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Reduction of Pulmonary Function After Surgical Lung Resections of Different Volume

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ABSTRACT

Introduction: In recent years an increasing number of lung resections are being done because of the rising prevalence of lung cancer that occurs mainly in patients with limited lung function, what is caused with common etiologic factor - smoking cigarettes. **Objective:** To determine how big the loss of lung function is after surgical resection of lung of different range. **Methods:** The study was done on 58 patients operated at the Clinic for thoracic surgery KCU Sarajevo, previously treated at the Clinic for pulmonary diseases “Podhrastovi” in the period from 01.06.2012. to 01.06.2014. The following resections were done: pulmectomy (left, right), lobectomy (upper, lower: left and right). The values of postoperative pulmonary function were compared with preoperative ones. As a parameter of lung function we used FEV1 (forced expiratory volume in one second), and changes in FEV1 are expressed in liters and in percentage of the recorded preoperative and normal values of FEV1. Measurements of lung function were performed seven days before and 2 months after surgery. **Results:** Postoperative FEV1 was decreased compared to preoperative values. After pulmectomy the maximum reduction of FEV1 was 44%, and after lobectomy it was 22% of the preoperative values. **Conclusion:** Patients with airway obstruction are limited in their daily life before the surgery, and an additional loss of lung tissue after resection contributes to their inability. Potential benefits of lung resection surgery should be balanced in relation to postoperative morbidity and mortality.

Key words: lung resection, pulmonary function.

1. INTRODUCTION

Surgical treatment is the best option for the treatment of many pulmonary diseases but many potentially curable diseases, first of all bronchopulmonary carcinoma, occurs in patients with impaired pulmonary function due to the associated chronic obstructive pulmonary disease (COPD), which is caused by common etiologic factors primarily smoking (1, 2). Patients with airway obstruction are limited in their daily lives; additional loss of lung tissue contributes to their disability. Loss of lung tissue in them can severely deteriorate the function of ventilating the lungs which may lead to respiratory failure, various cardiopulmonary complications including death. These patients are at increased risk of perioperative immediate and postoperative complications such as acute respiratory failure, need for mechanical ventilation for more than 48 hours, or the need to re-intubation, atelectasis of lung tissue of different volumes, pneumonia, pulmonary embolism, and cardiac complications as acute myocardial infarct, heart rhythm disorders, heart failure, pulmonary edema, and also chronic pulmonary insufficiency because of the removal of functional lung tissue (1-9).

The aim of the surgeon in performing resection surgery is curative resection with preservation of the maximum amount of functional lung tissue. Functional loss that results due to pulmonary resection depends on the extent of resection, the relative functional status of removed in

relation to the remaining tissue and on the degree of damage of lung function preoperatively (1-3, 8-11).

The assessment of possibility of the planned operation is possible after a detailed analysis of the clinical, laboratory and radiological findings, and pulmonary function tests (1-24). High risk can be justified if patients are suffering from cancer and there may be placed a question -what is the risk of postoperative complications in relation to the disease that is certainly fatal if not operated.

Various types of lung resection surgery are performed from segmentectomy to pulmectomy. The possible extent of resection is carefully planned preoperatively, depending on the patient's cardiovascular and pulmonary functional status and there is a need for a close coordination of pulmonologists and surgeons (1-24).

Several authors dealt with predicting lung function after the planned surgical resection of lung parenchyma and monitored the accuracy of the forecasts according to the methods of forecasting, and less of them compared the lung function before and after resection and determined the functional loss.

2. OBJECTIVE

To determine how big the reduction of lung function is after surgical resection of lung parenchyma of different volumes.

3. MATERIAL AND METHODS

The study was done on 58 patients operated at the Clinic of thoracic surgery of KCU Sarajevo, who had previously treated at the Clinic of Pulmonary Diseases "Podhrastovi" in a period from 01.06.2012. to 01.06.2014. Patients were undergone to following resection surgery: pulmnectomy (left, right), lobectomy (left and right: upper, lower). Patients were selected at random. Values of postoperative pulmonary functional tests are compared with preoperative values. Pulmonary function tests were done when the patient was clinically stable, and after taking a complete bronchodilator therapy if it was needed. All patients did a complete spiropletizmographic processing as follows: FVC (forced vital capacity), FEV1 (forced expiratory volume in one second), and the flow-volume curve, total pulmonary resistance (R tot) including bronchodilator test, RV (residual lung volume), TLC (total lung capacity). Arterial blood gas analysis was performed, too.

The patients were divided into 12 groups of which can be seen in Table 1.

Ordinal number of group	Type of operation	Number of cases	Sex	Average age (years)
1.	Left pulmnectomy	9	M	64.55
2.	Left pulmnectomy	2	F	47.00
3.	Right pulmnectomy	5	M	54.40
4.	Right pulmnectomy	1	F	55.00
5.	Left upper lobectomy	6	M	59.30
6.	Left upper lobectomy	4	F	52.70
7.	Left lower lobectomy	7	M	59.71
8.	Left lower lobectomy	2	F	59.50
9.	Right upper lobectomy	9	M	62.78
10.	Right upper lobectomy	3	F	54.67
11.	Right lower lobectomy	9	M	62.20
12.	Right lower lobectomy	1	F	65.00

Table 1. Type of surgical resection, the number of cases for each operation, sex and average age of patients

Table1. The study included 45 males average age of 60.49 and 13 females average age of 55.65 years.

The degree of lung function impairment is preferably determined based on FEV1 as this is the most objective parameter of lung function, and indicates the obstructive and restrictive disorders ie. indicates the type and degree of impairment of ventilatory lung function.

For normal spirometric parameters are taken so-called "European standards" or C.E.C.A. standards established under the auspices of European Coal and Steel Community, which was the forerunner of today's European Union, taking into account height, weight, age and sex of the patient and which are entered into the computer of each spiropethygmographic apparatus.

Complete spiropethygmographic processing was done on the device Master Lab Jaeger, a determination of blood gases on the device Radiometer ABL 505 in the Laboratory of Clinical Physiology of Breathing of Clinic for Pulmonary Diseases and TB "Podhrastovi." Pulmonary functional tests were done 7 and 10 days before surgery, and after the patient has taken a bronchodilator (if it was required), and 2 months after the operation, when it is considered

that there is the stabilization of the resulting functional lung status. If more testing has been done, highest realized value is taken into consideration.

4. RESULTS

The results are shown in the tables and figure, where it can be seen how FEV1 decreased after the surgical lung resection of different volumes. It is showed how much the average values of FEV1 were in each group of patients, that is : what is the normal value in liters for that group, how much they have achieved before surgery in liters and as a percentage of their normal value, what are the actual postoperative FEV 1 values in liters and as percentage of the normal values, and how much the postoperative decrease in FEV1 in liters , and as percentage of actual preoperative values and as percentages of the average norm for the group is.

FEV1 Preoperative				FEV1 Postoperative				
				Realized		Loss of function in		
patients	norm. (L)	real-ized (L)	% of nor-mal	L	% of nor-mal	L	% of preop. values	% of nor-mal
9m	3.21	2.67	83.18	1.69	52.65	0.98	36.70	30.53.
2f	2.83	2.04	72.08	1.14	40.28	0.90	44.12	31.80

Table 2. Reduction in pulmonary function after left pulmnectomy

Table 2. FEV1 decreased as compared to preoperative values for 0.98L or 36.70% in men, and 0.90L or 44.12% in women.

Legend: FEV1 = forced expiratory volume in one second. Normal = norm. -average normal value of FEV1 (according to gender, age, height, weight) for this group of patients in liters (L). Realized - achieved average value of FEV1 in liters (L) . % of normal - achieved (realized) average value of FEV1 in per cents of normal values for this group of patients

Loss of function – reduction of FEV1 compared to preoperative values expressed in liters (L), in per cents of preoperative values, and in per cents of normal values m-males f-females

FEV1Preoperative				FEV1 Postoperative				
				Realized		Loss of function in		
patients	norm. (L)	real-ized (L)	% of nor-mal	L	% of nor-mal	L	% of preop. values	% of nor-mal
5m	3.77	3.15	83.55	1.77	46.95	1.38	43.81	36.60
1f	2.47	1.55	62.75	1.01	40.90	0.54	34.84	21.86

Table 3. Reduction in pulmonary function after right pulmnectomy

FEV1Preoperative				FEV1 Postoperative				
				Realized		Loss of function in		
patients	norm. (L)	real-ized (L)	% of nor-mal	L	% of nor-mal	L	% of preop. values	% of nor-mal
6m	3.33	2.89	86.79	2.38	71.47	0.51	17.65	15.32
4f	2.42	2.31	95.45	1.80	74.38	0.51	22.08	21.08

Table 4. Reduction in pulmonary function after left upper lobectomy

Table 3. FEV1 decreased as compared to preoperative values for 1.38 L or 43.81% in men, and 0.54 L or 34.84% in women.

Table 4. FEV1 decreased as compared to preoperative values for 0.51L or 17.65% in men, and 0.51L or 22.08% in women.

FEV1 Preoperative				FEV1 Postoperative				
patients	norm. (L)	realized (L)	% of normal	Realized		Loss of function in		
				L	% of normal	L	% of preop. values	% of normal
7m	3.29	2.98	90.58	2.43	73.86	0.55	18.46	16.72
2f	2.23	2.12	96.07	1.74	78.03	0.38	17.02	17.04

Table 5. Reduction in pulmonary function after left lower lobectomy

Table 5. FEV1 decreased as compared to preoperative values for 0.55L or 18.46% in men, and 0.38L or 17.02% in women.

FEV1 Preoperative				FEV1 Postoperative				
patients	norm. (L)	realized (L)	% of normal	Realized		Loss of function in		
				L	% of normal	L	% of preop. values	% of normal
9m	3.32	2.72	81.93	2.31	69.58	0.41	15.07	12.35
3f	2.48	2.02	81.45	1.61	64.92	0.41	20.30	16.53

Table 6. Reduction in pulmonary function after right upper lobectomy

Table 6. FEV1 decreased as compared to preoperative values for 0.41 L or 15.07% in men, and 0.41L or 20.27% in women

FEV1 Preoperative				FEV1 Postoperative				
patients	norm. (L)	realized (L)	% of normal	Realized		Loss of function in		
				L	% of normal	L	% of preop. values	% of normal
9m	3.36	2.71	80.65	2.11	52.80	0.60	22.14	17.86
1f	1.94	1.68	86.60	1.46	75.26	0.22	13.10	11.34

Table 7. Reduction in pulmonary function after right lower lobectomy

Table 7. FEV1 decreased as compared to preoperative values for 0.60 L or 22.14% in men, and 0.22 L 13.10% in women

Figure 1. FEV1 decreased as compared to preoperative values for each type of lung resection

5. DISCUSSION

Although surgical treatment is the best option for treating many lung diseases including bronchopulmonary cancer, many lung diseases, tumors in the first place, occur in patients with impaired pulmonary function due to the associated COPD, what is caused by the common etiological factors, especially cigarette smoking (1, 2). The decision about surgery in these patients is difficult because of the lack of respiratory reserve causing postoperative morbidity and mortality (3-5). Leading cause of postoperative

Figure 1. Reduction in pulmonary function after different volumes of lung resection compared to preoperative values expressed as percents

morbidity and mortality are pulmonary complications (5, 6, 8, 9).

Indicating of thoracic surgical operation depends on the type, localization and extent of the lung process (3, 4, 6-9, 12-16). In the assessing the possibility of performing each thoracic surgical operation there is necessary close cooperation between pulmonologists and thoracic surgeons (6-9). The possible extent of lung resection is planned preoperatively depending on the cardiovascular and pulmonary functional status (1-24). For each patient preoperative staging is essential that, if carefully designed, may be correct in 70-80% of cases (17).

Pierce J. et al. (18) in a series of 54 patients examined functional loss 3 months after surgery. According to them pulmectomy reduces lung volume by 30 to 40%, and less resection to 15%. In our study, the functional loss was, at left pulmectomy for men for FEV1 0.98 L or 36.7% compared to preoperative values, and in women, 0.9 L, or 44.12%. With the right pulmectomy functional loss in men is for FEV1 1.38 L, or 43.81%, while for women it is 0.54 L or 34.84%. In the left upper lobectomy in men FEV1 is reduced to 0.51 L, or 17.65%, in women it is also 0.51 L, but 22.08%. In the left lower lobectomy in men FEV1 decline of 0.55 L, or 18.46%, and 0.38 L in women or 17.92%. In the right upper lobectomy men and women lost in FEV1 0.41 L but compared to preoperative values, the decrease was 15.97% for men and for women 20.30%. In the right lower lobectomy in men FEV1 decreased by 0.60 L, or 22.14%, while for women it is 0.22 L, or 13.10%.

Bolliger CT and colleagues (19) have been doing tests of lung function in 68 patients before and 3 and 6 months after lung resection. In 50 patients lobectomy and in 18 pulmectomy was done Three months after lobectomy FVC, FEV1, TLC, DLCO, and maximum oxygen consumption were significantly lower than the preoperative values, grew between 3 and 6 months, and 6 months later still showed significantly less values than preoperative ones. In pulmectomy these tests were significantly lower three months after surgery and did not subsequently repaired. Six months after resection a functional deficit has persisted in comparison with preoperative values for FEV1 and so 9% for lobectomy and 34% for pulmectomy. The results were identical regardless of whether the preoperative pulmonary function was normal or damaged.

Bria MF et al. (20) did testing on 20 patients with lobectomy whose average preoperative FEV1 was 1.73 L.

Preoperative tests were performed within a month before the surgery and post-operative after 1 week to 3 years (average 1.5 years). The average loss of FEV1 in lobectomy was 150 ml and the biggest fall was 870 ml. These authors suggest that up to 70% of lung function may be present in diseased parts of the lung and therefore they require careful preoperative tests. In our study the biggest drop occurred after lobectomy in a patient 69 years old who had right lower lobectomy and in whom the FEV1 decreased by 0.93 L, but as compared to preoperative values expressed as% of normal for the patient it made a reduction of 25.2%. The largest decline after pulmectomy occurred in a patient who had right pulmectomy where FEV1 decreased by 1.66 L but as compared to preoperative values expressed as% of normal for the patient it was 52% (it was the patient with advanced COPD who did not take the recommended bronchodilator therapy) and patient with left pulmectomy where FEV1 decreased by 1.71 L but as compared to preoperative values expressed as% of normal for the patient it was 49%.

Zether BH et al. [21] have determined the effects of pulmonary resection on lung function in 62 patients. Of the patients who had lobectomy eight had irradiation treatment after surgery. They lost an average of 5.47% FEV1 per resected segment, although it is not clear whether this is a transient phenomenon due to regional postirradiative pneumonitis or permanent loss, and patients who had not irradiation have lost on average 2.84% of FEV1 by resected segment. These authors worked postoperative pulmonary function tests, on average, 8.5 months after lobectomy and 7.2 months after pulmectomy (from 24 days to 5 years). In 49 patients who had lobotomy mean preoperative value for FEV1 were 2.49 ± 0.13 L, mean post-operative value of FEV1 was 2.12 ± 0.1 . FEV1 is reduced for $13.3 \pm 2.2\%$ and $3.27 \pm 0.55\%$ for the resected segment. Middle FEV1 of 13 patients with pulmectomy before surgery was 2.24 ± 0.52 L. Middle postoperative FEV 1 was 1.56 ± 0.37 L, It was $29.0 \pm 3.94\%$ decrease in FEV1 or $3.07 \pm 0.42\%$ for the resected segment.

The remaining lung tissue, after lung resection, adapts to the loss of part of the area for gas exchange by creating a new functional area of ventilation and perfusion with an increase of relationship-RV/TLC. This adaptation occurs in the first few months after surgery, and for 6-12 months remaining lung tissue receives its definitive form. This is a result of distension of the lungs (23). However, in patients with COPD distension is not likely to happen because the lung before surgery was maximally stretched and can not be further stretched. Therefore the creation of new functional area is limited (24). In pulmectomy the asymmetry of ventilation between the two lungs may preexisted. Before surgery FEV1 is the summation of expiratory flow of left and right lung. Unilateral obstruction due to tumor or partially destroyed parenchyma can reduce postoperative forced expiratory flow rate less than expected.

Alli MK (22) showed that lung function was relatively stable after pulmectomy but in lobectomy it is reported to exist disproportionate early loss, and afterward it came to significant functional improvement as found in the study Bolliger J et al. (19). Pulmonary function was significantly increased during the long follow-up (more than 3

months). Clinicians should be aware of this phenomenon, especially in patients with marginal lung function and be ready to intervene to prevent the development of acute respiratory failure shortly after operation. Alli MK (22) found that, in the early postoperative period, a decline in FEV1 of 30 % for lobectomy existed with subsequent recovery. In a study of Marcos J (15) it is not confirmed, he found the mean decrease for 3 months for FEV1 of 17% compared to preoperative values.

6. CONCLUSION

Today there is an increasing need for resective thoracoscopic operations, primarily due to an increase in the number of patients with lung cancer, which often develops in patients with already impaired pulmonary function due to associated chronic obstructive pulmonary disease (COPD), that is caused by the common etiological factors primarily cigarette smoking. Patients with airway obstruction are limited in their daily lives before surgery, and an additional loss of lung tissue after resection contributes to their inability. Each resection of lung tissue leads to a decrease in lung function and according to our study in pulmectomy up to 44%, and lobectomy and up to 22% compared to preoperative values which should be taken into account in preoperative assessment. During the preoperative functional assessment two questions should be asked: whether cardiopulmonary reserve is sufficient to make the patient survive the operation and whether the patient will be chronically unable of daily life due to insufficient lung function. Potential benefit from pulmonary resection should be carefully balanced in relation to postoperative morbidity and mortality.

CONFLICT OF INTEREST: NONE DECLARED

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