# Original Article

# Lobectomy for treating bronchial carcinoma: analysis of comorbidities and their impact on postoperative morbidity and mortality*

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## ABSTRACT

**Objective:** To analyze the impact that comorbidities have on the postoperative outcomes in patients submitted to lobectomy for the treatment of bronchial carcinoma. **Methods:** A retrospective study of 493 patients submitted to lobectomy for the treatment of bronchial carcinoma was conducted, and 305 of those patients met the criteria for inclusion in the final study sample. The surgical technique used was similar in all cases. The Torrington-Henderson scale and the Charlson scale were used to analyze comorbidities and to categorize patients into groups based on degree of risk for postoperative complications or death. **Results:** The postoperative (30-day) mortality rate was 2.9%, and the postoperative complications index was 44%. Prolonged air leakage was the most common complication (in 20.6%). The univariate analysis revealed that gender, age, smoking, neoadjuvant therapy and diabetes all had a significant impact on the incidence of complications. The factors found to be predictive of complications were body mass index (23.8 ± 4.4), forced expiratory volume in one second (74.1 ± 24%) and the ratio between forced expiratory volume in one second and forced vital capacity (0.65 ± 0.1). The scales employed proved efficacious in the identification of the risk groups, as well as in drawing correlations with morbidity and mortality ($p = 0.001$ and $p < 0.001$). In the multivariate analysis, body mass index and the Charlson index were found to be the principal determinants of complications. In addition, prolonged air leakage was found to be the principal factor involved in mortality ($p = 0.01$). **Conclusion:** Reductions in forced expiratory volume in one second, in the ratio between forced expiratory volume in one second and forced vital capacity, and in body mass index, as well as a Charlson score of 3 or 4 and a Torrington-Henderson score of 3, were associated with a greater number of postoperative complications in patients submitted to lobectomy for the treatment of bronchial carcinoma. Air leakage was found to be strongly associated with mortality.

**Keywords:** Lung neoplasms/surgery; Postoperative complications; Pneumonectomy; Morbidity

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## INTRODUCTION

Currently, of the 1.2 million lung cancer deaths, 87% are related to smoking. Between 1980 and 1990, the incidence of bronchial neoplasia among women quintupled, whereas it remained stable with a tendency toward a decline among men.[1] It was estimated that, in 2005, there would be 163,510 lung cancer deaths in the USA, 29% of all the cancer deaths in that country.[2] In Brazil, in a population of 186 million inhabitants with 30 million smokers, lung cancer is the leading cause of death from neoplasia among men and the second among women. The number of new lung cancer cases estimated for Brazil in 2006 is 27,170, with an estimated risk of 19 new cases per 100,000 men.[3]

Total mean cumulative 5-year survival remains low, ranging from 13% to 21% in developed countries and from 7% to 10% in developing countries.[3]

Surgical treatment remains the therapeutic measure related to better survival rates among correctly staged patients, with lobectomy being the most frequently used type of resection, accounting for 80% of the cases in some studies.[4]

Postoperative complications have a significant impact on outcomes and survival in these patients. Factors that influence the incidence of postoperative complications include pre-existing cardiovascular disease, chronic obstructive pulmonary disease (COPD) and neoadjuvant treatment.[5-8] Few studies have focused on lobectomy in the analysis of morbidity and mortality in lung cancer and its risk factors.[5] This study is a retrospective analysis of patients submitted to lobectomy for lung cancer, with an emphasis on the most prevalent accompanying diseases in this group, as well as on the complications and their impact on postoperative mortality.

## METHODS

The medical charts of patients submitted to lobectomy for lung cancer between January of 1998 and December of 2004 were reviewed. Only patients submitted to resection of a single lobe of the lung parenchyma were included. Those in which the resection extended to other lobes, other segments, the chest wall or diaphragm were excluded, as were those undergoing bronchial sleeve resections and those who had previously been submitted to lung resection. The diagnosis and staging included computed tomography scans of the chest and upper abdomen as well as fiberoptic bronchoscopy. Patients with bone or neurological symptoms were submitted to a specific inventory, whereas those unequivocally without any involvement of these systems were referred for surgery.

The same team performed the surgical procedures in all patients, using similar surgical and anesthesia techniques. All patients were submitted to mediastinoscopy during the same anesthetic session employed for the thoracotomy. If the lymph node biopsies tested negative for neoplasia, the resection proceeded. Patients in which the lymph nodes ipsilateral to the lesion were affected by neoplasia and a prescalene ipsilateral biopsy was negative were referred to the oncology clinic for neoadjuvant treatment (if indicated). The resections were carried out through posterior lateral thoracotomy with preservation of the dorsal muscle, manual suture of the lobar bronchus using nonabsorbable monofilament sutures, closure of the remaining fissures with a surgical stapler and ipsilateral mediastinal lymph node drainage. Two drains were placed in the pleural cavity and were kept water-sealed until the arrival in the intensive care unit, at which time continuous aspiration was started (15 to 20 cm $H_2O$). Ventilation during the procedure was monopulmonary and was performed using a double-lumen orotracheal tube.

Most patients were extubated in the operating room or immediately after arriving in the intensive care unit. No patient remained intubated for more than 12 h after surgery. All the patients received epidural analgesia through postoperative catheter. Chest X-rays were taken every 24 h in the first 72 h to assess lung re-expansion and to detect any potential complications. The patients were discharged from the intensive care surgical unit after 48 h, or when they presented favorable clinical conditions. If there was no air leak, the chest tubes were removed when the drainage was less than 200 ml/24 h. Prolonged air leak was defined as the loss of air through the drains beyond postoperative day seven. The duration of hospitalization was counted from the day of surgery until discharge or death.

In this study, COPD was defined as obstruction of the respiratory tract that is irreversible in the

bronchodilator test. According to the criteria established by the American Thoracic Society and European Respiratory Society,(9) patients with a ratio of forced expiratory volume in one second to forced vital capacity ($FEV_1/FVC$) = 0.7 were considered to have COPD. The $FEV_1$ value (% of predicted) was used to classify the disease severity. For smokers, cigarette consumption was quantified in pack-years. Comorbidities and their frequency are described in Table 1. The perioperative respiratory therapy risk assessment scoring system devised by Torrington & Henderson[10] was applied to define the risk groups for respiratory complications, and the Charlson index was used to identify the risk groups for postoperative complications and mortality according to the comorbidities (Table 2).

TABLE 1

**Preoperative comorbidities and their frequencies**

| Comorbidities | n | % |
|---|---|---|
| **Cardiovascular** | | |
| Acute myocardial infarction | 8 | 2.6 |
| Angina | 38 | 14.4 |
| Arrhythmias | 25 | 8.2 |
| Cardiac insufficiency | 20 | 6.5 |
| Valvulopathies | 38 | 22.3 |
| Systemic arterial hypertension | 109 | 35.7 |
| Peripheral arterial disease | 10 | 3.27 |
| **Respiratory** | | |
| COPD | 171 | 56 |
| Pulmonary fibrosis | 3 | 1 |
| Sarcoidosisin | 1 | 0.3 |
| **Nutritional** | | |
| Dyslipidemia | 14 | 4.6 |
| Obese | 34 | 11.1 |
| Underweight | 16 | 5.2 |
| **Endocrine** | | |
| *Diabetes mellitus* | 30 | 9.8 |
| Hypothyroidism | 5 | 1.6 |
| **Hepatic** | 3 | 1 |
| **Rheumatologic** | 5 | 1.6 |
| **Autoimmune** | 6 | 2 |
| **Renal** | | |
| Chronic renal insufficiency | 6 | 2 |
| **Neurological** | | |
| Cerebrovascular accident | 7 | 2.2 |
| **Infectious** | | |
| HIV | 1 | 0.3 |

COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus

The data were stored in an electronic spreadsheet (Microsoft Excel®) and assessed through univariate and multivariate analysis using the SPSS 12.0 statistical program (SPSS Inc., Chicago, IL, USA).Risk factors for complications and their respective incidences were identified. The categorical variables were compared using the chi-square and Fisher's exact tests. Pearson's correlation coefficient was used to identify correlations among the quantitative variables. The Student t-test was utilized for comparisons between the groups. In order to identify possible confounding variables, multiple logistic regression was used. The data are represented as mean standard deviation from the mean. The statistical significance was set at $p < 0.05$.

## RESULTS

Of the 493 patients undergoing lobectomies for lung cancer during the studied period, 305 met the inclusion criteria. Males predominated (68.5%), and the average age was 63.7 ± 9.7 years. There were 79 patients (26%) who were over 70 years of age. Of the patients studied, 90% of the patients had a history of smoking, with a mean consumption of 49.9 ± 27.7 pack-years. The mean body mass index (BMI) was 24.4 ± 4.4 $kg/m_2$. A total of 27 patients (8.8%) received preoperative chemotherapy. Preoperative comorbidities were reported in 256 patients (83.9%) (Table 1).

The most commonly performed lobectomy was of the upper right lobe (in 34%), followed by the upper left lobe (in 31%), lower right lobe (in 16%), lower left lobe (in 14%) and middle lobe (in 5%). The mean duration of chest tube usage was 5.9 4.3 days, and the mean duration of the postoperative hospital stay was 9.6 ± 8.7 days. Postoperative complications occurred in 44% of the patients, with surgical complications being the most frequent (79 patients, 25.9%) (Table 3). Respiratory complications occurred in 24.9% of the patients, with atelectasis being the most common. Among the cardiovascular complications, atrial fibrillation predominated. The 30-day operative mortality rate was 2.9%, and overall in-hospital mortality was 3.9%.

The postoperative histopathological tests revealed the following: adenocarcinoma (in 58.3%); epidermoid carcinoma (in 31.8%);

TABLE 2

**Escala de Torrington e Henderson e índice de Charlson aplicados às 305 lobectomias por carcinoma brônquico**

| **Torrington-Henderson Score** | | **Charlson Index of Comorbidity** | |
|---|---|---|---|
| Risk factors | Points | Comorbidities | Points |
| Spirometry (0-4 points) | | Coronary disease | 1 |
| | | Cardiac insufficiency | |
| FVC < 50% | 1 | Chronic obstructive disease | |
| | | Peptic ulcer | |
| $FEV_1$/FVC | | Peripheral vascular disease* | |
| 65-75% | 1 | Mild liver disease | |
| 50-65% | 2 | Cerebrovascular disease | |
| < 50% | 3 | Diseases of the connective tissue | |
| | | Diabetes | |
| | | Dementia | |
| Age > 65 years | 1 | | |
| | | Hemiplegic | 2 |
| | | Moderate to severe kidney disease | |
| | | Diabetes with lesions in organs | |
| Morbid obesity BMI > 45kg/m$^2$ | 1 | History of neoplasia (up to 5 years prior)** | |
| | | Leukemia | |
| | | Lymphoma | |
| **Locale of surgery** | | | |
| Thoracic | 2 | | |
| Upper abdominal | 2 | | |
| Other | 1 | | |
| **Pulmonary history** | | Moderate to severe liver disease | 3 |
| Smoker (last 2 months) | 1 | | |
| Respiratory symptoms | 1 | | |
| History of lung disease | 1 | Solid metastatic tumor AIDS | 6 |
| Points | Risk | Index | RisK*** |
| 0-3 | Low | 0 | - |
| 4-6 | Moderate | 1-2 | (0.8-17.1) |
| ≥ 7 | High | 3-4 | (2.1-45.9) |
| | | ≥ 5 | (0.7-186) |

FVC: forced vital capacity; $FEV_1$: forced expiratory volume in one second; BMI: body mass index; AIDS: acquired immunodeficiency syndrome; *Peripheral arterial disease; **Skin tumors are not considered; ***95% Confidence interval

undifferentiated (in 2.3%); large-cell carcinoma (in 2.3%); carcinoid (in 1.6%); adenosquamous cell carcinoma (in 1.6%); and other pathologies (in 1.9%). The final staging was: IA (in 17%); IB (in 45%); IIA (in 3.3%); IIB (in 13.4%); IIIA (in 17%); IIIB (in 6%); and IV (in 1.7%).

The univariate analysis revealed that gender and smoking habits presented no significant differences in terms of the incidence of postoperative complications. Being over 70 years of age also had no significant impact, since the mean age of those who presented complications was 65. Among those who presented complications (Table 4), the mean BMI was significantly lower. The absolute $FEV_1$ values, $FEV_1$ percentages and $FEV_1$/FVC ratios were also lower in this group.

Patients with COPD did not present a higher percentage of complications than did those in the group without COPD. For the patients with COPD, its severity was classified according to $FEV_1$ (%), and those with more severe COPD had more complications ($p < 0.001$).

Complications were more common among patients with higher Charlson indices. In the logistic regression, the Charlson index and BMI correlated significantly with the occurrence of complications ($p = 0.001$ and $p = 0.003$, respectively). A history of diabetes, neoadjuvant therapy, COPD and obesity presented no statistical significance, in contrast with $FEV_1$, FVC, $FEV_1$/FVC, low BMI and prolonged

TABLE 3

**Postlobectomy complications among the 305 patients with lung cancer**

| Complications | Patients | % |
|---|---|---|
| **Respiratory** | 76 | 21 |
| Atelectasis | 47 | 15.4 |
| Pneumonia | 28 | 9.2 |
| Tracheobronchitis | 23 | 7.5 |
| Re-intubation and MV for 48 h | 14 | 4.5 |
| ARDS | 10 | 3.3 |
| Bronchospasm | 2 | 0.6 |
| PTE | 5 | 1.6 |
| **Cardiovascular** | 33 | 9 |
| Atrial fibrillation | 24 | 7.8 |
| Ventricular fibrillation | 1 | 0.32 |
| AMI | 9 | 2.9 |
| Acute pulmonary edema | 1 | 0.32 |
| Surgery | 79 | 22 |
| Prolonged air leak | 63 | 20.6 |
| Empyema | 20 | 6.5 |
| Hemothorax | 14 | 4.6 |
| Bronchial fistula | 2 | 0.6 |
| Chylothorax | 3 | 0.9 |
| Pneumothorax | 5 | 1.6 |

MV: Mechanical ventilation; ARDS: acute respiratory distress syndrome; PTE: Pulmonary thromboembolism; AMI: acute myocardial infarction

air leak, which were found to be predictive of respiratory complications (Table 5). The Torrington & Henderson scoring system applied in the preoperative assessment showed that high-risk patients presented more complications than did those in the other groups (p = 0.001). The multivariate analysis revealed that $FEV_1$ and prolonged air leak were determinants of respiratory complications (p = 0.001 and p < 0.001, respectively). A preoperative history of arterial hypertension, valvulopathies, heart failure, myocardial infarction, diabetes, dyslipidemia, obesity, COPD and low BMI were not significant factors in the development of cardiovascular complications. However, preoperative arrhythmias, angina and peripheral arterial disease were associated with the occurrence of postoperative cardiovascular complications (Table 5). Of the variables analyzed, the principal surgical complication was prolonged air leak, which was not associated with the lobe resected (p = 0.3). The multivariate analysis showed that the only variables significantly correlated with prolonged air leak were $FEV_1$ (%) and BMI (p = 0.006 and p = 0.04, respectively). The lobe resected also did not correlate with pulmonary or cardiovascular complications. However, a positive correlation was observed between atrial fibrillation and upper left lobe lobectomy (p = 0.015).

Mortality did not differ between the genders with respect to smoking, preoperative chemotherapy, COPD or BMI. Among the patients who were more elderly, the mortality was significantly higher (69.2  6.8 years vs. 63.5  9.7 years; p = 0.05). Despite this finding, mortality was not significantly higher among individuals over the age of 70 than among those younger than 70 (7.6% vs. 2.7%; p = 0.8). The $FEV_1$ values were also lower among patients who died than among those who survived (67.3 ± 19 and 81.4 ± 23; p = 0.04). The absolute $FEV_1$/FVC value was lower in the group of patients who died than in that of those who survived (0.59 ± 0.1 and 0.69 ± 0.12; p = 0.009). Higher Torrington & Henderson scores and Charlson indices were correlated with higher mortality. Mortality among patients with a Torrington & Henderson score of 3 was 20%, compared with 0.8% and 5.6%, respectively, among those with a score of 1 or 2 (p = 0.003). Among patients presenting a Charlson index of 3 or 4, the mortality was 13.6%. However, that value was not significantly different from that found for patients presenting a Charlson index of 1 or 2 (4.3% and 1.7%, respectively; p = 0.067).

Prolonged air leak was found to correlate significantly with the development of respiratory complications (p < 0.001), including empyema and the consequent acute respiratory distress syndrome. Mortality was higher among patients with prolonged air leak than among those without (9.5% vs. 2.5%). The univariate and multivariate analyses demonstrated that prolonged air leak was the principal determinant of postoperative mortality (p = 0.02 and p = 0.01, respectively).

## DISCUSSION

In recent studies involving patients with lung cancer, emphasis has been placed on survival, noting the discrepancies between staging and 5-year survival rates.[12] This is related to the fact that lung cancer patients present pre-existing clinical conditions that can affect survival. Some

TABLE 4

**General characteristics of the group of patients that developed postoperative complications**

| Characteristic | With complications | | Without complications | | |
|---|---|---|---|---|---|
| | n | % | n | % | p |
| Males | 95 | 45.5 | 114 | 54.5 | NS |
| Females | 38 | 39.6 | 58 | 60.4 | |
| Age* | 65.1 ± 8.9 | - | 62,7 ± 10,1 | - | NS |
| > 70 years of age | 35 | 44.3 | 44 | 55.7 | NS |
| BMI * | 23.8 ± 4.4 | - | 25,3 ± 4,3 | - | 0.0004 |
| Obese (> 30 kg/m$^2$) | 14 | 41.4 | 20 | 58.8 | NS |
| Underweight (< 18.5 kg/m$^2$) | 11 | 68.8 | 5 | 31.3 | 0.03 |
| Smokers | 125 | 45 | 151 | 55 | NS |
| Pack-years | 8 | 27.6 | 21 | 72 | NS |
| Nonsmokers* | 46.2 ± 30.2 | - | 44,4 ± 30,1 | - | NS |
| Neoadjuvant therapy | 14 | 51.9 | 13 | 48.1 | NS |
| $FEV_1$ (liters)* | 1.96 ± 0.74 | - | 2,3±0,73 | - | < 0.001 |
| $FEV_1$ (%)* | 74.1 ± 24 | - | 86,1±21 | - | < 0.001 |
| FVC (liters)* | 3 ± 0.9 | - | 3,2 ± 0,9 | - | NS |
| FVC (%)* | 88.8 ± 23 | - | 92,5 ± 18 | - | NS |
| $FEV_1$/CVF* | 0.65 ± 0.1 | - | 0,72 ± 0,09 | - | < 0.001 |
| $FEV_{1/}$CVF (%)* | 83.5 ± 17 | - | 92,9 ± 12 | - | < 0.001 |
| COPD | 74 | 43.3 | 97 | 56.7 | NS |
| No COPD | 59 | 44 | 75 | | 56 |
| COPD | | | | | |
| Mild ($FEV_1 \geq 80\%$) | 26 | 29.9 | 62 | 70.5 | |
| Moderate ($FEV_1$ 80-50%) | 33 | 50 | 33 | 50 | < 0,001 |
| Severe ($FEV_1$ < 50%) | 15 | 88.2 | 2 | 11.8 | |
| Torrington & Henderson score | | | | | |
| 1 | 42 | 32 | 91 | 68 | |
| 2 | 81 | 50 | 81 | 50 | < 0.001 |
| 3 | 10 | 100 | - | - | |
| Charlson index | | | | | |
| 0 | 34 | 28.8 | 84 | 71.2 | |
| 1-2 | 79 | 49.1 | 82 | 50.9 | < 0.001 |
| 3-4 | 47 | 77.3 | 5 | 22.7 | |
| ≥ 5 | 3 | 75 | 1 | 25 | |

BMI: body mass index; $FEV_1$: forced expiratory volume in one second; FVC: forced vital capacity; COPD: chronic obstructive pulmonary disease; NS: not significant; *mean ± standard deviation; **FEV1/FVC = 0.7; ***$FEV_1$/FVC =0.7; ****American Thoracic Society-European Respiratory Society standards for the diagnosis and management of patients with COPD

authors[13] reported that, among 450 patients with stage I lung cancer, 90% presented morbidities. After classifying the patients according to the Kaplan-Feinstein index, the authors concluded that the risk of dying within five years was doubled in those with moderate to severe comorbidities. Comorbidities are important prognostic factors in assessing lung cancer survival and are also related to postoperative morbidity and mortality.[14]

Although cardiovascular diseases increase the risk among patients with lung cancer, COPD continues to be the most significant factor, with the decrease in cardiopulmonary reserve among these patients being the factor that favors the principal postoperative complications, such as hypoxemia, prolonged fistula air flow, pneumonia, arrhythmias and the need for more than 48 h of mechanical ventilation.[15-16]

Postoperative complications in cases of lung cancer are related to various factors, including the type of resection performed. Some authors,[5] in their analysis of factors related to postoperative morbidity, found that resection of the thoracic wall or diaphragm and bronchial sleeve resection are factors

TABLE 5

**Characteristics of the patients that developed postoperative respiratory or cardiovascular complications**

| Characteristic | Respiratory complications | | | Cardiovascular complications | | |
|---|---|---|---|---|---|---|
| | n | % | p | n | % | p |
| **Age*** | 66 ± 8.9 | - | 0.01 | 66.9 + 8 | - | 0.04 |
| > 70 years | 24 | 30.3 | NS | 12 | 15.2 | NS |
| **Smokers** | 72 | 26 | NS | 31 | 11.3 | NS |
| Pack-years* | 50 ± 27 | - | NS | 50 + 36 | - | NS |
| **BMI kg/m$^2$ *** | 23.6 ± 4.5 | - | 0.02 | 24.21 ± 4.7 | - | NS |
| Obese | 9 | 26 | NS | 6 | 17.6 | NS |
| Underweight | 8 | 50 | 0.03 | 2 | 12.5 | NS |
| **Diabetes** | 8 | 26.6 | NS | 4 | 13.3 | NS |
| **Neoadjuvant therapy** | 8 | 29.6 | NS | 1 | 3.7 | NS |
| **Spirometry*** | | | | | | |
| $FEV_1$ (liters) | 1.80 ± 0.62 | - | <0.001 | 1.88 ± 0.6 | - | 0.03 |
| $FEV_1$ (%) | 70.4 ± 22.3 | - | <0.001 | 74 ± 22 | - | NS |
| FVC (liters) | 2.8 ± 0.85 | - | 0.001 | 2.9 ± 0.85 | - | NS |
| FVC (%) | 86.5 ± 21.8 | - | 0.035 | 90 ± 24 | - | NS |
| $FEV_1$/FVC | 0.64 ± 0.14 | - | 0.001 | 0.65 ± 0.13 | - | NS |
| $FEV_1$/FVC (%) | 81.7 ± 17.9 | - | <0.001 | 83.7 ± 19 | - | 0.05 |
| **COPD** | 46 | 26.9 | NS | 22 | 12,9 | NS |
| **No COPD** | 30 | 22.4 | | 11 | 8.2 | |
| **COPD** | | | | | | |
| Mild ($FEV_1 \geq 80\%$) | 14 | 16 | | 8 | 9 | |
| Moderate($FEF_1$ 79-50%) | 20 | 30 | <0,001 | 12 | 18 | NS |
| Severe ($FEV_1$ < 50 %) | 12 | 71 | | 2 | 12 | |
| **Torrington & Henderson score** | | | | | | |
| 1 | 21 | 15.7 | | 6 | 4,5 | |
| 2 | 49 | 30.3 | 0,001 | 24 | 14.8 | 0.003 |
| 3 | 6 | 60 | | 3 | 30 | |
| **Charlson index** | | | | | | |
| 0 | 16 | 13.5 | | 5 | 4.3 | |
| 1-2 | 47 | 30 | <0,001 | 21 | 13 | 0.004 |
| 3-4 | 12 | 54.5 | | 6 | 27.3 | |
| ≥ 5 | 1 | 25 | | 1 | 25 | |
| **Bleeding (ml)** | | | | | | |
| Operative* | 609 ± 458 | - | 0,01 | 587 ± 425 | 5 | 0.02 |
| Postoperative | 7 | 50 | 0,05 | 5 | 35.7 | 0.01 |

BMI: body mass index; $FEV_1$: forced expiratory volume in one second; FVC: forced vital capacity; COPD: chronic obstructive pulmonary disease; NS: not significant; *mean ± standard deviation; **$FEV_1$/FVC = 0.7; ***$FEV_1$/FVC =0.7; ****American Thoracic Society-European Respiratory Society standards for the diagnosis and management of patients with COPD

that increase the rate of complications. The present study assessed the impact of postoperative comorbidities in a sample of lobectomies with resection of the pulmonary parenchyma exclusively.

Age, until recently considered a limiting factor in the surgical treatment of lung cancer, has lost its importance in current series due to better selection of patients and conservative resections of the parenchyma, as well as to advances in anesthesia and intensive care. To date, there have been no studies showing age-related differences in morbidity and mortality among patients over 70 or even over 80, except in cases of pneumonectomy.[17] In the present study, the average age of patients who presented complications was higher that that of those not presenting complications. However, the rate of complications was no higher for the patients over

70 years of age than for those younger than 70.

Even in the absence of COPD, smoking is considered a risk factor for complications due to mechanisms that are secondary to the inflammatory effects of smoking. Such mechanisms include ciliary dyskinesia, increased neutrophil activity and the retention of secretions. These mechanisms typically return to normal only eight weeks after a smoker has quit the habit. This has lead some authors to advise that surgery not be performed before this period of smoking cessation has elapsed.[18] However, a recent study reported no differences between patients that quit smoking up to eight weeks before the surgery and those who did not in terms of postoperative respiratory complications.[19] Similarly, we found no differences between patients who had stopped smoking (former smokers) and those that were smokers at the time of the surgery. Likewise, the complications were not correlated with the number of pack-years. This may perhaps be explained by the fact that we did not find a significant correlation between the number of pack-years and a loss of pulmonary function.

The influence of nutritional status on morbidity is an important factor to be considered in lung surgery. Malnourished patients presenting a loss of muscle mass develop respiratory muscle fatigue, a predisposing factor in the accumulation of secretions and postoperative respiratory infection, which increases the probability of using mechanical ventilation and death.[7] Since the present study is retrospective, it has the limitation of the BMI being the only available indicator for the assessment of nutritional state. However, in the analysis of variables such as prolonged air leak and other more common respiratory complications, the patients who presented more complications were found to have lower BMI. Likewise, patients categorized as underweight (BMI < 18.5 kg/m$^2$) presented air leak beyond postoperative day seven more frequently than did those with normal BMI. This might have favored the occurrence of a greater number of respiratory complications, due to bed confinement and chest tube-related pain, as well as to the reduced respiratory muscle function.

In our study, diabetes mellitus, which is considered a risk factor for the occurrence of pneumonia in noncardiac surgical procedures,[20] did not present a correlation with respiratory complications, with the occurrence of empyema or with prolonged air leak, which is in agreement with the findings of other authors.[21]

The significance of preoperative chemotherapy as a risk factor for postoperative complications remains controversial.[22-23] Among the 27 patients submitted to neoadjuvant therapy, the rates of postoperative complications and mortality were comparable to those observed among the patients not receiving neoadjuvant treatment.

For defining the pulmonary status of a patient who is a candidate for resection, $FEV_1$ continues to be the most widely used parameter. It is thought that patients with no history of major cardiovascular disease who present values of $FEV_1$ and diffusing capacity of the lung for carbon monoxide above 80% can be submitted to pulmonary resection with no increased risk. In most of the patients included in this study, diffusing capacity of the lung for carbon monoxide was not tested prior to spirometry. Nevertheless, the analysis of the absolute values and percentages of $FEV_1$ and $FEV_1$/FVC correlated significantly with the occurrence of respiratory complications and prolonged air leak. The lowest mean values were found for patients presenting postoperative complications. The $FEV_1$/FVC ratio had a significant impact on mortality, the lowest mean values having been reported for patients who died. This might be due to the correlation between prolonged air leak and low $FEV_1$/FVC percentages.

No significant differences were found between the patients with COPD, defined as irreversible obstruction of the respiratory tract ($FEV_1$/FVC < 0.7 postbronchodilator), and those without in terms of the incidence of complications and death. This probably results from the fact that the majority of patients (51%) belong to the group classified as having the mild form of the disease, whereas only 10% had the severe form. This stratification by risk group proved effective in comparing the degree of disease severity with the complications, revealing that the percentage of patients with complications was higher in the groups of patients with moderate or severe COPD.

It is common for cardiovascular disease and lung cancer to be seen concomitantly.[24] Multifocal vascular lesions increase the risk of developing complications in pulmonary resections.[25] This study revealed that a history of angina, peripheral arterial disease and arrhythmias were significant

determinants of postoperative cardiovascular complications. The correlation between atrial fibrillation and the type of resection performed has been reported by other authors, especially in terms of pneumonectomy or lobectomy of the upper right lobe.[25] However, the correlation we found in this study with lobectomy of the upper left lobe has not been described in the literature and might be only a coincidence.

Our decision to apply two risk scales was based on the fact that they provide complementary information. The Torrington & Henderson scoring system was initially developed to identify individuals who would benefit from perioperative respiratory therapy. It was validated for use in Brazil as a means of identifying risk groups for respiratory complications in thoracic or upper abdominal surgery.[10,26] In the present study, the Torrington & Henderson scores revealed a direct correlation between the groups and the respiratory complications, with high-risk patients presenting more complications. The incidence of prolonged air leak was greater in the group of high-risk patients, and this was probably due to the influence that $FEV_1$/FVC had on the Torrington & Henderson score. In the present study, high-risk patients were also those in which mortality was most affected by the influence of prolonged air leak and its consequences. The use of continuous aspiration in our standard protocol might be considered a predisposing factor for prolonged air leak, although this would be contradictory to the findings in the literature.[21]

The Charlson index[11] is the most extensively studied comorbidity index. Compared with other indices that confirm its validity, it has been used in diverse situations as a predictor of mortality, duration of hospitalization and re-admission.[27] For lung cancer and the related postoperative morbidity/mortality, the index was validated in 2003.[14] Its use was recommended because it has greater predictive power than do the individual variables. Its application in our study revealed a positive correlation between higher indices and the incidence of greater respiratory/cardiovascular complications. In terms of mortality, higher indices were associated with greater mortality, with the exception of those patients with Charlson index of 5, which might be attributed to the low number of patients in that group (n = 4). For its practicality, this index is a useful tool in the classification of the risk levels of patients according to their respective comorbidities.

We concluded that, in this series of 305 lobectomies for lung cancer, lower values of $FEV_1$, $FEV_1$/FVC and BMI were associated with a greater number of complications. The Torrington & Henderson scoring system and the Charlson index were useful in the classification of the patients with greater risk of complications and death, and prolonged air leak through drains was the principal determinant of mortality.

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