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Bilobectomy for lung cancer: contemporary national early morbidity and mortality outcomes†

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Abstract

OBJECTIVES: To determine contemporary early outcomes associated with bilobectomy for lung cancer and to identify their predictors using a nationally representative general thoracic surgery database.

METHODS: A total of 1831 patients, who underwent elective bilobectomy for primary lung cancer between 1 January 2004 and 31 December 2013, were selected. Logistic regression analysis was performed on variables for major adverse events.

RESULTS: There were 670 upper and 1161 lower bilobectomies. Video-assisted thoracic surgery was seldom performed (2%). Induction therapy and extended resection were performed in 293 (16%) and 279 patients (15.2%), respectively. Operative mortality was 4.8% (upper: 4.5%/lower: 5%; $P = 0.62$), and significantly higher following extended procedures when compared with standard bilobectomy (4.3 vs 7.5%; $P = 0.013$). Pulmonary complication rate was 21.1%. Bronchial fistula occurred in 46 patients (2.5%) and pleural space complications in 296 (16.2%). Their respective incidence rates were significantly higher following lower than upper bilobectomy (3.5 vs 0.7%; $P < 0.001$ and 17.8 vs 13.3%; $P = 0.007$). At multivariate analysis, extended procedures [odds ratio (OR), 2.3; 95% confidence interval (CI), 1.03–5.31; $P = 0.04$], ASA scores of 3 or greater (OR, 2.02; 95% CI, 1.33–3.07; $P < 0.001$) and World Health Organization performance status 2 or greater (OR, 1.47; 95% CI, 1.01–2.13; $P = 0.04$) were risk predictors of mortality. Female gender (OR, 0.39; 95% CI, 0.19–0.80; $P = 0.01$), highest body mass index (BMI) values (OR, 0.91; 95% CI, 0.86–0.96; $P = 0.001$) and recent years of surgery (OR, 0.91; 95% CI, 0.84–0.99; $P = 0.02$) were protective. Predictors of bronchial fistula were male gender, lowest BMI values, lower bilobectomy and longest operative times. Male gender, lowest BMI values and longest operative times were also predictors of pulmonary complications, together with highest ASA scores and lowest forced expiratory volume in 1 s values.

CONCLUSIONS: Risks related to lower bilobectomy lie halfway between those reported for lobectomy and pneumonectomy. Additional surgical measures to prevent pleural space complications and bronchial fistula should be encouraged with this operation. In contrast, upper bilobectomy shares more or less the same hazards as lobectomy.

Keywords: Non-small-cell lung carcinoma • Surgery • Treatment outcome

INTRODUCTION

Bilobectomy is commonly defined as an operation consisting of the resection of two pulmonary lobes on the right side, including the middle lobe. Upper and lower bilobectomy, preserving the middle lobe, is not viable due to the marked mismatch between the size of the pleural cavity and that of the remaining lung, even if such an operation has been reported once for primary lung cancer [1]. Upper bilobectomy refers to the concomitant removal of the upper lobe, whereas lower bilobectomy refers to the concomitant removal of the lower lobe. Churchill first reported application of bilobectomy in the treatment of bronchogenic carcinoma in 1933 [2]. Yet, the publication of the very first dedicated

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analysis of its risk/benefit ratio in this setting has taken 55 years [3]. Because bilobectomy is a rare operation, most published series so far, coming from single institutions, hardly gathered more than 100 patients over 1–2 decades [4–13]. As a result, its place and indications still remain unclear. Bilobectomy for primary lung cancer is thought to be an alternative option to pneumonectomy that achieves the balanced surgical effects of both curability and functional preservation. Furthermore, as right pneumonectomy has been reported to carry the highest risk of postoperative complications and mortality among all types of major pulmonary resections, bilobectomy is often primarily taken to avoid right pneumonectomy. Our working group recently reported on the risks of pneumonectomies and lobectomies in real life situations over the last decade on a nation-based scale [14, 15]. We pursue our efforts with the present study that aimed at determining contemporary early outcomes associated with bilobectomy for lung cancer and identifying their predictors using EPITHOR, a nationally representative general thoracic surgery database.

MATERIALS AND METHODS

The Institutional Review Board of the French Society of Thoracic and Cardiovascular Surgery (FSTCVS) approved the study (approval number 2015-1-17-20-5-58-ThPa). Patient consent has been obtained for entry into the database, and patients were aware that these data would be used for research purposes.

The French National Database EPITHOR

EPITHOR, the FSTCVS database, was created in 2002 as a voluntary and free initiative of general thoracic surgeons. Its technical characteristics have been previously described in detail [14, 15]. EPITHOR is a government-recognized clinical database, financially supported by the National Cancer Institute (Institut National du Cancer) for data-quality monitoring. EPITHOR is labelled by the French National High Authority for Health (Haute Autorité de Santé), a governmental agency designed to improve the quality of patient care and to guarantee equity within the health care system, as a methodologically correct tool to assess professional surgical practices. Participating in EPITHOR is now part of the required criteria for medical accreditation and thoracic surgery unit certification in France. Completeness and accuracy of the data are facilitated by the use of hierarchic pull-down menus and the absence of free text spaces. The software incorporates routine utilities for data consistency, alerting to aberrant or contradictory values in some fields. Each patient's file includes some mandatory items to initialize and close the process. Fifty variables are collected per patient, covering information about patients' personal characteristics, medical history, pulmonary function, surgical procedures, cancer staging and outcomes. Data are sent through the Internet to the national database; patients are anonymous. Each participating centre has to implement and download the national database at least every 2 months to avoid becoming temporarily unauthorized to access the database. The software includes functions allowing participating surgeons to benchmark their activity against the national picture almost in a real-time context. Moreover, participants have to check the quality of the local database for missing values by comparing its completeness with that of the national database. This comparison is expressed through a quality score ranging from 0 to 100%. A score exceeding 80% is mandatory to have the local data incorporated in the national database. The accuracy of data collection is checked in regular external onsite audits initiated in 2010 [14].

Patient population and clinical variables

From January 2004 to December 2013, 169 147 patients were registered in EPITHOR among whom 41 608 with the main diagnosis of primary lung cancer. We selected 1987 patients who underwent an elective bilobectomy. After discarding data fields with too many inconsistent or missing values and patients with unknown information on variables otherwise suitable for study, a group of 1831 patients was selected for further analysis. Twenty-nine baseline variables per patient were analysed [14]. Nineteen patient-related variables were recorded: age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) scores, World Health Organization (WHO) performance status, Medical Research Council (MRC) dyspnoea score, history of cancer and presence of several comorbid diseases: diabetes mellitus, coronary artery disease, peripheral vascular disease, cerebrovascular disease, valvular heart disease, any other cause of cardiomyopathy, use of antiplatelet or anticoagulant therapy. Forced expiratory volume in 1 s (FEV1) values were recorded as percentages of predicted values. Patients with chronic obstructive pulmonary disease included those with emphysema, chronic bronchitis or a FEV1/forced vital capacity ratio of less than 70%. The presence of chronic lung infection as the consequence of an obstructive bronchial tumour was also recorded. Tobacco consumption within 2 weeks before surgery defined the active smoking. Alcohol dependence or abuse was diagnosed on the basis of excessive habitual drinking or characteristic withdrawal syndrome. The eight treatment-related variables were type of bilobectomy (upper or lower), standard or extended resections to the bronchus or the chest or mediastinal structures (e.g. superior vena cava and left atrium), need for pneumolysis or not, technique of lymphadenectomy (systematic dissection versus sampling or none), open or video-assisted approach, year of the operation, duration of the procedure and performance of a neoadjuvant therapy. The two disease-related variables included tumour histology (adenocarcinoma, squamous cell, large cell, others) and pathological staging in accordance with the International Association for the Study of Lung Cancer classification, which was presented as consisting of three categories to encompass the modifications of subgroup classification during the study period (early I–II, locally advanced III, metastatic IV).

Outcome definition

The primary end-point was operative mortality defined as any death within 30 days after the operation or later if the patient was still in the hospital. Secondary end-points were pulmonary, cardiovascular, infectious and surgical complications. Pulmonary complications included atelectasis requiring bronchial aspiration by fibroscopy, confirmed or suspected pneumonia and respiratory failure requiring invasive (acute respiratory distress syndrome) or non-invasive mechanical ventilation. Cardiovascular complications included deep venous thrombosis and pulmonary embolism, atrial fibrillation, stroke, acute coronary events and acute heart failure. Infectious complications included septicaemia, isolated fever unrelated to pneumonia or to any specific surgical complication and urinary tract infections. Surgical complications included vocal cord palsy, bronchial fistula, haemothorax, chylothorax, empyema and wound abscess [14]. Besides, we defined 'pleural space' complications as the occurrence of any of the following events: pleural effusion, haemothorax, empyema without bronchial fistula, prolonged air leaks.

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Statistical analysis

Descriptive data were expressed as counts and percentages for qualitative variables, and as means and (±) standard deviations for continuous variables. To handle missing data that represented 6.8% of all collected fields, multiple imputations were performed from the original dataset, using IBM SPSS statistics version 20 (generation of five imputations). Then, datasets have been treated as a multiple imputation dataset in which missing values have been replaced with imputed values. Multivariable logistic regression analyses were performed to determine variables that might predict on the one hand, the primary outcome (occurrence of death) and, on the other hand, the secondary outcome (occurrence of pulmonary, cardiovascular, infectious and surgical complications). These analyses were performed on each imputed dataset. The final result was produced by fusing results after multiple imputation (multiple imputation algorithms) (http://pic.dhe.ibm.com/infocenter/spssstat/v21r0m0/index.jsp?topic=%2Fcom.ibm.spss.statistics.help%2Falg_mi-pooling_rubin.htm). The variables relevant to the models were selected from the univariable analyses (χ^2 tests used for qualitative variables; Student's *t*-tests used for continuous variables) provided that they were associated with the outcome to explain with a *P*-value of ≤0.10, or from their clinical relevance. The final models displayed adjusted odds ratios (ORs), including 95% confidence intervals (CIs). Statistical analyses were performed using IBM SPSS Statistics software version 20 (IBM SPSS, Inc., Chicago, IL, USA) and SAS 9.2. The statistical significance level was set at $P < 0.05$ in a two-sided test.

RESULTS

Bilobectomies represented 4.8% of all surgeries registered in the database. Over the study period, the most frequently performed lung cancer operation, by far, was lobectomy (68.4%). Pneumonectomy accounted for 12.8%, sub-lobar resection for 12% and open and close procedures for 2%. Video-assisted thoracic surgery bilobectomy was seldom done ($n = 36$, 2%). Induction therapy was performed in 293 (16%), having consisted of chemotherapy in 267 patients, radiotherapy in 3 and chemo-radiation therapy in 23. There were 670 upper (36.6%) and 1161 lower (63.4%) bilobectomies. Table 1 reports the main statistically significant differences between the two groups of patients as defined according to the type of bilobectomy. Extended resections were performed in 279 patients (15.2%). Table 2 displays surgical details regarding these extended procedures.

Operative mortality was 4.8% ($n = 88$): upper bilobectomy: 4.5% vs lower bilobectomy: 5%; $P = 0.62$. It was significantly higher following extended procedures when compared with standard bilobectomy (4.3 vs 7.5%; $P = 0.013$). Mortality of standard bilobectomy was 3.3% after upper bilobectomy and 4.6% after lower bilobectomy ($P = 0.29$). Mortality of extended upper bilobectomy was 7.1, and 7.9% after extended lower bilobectomy ($P = 0.827$). At multivariable analysis, extended procedures (OR, 2.3; 95% CI, 1.03–5.31; $P = 0.04$), ASA scores of 3 or greater (OR, 2.02; 95% CI, 1.33–3.07; $P < 0.001$) and WHO performance status 2 or greater (OR, 1.47; 95% CI, 1.01–2.13; $P = 0.04$) were risk predictors. Female gender (OR, 0.39; 95% CI, 0.19–0.80; $P = 0.01$), highest BMI values (OR, 0.91; 95% CI, 0.86–0.96; $P = 0.001$) and recent years of surgery (OR, 0.91; 95% CI, 0.84–0.99; $P = 0.02$) were protective.

Overall, 839 patients (45.8%) experienced at least one postoperative complication: 281 patients (41.9%) having had an upper bilobectomy and 558 (48.1%) a lower bilobectomy ($P = 0.011$). Pulmonary complication rate was 21.1% and was associated with 11.1% lethality. They occurred in 132 patients after upper bilobectomy (19.7%) and in 254 patients after lower bilobectomy (21.9%), but this difference was not statistically significant ($P = 0.27$). At multivariable analysis, ASA scores of 3 or greater (OR, 1.66; 95% CI, 1.34–2.06; $P < 0.001$), longest operative times (OR, 1.003; 95% CI, 1.001–1.005; $P = 0.006$), underweight BMI category (OR, 2.3; 95% CI 1.3–4; $P = 0.005$), presence of COPD (OR, 1.33; 95% CI, 1.02–1.74; $P = 0.036$) and presence of cerebrovascular disease (OR, 1.95; 95% CI, 1.08–3.51; $P = 0.025$) were independent risk factors, whereas female gender (OR, 0.64; 95% CI, 0.46–0.89; $P = 0.008$) and highest FEV1 values (OR, 0.988; 95% CI, 0.981–0.995; $P = 0.001$) were protective.

Cardiovascular complications occurred in 162 patients (8.8%) and had 12.3% lethality. At multivariable analysis, age (OR, 1.052; 95% CI, 1.033–1.071; $P < 0.001$), longest operative times (OR, 1.004, 95% CI, 1.001–1.006; $P = 0.005$), presence of coronary artery disease (OR, 2.212; 95% CI, 1.362–3.593; $P = 0.001$) and active smoking (OR, 1.721; 95% CI, 1.118–2.652; $P = 0.013$) were predictors.

Infectious complications were rare (1.25%), and had a 14.3% mortality. No predictor of these complications was disclosed.

Overall, surgical complications occurred in 361 patients (19.7%) and their related mortality was 6.1%. At multivariable analysis, lower bilobectomy (OR, 1.58; 95% CI, 1.23–2.03; $P < 0.001$), lowest BMI values (OR, 1.05; 95% CI, 1.02–1.08; $P < 0.001$) and increasing operative times (OR, 1.002, 95% CI, 1.000–1.004; $P = 0.019$) were independent predictors.

Bronchial fistula occurred in 46 patients (2.5%) and pleural space complications in 296 (16.2%). Their respective incidence rates were significantly higher following lower than upper bilobectomy (3.5 vs 0.7%; $P < 0.001$, and 17.8 vs 13.3%; $P = 0.007$). Lethality of bronchial fistula was 15.2%. Predictors of bronchial fistula at multivariable analysis were lower bilobectomy (OR: 3.05; 95% CI, 1.5–10.4; $P < 0.001$), male gender (OR: 4.9; 95% CI, 1.44–16.7; $P = 0.011$), lowest BMI values (OR: 1.16; 95% CI, 1.07–1.25; $P < 0.001$) and increasing operative times (OR: 1.005; 95% CI, 1.001–1.009, $P = 0.010$).

DISCUSSION

This study shows that during the period 2004–13, bilobectomies represented 4.8% of all lung cancer operations performed in France, and also had a related mortality of 4.8%. These figures are strangely similar to those observed >25 years ago at Memorial Sloan-Kettering Cancer Center, New York: 3.5 and 4.2%, respectively [3]. They also echo contemporary national figures reported in the USA [16] and in Europe [17]: 3.6 and 3.4% and 4.7 and 3.9%, respectively. It confirms that the mortality associated with bilobectomy lies halfway between that observed for lobectomy and pneumonectomy.

Looking at details however, it becomes obvious that considering lung cancer patients having had upper or lower bilobectomies as a homogeneous group is erroneous. In our national cohort, patients differed significantly according to several meaningful clinical characteristics. Mortality related to lower bilobectomy was as high as 5% despite the addition of acknowledged protective factors, such as younger age, higher BMI and non-smoking status. Indications were also clearly different. As presented in Table 1, patients who underwent lower bilobectomy were more likely to have a squamous cell carcinoma and a central tumour, and/or an advanced nodal disease, and thus to receive bilobectomy as a result of endobronchial tumour and/or extrinsic bronchial

Table 1: Patients' characteristics

Variables	Overall population	Bilobectomy		P-value
	n = 1831	Upper (n = 670)	Lower (n = 1161)	
Age (years, mean ± SD)	62.7 ± 11.1	63.4 ± 10.3	62.2 ± 11.5	**0.027**
>65 years	754 (40.7%)	279 (41.6%)	1277 (40.1)	0.52
≤65 years	1086 (59.3%)	391 (58.4%)	1985 (59.9%)	
Sex				
Female	479 (26.2%)	224 (33.4%)	255 (22.0%)	**<0.001**
Male	1352 (73.8%)	446 (66.6%)	906 (78.0%)	
Body mass index	25.2 ± 4.6	24.7 ± 4.3	25.4 ± 4.7	**0.002**
Normal (18.5 kg/m^{-2} ≤ BMI < 25 kg/m^{-2})	877 (48.1%)	343 (51.5%)	534 (46.1%)	**0.018**
Underweight (BMI < 18.5 kg/m^{-2})	91 (5.0%)	39 (5.9%)	52 (4.5%)	
Overweight (25 kg/m^{-2} ≤ BMI < 30 kg/m^{-2})	598 (32.8%)	207 (31.1%)	391 (33.8%)	
Obesity (BMI ≥ 30 kg/m^{-2})	258 (14.1%)	77 (11.6%)	181 (15.6%)	
Active smokers				
No	1274 (69.6%)	440 (65.7%)	834 (71.8%)	**0.006**
Yes	557 (30.4%)	230 (34.3%)	327 (28.2%)	
History of cancer				
No	1540 (84.1%)	545 (81.3%)	995 (85.7%)	**0.014**
Yes	291 (15.9%)	125 (18.7%)	166 (14.3%)	
FEV1% predictive (mean ± SE)	71.1 ± 19.9	75.5 ± 19.2	68.3 ± 19.9	**<0.001**
Operative time (min, (mean ± SE)	156.9 ± 59.8	152.6 ± 60.4	159.4 ± 59.4	**0.023**
Type of procedure				
Standard	1552 (84.8%)	543 (81.0%)	1009 (86.9%)	**<0.001**
Extended	279 (15.2%)	127 (19%)	152 (13.1%)	
Histology				
Squamous cell	787 (45.7%)	181 (29.1%)	606 (55.1%)	**<0.001**
Adenocarcinoma	664 (38.6%)	378 (60.8%)	286 (26.0%)	
Large cell	66 (3.8%)	25 (4.0%)	41 (3.7%)	
Others	204 (11.9%)	38 (6.1%)	166 (15.1%)	
p Stage				
Localized (I–II)	1028 (63.4%)	395 (66.9%)	633 (61.3%)	**0.037**
Locally advanced (III)	520 (32.1%)	166 (28.1%)	354 (34.3%)	
Metastatic (IV)	74 (4.6%)	29 (4.9%)	45 (4.4%)	

BMI: body mass index; FEV1: forced expiratory volume in 1 s; SD: standard deviation; SE: standard error.
The numbers in bold represent a P-value that are statistically significant.

Table 2: Extended procedures

Extension	Overall	Upper bilobectomy	Lower bilobectomy	P-value
Chest wall	31 (1.7%)	25 (3.7%)	6 (0.5%)	<0.001
Bronchial sleeve	73 (4.0%)	40 (6.0%)	33 (2.8%)	0.0015
Mediastinal (SVC/LA)	175 (9.6%)	62 (9.3%)	113 (9.7%)	0.73

SVC: superior vena cava; LA: left atrium.

involvement. In contrast, patients who underwent upper bilobectomy were more likely to have an adenocarcinoma and a peripheral tumour, and thus to receive bilobectomy as a result of direct extension to the adjacent lobe across the fissure. Lower bilobectomies seemed to have been used for functional reasons in several occasions to avoid right pneumonectomy as suggested by the lower mean value of FEV1 in this group of patients. These observations are totally in line with the literature when available [3–7, 9, 11, 13].

At a glance, both types of bilobectomy shared the same early mortality. In fact, upper bilobectomies were more likely to combine extended resections, a factor that has been identified as an independent risk factor by our analysis. The risk associated with standard upper bilobectomy (3.3%) aimed towards the one observed during the study period for right lobectomies (2.8%) [14]. In contrast, the risk associated with standard lower bilobectomy (4.6%) was in line with that of left pneumonectomy (5.8%), but far lower than that of right pneumonectomy (10.8%) [15]. These figures are grossly similar to those observed in most single institution cohorts [3–8, 11–13]. Two series however reported on operative mortality rates ∼1% [9, 10]. It should be emphasized that, in both series, the relative proportion of lower bilobectomies was fairly lower than that of our cohort. Induction therapy did not seem to influence the early postoperative course conversely to Cho *et al.* findings [8]. Of note, these authors reported on neoadjuvant concurrent chemoradiotherapy whereas the regimen consisted of chemotherapy alone in almost all of those patients who received induction therapy in our national cohort.

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The comprehensive analysis of early outcomes demonstrated very different behaviours actually. Overall, early morbidity edged 50% and was significantly higher following lower bilobectomy when compared with upper bilobectomy. Of note, the incidence of pulmonary complications did not differ between the two types of bilobectomy despite the greater amount of lung parenchyma removed with a lower bilobectomy (seven segments) when compared with upper bilobectomy (five segments). Among risk factors of these respiratory complications, we found the pivotal role of the nutritional status as we did for lobectomy [14] and pneumonectomy [15].

As expected, pleural space complications were significantly more frequent. Indeed, pleural space problems are those assumed to be related to discrepancies between the volume of the pleural cavity and the remnant lung. A recent study underlined the difficulty of a subjective assignment of adverse postoperative events to space problems, especially on a retrospective basis [12]. We used a minimalist definition of these problems, and especially we do not include atelectasis among them even if the lack of negative pleural pressure and residual pneumothorax may be in some occasions the first step leading to lung collapse. Nevertheless, some single or combined prophylactic measures to reduce the residual pleural space have been advocated, such as insertion of a supplemental drain with a high suction level of 150 mmHg [5], performance of a pneumoperitoneum [4], intrathoracic muscle flap transposition [11], pleural tenting, resection of the sixth rib [10] or phrenic nerve scratch [9]. Only the efficacy of pleural tenting [18] and pneumoperitoneum [19, 20] has been sustained by the results of randomized trials in this setting. Unfortunately, the latter may also lead to some disastrous complications [21].

Likewise, bronchial fistula was more frequent following lower than upper bilobectomy despite the existence of two bronchial stumps in the latter. Moreover, lower bilobectomy has been identified at multivariate analysis as a robust independent risk factor of bronchial fistula. Such finding has been already reported in a Japanese series of lobectomies/bilobectomies [22]. It is consistent with the concomitant higher incidence of pleural space problems when bronchial fistula is related to the spontaneous drainage of empyema through the bronchial suture line. It is also in accordance with the findings of Hollaus *et al*. who showed that the diameter of the bronchial stump was a major risk factor of impaired bronchial healing after major pulmonary resections explaining the predominance of the male gender, right side and pneumonectomy [23]. In line with our previous study on lobectomies [14], lowest BMI values were correlated with the occurrence of bronchial fistula, suggesting a key role for nutritional considerations in its origin. Of note, incidence of and mortality from bronchial fistula after lower bilobectomy were similar to those related to right pneumonectomy [15]. These findings support the application of intensive nutritional support in malnourished individuals and the routine use of regional flaps for bronchial stump reinforcement [24].

There are several limitations to our study. Although collected prospectively, there was a substantial number of missing values. In addition, extensive preoperative pulmonary function data were not available, in particular routine diffusion capacity values (diffusing capacity for carbon monoxide), quantitative ventilation perfusion scanning and maximal oxygen consumption when appropriate, which are important preoperative indicators of operative risk. Our study also focused on in-hospital and 30-day mortality, which is an imprecise proxy for determining the safety of lung cancer surgery. Ninety-day mortality is now increasingly suggested as a finer risk indicator, but could not be evaluated thoroughly in EPITHOR because of the lack of mid-term follow-up information. However, we believe that these limitations are favourably compensated by the other characteristics of the EPITHOR database: best available clinical data, large-sized-, risk- and case-mix-adjusted, nationally benchmarked and audited outcome.

In conclusion, bilobectomy for primary lung cancer is a rare operation that still carries a substantial morbidity and mortality. This operation should be undertaken to avoid right pneumonectomy, a procedure presenting a higher risk, whenever it allows a complete oncological resection. These statements are chiefly fitted to lower bilobectomy, whereas upper bilobectomy shares more or less the same indications and risks as a lobectomy. Routine additional surgical measures to prevent pleural space complications and bronchial fistula should be encouraged when performing a lower bilobectomy. We finally propose to rename upper bilobectomy as 'double lobectomy', and restrain the use of 'bilobectomy' to lower and middle lobe resections, given their respectively different indications and outcomes. This terminology would soundly help at grouping the patients in homogeneous sets when the risk/benefit ratio associated with different types of major pulmonary resections is under investigation.

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APPENDIX. CONFERENCE DISCUSSION

Dr G. Decker *(Luxembourg, Luxembourg)*: One of your slides indicated that quite a few sleeve bi-lobectomies, were done. This is a very infrequent operation, as you know. Did these have any different outcome from the two standard types of bi-lobectomies?

Dr Thomas: Not really, but, as you have seen, the numbers were very small in this group. It is very difficult to separate them from the rest. So no conclusion on this type of extension.

Dr H. Date *(Kyoto, Japan)*: Can you tell us, if you have the data, how many of these patients had bronchial coverage at the time of surgery?

Dr Thomas: Unfortunately version 1 of the Epithor programme was unable to provide this kind of information, but we are currently launching version 2 of the programme which will provide it. For the moment we can only see the outcomes, but some specific measures are not captured by the database, unfortunately.

Dr Date: Do you have the data on bronchial fistula rate after pneumonectomy in the same dataset?

Dr Thomas: Yes. We provided all this information last year at the AATS. The rate is around 3% after pneumonectomy and 6% when you look specifically at the right side.

Dr W. Weder *(Zürich, Switzerland)*: A 5% mortality seems to be relatively high. Do you have an analysis to show whether specific thoracic centres in comparison to, let's say, low volume centres, have a difference in mortality and outcome?

Dr Thomas: Yes and no. Last year, Pierre-Emmanuel Falcoz presented the impact of volume on early outcomes at the AATS meeting. In France there is no longer an impact of volume since the government's measure specifying minimum thresholds of activity: this level was 30 major lung cancer resections per year. By doing so, the government deleted 75% of the locations where thoracic surgery was done. So no impact on the outcome. But I agree that we were very surprised to see that high 5% mortality. It was not surprising, in my opinion, for lower bi-lobectomies, but more for upper bi-lobectomies. Therefore we have to provide the current risk for lobectomy and pneumonectomy in France in order to appreciate this data. The current risk of lobectomy in France is 2%, and for pneumonectomy, it is 5.8% at 30 days. What is very surprising is the mortality associated with upper bi-lobectomy, which is almost the same operation as a left upper lobectomy. We have no clear explanation of this fact.

Dr D. Waller *(Leicester, UK)*: So much data and so many questions to ask. What is the difference between a right superior bi-lobectomy and a left upper lobectomy, because they are the same operation, really, and you have alluded to the fact that there probably isn't any difference there.

Dr Thomas: In theory it is the same operation, but, as you know, the facts remain, and when we looked inside our database, the risk of left upper lobectomy is less than 1.5%, whereas it is 5% after upper bi-lobectomy. I have no clear explanation, but these are the facts.

Dr Waller: But the more significant question is, how important is the middle lobe? It must be fantastically important, because inferior bi-lobectomy is so much more risky than right lower lobectomy. So why is the middle lobe so important and, if it is, then we really should be trying to conserve it with bronchoplastic procedures.

Dr Thomas: The database does not provide a clear explanation, but in my personal small experience I would say that this is due to a conflict between the volume of the residual lung and the pleural cavity. Some of these patients in our own experience begin their postoperative course with mild complications, such as prolonged air leaks, and then atelectasis, pneumonia, ARDS, and so on and so on. I think it is maybe one part of the explanation.

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