Risk Factors for Early Mortality and Morbidity After Pneumonectomy: A Reappraisal

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Background. **Pneumonectomy remains a high-risk procedure. Comprehensive patient selection should be based on analysis of proven risk factors.**

Methods. **The records of 323 pneumonectomy patients were retrospectively reviewed. Multiple demographic data were collected. End points were operative mortality at 30 and at 90 days, major procedurally related complications, and cardiovascular events. Univariate and multivariate statistical analyses were performed.**

Results. **Smoking habits, chronic obstructive pulmonary disease (COPD) status, induction chemotherapy status, diabetes, and obesity had no statistical influence on short-term outcomes. After right pneumonectomy, 30-day mortality ($p = 0.045$) and the incidence of bronchopleural fistulas ($p = 0.009$) were increased. Multivariate analysis for postoperative bronchopleural fistulas discovered that right pneumonectomies are the sole risk factor ($p = 0.015$). Univariate analysis for postoperative atrial fibrillation showed that male gender, age 70 and older, hypertension, and dyslipidemia are risk factors. Multivariate analysis found no definite risk factor. Patients with coronary artery disease had more postoperative cardiovascular events ($p = 0.003$). Among patients free of coronary artery disease, COPD led to an increased 90-day mortality rate ($p = 0.028$).**

Conclusions. **Patients with right pneumonectomies are at increased risk. Postoperative cardiovascular events are more frequent in coronary artery disease patients. COPD is a risk factor in patients free of coronary disease.**

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Despite improvements in operative techniques and postoperative care, pneumonectomy remains a high-risk procedure. When all types of pulmonary resections were considered, pneumonectomy itself was a risk factor [1–9]. Comprehensive selection for patients undergoing pneumonectomy should be based on analysis of proven risk factors; this might lead to a significant decrease in postoperative complications and thus reduce the hospital length of stay and medical expenses. Few reports have attempted to find exclusive risk factors for pneumonectomies [10–12]. We therefore reviewed our series of pneumonectomy patients, to try to elucidate risk factors that influenced the postoperative short-term outcomes.

Patients and Methods

The Institutional Review Board of Strasbourg University Hospital approved the present study, and because it is retrospective and individual patients are not identified, no individual consent was needed.

Data Collection

Between January 1999 and July 2005, 341 patients underwent a pneumonectomy, and their records were retrospectively reviewed. Requested data were complete in all but 8 patients, who were excluded from the study. The records of the remaining 323 patients were screened for demographic data and postoperative short-term results. Demographic data collected were age, sex, side of operation, body mass index, smoking habits, chronic obstructive pulmonary disease (COPD), induction chemotherapy, coronary artery disease, hypertension, diabetes, dyslipidemia, and peripheral artery disease (PAD).

A patient was considered to have COPD when the forced vital capacity in 1 second (FEV_1) was less than 80% of predicted values or when FEV_1/forced vital capacity (FVC) was less than 70%, or both. A patient was considered obese when the body mass index was 30 kg/m^2 or more.

End points were operative mortality at 30 and at 90 days, major procedurally related complications such as empyema, bronchopleural fistulas (BPFs), and acute respiratory distress syndrome (ARDS), as well as cardiovascular events such as the occurrence of an atrial fibrillation (AF), a myocardial infarction, or a cerebrovascular event. A series of potential risk factors for mortality and morbidity were tested and are listed in Table 1.

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Table 1. List of the Potential Variables Tested Related to Perioperative Mortality and Morbidity

Factors tested
- Age ≥ 70 years
- Gender
- Side of pneumonectomy
- Presence of chronic obstructive pulmonary disease
- Induction chemotherapy
- Obesity
- Smoking status
- Coronary artery disease
- Hypertension
- Diabetes
- Dyslipidemia
- Peripheral artery disease

Operative Details

Patients were operated on by one of the department's 3 thoracic surgeons through a muscle-sparing anterolateral or axillary thoracotomy, or a non-muscle-sparing posterolateral thoracotomy. Patients were cared for by the same team of anesthesiologists, who initiated thoracic peridural analgesia whenever possible.

Complete lymph node resection was performed in all patients with a neoplastic disease. On the right side it included upper mediastinal nodes (levels 2, 4 and 10), subcarinal nodes (levels 7 and 8), and pulmonary ligament (level 9); on the left side we dissected the paraaortic nodes (levels 5 and 6), subaortic nodes (levels 10 and 4), subcarinal nodes, and pulmonary ligament.

The bronchial suture was preferentially made with a stapling device. We routinely covered the bronchial stump after right-sided pneumonectomy; our preferred technique is a pericardial fat pad placed below the superior vena cava. The chest was systematically drained with a single tube connected to a balanced drainage system and kept in place for 48 hours. Patients stayed in the surveillance unit for at least 48 hours before being transferred to the ward.

Table 2. Demographic and Comorbidity Data

Demographics	No (%) or Mean ± SD
Total patients	323
Age, years	60.54 ± 9.99
Female patients	52 (16.1)
Right pneumonectomy	144 (44.6)
COPD	162 (50.2)
Induction chemotherapy	66 (20.4)
Obesity	56 (17.3)
Weaned smokers	148 (45.8)
Coronary artery disease	38 (11.8)
Hypertension	122 (37.8)
Diabetes	57 (11.5)
Dyslipidemia	69 (21.4)
Peripheral arterial disease	33 (10.2)

COPD = chronic obstructive pulmonary disease; SD = standard deviation.

Table 3. Short-term Outcomes

Outcome	No. (%)
Mortality	
At 30 days	18 (5.6)
At 90 days	34 (10.5)
Morbidity	
At least 1 complication	127 (39.3)
Acute respiratory distress syndrome	10 (3.1)
Empyema	7 (2.2)
Bronchopleural fistula	14 (4.3)
Atrial fibrillation	32 (9.9)
Overall cardiovascular complications	10 (3.1)

Statistical Analysis

A biostatistician of the Strasbourg University Hospital Department of Biostatistics controlled the overall statistical analyses and performed the multivariate analyses. Demographic data and results were calculated using SPSS 11.5 software (SPSS Inc, Chicago, IL). The Pearson χ^2 test or the Fisher exact test (when needed) were used to compare proportions, and the t test was used to compare means. Data were reported as mean ± standard deviation or as proportions. Multiple univariate analyses were performed, and all compared variables with a value of $p < 0.1$ were included in multivariate analyses, using logistic regression statistics. A value of $p < 0.05$ was considered as significant.

Results

Patient Population

From January 1999 until July 2005, 323 consecutive patients underwent pneumonectomy at the Thoracic Surgery Department in Strasbourg University Hospital. Of these, 298 (92.26%) were diagnosed to have a non-small cell lung cancer, and 9 (2.78%) underwent a pneumonectomy secondary to a metastatic disease. Pneumonectomies were performed due to mesotheliomas in 5 (1.54%), typical carcinoid tumors in 4, lymphomas in 3, and benign diseases in 4, consisting of tuberculosis in 2, bronchiectasis in 1, and polycystic lung in 1. A total of 144 right pneumonectomies (44.6%) were performed.

Demographic and comorbidity data are summarized in Table 2. The mean patient age was 60.54 ± 9.99 years and 52 were women (16.1%). COPD was present in 162 patients (50.2%), 66 (20.4%) had undergone induction chemotherapy, 56 (17.3%) were obese, 148 (45.8%) were weaned smokers, 38 (11.8%) had a history of coronary artery disease, 122 (37.8%) were hypertensive, 37 (11.5%) were diabetic, 69 (21.4%) had dyslipidemia, and 33 (10.2%) had PAD.

Short-Term Outcomes

The 30-day and 90-day mortality rates as well as short-term overall and severe complications are summarized in Table 3. The overall 30-day mortality rate was 5.6% (18 patients), and the overall 90-day mortality rate was 10.5% (34 patients). At least one major or minor complication occurred in 127 patients (39.3%), including ARDS in 10 (3.1%), em-

Table 4. Statistically Significant Results on Univariate Analyses

Risk Factor	Influenced Outcome	*p* Value
Age ≥ 70 years	Increased atrial fibrillation	0.019
Male sex	Increased atrial fibrillation	0.021
Right pneumonectomy	Increased 30-day mortality	0.045
Right pneumonectomy	Increased bronchopleural fistulas	0.009
Coronary artery disease	Increased cardiovascular events	0.003
Hypertension	Increased atrial fibrillation	0.020
Dyslipidemia	Increased atrial fibrillation	0.021

pyemas in 7 (2.2%), BPF in 14 (4.3%), AF in 32 (9.9%), and cardiovascular complications in 10 (3.1%).

Univariate Analyses

Univariate analyses were performed when the cohort was divided into different subsets according to a specific variable. Details of specific univariate analyses were prepared. These data are not shown in detail because of a limit on the graphic illustrations. Risk factors that significantly influenced specific outcomes in univariate statistical analyses are listed in Table 4.

We first wanted to test the influence of age on short-term morbidity and mortality; therefore, the patients were divided into a subset that included those aged younger than 70 years and a second subset of those aged 70 years or older. Patients aged 70 years or older did not present more mortality or morbidity, except for the occurrence of postoperative AF (18.3% vs 8.0%; $p = 0.019$). When gender was tested, male sex only influenced the postoperative occurrence of AF (11.4% vs 1.9%; $p = 0.021$).

After right pneumonectomy, 30-day mortality was increased (8.3% vs 3.4% for left; $p = 0.045$), as well as the incidence of BPFs (7.6% vs 1.7% for left; $p = 0.009$).

Table 6. Multivariate and Univariate Analysis in Atrial Fibrillation

	p Value	
Variable	Univariate	Multivariate
Age ≥ 70 years	0.019	0.131
Male sex	0.021	0.059
Hypertension	0.02	0.291
Dyslipidemia	0.021	0.141
Induction chemotherapy	0.073	0.152
Peripheral artery disease	0.091	0.513

COPD had no influence on early postoperative outcomes, the 90-day mortality rate for COPD patients of 13.6% approached statistical significance compared with the 7.5% rate for patients free of COPD ($p = 0.053$).

There was no difference in early outcomes of pneumonectomies while testing the influence of induction chemotherapy. The rates of 30-day and 90-day mortality were identical. Even though no statistical difference was noted in occurrence of AF, AF was likely to occur in patients having not received induction chemotherapy (4.5% vs 11.3%; $p = 0.073$).

Obesity did not influence short-term outcomes.

Patients who were known to have preoperative CAD had more postoperative cardiovascular events than those who had no known preoperative CAD (13.2% vs 1.8%; $p = 0.003$). The difference in 90-day mortality rates when considering CAD tended to statistical significance (18.4% vs 9.5%; $p = 0.086$). Otherwise, CAD had no statistical influence on postoperative outcomes.

Smoking status did not have any influence on early postoperative results. Hypertensive patients had more postoperative AF than nonhypertensive ones (14.8% vs 7.0%; $p = 0.020$). Other outcomes were not influenced by hypertension. Diabetes had no adverse effects on short-term results after pneumonectomies. The only adverse effect of dyslipidemia was the occurrence of AF in the early postoperative period (17.4% vs 7.9%; $p = 0.021$). Patients with PAD had no worse postoperative outcomes than those without PAD.

Table 5. A Bivariate Analysis Associating Chronic Obstructive Pulmonary Disease and Coronary Artery Disease

	CAD			Non-CAD		
Variable	COPD	Non-COPD	*p* Value	COPD	Non-COPD	*p* Value
Patients, No.	16	22	...	146	139	...
Mortality						
30-day, %	12.5	9.1	0.567	6.8	2.9	0.100
90-day, %	18.8	18.2	0.641	13.0	5.8	0.028
Empyemas, %	6.3	4.5	0.671	2.1	1.4	0.523
BPF, %	6.3	0.0	0.421	6.2	2.9	0.148
ARDS, %	6.3	4.5	0.671	3.4	2.2	0.389
Atrial fibrillation, %	18.8	4.5	0.192	8.2	11.5	0.232
Cardiovascular events, %	18.8	9.1	0.346	2.7	0.7	0.201

ARDS = acute respiratory distress syndrome; BPF = bronchopleural fistulas; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease.

Table 7. Multivariate and Univariate Analysis in Bronchopleural fistula

	p Value	
Variable	Univariate	Multivariate
Male sex	0.081	0.997
Right pneumonectomy	0.009	0.015
COPD	0.087	0.173

COPD = chronic obstructive pulmonary disease.

Bivariate Analysis

The bivariate analysis associating COPD and CAD showed that the 90-day mortality rate was higher in patients free from CAD if there was a concomitant COPD than in the absence of COPD (13.0% vs 5.8%; $p = 0.028$). COPD did not influence outcomes in patients with a preexistent CAD. Non-CAD non-COPD patients have the lowest 30-day and 90-day mortality rates (Table 5).

Multivariate Analyses

All comparisons performed in the univariate analyses with a value of $p < 0.1$ were considered for multivariate analyses (binary logistic regressions). The multivariate analysis performed when considering the occurrence of postoperative AF included age, sex, hypertension, dyslipidemia, induction chemotherapy status, and PAD. The analysis showed that male gender approached but did not reach statistical significance ($p = 0.059$) for the occurrence of postoperative AF (Table 6). Other variables were not statistically significant for the occurrence of postoperative AF; thus, we found no independent preoperative risk factor for the occurrence of postoperative AF. Regardless of whether AF occurred, the postoperative hospital stay was similar, at 12.56 ± 3.59 days for the 32 patients with AF vs 12.64 ± 6.99 days for the 291 without AF ($p = 0.949$).

For the multivariate analysis for the occurrence of postoperative BPFs, the sex, the side of the pneumonectomy, and the COPD status were included. Only right pneumonectomies were found to be an independent risk factor for the occurrence of BPF (Table 7). A BPF prolonged the postoperative hospital stay to a mean of 10.31 days, comprising 22.5 ± 13.45 days for the 14 patients with BPF vs 12.19 ± 5.92 days for the 309 without BPF ($p < 0.001$).

Comment

This study shows that patients with right pneumonectomies are at increased risk, postoperative cardiovascular events are more frequent in patients with CAD, and COPD is a risk factor in patients free of CAD. From a different angle, we can see that 30-day mortality was only increased in right pneumonectomies and that the 90-day mortality has its lowest rate in non-CAD non-COPD patients. At the same time, right pneumonectomy is an independent risk factor for BPF, but empyemas and ARDS had no identified risk factors. AF occurrence did not have an independent risk factor, but male gender

Table 8. Mortality Risk Factors After Pneumonectomies in Published Reports and in the Present Study by Univariate and Multivariate Analyses

	Univariate Analyses					Multivariate Analyses	
Variable	Licker	Darling	Leo	López Pujol	Present Series	Licker	Darling
Age	−	...	...	+	−	...	...
Sex	+	...	...	...	−	...	...
Side	...	−	...	+	+	...	+
COPD	−	...	...	...	−	...	...
Induction chemotherapy	...	−	−	+	−	...	...
Obesity	−	...	...	...	−	...	...
Coronary artery disease	−	...	...	...	−	+	...
Smoking	...	+	...	...	−	...	...
Hypertension	−	...	...	...	−	...	...
Diabetes	...	...	...	+	−	...	...
Dyslipidemia	...	...	...	...	−	...	...
Peripheral artery disease	...	...	...	...	−	...	...
Pathologic stage	−	−	...	...	...	...	...
ASA score	−	...	...	...	...	...	...
Operation length	−	...	...	...	...	...	...
Extended resection	−	−	...	+	...	...	...
No bronchial stump coverage	...	...	...	+	...	...	...

The + sign means the specific parameter is a risk factor.

The − sign means the specific parameter is not a risk factor.

The ... means that the specific parameter was not studied.

ASA = American Society of Anesthesiology; COPD = chronic obstructive pulmonary disease.

Table 9. Morbidity Risk Factors After Pneumonectomies After Univariate and Multivariate Analyses

	Univariate Analyses				Multivariate Analyses		
Variable	Licker	Darling	Leo	Present Series	Licker	Leo	Present Series
Age	+	...	+	+	+	+	−
Sex	−	...	...	+	...	...	−
Side		+		+	...	...	+
COPD	−	...	...	−	...	...	−
IC		−	+	−	...	+	−
Obesity	−	...	...	−	...	...	...
CAD	−	...	...	+	...	...	...
Smoking	−	...	...	−	...	...	...
Hypertension	−	...	...	+	...	...	−
Diabetes		...	...	−	...	...	...
Dyslipidemia		...	...	+	...	...	−
PAD		...	...	−	...	...	−
Pathologic stage	−	...	...	...	+	...	...
ASA score	−	...	...	...	...	...	...
Operation length	−	...	...	...	...	...	...
Extended resection	+	...	...	...	...	...	...
Epidural analgesia	+	...	...	...	...	...	...
DLCO/VA, %		...	+	...	...	+	...

The + sign means that the specific parameter is a risk factor.

The − sign means that the specific parameter is not a risk factor.

The ... sign means that the specific parameter was not studied.

ASA = American Society of Anesthesiology; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; DLCO/VA % = diffusion capacity for carbon monoxide adjusted for alveolar volume; IC = induction chemotherapy; PAD = peripheral artery disease.

approached statistical significance. Cardiovascular events were more frequent in CAD patients.

Four authors have reported risk factors in pneumonectomies. Licker and colleagues [10], in a series of 193 pneumonectomies, found an increased 30-day mortality in male gender and an increased cardiac morbidity in patients aged older than 70 years. An extended resection had a negative outcome on respiratory morbidity, whereas epidural analgesia had a protective influence.

Darling and colleagues [11], in a series of 187 pneumonectomies, found that factors associated with increased mortality were hand-sewn bronchial stump closure, a history of smoking, and BPF; the latter was proved by univariate and multivariate analyses. They also found that right pneumonectomies were associated with a higher mortality rate than left, mainly due to the increased risk of BPFs.

Leo and colleagues [12], in a series of 202 pneumonectomies, proved that induction chemotherapy did not influence the mortality rate. Their univariate and multivariate analyses showed higher postoperative complications in patients aged older than 70 years, in patients who had received induction chemotherapy, and in those who had a lower diffusion capacity adjusted for alveolar volume.

López Pujol and colleagues [13], in a series of 266 pneumonectomies with similar demographic data comparing with the present study, found a similar 30-day mortality rate. Their univariate analyses showed the following mortality risk factors: age older than 70 years, diabetes, induction chemotherapy, FEV_1 of less than 1800 mL, right pneumonectomy, extended pneumonectomy, absence of bronchial stump coverage, cardiac complications, lung complications, and digestive complications. They did not investigate morbidity risk factors.

A fifth study in 2001 by Joo and colleagues [14] dealt with the same subject in relatively restricted cohort (n = 105) but was not included in the following analysis. This team found that respiratory failure, sepsis, and male sex were predictors of postoperative mortality.

Our study included 323 pneumonectomy patients in an attempt to find the risk factors that influenced the early postoperative outcomes. The overall 30-day mortality rate was 5.6%; it almost doubled on postoperative day 90 to reach 10.5%. These rates are slightly better than those by Licker and colleagues, and are similar to those of Darling, Leo, and López Pujol and their colleagues. The overall complications rate was 39.3%, identical to those of Darling, Leo, and López Pujol, and slightly better than the one of Licker. Tables 8 and 9 summarize mortality and morbidity risk factors described in the literature and in the present study.

Univariate analyses did not find any influence of COPD, induction chemotherapy, obesity, smoking habits, and diabetes on the short-term mortality or morbidity after pneumonectomies. Licker and colleagues had the same conclusion concerning COPD. Induction chemotherapy was associated with more mortality in the series of López

Pujol and colleagues, and more morbidity in the series of Leo and colleagues but was free from negative outcomes in other series, including ours. We, along with Darling and colleagues, found that obesity does not have a negative influence on postoperative outcomes. Smoking increased mortality in the Darling series, but not in ours, and was not associated with increased morbidity in the Licker series or in ours. López Pujol and colleagues found increased mortality in diabetic patients, but we found no relation between diabetes and postoperative outcomes (Tables 8 and 9).

Licker and colleagues agreed with us on the absence of influence of CAD on postoperative mortality, but we disagreed on the influence of CAD on postoperative morbidity. We found increased cardiovascular events in patients with known CAD, but they found no influence of CAD on cardiac and respiratory morbidity (Tables 8 and 9).

The bivariate analysis we performed after combining CAD and COPD, due to the 90-day mortality rates of these two variables that approached statistical significance, showed best results in non-CAD non-COPD patients (Table 5). This might be because these patients had the lowest major comorbidities. It also showed that among non-CAD patients, those without COPD have a statistically better 90-day survival than the other subsets.

Unsurprisingly, like most other reports, univariate analyses found out that right pneumonectomies are associated with increased 30-day mortality, a fact proved by López Pujol and colleagues but which Darling and colleagues failed to prove.

Right pneumonectomy was also associated with an increased incidence of postoperative BPFs, which Darling and colleagues proved (Tables 8 and 9). BPFs were only influenced by right pneumonectomies in the univariate analysis, which was proved by the multivariate analysis (Table 7). BPFs are more likely to occur after right pneumonectomies because right bronchial stumps, in the absence of a protective flap or in the presence of a defective one, swim freely in the right pleural cavity fluid, whereas left bronchial stumps are relatively protected by the pericardium and the esophagus. In addition to the deleterious medical effect of the BPF on the patient, one must also consider the economic aspect of this complication. Patients with BPF had to be hospitalized about 10 days more than those without BPF, with a mean supplemental hospital expenses of about €10,000 per patient. For these reasons, coverage of the bronchial stump, especially in right pneumonectomies, should become routine.

Many authors treated cardiac dysrhythmias (including AF) after pulmonary resections, but few treated cardiac dysrhythmias exclusively after pneumonectomies. Because cardiac dysrhythmia is not the main aim of this study, we will only cite three selected reports

- Krowka and colleagues [15] in a series of 236 pneumonectomies, noted increased tachydysrhythmia in patients undergoing intrapericardial dissections and those with postoperative interstitial or perihilar pulmonary edema.
- Douchet and colleagues [16] in a series of 100 pneumonectomies, found 24% of significant supraventricular arrhythmias, corresponding to AF in 75% of patients. The only risk factor found for the occurrence of these arrhythmias was the patient's age.
- Foroulis and colleagues [17], in a series of 259 pneumonectomies, found that arrhythmias complicated right and intrapericardial pneumonectomies, patients with elevated right heart pressures, and long operative durations. These arrhythmias were associated with high mortality rates.

According to univariate analyses in our series, postoperative AF predominated in men, in patients aged 70 years and older, in hypertensive patients, and in dyslipidemic patients. Multivariate analysis did not retain any of these risk factors as an independent factor, even though male gender approached statistical significance (Table 6). As we already have noted, a multitude of risk factors have been described, but the data are not unanimous. Therefore, no exact risk factor or a single mechanism of physiopathology for AF can be retained.

AF is a relatively benign complication, is easy to treat, and is almost always reversible. We found no adverse effects of AF in our patients who had this complication. AF did not result in prolonged postoperative hospitalization. Nevertheless, this does not mean that we should not try to prevent AF. Many prophylactic protocols have been described, based on β-blockers such as metoprolol [18], calcium channel blockers such as diltiazem [19, 20], and class III antiarrhythmic drugs such as amiodarone [21], with encouraging results. Amar and colleagues [22] showed that the use of preoperative statins statistically reduced the incidence of postoperative AF. This finding might go in parallel with our univariate analysis that found that the risk of postoperative AF is increased in patients with known history of dyslipidemia. This could be a leading hypothesis for a future prospective study to clarify the physiopathology of postoperative AF occurrence after pneumonectomies.

Of note in our series, AF was less likely to occur in patients who had received induction chemotherapy than those who had not (4.5% vs 11.3% respectively). One might think that chemotherapy regimens might have some protective effect from AF, probably by reducing inflammatory status. In our opinion, AF should be systematically prevented before scheduled pneumonectomies, especially in men.

This original study is retrospective and has the limitations of all retrospective studies. Even though patients were referred to our department from different medical facilities, they were operated on in a single center. We think that the actual study may serve as a basis for multiple prospective investigations trying to prevent postoperative complications of pneumonectomy by a preoperative correction of modifiable risk factors.

In conclusion, the exhaustive statistical study on our series of patients showed that COPD, induction chemotherapy, obesity, smoking habits, and diabetes did not influence

the short-term mortality or morbidity after pneumonectomies; right pneumonectomies were associated with higher 30-day mortality rate, and higher incidence of BPF; right pneumonectomies present an independent risk factors for the occurrence of BPF; non-CAD non-COPD patients have the best postoperative survival; and no independent factor for the occurrence of postoperative AF was identified.

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INVITED COMMENTARY

The study by Mansour and colleagues [1] is conducted to determine preoperative risk factors for early mortality and morbidity after pneumonectomy. Endpoints of this study are operative mortality, major procedure-related complications, and cardiovascular events. The authors have analyzed risk factors in an impressive number (323) of pneumonectomy patients. The major findings are that pneumonectomy of the right lung is a risk factor for bronchopleural fistulas and resulted in increased 30-day mortality, the cardiovascular event is more frequent in coronary artery disease patients, and chronic obstructive pulmonary disease is a risk for patients without coronary disease. The study is interesting and aims to give insight in the difficult matter of adequate patient selection for pneumonectomy. Still, there are several elements to comment on.

First, important complications related to pneumonectomy, such as postoperative bleeding that requires reoperation, pneumonia of the contralateral lung, and cardiac arrhythmias other than atrial fibrillation (AF) have not been investigated. In addition, significant preoperative details of patients are lacking, such as American Society of Anesthesiologists (ASA) classification, type of pneumonectomy performed (ie, normal, extended, or completion pneumonectomy), epidural analgesia, underlying disease, and TNM classification. Furthermore, the study lacks association between morbidity and mortality, because it does identify risk factors for operative mortality and postoperative complications, whereas the end result of these complications on mortality is unclear. Finally, in an attempt to find similarities between this study and other studies, the authors focused on four particular studies [2–5], but they did not include other important studies [6–9]. If all these studies were compared, few parallel risk factors would be identified. Still, there seems to be enough evidence that right-sided pneumonectomy results in worse outcome than left-sided pneumonectomy. One of the contributing factors may be a shorter main bronchus of the right lung, which is a risk factor for

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