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Original Research Article

Does preoperative predictive lung functions correlates with post surgical lung functions in lobectomy?

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Abstract

Background: Patients with normal pulmonary function tolerate removal of an entire lung without respiratory problems. In patients with impaired pulmonary function, post resectional function is of importance for the assessment of surgical risk. This necessitates the ability to measure the relative contribution of the parenchyma to be resected to the total lung function and the predicted postoperative lung functions.

Objective: To determine preoperative lung functions as assessed with split lung functions and correlates with postsurgical lung functions and to determine the effect of lung resections on spirometric lung function.

Material and methods: All those patients planned for lung resection surgery were included in the study. Predicted postoperative FEV_1 and FVC were calculated. Preoperative spirometry was performed within a week before surgery. Predicted postoperative values were calculated. Postoperative spirometry was performed at the end of first month, third month, and sixth month for each patient. The relationship between potential predictors and postoperative complications were assessed. The predicted values were correlated with measured values (actual values) during the postoperative follow up.

Results: Lobectomy was done in 64 persons. The predicted postoperative FEV_1 and FVC correlated well with observed FEV_1 and FVC in lobectomy ($p<.05$). The mean preoperative FEV_1/L were 1.8 and the mean predicted postoperative (L) FEV_1 were 1.4. The mean FEV_1 at 1 month follow up were 1.6 and the mean FEV_1 at 3 month follow up were 179.8.

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Conclusion: Our study showed that simple calculations based on preoperative pulmonary function studies correlated well with the actual postoperative FEV_1 and FVC for patients undergoing lobectomy. This calculation, however, underestimates the actual postoperative FEV_1 and FVC by 230 ml in lobectomy.

Key words

Lobectomy, Spirometry, Pulmonary function.

Introduction

The lobar arrangement is defined early in fetal life. Right lung is divided into three lobes (upper, middle and lower). Left is divided into two lobes (upper and lower lobes). The right lung has 10 bronchopulmonary segments and left lung has 9 bronchopulmonary segments [1]. Lung resection is a therapeutic procedure for variety of pulmonary diseases that was introduced by Tuffier in 1891 [2].

Lungs are composed of sections called lobes; right has three and left has two. When a complete lobe of lung is removed, it is known as lobectomy. When entire lung is removed, it is known as pneumonectomy. The Indications of lobectomy includes Lung abscess, Bronchiectasis, Drug resistant tuberculosis, Mycetoma, Emphysema, Hemoptysis, AV malformation, Sequestration of lobe/lung, Adenomyomatosis and Malignant [3, 4] like Non-small cell carcinoma, Small cell carcinoma, Metastatic tumours and others.

The pulmonary function tests are done with the help of spirometer [5, 6]. Spirometry is an expiratory maneuver. It measures exhaled volume or vital capacity but does not measure residual volume, functional residual capacity or total lung capacity (TLC). Vital capacity (VC) is a simple measure of lung volume usually reduced in restrictive disorders. VC is an indirect measure of other lung volumes. Other tests such a residual volume, gas diffusion tests, inhalation challenge test, and exercise stress tests may also be performed to determine lung function.

Studies on pulmonary function testing in the preoperative evaluation for the lung resection surgery indicate that the following criteria are predictive of increased postoperative complications and mortality. For lobectomy, FEV_1 <1 L; MVV <40% of predicted; FEF 25-75% <0.6 L/second and DLCO <50% of predicted. There is general agreement that at least, the preoperative pulmonary testing of patients of whom lung resection is being considered should include spirometry and arterial blood gases [7].

Split lung function studies [8] showed patients with normal pulmonary function tolerate removal of an entire lung without respiratory problems. In patients with impaired pulmonary function, however, knowledge of post resectional function is of importance for the assessment of surgical risk. This necessitates the ability to measure the relative contribution of the parenchyma to be resected to the total lung function. Kearney, et al. [9] found the predicted postoperative FEV_1, the only independent predictor of postoperative complications.

Zeiher, et al. obviates the need for a perfusion scan by the formula used as below [1, 2, 3, 4, 5, 6, 7, 8, 9, 10].

- Predicted postoperative FEV1 or FVC = preoperative FEV1 or FVC x (1-S x 1/19).

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- Predicted postoperative FEV1 or FVC = preoperative FEV1 or FVC x (1-S x 0.0526).
- Predicted postoperative FEV1 or FVC = preoperative FEV1 or FVC x (1-S x 5.26/100) (where S is the number of bronchopulmonary segments to be removed and 19 the total number of bronchopulmonary segments)

Postoperative complications were defined as those occurring within 30 days after surgery [11]. Present study was aimed to determine preoperative lung functions as assessed with split lung functions and correlates with postsurgical lung functions and to determine the effect of lung resections on spirometric lung function.

Material and methods

The study was conducted in the Department of Cardiovascular and Thoracic Surgery, SKIMS, Srinagar, Kashmir, India on 64 patients. All those patients who were planned for lung resection surgery in the Department of Cardiovascular and Thoracic Surgery were included in the study protocol prospectively. Informed consent was taken from all cases enrolled for the study. Besides routine investigations, specific investigations include pulmonary specific evaluation (pulmonary function tests) were done.

Pulmonary specific evaluation was performed in graded manner to meet the cited goals and help-risk stratifies the patients prior to anticipate surgery. The first stage of assessment was spirometry. Spirometeric indices that were commonly used and have been extensively studied include FEV_1, FVC, FEV_1/FVC% and MVV. Out of all these indices, FEV_1 and FVC were regarded as best for predicting complications of lung resection and were most commonly used for decision making.

Predicted postoperative FEV_1 and FVC were calculated as per the formulae given below.

- Predicted postoperative FEV_1 = preoperative FEV_1 X [1-(S x 0.0526)] S = No. of bronchopulmonary segments resected.
- Predicted postoperative FVC = preoperative FVC X [1-(S x 0.0526)]. S = No. of bronchopulmonary segments resected.

Calculation of predicted postoperative FEV_1 and FVC were performed using preoperative data and information on the number of bronchopulmonary segments resected was predicted on the basis of preoperative radiologic studies (chest X-ray and computed tomography of chest). Number of bronchopulmonary segments resected was recorded for each patient.

Preoperative spirometry was performed within a week before surgery. Predicted postoperative values were calculated. Postoperative spirometry was performed at the end of first month, third month, and sixth month for each patient. The relationship between potential predictors and postoperative complications were assessed. The predicted values were correlated with measured values (actual values) during the postoperative follow up.

The data was subjected to statistical analysis using parametric and non-parametric tests for comparative evaluation. Besides correlation and regression, we also assessed the sensitivity of the predicted postoperative lung functions to predicted/infer the postoperative complications.

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Results

The age range of our study of 64 patients was 14 years to 75 years with mean age of 54.6 years. Most of the patients were farmer by occupation (41.7%) and student least common (2.9%). The most common symptom was cough (73.8%), the most common co-morbidity was hypertension in (19.4%) and (76.7%) had history of smoking.

The most common procedure performed was lower lobectomy (29.1%) and the commonest indication was squamous cell carcinoma (84%) and the least common was carcinoid (1.5%). The most common complication was breathlessness (95%). The other complications were bronchopleural fistula (3.1%), prolonged air leak (1.6%), pneumonia (1.6%), arrhythmia and death (1.6%) as per **Table – 1**.

Complications as per predicted values

The most common complication breathlessness was seen in patients with predicted postoperative FEV_1 <1.45 L and predicted postoperative FVC <1.67 L (p <0.01). Bronchopleural fistula, prolonged air leak, pneumonia, arrhythmia or death was seen in patients with predicted postoperative FEV_1 <0.66 L and predicted postoperative FVC <0.70 L (p<0.01).

Correlations of predicted postoperative FEV_1 with observed FEV_1 in lobectomy

Predicted postoperative FEV_1 correlated with observed FEV_1 at 1st (r = 0.996), 3rd (r = 0.995) and 6th (r = 0.998) month in the post operative follow up.

Correlations of predicted postoperative FVC with observed FVC in lobectomy

Predicted postoperative FVC correlated with observed FVC at 1st (r = 0.989), 3rd (r = 0.990) and 6th (r = 0.990) month in the post operative follow up.

Discussion

This study was conducted in the Department of Cardiovascular and Thoracic Surgery, Sher-i-Kashmir Institute of Medical Sciences, Srinagar, India, which is the only tertiary care institute of Jammu and kashmir State. The preoperative evaluation of patients having lung diseases is a complex and perplexing problem. It is important not only to identify the patients with potentially resectable lung disease, but also to identify those patients who can or can't tolerate lung resection. The predicted postoperative FEV_1 and FVC are the frequently used criteria for defining physiologic operability.

Age distribution and sex distribution

The age range in our series of 64 patients were 14 years to 75 years with a mean age of 54.6 years, study population comprised of 50 males and 14 females with a male to female ratio of 4: 1.This corresponds to the study of Nakahara K [12] and Zeiher BG, et al. [10].

Occupation, presenting symptoms and co-morbidity

43 patients (67%) were farmer (most common) and the least common students (4%). The most common symptom was cough (73.8%) and the least common was weight loss (1.9%). 19.4% were hypertensive and 76.7% were smokers. This corresponds to the study conducted by Camili, et al. [13].

Indications

The most common indication for surgery was squamous cell carcinoma lung (56 patients i.e. 87%) and the least common was carcinoid (1 patient only). This is consistent with the study of Zeiher BG, et al. [10] in which lung resections were performed for neoplastic conditions of lung in majority of cases (56%), lung abscess in 1, tuberculosis in 1 and carcinoid in 4 patients.

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Procedure

Lower lobectomy was performed in 30 patients (46%) and upper lobectomy in 20 patients (31%) while middle lobectomy in 5 patients (7.8%). This corresponds to the study conducted by Zeiher BG, et al. [10] in which 13 pneumonectomies, 41 lobectomies, 7 bilobectomies and 1 wedge resection were performed. This is also corresponds to the study conducted by Markos J, et al. [5] in which 18 pneumonectomies, 29 lobectomies, 6 thoracotomy without resection were performed.

Lung function parameters in lobectomy

Lobectomy was performed in 64 patients. The measurement of spirometric indices FEV_1 and FVC was done preoperatively and postoperatively. The predicted postoperative FEV_1 and FVC were calculated by using simple segment counting technique given by juhl and Frost. The actual postoperative FEV_1 and FVC measurement was done at 1, 3 and 6 month. The mean preoperative FEV_1 was 1.8 L. The mean predicted postoperative FEV_1 was 1.4 L, the mean observed FEV_1 at 1 month was 1.6 L, at 3 month 1.6 L and at 6 months 1.6 L. The predicted postoperative value FEV_1 was compared with the postoperative measured values FEV_1 at 1 month, 3 month and 6 month. The predicted postoperative value FEV_1 consistently underestimated the actual postoperative FEV_1 by approximately 158 ml at 1 month ($p < 0.0001$), 180 ml at 3 month ($p < 0.0001$), and 230.8 ml at 6 month ($p<0.0001$). The mean predicted postoperative FVC was 1.6 L and the mean observed FVC value at 1 month, at 3 month and at 6 month was 1.8 L, 1.8 L and 1.8 L respectively. The predicted postoperative FVC was compared with the postoperative measured values at 1 month, 3 month and at 6 month, the predicted postoperative value FVC consistently underestimated the mean actual postoperative FVC by approximately 124 ml at 1 month ($p<0.0001$), 147 ml at 3 month ($p<0.0001$) and 185 ml at 6 month ($p<0.0001$). This study corresponds to the study conducted by Zeiher BG, et al. [10] in which predicted postoperative values were calculated and were compared with postoperative measured values. The predicted postoperative FEV_1 and FVC consistently underestimated the actual postoperative FEV_1 and FVC by approximately 250 ml. Our study is consistent with the study conducted by the Bolliger CT, et al. [14] and Brunelli, et al. [15] in which predicted postoperative FEV_1 and FVC were compared with the postoperative measured FEV_1 and FVC values. Both the studies documented underestimation of postoperative FEV_1 and FVC by 250 ml and 200 ml when predicted postoperative lung functions were evaluated in patients of lung resections.

Complications as per the predicted postoperative FEV_1 and FVC

The most common complication was breathlessness (grade I and grade II) in 61 patients (95%). The other complications were bronchopleural fistula, prolonged air leak, pneumonia, arrhythmia or death. Breathlessness (grade II) was seen in patients with predicted postoperative FEV_1 ≤1.4 L ($p < 0.0001$) and predicted postoperative FVC ≤1.67 L ($p < 0.0001$). Bronchopleural fistula, prolonged air leak, pneumonia, arrhythmia or deaths were seen in patients with predicted postoperative FEV_1 ≤0.66L ($p < 0.0001$) and predicted postoperative FVC ≤0.70 L ($p < 0.0001$). This study corresponds the study conducted by Markos J, et al. [5] in which predicted postoperative FEV_1 and FVC were predictive of postoperative complications indicating death and respiratory failure, the best predictor of death was predicted postoperative FEV_1.

Bechard, et al. [16] conducted a study in which criterion for surgical resection included an FEV_1 >1.7 L for pneumonectomy, >1.2 L for lobectomy

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and greater than 0.9 L for wedge resection. Busch, et al. [17] conducted a study in which pulmonary complications occurred in 82% patients. This study is consistent with the study of Olsen GN, et al. [18] in which predicted postoperative FEV_1 <0.8 L was associated with complications. Markos J, et al. [5] reported that low predicted postoperative FEV_1 was associated with higher mortality and morbidity. Fujiu K, et al. [19] conducted a study in which postoperative complications were divided into two groups; respiratory complications (pneumonia/atelectasis) and other complications (bronchopleural fistula/prolonged air leak/arrhythmia etc.). Postoperative mortality of 3.9% was reported to be associated with predicted postoperative FEV_1 <40%. The maximum number of lobectomy patients (94%) developed breathlessness postoperatively. Two patients had bronchopleural fistula, 1 had prolonged air leak, 1 had pneumonia and 1 died due to respiratory failure. Among pneumonectomy patients, 5 developed breathlessness, 6 had bronchopleural fistula, 5 had prolonged air leak, 1 had pneumonia, 1 had arrhythmia and 4 died due to respiratory failure. Three patients developed breathlessness in segmentectomy and 5 patients developed breathlessness in wedge resection patients. This study corresponds to the study conducted by Kearney DJ, et al. [9] in which complications were seen in 39% of patients undergoing pneumonectomy, 19% patients undergoing lobectomy. Our study was in conformity with the study of Busch E, et al. [17] who reported 6 deaths in the entire series of 103 patients, 2 of which were directly caused by a pulmonary complication and 1 was due to a contributing factor. Fujiu K, et al. [19] documented 27% postoperative respiratory complications in pneumonectomy patients.

Correlations of predicted postoperative FEV_1 and FVC with measured postoperative FEV_1 and FVC in lobectomy

The predicted postoperative FEV_1 correlated well with postoperative FEV_1 measured values at 1 month ($r = 0.996$, $p < 0.001$), 3 month ($r = 0.995$, $p < 0.0001$) and 6 month ($r = 0.998$, $p < 0.0001$) in patients of lobectomy. The predicted postoperative FVC correlated well with postoperative measured FVC values at 1 month ($r = 0.989$, $p < 0.0001$), 3 month ($r = 0.990$, $p < 0.0001$) and 6 month ($r = 0.998$, $p < .0001$) in patients of lobectomy. This study corresponds to the study conducted by Zeiher BG, et al. [10] in which the actual postoperative FEV_1 and FVC correlated well with the predicted postoperative FEV_1 and FVC for patients undergoing lobectomy ($r = 0.867$ and $r = 0.832$ respectively). Winthida, et al. [20] conducted a study in which there was statistically significant correlation ($p < 0.01$) between the predicted postoperative FEV_1 and FVC and actual postoperative FEV_1 and FVC. Markos J, et al. [5] conducted a study in which the predictions of postoperative function correlated well with the measured values at 3 month. For FEV_1, $r = 0.89$ in lobectomy ($p < 0.001$). This present study establishes beyond doubt the correlation of predicted postoperative FEV_1 and FVC with the actual postoperative lung functions. There is direct correlation between the predicted postoperative lung function with the incidence/ prevalence of postoperative complications. These findings hold true especially for major lung resections.

Conclusion

Our study showed that simple calculations based on preoperative pulmonary function studies correlated well with the actual postoperative FEV_1 and FVC for patients undergoing lobectomy. This calculation, however, underestimates the actual postoperative FEV_1 and FVC by 230 ml in lobectomy.

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Table - 1: Lung function parameters in the lobectomy subjects. (n = 64)

		min	max	Mean	SD	p value
FEV_1	Preoperative (L)	0.4	3.3	1.8	0.6	a: p = 0.000*, b: p = 0.000*, c: p = 0.000*, d: p = 0.000*, e: p = 0.000*, f: p = 0.000*, Fredmans test P = 0.000*
	Predicted postoperative (L)	0.29	2.5	1.4	0.5	
	1 month follow up (L)	0.4	2.7	1.6	0.5	
	3 month follow up (L)	0.5	2.72	1.6	0.5	
	6 month follow up (L)	0.54	2.75	1.6	0.5	
	Difference at 1 month (ml)	80	230	157.9	47.6	
	Difference at 3 month (ml)	70	250	179.8	53.1	
	Difference at 6 month (ml)	130	250	230.8	29.5	
FVC	Preoperative	0.5	3.5	2.2	0.7	a: p = 0.000*, b: p = 0.000*, c: p = 0.000*, d: p = 0.000*, e: p = 0.000*, f: p = 0.000*, Fredmans test p = 0.000*
	Predicted postoperative	0.36	2.94	1.6	0.6	
	1 month follow up	0.5	2.74	1.8	0.6	
	3 month follow up	0.6	2.76	1.8	0.6	
	6 month follow up	0.61	2.8	1.8	0.6	
	Difference at 1 month (ml)	-200	250	124.5	98.2	
	Difference at 3 month (ml)	-180	250	147.1	100.9	
	Difference at 6 month (ml)	-180	250	185.8	106.3	

a: Predicted postoperative FEV_1 or FVC in comparison to FEV_1 or FVC - 1 month follow up
b: Predicted postoperative FEV_1 or FVC in comparison to FEV_1 or FVC - 3 month follow up
c: Predicted postoperative FEV_1 or FVC in comparison to FEV_1 or FVC - 6 month follow up
d: FEV_1 or FVC - 1 month follow up in comparison to FEV_1 or FVC - 3 month follow up
e: FEV_1 or FVC - 1 month follow up in comparison to FEV_1 or FVC - 6 month follow up
f: FEV_1or FVC - 3 month follow up in comparison to FEV_1 or FVC - 6 month follow up
F: Overall change in FEV_1 or FVC
'p value' flagged by asterisk mark indicates significant difference of compared groups