3 (2.2%)	0.856
Pneumonia	64 (44.1%)	62 (45.6%)	36 (27.1%)	44 (32.8%)	0.003
Acute kidney injury	4 (2.8%)	3 (2.2%)	0 (0.0%)	5 (3.7%)	0.062
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Readmission within 30 days	1 (0.7%)	0 (0.0%)	2 (1.5%)	3 (2.2%)	0.197

Values are presented as n (%).

	FVC %				
	Quartile 1 (n=145), ≤80.0%	Quartile 2 (n=136), >80.0–92.0%	Quartile 3 (n=133), >92.0–101.0%	Quartile 4 (n=134), >101.0%	P value

Table S6 Clinical characteristics of patients based on FEV1%

Characteristic	FEV1%				P value
	Quartile 1 (n=138), ≤78.4%	Quartile 2 (n=148), >78.4–92.0%	Quartile 3 (n=130), >92.0–103.0%	Quartile 4 (n=132), >103.0%	
ASA score					0.228
I	111(80.4%)	125 (84.5%)	107(82.3%)	116 (87.9%)	
II	16 (11.6%)	19 (12.8%)	18 (13.8%)	13 (9.8%)	
III	11 (8.0%)	4 (2.7%)	5 (3.8%)	3 (2.3%)	
Age	66.0±9.3	63.1±10.9	61.3±11.4	61.3±10.0	0.000
Gender (female/male)	81/57	92/56	71/59	87/45	0.278
Weight, kg	63.6±11.1	61.7±8.8	61.1±10.2	59.0±8.5	0.004
BMI, kg/m^2	23.8±3.1	23.1±2.8	22.9±2.7	22.7±2.6	0.006
Smoking	49 (35.5%)	39 (26.4%)	34 (26.2%)	24 (18.2%)	0.015
Diabetes mellitus	16 (11.6%)	10 (6.8%)	11 (8.5%)	11 (8.3%)	0.537
Coronary heart disease	6 (4.3%)	0(0.0%)	3(2.3%)	0(0.0%)	0.003
FEV1, L	1.8±0.4	2.2±0.4	2.6±0.5	2.8±0.5	0.000
FVC, L	2.5±0.6	2.8±0.7	3.2±0.7	3.3±0.7	0.000
PEF, L/s	3.3±1.3	4.2±1.6	5.4±1.7	5.9±1.8	0.000
FEV1%	(69.0±7.4) %	(86.1±4.1) %	(97.7±3.2) %	(113.1±9.0) %	0.000
FVC%	(76.0±11.9) %	(86.7±9.4) %	(96.3±9.7) %	(107.5±11.4) %	0.000
PEF%	(47.9±14.9) %	(62.2±19.8) %	(76.6±20.6) %	(85.4±21.4) %	0.000
Intraoperative bleeding, mL	51.0±42.8	49.3±32.5	45.4±21.5	42.7±25.7	0.475
Intraoperative blood transfusion, mL	0	0	0	0	-
Length of operation, min	133.4±40.7	133.2±35.2	134.9±33.3	128.9±32.5	0.613
NSCLC staging					0.030
IA	107(77.5%)	127 (85.8%)	105(80.8%)	108 (81.8%)	
IB	18 (13.0%)	8 (5.4%)	8 (6.2%)	3 (2.3%)	
IIA	6 (4.3%)	4 (2.7%)	11 (8.5%)	8 (6.1%)	
IIB	0 (0.0%)	1 (0.7%)	0 (0.0%)	1 (0.8%)	
IIIA	7 (5.1%)	8 (5.4%)	6 (4.6%)	12 (9.1%)	
Postoperative pathology					0.034
Adenocarcinoma, n	121 (87.7%)	138 (93.2%)	117 (90.0%)	128 (97.0%)	
Squamous cell carcinoma, n	16 (11.6%)	9 (6.1%)	9 (6.9%)	3 (2.3%)	
Adenosquamous carcinoma, n	1 (0.7%)	1 (0.7%)	4 (3.1%)	1 (0.8%)	
Postoperative length of stay, days	5.6±1.6	6.0±2.6	5.9±2.2	5.9±2.0	0.394
Total hospital care costs (Renminbi)	59089.3±9764.3	59150.7±10326.5	59378.5±9167.6	55671.8±8954.3	0.004

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S7 Univariate results of postoperative outcomes based on FEV1%

Postoperative outcome	FEV1%				P value
	Quartile 1 (n=138), ≤78.4%	Quartile 2 (n=148), >78.4–92.0%	Quartile 3 (n=130), >92.0–103.0%	Quartile 4 (n=132), >103.0%	
Postoperative pulmonary complications					
Acute respiratory distress syndrome	0 (0.0%)	2 (1.4%)	1 (0.8%)	1 (0.8%)	0.448
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	0 (0.0%)	2 (1.4%)	1 (0.8%)	0 (0.0%)	0.230
Need for bedside bronchoscopy	0 (0.0%)	2 (1.4%)	2 (1.5%)	0 (0.0%)	0.140
Prolonged air leak	0 (0.0%)	6 (4.1%)	2 (1.5%)	2 (1.5%)	0.041
Failure to expand	4 (2.9%)	4 (2.7%)	4 (3.1%)	1 (0.8%)	0.477
Atelectasis	2 (1.4%)	3 (2.0%)	3 (2.3%)	5 (3.8%)	0.650
Pneumonia	56 (40.6%)	64 (43.2%)	43 (33.1%)	43 (32.6%)	0.166
Acute kidney injury	2 (1.4%)	6 (4.1%)	0 (0.0%)	4 (3.0%)	0.037
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	0 (0.0%)	1 (0.7%)	2 (1.5%)	3 (2.3%)	0.186

Values are presented as n (%).

Table S8 Full-model multivariate results of 4 groups of different PEF%

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.022
I	1.000		
II	3.124	1.325–7.366	0.009
III	2.813	0.730–10.847	0.133
Age			
<60	1.000		
60–	1.527	1.012–2.303	0.044
Gender			
Male	1.000		
Female	1.322	0.750–2.332	0.335
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.642	1.103–2.444	0.015
Smoking			
No	1.000		
Yes	0.912	0.471–1.765	0.784
Diabetes mellitus			
No	1.000		
Yes	0.101	0.035–0.292	0.000
Coronary heart disease			
No	1.000		
Yes	0.468	0.069–3.188	0.438
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.967	0.647–1.446	0.870
Length of operation			
<2 h	1.000		
2 h–	1.547	1.030–2.326	0.036
NSCLC staging			0.479
IA	1.000		
IB	0.989	0.461–2.124	0.978
IIA	2.077	0.895–4.821	0.089
IIB	3.117	0.179–54.389	0.436
IIIA	1.014	0.460–2.239	0.972
Postoperative pathology			0.223
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.052	0.910–4.627	0.083
Adenosquamous carcinoma	0.000	0.000	0.999
PEF%			0.013
≤49.0%	2.076	1.211–3.558	0.008
>49.0–65.6%	1.000		
>65.6–84.0%	1.157	0.677–1.978	0.595
>84.0%	1.962	1.129–3.411	0.017

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; NSCLC, non-small cell lung cancer; OR, odds ratio; PEF%, peak expiratory flow as a percentage of predicted.

Table S9 Full-model multivariate results of 4 groups of different FVC%

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.021
I	1.000		
II	3.188	1.339–7.587	0.009
III	2.821	0.740–10.757	0.129
Age			
<60	1.000		
60–	1.297	0.862–1.952	0.213
Gender			
Male	1.000		
Female	1.209	0.686–2.131	0.512
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.461	0.977–2.185	0.065
Smoking			
No	1.000		
Yes	0.937	0.487–1.801	0.844
Diabetes mellitus			
No	1.000		
Yes	0.108	0.037–0.315	0.000
Coronary heart disease			
No	1.000		
Yes	0.470	0.069–3.187	0.439
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.982	0.654–1.474	0.930
Length of operation			
<2 h	1.000		
2 h–	1.514	1.009–2.270	0.045
NSCLC staging			0.385
IA	1.000		
IB	0.782	0.363–1.686	0.530
IIA	2.237	0.946–5.289	0.067
IIB	2.043	0.116–35.835	0.625
IIIA	1.145	0.514–2.550	0.741
Postoperative pathology			0.157
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.208	0.985–4.949	0.054
Adenosquamous carcinoma	0.000	0.000	0.999
FVC %			0.012
≤80.0%	2.125	1.226–3.683	0.007
>80.0–92.0%	2.230	1.298–3.832	0.004
>92.0–101.0%	1.000		
>101.0%	1.399	0.802–2.440	0.237

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FVC%, forced vital capacity as percentage of predicted; NSCLC, non-small cell lung cancer; OR, odds ratio.

Table S10 Full-model multivariate results of 4 groups of different FEV1%

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.022
I	1.000		
II	3.121	1.325–7.354	0.009
III	2.813	0.745–10.623	0.127
Age			
<60	1.000		
60–	1.344	0.898–2.012	0.151
Gender			
Male	1.000		
Female	1.266	0.716–2.239	0.417
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.532	1.029–2.282	0.036
Smoking			
No	1.000		
Yes	0.932	0.482–1.801	0.834
Diabetes mellitus			
No	1.000		
Yes	0.114	0.040–0.330	0.000
Coronary heart disease			
No	1.000		
Yes	0.500	0.074–3.363	0.476
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.983	0.659–1.466	0.934
Length of operation			
<2 h	1.000		
2 h–	1.522	1.016–2.279	0.042
NSCLC staging			0.457
IA	1.000		
IB	0.826	0.382–1.786	0.627
IIA	2.145	0.920–5.001	0.077
IIB	1.833	0.107–31.433	0.676
IIIA	1.120	0.513–2.441	0.776
Postoperative pathology			0.151
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.214	0.994–4.933	0.052
Adenosquamous carcinoma	0.000	0.000	0.999
FEV1%			0.349
≤78.4%	1.309	0.755–2.269	0.338
>78.4–92.0%	1.465	0.876–2.448	0.146
>92.0–103.0%	0.979	0.564–1.700	0.940
>103.0%	1.000		

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FEV1%, forced expiratory volume in 1 s as percentage of predicted; NSCLC, non-small cell lung cancer; OR, odds ratio.

Table S11 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on FVC%

Variables	FVC %				P value
	Quartile 1 (n=145), ≤80.0%	Quartile 2 (n=136), >80.0–92.0%	Quartile 3 (n=133), >92.0–101.0%	Quartile 4 (n=134), >101.0%	
Number of deaths	1 (0.7%)	3 (2.2%)	1 (0.8%)	4 (3.0%)	0.351
Cause of death					0.256
Postoperative complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Cancer related	0 (0.0%)	2 (66.7%)	0 (0.0%)	3 (75.0%)	
Non-cancer related	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Uncertain	1 (100.0%)	1 (33.3%)	1 (100.0%)	1 (25.0%)	

Values are presented as n (%). FVC%, forced vital capacity as percentage of predicted.

Table S12 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on FEV1%

Variables	FEV1%				P value
	Quartile 1 (n=138), ≤78.4%	Quartile 2 (n=148), >78.4–92.0%	Quartile 3 (n=130), >92.0–103.0%	Quartile 4 (n=132), >103.0%	
Number of deaths	2 (1.5%)	1 (0.7%)	2 (1.5%)	4 (3.0%)	0.498
Cause of death					0.022
Postoperative complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Cancer related	1 (50.0%)	0 (0.0%)	0 (0.0%)	4 (100.0%)	
Non-cancer related	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Uncertain	1 (50.0%)	1 (100.0%)	2(100.0%)	0 (0.0%)	

Values are presented as n (%). FEV1%, forced expiratory volume in 1 s as percentage of predicted.

Table S13 Multivariate Cox regression results for overall survival based on PEF%

Variables	HR	95% CI	P value
ASA score			0.999
I	1.000		
II	0.000	0.000	0.963
III	0.000	0.000	0.972
Age			
<60	1.000		
60–	0.772	0.184–3.241	0.724
Gender			
Male	1.000		
Female	0.648	0.062–6.740	0.717
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.695	0.131–3.695	0.669
Smoking			
No	1.000		
Yes	5.083	0.616–41.916	0.131
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.959
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.996
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	6.692	0.632–70.866	0.114
Length of operation			
<2 h	1.000		
2 h–	1.620	0.300–8.755	0.575
NSCLC staging			0.121
IA	1.000		
IB	0.000	0.000	0.969
IIA	0.000	0.000	0.971
IIB	0.000	0.000	0.998
IIIA	13.667	2.047–91.264	0.007
Postoperative pathology			0.999
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.960
Adenosquamous carcinoma	0.000	0.000	0.985
PEF%			0.533
≤49.0%	0.737	0.107–5.076	0.757
>49.0–65.6%	0.279	0.029–2.678	0.269
>65.6–84.0%	0.263	0.028–2.510	0.246
>84.0%	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; HR, hazard ratio; NSCLC, non-small cell lung cancer; PEF%, peak expiratory flow as a percentage of predicted.

Table S14 Multivariate Cox regression results for overall survival based on FVC%

Variables	HR	95% CI	P value
ASA score			0.998
I	1.000		
II	0.000	0.000	0.956
III	0.000	0.000	0.974
Age			
<60	1.000		
60–	0.859	0.199–3.709	0.839
Gender			
Male	1.000		
Female	0.425	0.045–4.036	0.456
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.518	0.093–2.893	0.454
Smoking			
No	1.000		
Yes	4.045	0.577–28.338	0.159
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.951
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.995
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	11.069	0.995–123.208	0.051
Length of operation			
<2 h	1.000		
2 h–	1.272	0.226–7.149	0.785
NSCLC staging			0.137
IA	1.000		
IB	0.000	0.000	0.983
IIA	0.000	0.000	0.978
IIB	0.000	0.000	0.998
IIIA	14.556	1.997–106.085	0.008
Postoperative pathology			0.998
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.956
Adenosquamous carcinoma	0.000	0.000	0.988
FVC %			0.559
≤80.0%	0.400	0.036–4.445	0.455
>80.0–92.0%	1.268	0.247–6.520	0.776
>92.0–101.0%	0.271	0.026–2.870	0.278
>101.0%	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FVC%, forced vital capacity as percentage of predicted; HR, hazard ratio; NSCLC, non-small cell lung cancer.

Table S15 Multivariate Cox regression results for overall survival based on FEV1%

Variables	HR	95% CI	P value
ASA score			0.999
I	1.000		
II	0.000	0.000	0.971
III	0.000	0.000	0.977
Age			
<60	1.000		
60–	0.756	0.181–3.152	0.701
Gender			
Male	1.000		
Female	0.496	0.049–4.991	0.552
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.623	0.120–3.227	0.573
Smoking			
No	1.000		
Yes	3.867	0.509–29.355	0.191
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.968
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.998
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	9.052	0.823–99.550	0.072
Length of operation			
<2 h	1.000		
2 h–	1.618	0.298–8.768	0.577
NSCLC staging			0.090
IA	1.000		
IB	0.000	0.000	0.981
IIA	0.000	0.000	0.981
IIB	0.000	0.000	0.997
IIIA	15.354	2.321–101.557	0.005
Postoperative pathology			0.998
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.950
Adenosquamous carcinoma	0.000	0.000	0.987
FEV1%			0.762
≤78.4%	0.860	0.125–5.917	0.878
>78.4–92.0%	0.318	0.033–3.091	0.324
>92.0–103.0%	0.555	0.091–3.404	0.525
>103.0%	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FEV1%, forced expiratory volume in 1 s as percentage of predicted; HR, hazard ratio; NSCLC, non-small cell lung cancer.

Table S16 Clinical characteristics of patients based on PEF

Characteristic	PEF				P value
	Quartile 1 (n=142), ≤3.3 L/s	Quartile 2 (n=136), >3.3–4.4 L/s	Quartile 3 (n=136), >4.4–5.8 L/s	Quartile 4 (n=134), >5.8 L/s	
ASA score					0.035
I	114 (80.3%)	113 (83.1%)	123 (90.4%)	109 (81.3%)	
II	16 (11.3%)	18 (13.2%)	11 (8.1%)	21 (15.7%)	
III	12 (8.5%)	5 (3.7%)	2 (1.5%)	4 (3.0%)	
Age	64.8±9.7	64.6±10.5	62.0±11.1	60.4±10.6	0.001
Gender (female/male)	103/39	86/50	98/38	44/90	0.000
Weight, kg	59.6±8.5	62.2±10.8	59.4±9.4	64.4±9.5	0.000
BMI, kg/m^2	23.3±2.6	23.3±3.3	22.7±2.9	23.3±2.6	0.125
Smoking	33 (23.2%)	36 (26.5%)	26 (19.1%)	51 (38.1%)	0.003
Diabetes mellitus	15 (10.6%)	12 (8.8%)	6(4.4%)	15 (11.2%)	0.188
Coronary heart disease	4 (2.8%)	2 (1.5%)	1 (0.7%)	2 (1.5%)	0.590
FEV1, L	1.8±0.4	2.2±0.5	2.4±0.4	2.9±0.5	0.000
FVC, L	2.5±0.6	2.8±0.7	2.9±0.5	3.5±0.7	0.000
PEF, L/s	2.6 ±0.4	3.9 ±0.3	5.0 ±0.4	7.3±1.2	0.000
FEV1%	(78.5±13.6) %	(87.3±15.3) %	(97.7±17.1) %	(101.5±12.4) %	0.000
FVC%	(84.1±14.2) %	(87.1±15.4) %	(95.6±15.1) %	(98.7±13.4) %	0.000
PEF%	(42.2±9.0) %	(58.5±10.4) %	(76.4±13.1) %	(94.9±19.7) %	0.000
Intraoperative bleeding, mL	49.4±41.4	51.4±34.6	45.3±27.5	42.6±19.1	0.682
Intraoperative blood transfusion, mL	0	0	0	0	-
Length of operation, min	124.8±37.0	141.0±32.6	131.0±35.9	133.8±35.2	0.002
NSCLC staging					0.002
IA	122 (85.9%)	99 (72.8%)	110 (80.9%)	116 (86.6%)	
IB	4 (2.8%)	14 (10.3%)	12 (8.2%)	7 (5.2%)	
IIA	4 (2.8%)	17 (12.5%)	6 (4.4%)	2 (1.5%)	
IIB	1 (0.7%)	1 (0.7%)	0 (0.0%)	0 (0.0%)	
IIIA	11(7.7%)	5 (3.7%)	8 (5.9%)	9 (6.7%)	
Postoperative pathology					0.891
Adenocarcinoma, n	134 (94.4%)	123 (90.4%)	123 (90.4%)	124 (92.5%)	
Squamous cell carcinoma, n	7 (4.9%)	11 (8.1%)	11 (8.1%)	8 (6.0%)	
Adenosquamous carcinoma, n	1 (0.7%)	2 (1.5%)	2 (1.5%)	2 (1.5%)	
Postoperative length of stay, days	5.4±1.7	6.0±2.2	5.9±1.8	6.1±2.7	0.032
Total hospital care costs (Renminbi)	59532.8±10549.5	59312.3±10203.7	57275.2±8749.6	57216.0±8927.6	0.072

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S17 Univariate results of postoperative outcomes based on PEF

Postoperative outcome	PEF				P value
	Quartile 1 (n=142), ≤3.3 L/s	Quartile 2 (n=136), >3.3–4.4 L/s	Quartile 3 (n=136), >4.4–5.8 L/s	Quartile 4 (n=134), >5.8 L/s	
Postoperative pulmonary complications					
Acute respiratory distress syndrome	1 (0.7%)	2 (1.5%)	0 (0.0%)	1 (0.7%)	0.425
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	1 (0.7%)	2 (1.5%)	0 (0.0%)	0 (0.0%)	0.214
Need for bedside bronchoscopy	0 (0.0%)	2 (1.5%)	0 (0.0%)	2 (1.5%)	0.128
Prolonged air leak	1 (0.7%)	0 (0.0%)	3 (2.2%)	6 (4.5%)	0.017
Failure to expand	4 (2.8%)	6 (4.4%)	0 (0.0%)	3(2.2%)	0.035
Atelectasis	0 (0.0%)	5 (3.7%)	7 (5.1%)	1 (0.7%)	0.004
Pneumonia	62 (43.7%)	49 (36.0%)	54 (39.7%)	41 (30.6%)	0.143
Acute kidney injury	2 (1.4%)	2 (1.5%)	2 (1.5%)	6 (4.5%)	0.292
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	0 (0.0%)	2 (1.5%)	2 (1.5%)	2 (1.5%)	0.305

Values are presented as n (%).

Table S18 Clinical characteristics of patients based on FVC

Characteristic	FVC				P value
	Quartile 1 (n=122), ≤2.3 L	Quartile 2 (n=170), >2.3–2.9 L	Quartile 3 (n=115), >2.9–3.4 L	Quartile 4 (n=141), >3.4 L	
ASA score					0.004
I	89 (73.0%)	146 (85.9%)	102 (88.7%)	122 (86.5%)	
II	24 (19.7%)	14 (8.2%)	11 (9.6%)	17 (12.1%)	
III	9 (7.4%)	10 (5.9%)	2 (1.7%)	2 (1.4%)	
Age	68.2±8.1	62.7±10.9	60.6±10.9	60.8±10.4	0.000
Gender (female/male)	113/9	137/33	62/53	19/122	0.000
Weight, kg	59.0±8.6	58.3±8.9	61.5±9.0	66.9±10.0	0.000
BMI, kg/m^2	23.7±3.0	22.8±2.8	22.9±2.6	23.3±2.8	0.032
Smoking	7 (5.7%)	28 (16.5%)	35 (30.4%)	76 (53.9%)	0.000
Diabetes mellitus	15(12.3%)	12 (7.1%)	10 (8.7%)	11 (7.8%)	0.443
Coronary heart disease	4(3.3%)	3 (1.8%)	0 (0.0%)	2 (1.4%)	0.142
FEV1, L	1.7±0.2	2.1±0.3	2.4±0.3	3.0±0.4	0.000
FVC, L	2.0±0.2	2.6±0.2	3.1±0.1	3.9±0.4	0.000
PEF, L/s	3.5±1.2	4.3±1.5	4.7±1.5	6.1±2.1	0.000
FEV1%	(78.4±11.6) %	(90.0±16.9) %	(95.6±18.3) %	(99.6±13.9) %	0.000
FVC%	(75.8±9.9) %	(89.7±12.9) %	(95.7±13.4) %	(103.0±12.8) %	0.000
PEF%	(59.7±21.5) %	(67.0±23.7) %	(68.7±23.6) %	(74.4±24.6) %	0.000
Intraoperative bleeding, mL	52.1±45.0	46.4±25.7	47.0±31.7	44.1±24.4	0.231
Intraoperative blood transfusion, mL	0	0	0	0	-
Length of operation, min	131.1±38.4	134.9±36.9	131.7±33.0	131.8±33.9	0.781
NSCLC staging					0.138
IA	100 (82.0%)	139 (81.8%)	95 (82.6%)	113 (80.1%)	
IB	11 (9.0%)	10 (5.9%)	9 (7.8%)	7 (5.0%)	
IIA	6 (4.9%)	6 (3.5%)	9 (7.8%)	8(5.7%)	
IIB	1 (0.8%)	0 (0.0%)	0 (0.0%)	1 (0.7%)	
IIIA	4 (3.3%)	15 (8.8%)	2 (1.7%)	12 (8.5%)	
Postoperative pathology					0.101
Adenocarcinoma, n	116 (95.1%)	156 (91.8%)	107 (93.0%)	125 (88.7%)	
Squamous cell carcinoma, n	4 (3.3%)	10 (5.9%)	8 (7.0%)	15 (10.6%)	
Adenosquamous carcinoma, n	2 (1.6%)	4 (2.4%)	0 (0.0%)	1 (0.7%)	
Postoperative length of stay, days	5.8±2.5	5.5±1.5	5.9±2.0	6.3±2.5	0.027
Total hospital care costs (Renminbi)	58689.2±11611.1	57742.1±9218.8	57714.8±8762.0	59312.5±9124.4	0.440

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S19 Univariate results of postoperative outcomes based on FVC

Postoperative outcome	FVC				P value
	Quartile 1 (n=122), ≤2.3 L	Quartile 2 (n=170), >2.3–2.9 L	Quartile 3 (n=115), >2.9–3.4 L	Quartile 4 (n=141), >3.4 L	
Postoperative pulmonary complications					
Acute respiratory distress syndrome	2 (1.6%)	0 (0.0%)	0 (0.0%)	2 (1.4%)	0.115
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	2 (1.6%)	0 (0.0%)	0 (0.0%)	1 (0.7%)	0.177
Need for bedside bronchoscopy	0 (0.0%)	0 (0.0%)	1 (0.9%)	3 (2.1%)	0.078
Prolonged air leak	0 (0.0%)	2 (1.2%)	1(0.9%)	7 (5.0%)	0.012
Failure to expand	2 (1.6%)	3(1.8%)	4 (3.5%)	4 (2.8%)	0.736
Atelectasis	5 (4.1%)	4 (2.4%)	2 (1.7%)	2 (1.4%)	0.540
Pneumonia	61 (50.0%)	51 (30.0%)	53 (46.1%)	41 (29.1%)	0.000
Acute kidney injury	2 (1.6%)	2 (1.2%)	3 (2.6%)	5 (3.5%)	0.517
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	0 (0.0%)	1 (0.6%)	1 (0.9%)	4 (2.8%)	0.113

Values are presented as n (%).

Table S20 Clinical characteristics of patients based on FEV1

Characteristic	FEV1				
	Quartile 1 (n=122), ≤1.8 L	Quartile 2 (n=167), >1.8–2.3 L	Quartile 3 (n=127), >2.3–2.7 L	Quartile 4 (n=132), >2.7 L	P value
ASA score					0.006
I	90 (73.8%)	138 (82.6%)	111(87.4%)	120 (90.9%)	
II	21 (17.2%)	23 (13.8%)	12 (9.4%)	10 (7.6%)	
III	11 (9.0%)	6 (3.6%)	4(3.1%)	2 (1.5%)	
Age	68.4±8.4	64.5±9.3	59.6±11.7	59.3±10.4	0.000
Gender (female/male)	98/24	128/39	85/42	20/112	0.000
Weight, kg	59.2±9.9	59.5±8.7	60.2±8.6	66.9±10.0	0.000
BMI, kg/m^2	23.4±3.2	23.1±2.7	22.8±2.7	23.3±2.8	0.301
Smoking	19 (15.6%)	35 (21.0%)	27 (21.3%)	65 (49.2%)	0.000
Diabetes mellitus	13 (10.7%)	17 (10.2%)	10 (7.9%)	8 (6.1%)	0.513
Coronary heart disease	6 (4.9%)	1(0.6%)	0(0.0%)	2(1.5%)	0.012
FEV1, L	1.6±0.2	2.0±0.1	2.5±0.1	3.1±0.3	0.000
FVC, L	2.2±0.4	2.6±0.4	3.1±0.4	3.9±0.5	0.000
PEF, L/s	3.2±1.1	4.0±1.3	5.2±1.6	6.4±1.9	0.000
FEV1%	(72.0±10.7) %	(89.3±13.4) %	(99.9±14.4) %	(102.4±12.6) %	0.000
FVC%	(77.0±12.4) %	(89.0±12.1) %	(97.7±14.1) %	(101.2±13.1) %	0.000
PEF%	(51.9±16.6) %	(64.0±22.3) %	(76.7±23.7) %	(78.0±23.1) %	0.000
Intraoperative bleeding, mL	50.3±45.5	50.9±29.3	43.5±26.4	43.2±23.2	0.067
Intraoperative blood transfusion, mL	0	0	0	0	-
Length of operation, min	130.6±38.1	133.4±35.9	134.5±32.0	131.5±36.4	0.818
NSCLC staging					0.000
IA	89 (73.0%)	144 (86.2%)	113(89.0%)	101 (76.5%)	
IB	18 (14.8%)	9 (5.4%)	2 (1.6%)	8 (6.1%)	
IIA	6 (4.9%)	5 (3.0%)	10 (7.9%)	8 (6.1%)	
IIB	0 (0.0%)	1 (0.6%)	0 (0.0%)	1 (0.8%)	
IIIA	9 (7.4%)	8 (4.8%)	2 (1.6%)	14 (10.6%)	
Postoperative pathology					0.369
Adenocarcinoma, n	111 (91.0%)	154 (92.2%)	120 (94.5%)	119 (90.2%)	
Squamous cell carcinoma, n	8 (6.6%)	10 (6.0%)	7 (5.5%)	12 (9.1%)	
Adenosquamous carcinoma, n	3 (2.5%)	3 (1.8%)	0 (0.0%)	1 (0.8%)	
Postoperative length of stay, days	5.5±2.3	5.8±1.6	5.8±2.0	6.2±2.6	0.035
Total hospital care costs (Renminbi)	58686.9±11793.0	58427.9±9387.9	56796.9±7115.5	59439.7±9970.1	0.267

Values are presented as mean ± standard deviation, n or n (%). ASA, American Society of Anaesthesiologists; BMI, body mass index; FEV1, forced expiratory volume in 1 s; FEV1%, FEV1 as percentage of predicted; FVC, forced vital capacity; FVC%, FVC as percentage of predicted; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow; PEF%, PEF as percentage of predicted.

Table S21 Univariate results of postoperative outcomes based on FEV1

Postoperative outcome	FEV1				
	Quartile 1 (n=122), ≤1.8 L	Quartile 2 (n=167), >1.8–2.3 L	Quartile 3 (n=127), >2.3–2.7 L	Quartile 4 (n=132), >2.7 L	P value
Postoperative pulmonary complications					
Acute respiratory distress syndrome	0 (0.0%)	2 (1.2%)	0(0.0%)	2 (1.5%)	0.177
Reintubation	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	0 (0.0%)	2 (1.2%)	0 (0.0%)	1 (0.8%)	0.284
Need for bedside bronchoscopy	0 (0.0%)	2 (1.2%)	1 (0.8%)	1 (0.8%)	0.529
Prolonged air leak	0 (0.0%)	0 (0.0%)	6 (4.7%)	4 (3.0%)	0.001
Failure to expand	2 (1.6%)	6(3.6%)	0 (0.0%)	5 (3.8%)	0.040
Atelectasis	2 (1.6%)	5 (3.0%)	5 (3.9%)	1 (0.8%)	0.294
Pneumonia	52 (42.6%)	61 (36.5%)	46 (36.2%)	47 (35.6%)	0.632
Acute kidney injury	2 (1.6%)	2 (1.2%)	4 (3.1%)	4 (3.0%)	0.577
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	0 (0.0%)	0 (0.0%)	1 (0.8%)	5(3.8%)	0.008

Values are presented as n (%).

Table S22 Effect of PEF on postoperative outcomes

Postoperative outcome		PEF				Total P value
		Quartile 1 (n=142), ≤3.3 L/s	Quartile 2 (n=136), >3.3–4.4 L/s	Quartile 3 (n=136), >4.4–5.8 L/s	Quartile 4 (n=134), >5.8 L/s	
Postoperative pulmonary complications						
Acute respiratory distress syndrome	N (%)	1 (0.7%)	2 (1.5%)	0 (0.0%)	1 (0.7%)	0.966
Reintubation	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	N (%)	1 (0.7%)	2 (1.5%)	0 (0.0%)	0 (0.0%)	1.000
Need for bedside bronchoscopy	N (%)	0 (0.0%)	2 (1.5%)	0 (0.0%)	2 (1.5%)	1.000
Prolonged air leak	N (%)	1 (0.7%)	0 (0.0%)	3 (2.2%)	6 (4.5%)	0.756
Failure to expand	N (%)	4 (2.8%)	6 (4.4%)	0 (0.0%)	3(2.2%)	0.822
Atelectasis	N (%)	0 (0.0%)	5 (3.7%)	7 (5.1%)	1 (0.7%)	0.581
Pneumonia	N (%), OR (95% CI), P value	62 (43.7%), 1.661 (0.939–2.939), P=0.081	49 (36.0%), 0.940 (0.527–1.675), P=0.833	54 (39.7%), 1.391 (0.793–2.442), P=0.250	41 (30.6%), 1	0.130
Acute kidney injury	N (%)	2 (1.4%)	2 (1.5%)	2 (1.5%)	6 (4.5%)	0.521
In-hospital mortality	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	N (%)	0 (0.0%)	2 (1.5%)	2 (1.5%)	2 (1.5%)	0.905

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. The best-performing quartile 4 served as the reference group. CI, confidence interval; OR, odds ratio; PEF, peak expiratory flow.

Table S23 Full-model multivariate results of 4 groups of different PEF

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.014
I	1.000		
II	3.373	1.437–7.917	0.005
III	2.838	0.743–10.838	0.127
Age			
<60	1.000		
60–	1.339	0.889–2.016	0.162
Gender			
Male	1.000		
Female	1.175	0.648–2.130	0.596
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.620	1.089–2.410	0.017
Smoking			
No	1.000		
Yes	0.953	0.495–1.837	0.886
Diabetes mellitus			
No	1.000		
Yes	0.105	0.037–0.304	0.000
Coronary heart disease			
No	1.000		
Yes	0.467	0.068–3.196	0.438
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.982	0.659–1.463	0.928
Length of operation			
<2 h	1.000		
2 h–	1.652	1.095–2.490	0.017
NSCLC staging			0.450
IA	1.000		
IB	0.917	0.428–1.966	0.824
IIA	2.219	0.946–5.209	0.067
IIB	1.932	0.111–33.650	0.651
IIIA	1.080	0.494–2.363	0.847
Postoperative pathology			0.177
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.134	0.961–4.740	0.063
Adenosquamous carcinoma	0.000	0.000	0.999
PEF, L/s			0.130
≤3.3 L/s	1.661	0.939–2.939	0.081
>3.3–4.4 L/s	0.940	0.527–1.675	0.833
>4.4–5.8 L/s	1.391	0.793–2.442	0.250
>5.8 L/s	1.000		

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; NSCLC, non-small cell lung cancer; OR, odds ratio; PEF, peak expiratory flow.

Table S24 Effect of FVC on postoperative outcomes

Postoperative outcome		FVC				Total P value
		Quartile 1 (n=122), ≤2.3 L	Quartile 2 (n=170), >2.3–2.9 L	Quartile 3 (n=115), >2.9–3.4 L	Quartile 4 (n=141), >3.4 L	
Postoperative pulmonary complications						
Acute respiratory distress syndrome	N (%)	2 (1.6%)	0 (0.0%)	0 (0.0%)	2 (1.4%)	0.817
Reintubation	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	N (%)	2 (1.6%)	0 (0.0%)	0 (0.0%)	1 (0.7%)	1.000
Need for bedside bronchoscopy	N (%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	3 (2.1%)	0.996
Prolonged air leak	N (%)	0 (0.0%)	2 (1.2%)	1(0.9%)	7 (5.0%)	0.714
Failure to expand	N (%)	2 (1.6%)	3(1.8%)	4 (3.5%)	4 (2.8%)	0.572
Atelectasis	N (%)	5 (4.1%)	4 (2.4%)	2 (1.7%)	2 (1.4%)	0.363
Pneumonia	N (%), OR (95% CI), P value	61 (50.0%), 2.904 (1.397–6.035), P=0.004	51 (30.0%), 1.173 (0.619–2.225), P=0.625	53 (46.1%), 2.582 (1.432–4.659), P=0.002	41 (29.1%), 1	0.000
Acute kidney injury	N (%)	2 (1.6%)	2 (1.2%)	3 (2.6%)	5 (3.5%)	0.838
In-hospital mortality	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	N (%)	0 (0.0%)	1 (0.6%)	1 (0.9%)	4 (2.8%)	0.913

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. The best-performing quartile 4 served as the reference group. CI, confidence interval; FVC, forced vital capacity; OR, odds ratio.

Table S25 Full-model multivariate results of 4 groups of different FVC

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.022
I	1.000		
II	3.017	1.269–7.174	0.012
III	3.282	0.865–12.459	0.081
Age			
<60	1.000		
60–	1.262	0.822–1.937	0.288
Gender			
Male	1.000		
Female	0.947	0.475–1.888	0.878
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.497	1.000–2.243	0.050
Smoking			
No	1.000		
Yes	0.981	0.507–1.897	0.954
Diabetes mellitus			
No	1.000		
Yes	0.094	0.032–0.275	0.000
Coronary heart disease			
No	1.000		
Yes	0.452	0.069–2.975	0.409
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.957	0.638–1.436	0.833
Length of operation			
<2 h	1.000		
2 h–	1.618	1.072–2.442	0.022
NSCLC staging			0.431
IA	1.000		
IB	0.783	0.362–1.695	0.535
IIA	1.991	0.856–4.635	0.110
IIB	1.735	0.098–30.758	0.707
IIIA	1.413	0.636–3.141	0.396
Postoperative pathology			0.156
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.220	0.986–4.999	0.054
Adenosquamous carcinoma	0.000	0.000	0.999
FVC, L			0.000
≤2.3 L	2.904	1.397–6.035	0.004
>2.3–2.9 L	1.173	0.619–2.225	0.625
>2.9–3.4 L	2.582	1.432–4.659	0.002
>3.4 L	1.000		

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FVC, forced vital capacity; NSCLC, non-small cell lung cancer; OR, odds ratio.

Table S26 Effect of FEV1 on postoperative outcomes

Postoperative outcome		FEV1				Total P value
		Quartile 1 (n=122), ≤1.8 L	Quartile 2 (n=167), >1.8–2.3 L	Quartile 3 (n=127), >2.3–2.7 L	Quartile 4 (n=132), >2.7 L	
Postoperative pulmonary complications						
Acute respiratory distress syndrome	N (%)	0 (0.0%)	2 (1.2%)	0(0.0%)	2 (1.5%)	0.773
Reintubation	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Pulmonary embolism	N (%)	0 (0.0%)	2 (1.2%)	0 (0.0%)	1 (0.8%)	0.962
Need for bedside bronchoscopy	N (%)	0 (0.0%)	2 (1.2%)	1 (0.8%)	1 (0.8%)	0.452
Prolonged air leak	N (%)	0 (0.0%)	0 (0.0%)	6 (4.7%)	4 (3.0%)	0.308
Failure to expand	N (%)	2 (1.6%)	6(3.6%)	0 (0.0%)	5 (3.8%)	0.545
Atelectasis	N (%)	2 (1.6%)	5 (3.0%)	5 (3.9%)	1 (0.8%)	0.331
Pneumonia	N (%), OR (95% CI), P value	52 (42.6%), 1.027 (0.523–2.016), P=0.938	61 (36.5%), 0.878 (0.475–1.622), P=0.677	46 (36.2%), 0.954 (0.524–1.736), P=0.876	47 (35.6%), 1	0.939
Acute kidney injury	N (%)	2(1.6%)	2 (1.2%)	4 (3.1%)	4 (3.0%)	0.328
In-hospital mortality	N (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	-
Readmission within 30 days	N (%)	0 (0.0%)	0 (0.0%)	1 (0.8%)	5(3.8%)	0.666

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. The best-performing quartile 4 served as the reference group. CI, confidence interval; FEV1, forced expiratory volume in 1 s; OR, odds ratio.

Table S27 Full-model multivariate results of 4 groups of different FEV1

Variables	Postoperative pneumonia		
	OR	95% CI	P value
ASA score			0.019
I	1.000		
II	3.173	1.345–7.487	0.008
III	2.917	0.769–11.060	0.116
Age			
<60	1.000		
60–	1.405	0.920–2.147	0.116
Gender			
Male	1.000		
Female	1.404	0.724–2.722	0.315
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	1.565	1.050–2.331	0.028
Smoking			
No	1.000		
Yes	1.024	0.532–1.972	0.944
Diabetes mellitus			
No	1.000		
Yes	0.112	0.039–0.324	0.000
Coronary heart disease			
No	1.000		
Yes	0.454	0.067–3.077	0.418
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	0.993	0.666–1.481	0.973
Length of operation			
<2 h	1.000		
2 h–	1.525	1.020–2.280	0.040
NSCLC staging			0.604
IA	1.000		
IB	0.849	0.393–1.837	0.678
IIA	1.915	0.825–4.444	0.130
IIB	1.926	0.113–32.741	0.650
IIIA	1.071	0.490–2.340	0.863
Postoperative pathology			0.147
Adenocarcinoma	1.000		
Squamous cell carcinoma	2.222	0.999–4.940	0.050
Adenosquamous carcinoma	0.000	0.000	0.999
FEV1, L			0.939
≤1.8 L	1.027	0.523–2.016	0.938
>1.8–2.3 L	0.878	0.475–1.622	0.677
>2.3–2.7 L	0.954	0.524–1.736	0.876
>2.7 L	1.000		

Results of binary logistics regression are presented as adjusted OR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FEV1, forced expiratory volume in 1 s; NSCLC, non-small cell lung cancer; OR, odds ratio.

Table S28 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on PEF

Variables	PEF				P value
	Quartile 1 (n=142), ≤3.3 L/s	Quartile 2 (n=136), >3.3–4.4 L/s	Quartile 3 (n=136), >4.4–5.8 L/s	Quartile 4 (n=134), >5.8 L/s	
Number of deaths	2 (1.4%)	0 (0.0%)	1 (0.7%)	6 (4.5%)	0.019
Cause of death					0.376
Postoperative complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Cancer related	1 (50.0%)	0 (0.0%)	0 (0.0%)	4 (66.7%)	
Non-cancer related	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Uncertain	1 (50.0%)	0 (0.0%)	1 (100.0%)	2(33.3%)	

Values are presented as n (%). PEF, peak expiratory flow.

Table S29 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on FVC

Variables	FVC				P value
	Quartile 1 (n=122), ≤2.3 L	Quartile 2 (n=170), >2.3 L–2.9 L	Quartile 3 (n=115), >2.9 L–3.4 L	Quartile 4 (n=141), >3.4 L	
Number of deaths	1 (0.8%)	1 (0.6%)	2 (1.8%)	5 (3.6%)	0.203
Cause of death					0.413
Postoperative complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Cancer related	0 (0.0%)	1 (100.0%)	1 (50.0%)	3 (60.0%)	
Non-cancer related	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Uncertain	1 (100.0%)	0 (0.0%)	1 (50.0%)	2 (40.0%)	

Values are presented as n (%). FVC, forced vital capacity.

Table S30 Mortality following video-assisted thoracic surgery lobectomy for lung cancer based on FEV1

Variables	FEV1				P value
	Quartile 1 (n=122), ≤1.8 L	Quartile 2 (n=167), >1.8–2.3 L	Quartile 3 (n=127), >2.3–2.7 L	Quartile 4 (n=132), >2.7 L	
Number of deaths	1 (0.8%)	1 (0.6%)	1 (0.8%)	6 (4.6%)	0.057
Cause of death					0.193
Postoperative complication	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Cancer related	1 (100.0%)	0 (0.0%)	0 (0.0%)	4 (66.7%)	
Non-cancer related	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Uncertain	0 (0.0%)	1 (100.0%)	1 (100.0%)	2 (33.3%)	

Values are presented as n (%). FEV1, forced expiratory volume in 1 s.

Table S31 Multivariate Cox regression results for overall survival based on PEF

Variables	HR	95% CI	P value
ASA score			0.999
I	1.000		
II	0.000	0.000	0.960
III	0.000	0.000	0.976
Age			
<60	1.000		
60–	0.720	0.159–3.262	0.670
Gender			
Male	1.000		
Female	0.857	0.072–10.229	0.903
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.972	0.179–5.277	0.974
Smoking			
No	1.000		
Yes	5.820	0.684–49.509	0.107
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.955
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.995
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	8.747	0.852–89.843	0.068
Length of operation			
<2 h	1.000		
2 h–	1.447	0.254–8.249	0.677
NSCLC staging			0.121
IA	1.000		
IB	0.000	0.000	0.981
IIA	0.000	0.000	0.980
IIB	0.000	0.000	0.997
IIIA	12.589	2.004–79.074	0.007
Postoperative pathology			0.999
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.961
Adenosquamous carcinoma	0.000	0.000	0.990
PEF, L/s			0.920
≤3.3 L/s	0.000	0.000	0.926
>3.3–4.4 L/s	0.451	0.037–5.503	0.533
>4.4–5.8 L/s	0.936	0.115–7.636	0.951
>5.8 L/s	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; HR, hazard ratio; NSCLC, non-small cell lung cancer; PEF, peak expiratory flow.

Table S32 Multivariate Cox regression results for overall survival based on FVC

Variables	HR	95% CI	P value
ASA score			0.999
I	1.000		
II	0.000	0.000	0.963
III	0.000	0.000	0.975
Age			
<60	1.000		
60–	0.605	0.140–2.608	0.500
Gender			
Male	1.000		
Female	0.481	0.032–7.282	0.598
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.611	0.118–3.155	0.556
Smoking			
No	1.000		
Yes	4.829	0.625–37.325	0.131
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.959
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.997
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	11.595	0.986–136.357	0.051
Length of operation			
<2 h	1.000		
2 h–	1.598	0.284–9.000	0.595
NSCLC staging			0.072
IA	1.000		
IB	0.000	0.000	0.975
IIA	0.000	0.000	0.974
IIB	0.000	0.000	0.997
IIIA	22.032	2.784–174.356	0.003
Postoperative pathology			0.998
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.957
Adenosquamous carcinoma	0.000	0.000	0.988
FVC, L			0.825
≤2.3 L	0.257	0.014–4.837	0.364
>2.3–2.9 L	0.481	0.023–9.868	0.635
>2.9–3.4 L	0.339	0.014–7.990	0.502
>3.4 L	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FVC, forced vital capacity; HR, hazard ratio; NSCLC, non-small cell lung cancer.

Table S33 Multivariate Cox regression results for overall survival based on FEV1

Variables	HR	95% CI	P value
ASA score			0.999
I	1.000		
II	0.000	0.000	0.968
III	0.000	0.000	0.977
Age			
<60	1.000		
60–	0.835	0.193–3.604	0.809
Gender			
Male	1.000		
Female	1.092	0.064–18.546	0.952
BMI			
<24.0 kg/m^2	1.000		
≥24.0 kg/m^2	0.703	0.129–3.837	0.684
Smoking			
No	1.000		
Yes	4.917	0.640–37.806	0.126
Diabetes mellitus			
No	1.000		
Yes	0.000	0.000	0.964
Coronary heart disease			
No	1.000		
Yes	0.000	0.000	0.996
Intraoperative bleeding			
<50 mL	1.000		
50 mL–	9.980	0.936–106.453	0.057
Length of operation			
<2 h	1.000		
2 h–	1.745	0.307–9.922	0.530
NSCLC staging			0.170
IA	1.000		
IB	0.000	0.000	0.973
IIA	0.000	0.000	0.977
IIB	0.000	0.000	0.997
IIIA	11.694	1.743–78.475	0.011
Postoperative pathology			0.999
Adenocarcinoma	1.000		
Squamous cell carcinoma	0.000	0.000	0.961
Adenosquamous carcinoma	0.000	0.000	0.989
FEV1, L			0.611
≤1.8 L	0.327	0.018–5.818	0.446
>1.8–2.3 L	0.374	0.015–9.076	0.546
>2.3–2.7 L	1.283	0.060–27.572	0.873
>2.7 L	1.000		

Results of binary logistics regression are presented as adjusted HR, 95% CI and P value. ASA, American Society of Anaesthesiologists; BMI, body mass index; CI, confidence interval; FEV1, forced expiratory volume in 1 s; HR, hazard ratio; NSCLC, non-small cell lung cancer.