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**DOCTORATE THESIS**  
**RESPIRATORY RECOVERY POST  
THORACO-PULMONARY SURGERY**

**ABSTRACT**

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**Keywords:**

Pulmonary rehabilitation, bronchopulmonary cancer, FEV1, lobectomy, histopathological type.

## INTRODUCTION

This theme is still very actual, because of the growing incidence in bronchopulmonary pathology all over the world. It is well known that both chest and lung surgery causes changes of the pulmonary function. We consider that all patients following surgery should be included in respiratory recovery programs. Pulmonary rehabilitation is an efficient program, as well as an integrated part of both preoperative and postoperative thoracic surgery. This role is proven by its beneficial action on numerous organs and systems (pulmonary system, muscular system, osteoarticular system, neuropsychic system, etc). Spirometry is the most accessible method of quantification, diagnosis and control of respiratory function used for the evaluation in lung disease patients.

Bronchopulmonary Cancer (BPC) is a critical illness and the main cause of mortality, triggered by neoplasia around the world. Only 1/3 of cases could benefit from surgical treatment with the aim of oncological radicality, because of the later development in clinical signs and in many cases, the evolution is asymptomatic for a long time. Smoking, atmospheric pollution, occupational exposure to various noxes, genetic factors, preexisting lung lesions (pulmonary infarction, scars after old lung TB lesions, etc), all of these multiple causes are increasing the risk of bronchopulmonary cancer onset and development.

The thesis is structured as follows: the first part, the *General Part*, contains a presentation of the data in the literature with the most used thoracic surgical techniques, Pulmonary Rehabilitation programs, and the patients evaluation before performing the optimal surgical treatment.

*The special part* - personal contributions, the second part of the thesis, include two phases of scientific research:

**The first part** of this study aims to highlight the importance of neoplastic pathology in pulmonary surgery, the incidence of bronchopulmonary cancer in western area of Romania, the location of pulmonary cancer in the lung, the type of surgical procedure performed, and the histopathological type of bronchopulmonary cancer.

**Part II**, describes the implementation of Pulmonary Rehabilitation in postoperative lung surgery analysis. Pulmonary rehabilitation as part of thoracic surgery has a beneficial effect on reducing symptoms, increasing exercise capacity and, as well as improving quality of life. 32 tables and 23 figures and images were used for a more accessible argumentation and understanding processes. The bibliography includes 154 items from specific journals with a high impact index.

## **GENERAL PART**

### **Chapter 1. The importance of the studied domain**

Chronic Obstructive Bronchopneumopathy (COPD), asthma, and bronchopulmonary cancer, have a negative effect on duration and quality of life. According to the American Cancer Society (ACS), the incidence of this type of neoplasm has increased significantly, becoming the major cause of death in the world in both men and women (10). Pulmonary rehabilitation it is very useful in the treatment of patients with chronic respiratory diseases demonstrating a beneficial effect.

### **Chapter 2. Type of Surgery used in the Thoracic Surgery**

It includes 9 subchapters related to: the thorax and lung surgical anatomy, and the primary surgical approach of bronchopulmonary cancer according to the progressive stages of the disease. The description of the most common surgical techniques used for thoracic opening, and for pulmonary resection (pneumonectomy, lobectomy) made for both radical purposes as well as diagnosis or palliative purposes (atypical lung resection / pulmonary tumor biopsy) has an important role.

### **Chapter 3. Methods used for patients assessment in thoracic surgery**

It includes: respiratory function assessment using spirometry, interpretation of the most objective parameter that is FEV1, determining the maximum inspiratory pressure (PI<sub>max</sub>) and the maximum expiratory pressure (PE<sub>max</sub>), effort capacity assessment, the six-minute walk test (6MWT), and the quantification of the degree of dyspnea – using BORG scale.

### **Chapter 4. The evolution of the Pulmonary Rehabilitation concept**

Pulmonary rehabilitation is the art of medical practice in which an individual program is formulated based on multidisciplinary approach. This kind of program uses positive diagnosis, therapy, emotional support and education in order to reduce the symptoms. The program should be as flexible as possible in order to accommodate patients and adapted as needed in an individualized way (for example: In patient, Out patient, Home patient, Community rehabilitation).

## **SPECIAL PART**

### **Chapter 5. Study's aim and background**

The main objectives of the study were:

- The implementation of Pulmonary Rehabilitation procedure for bronchopulmonary cancer,

- How the following aspects on the implementation of Pulmonary Rehabilitation are included in thoracic surgery: location, type of surgical procedure (curative, palliative or diagnostic), histopathological type, pulmonary function testing?
- Establishing the role of respiratory function assessment in lung resections.

## **Chapter 6. Material and Method**

The prospective study was performed between 1 January 2008 and 31 December 2015 at Timisoara City Emergency Hospital – the Thoracic Surgery Clinic in collaboration with Timișoara "Victor Babeș" Hospital's Respiratory Medical Recovery Center. At first, the data of 279 patients diagnosed with bronchopulmonary neoplasm by thoracotomy in general anesthesia were analyzed. In the second part, we analyzed the postoperative data of 265 lung cancer patients who were included in the Pulmonary Rehabilitation Program.

Due to the postoperative complications or low compliance during the Rehabilitation Program, the majority of patients were excluded, so the final analysis was performed only on 26 patients. All those included in the Rehabilitation Program were initially evaluated and at 6 months follow up. The evolution of the different parameters (FEV1, CV, 6MWT, BORG scale, anxiety, depression) as well as the benefits of this program were registered. Pulmonary Rehabilitation programs were complex, started immediately postoperative, as soon as the first day after the intervention and several types of actions were included (education, physical training, medication, gymnastics and respiratory physiotherapy).

## **Chapter 7. Results and Discussions**

### **7.1 Surgically treated Bronchopulmonary Cancer in western part of Romania – Retrospective analysis (2008 – 2012) - Study I**

Bronchopulmonary cancer was more commonly diagnosed in males, 200 patients (representing 71.68%), the majority from urban areas - 174 patients (representing 62.36%). The most common localization of the bronchopulmonary cancers is in the upper pulmonary lobes: 31.54% upper left lobe (LSS) (n = 88); 30.82% upper right lobe (LSD) (n = 86). Patients who received radical surgical treatment were in smaller number 15.41% (n = 43) of cases were lobectomy or pneumonectomy. Because of the late diagnosis in bronchopulmonary cancer, 84.58% of patients received palliative / surgical intervention as follows: 48.02% of cases (n = 134) required atypical lung resection and 36.55% of cases (n = 102) required pulmonary tumor biopsy. The anatomopathological diagnosis of adenocarcinoma was established in 38.37% (n = 135), being the most common type of bronchopulmonary neoplasm in both genders: male (representing 24.40%) and females (representing 13.97%). The second type of bronchopulmonary neoplasm observed was squamous carcinoma: 27.59% (n = 77). Other types of neoplasms highlighted were: small cell carcinoma, typical carcinoid, undifferentiated non-small cell carcinoma (NSCLC), and pulmonary metastases (adenocarcinoma, malignant melanoma, leiomyosarcoma).

## 7.2 Pulmonary function assessment and the implementation of pulmonary rehabilitation in bronchopulmonary cancer analysis – Study II

The diagnosis of bronchopulmonary cancer was more frequent in male patients (n = 190, representing 71.7%), most of them from urban areas (n = 175, representing 66%). Increased incidence was in the age group between 60 - 69 years (n = 110, representing 41.5%). The most common location of the bronchopulmonary cancers is in the upper pulmonary lobes, especially in male as follows: 26.8% upper right lobe (LSD) (n = 71); 24.9% upper left lobe (LSS) (n = 66). The surgical intervention having the purpose of radical oncology was performed in 24.6% of patients (n = 65). Unfortunately the palliative or diagnosis surgical interventions were the most numerous, representing 75.4% (n = 200), followed by atypical resections representing 54.3% (n = 144).

Any thoracic surgery, especially pulmonary resection, requires a preoperative assessment in order to determine the type of intervention, risk and prognosis (according to the pulmonary function).

**Table 22 - Minimal functional respiratory assessment for lung resection**

Spirometry	Unit of measurement	Normal	Pneumonectomy	Lobectomy	Wedge resection	Pulmonary tumor biopsy
FEV1%	% of predicted value	100%	>64%	>51%	>37%	>30%
FVC%	% of predicted value	100%	>72%	>52%	>40%	>35%
FEV1%/FVC% (IPB)	% of predicted value	100%	>89%	>61%	>38%	>45%

After 6 months, of FEV1% was increased by + 4.3%, above the predicted value according to FEV1 ppo calculation in patients including rehabilitation program who have upper right lobectomy or right inferior lobectomy. At the time we observed a significant increase in FEV1% + 5% over the predicted value, according to FEV1 ppo calculation in patients included in this programme who were under surgery of left upper lobectomy or lower left lobectomy were performed.

Comparative tests between right lung and left lung radical surgery (lobectomy) showed that the right lobectomy is associated with a slower respiratory recovery and needs a longer period of time for achieving this target. In surgical treated lung carrier patients the process of rehabilitation was beneficial in trends of increasing functional status and exercise tolerance.

We observed a better performance at the 6 minute walk test. The average distance was increased by + 32.50 meters (from 471.15 meters to 503.65 meters), when compared to the control group, in which the distance had improved with an average value of + 26.4 meters.

It was also observed an improving clinical symptoms (meaning a decreasing dyspnea) in all compliant patients included in the pulmonary rehabilitation program. The BORG Scale was used for dyspnea quantification. After the test 6 minute walking (6MWT) the results showed that the dyspnea decrease with an average value of -0.81 units.

It is known that once communicated, the lung cancer diagnosis induces negative emotions, as general anxiety and depression. These negative changes have serious effects on the quality of life and even the survival could be influenced by them. At the beginning of the study, most of the patients had a normal a normal anxiety and depression score (ranging from 0-7 units) representing 77% (n = 20) anxiety, respective 85% (n = 22) for depression.

According to our results those who were proposed for surgery – lobectomy (n = 26), are more anxious, (representing 19%, n=5) achieved a score above 8.7 units. In the same time depression was found in 3 patients (n=3, representing 11%), they have a result of 7.67 units

The 6 months followed up rehabilitation program assessment shows an improvement in both anxiety (respectively a decrease of -5.27 units), and depression score (the score decrease by -3.55 units).

### **Chapter 8. Discussions**

British Thoracic Society, European Respiratory Society and American Thoracic Surgery - BTS, ERS/ATS guidelines recommends that preoperative FEV1% should not be <80% of the estimated value when talking about planned surgery. Now days the threshold value of 80% from the estimated FEV1% is used in current practice. The absolute contraindication for lung resection due to the operator's risk, the high incidence of cardio-respiratory complications and death in the postoperative period is the preoperative respiratory functional values of FEV1% less than 30% of those predicted. It is known that preoperative FEV1% values ranging between 30% and 40% have brought more risks than benefits of surgery. In patients with an increased postoperative risk the cardio-pulmonary testing is mandatory. It was observed that there is a low rate of morbidity and postoperative mortality, ranging between 1-15%, in surgical patients with a preoperative FEV1% <40%. Cesario et al reported in one study that non-small cell lung cancer patients, following surgical treatment (thoracotomy and pulmonary resection) would benefit from a postoperative pulmonary rehabilitation programme. The 6 minute exercise test assessment showed that they had an improved walking distance and a decreased dyspnea evaluated using the BORG scale (148).

If there are no postoperative complications during and immediately after pulmonary resection, the VC is recovering within the first month, and FEV1 within 3 months. Lobectomy reduces lung volume on average by 10%, and pneumonectomy reduces lung volume by 20% to 30%.Funakosi et al studied the effects of lobectomy on long-term lung cancer patients (150). He showed that after surgery the postoperative value of CV and FEV1 decreased significantly after 1 month and the recovery was slow, between 3 to 6 months and 1 year.

In all patients at 2 weeks after surgery the VC decreased by 33% and FEV1 by 28% compared to preoperative values. In our study we noticed that after lobectomy the postoperative FEV1% value followed rehabilitation increased by 4.3% over the predicted value. We also observed an increase in exercise tolerance, an improvement in respiratory

function with the improvement of dyspnea. After completing the 6 months Pulmonary Rehabilitation program the value of all the studied variables (FEV1, CV) were significantly improved.

Nomori et al showed that maximum inspiratory pressure (Pimax) and maximum expiratory pressure (Pemax) decreases after thoracotomy compared the preoperative values. (151). After 3 months of rehabilitation the Pimax and Pemax values improved by up to 80%, so the tendency to recover the strength of the respiratory muscles through this program is beneficial.

According to our data, those who have been proposed for surgery are more anxious. An improvement in both anxiety and depression scores was observed at the 6 months rehabilitation program assessment.

**Chapter 9.** It includes the limits of this study and the main future directions.

### **Chapter 10. Conclusion**

1. Bronchopulmonary cancer is a critical illness, with late clinical signs development that could have an asymptomatic evolution for a long period of time. Although this disease is very common, the percentage of patients who benefit from oncology radical surgery is low approximately 30%.
2. The bronchopulmonary cancer was predominant in male versus female gender. The M to F ratio was 2.53:1.
3. The majority of patients were from urban areas, the average age was  $58.24 \pm 9.26$  years, and the youngest patient diagnosed with bronchopulmonary cancer had only 24 years old.
4. The bronchopulmonary cancer most common location was in the upper pulmonary lobes.
5. The surgical treatment was performed using the open approach. The most cases were diagnosed in advance stages of the disease, so 436 patients, representing 79.99% underwent palliative / diagnostic surgery,
6. Adenocarcinoma was the most common type of bronchopulmonary neoplasm in both male and female gender. The majority of the tumors were NSCLC - 83.85%.
7. Radical surgery (pneumonectomy and lobectomy) can be performed in patients having preoperative FEV1% > 64%, respectively preoperative FEV1% > 51%.
8. Diagnostic or palliative surgery could be performed in patients with preoperative FEV1% > 30%.

9. In patients included in the Pulmonary Rehabilitation program, at 6 months after having left upper lobectomy or lower left lobectomy surgery we observed a significant increase in FEV1% + 5% over the predicted value, according to FEV1 ppo calculation.
10. In patients included in the Pulmonary Rehabilitation program, at 6 months after having right upper lobectomy or lower right lobectomy surgery we observed a significant increase in FEV1% + 4.3% over the predicted value, according to FEV1 ppo calculation.
11. At 6 months follow-up we observed a better performance at the 6 minute walk test. The average distance was increased by + 32.50 meters (from 471.15 meters to 503.65 meters), when compared to the control group, in which the distance had improved with an average value of + 26.4 meters.
12. The dyspnea score using BORG scale was also decreased by -0.81 units.
13. Thoracotomy affects the thoracic wall muscle. The patients included in the Rehabilitation Program, had a significant improvement in the respiratory muscles strength, evaluated using both Pimax (the average increase +0.74 kPa) and Pemax (the average increase +0.93 kPa).
14. In lung cancer patients the Pulmonary rehabilitation has a positive effect on the quality of life, by decreasing both the anxiety score ( by -5.27 units) as well as the depression score (by -3.55 units).