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

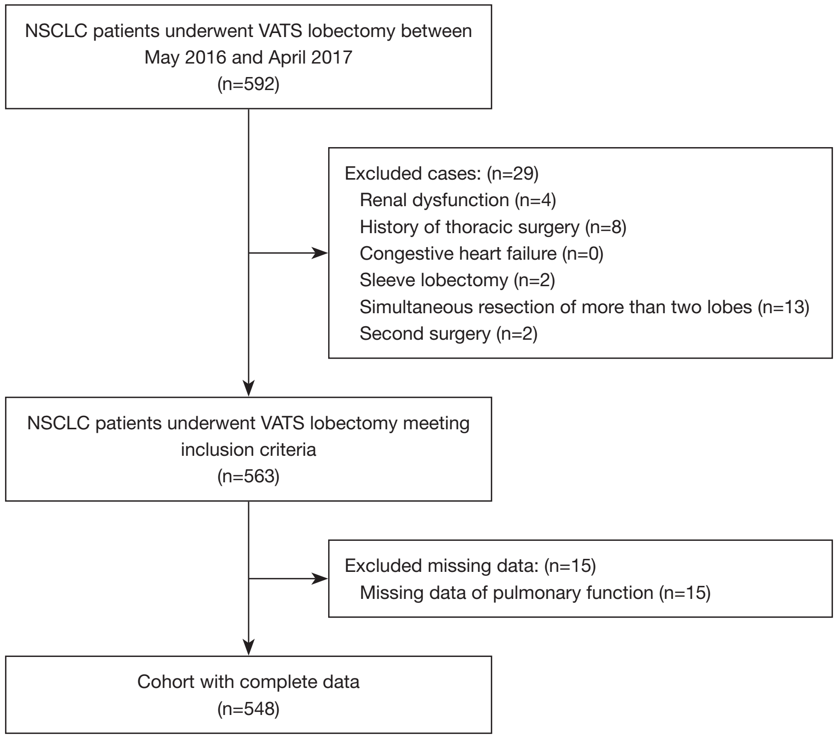

Figure 1 Study enrolment flow chart. NSCLC, non-small cell lung cancer; VATS, video-assisted thoracoscopic surgery.

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*).

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

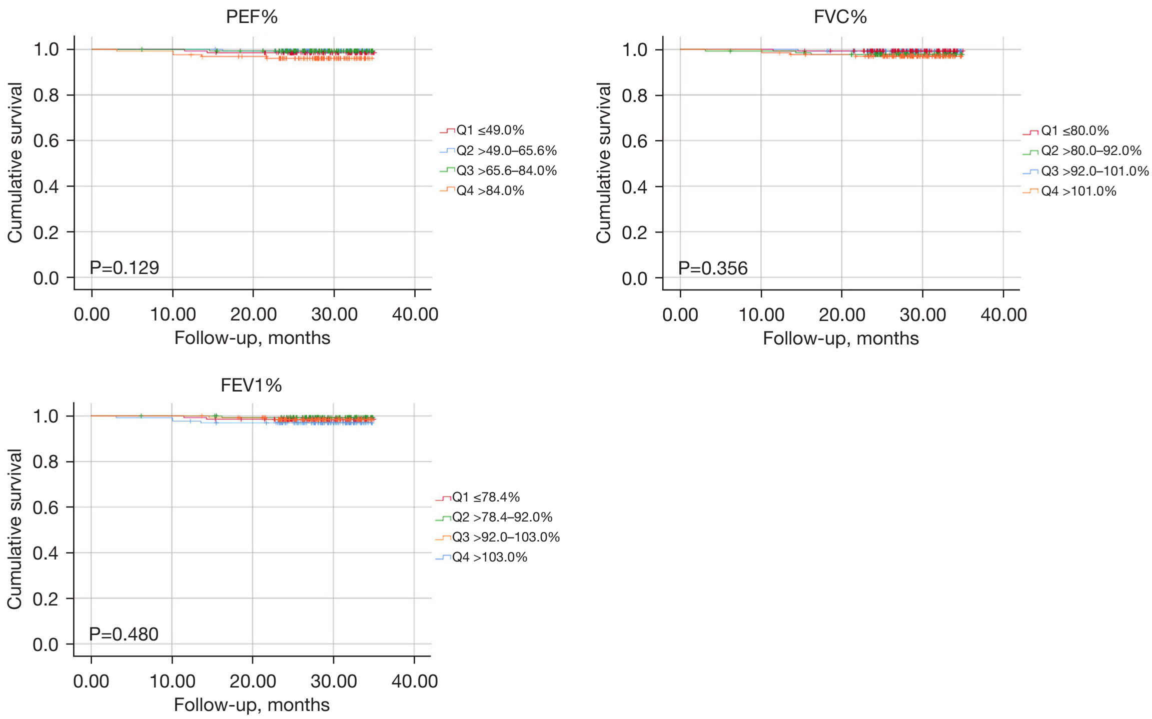

Figure 2 Overall survival curves in 548 patients among the 4 different groups according to the predicted pulmonary function values of PEF%, FVC%, and FEV1%. FEV1%, forced expiratory volume in 1 s as a percentage of predicted; FVC%, forced vital capacity as a percentage of predicted; PEF%, peak expiratory 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.

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Footnote

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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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