Interactive CardioVascular and Thoracic Surgery 17 (2013) 838–844
doi:10.1093/icvts/ivt292 Advance Access publication 17 July 2013

ORIGINAL ARTICLE – THORACIC

Predictive factors for complications of anatomical pulmonary segmentectomies

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Received 21 January 2013; received in revised form 7 May 2013; accepted 16 May 2013

Abstract

OBJECTIVES: The role of anatomical pulmonary segmentectomy is increasing, but there are few data about its complication rate. We have analysed the postoperative morbidity, mortality and risk factors in a consecutive series of 228 segmentectomies performed in our department.

METHODS: Between January 2007 and December 2011, 221 patients underwent 228 segmentectomies. There were 99 women (45%) and 122 men (55%). The mean age was 61 years (range 18–86 years). The mean forced expiratory volume in 1 s (FEV1) was 87%, and 30 patients had an FEV1 of ≤60%. Fifty-seven patients had a previous history of pulmonary resection. Indications for segmentectomy were: primary lung cancer (111 cases), metastases (71 cases), benign non-infectious (25 cases) and benign infectious diseases (21 cases). The approach was a posterolateral thoracotomy (Group PLT) in 146 patients (64%) and a thoracoscopy (Group TS) in 82 (36%). The two groups were homogenous in terms of age, gender, indications of surgery and type of segmentectomy.

RESULTS: The mortality rate at 3 months was 1.3% (3 patients). The overall complication rate was 34%. Ten patients were reoperated for the following reasons: haemothorax (4 cases), ischaemia of the remaining segment (3 cases), active bleeding (1 case), prolonged air leak (1 case) and dehiscence of thoracotomy (1 case). The average duration of drainage was 5 days (range 1–34 days) and the average length of stay was 9 days (range 3–126 days). On univariate analysis, FEV1, male gender and thoracotomy were statistically significant risk factors for complications. On multivariate analysis, the same three predictive factors of complications independently of age were found statistically significant: preoperative FEV1 < 60% [odds ratio (OR) = 5.9, 95% CI (2.5–13.7), $P < 0.001$] male gender [OR = 2.04, 95% CI (1.2–3.6), $P < 0.013$] and thoracotomy [OR = 2.14, 95% CI (1.33–3.46), $P = 0.001$].

CONCLUSIONS: Pulmonary anatomical segmentectomies have an acceptable morbidity rate. Postoperative complications are more likely to develop in male gender patients, with FEV1 ≤ 60% and operated by open surgery.

Keywords: Segmentectomy • VATS • Thoracotomy • Thoracoscopy

INTRODUCTION

Although thoracic surgeons are sensible to the need of sparing the pulmonary function of their patients [1], many of them still favour lobectomy to sublobar resection, even for some metastases or benign conditions. The reasons are several: (i) anatomical segmentectomies are considered difficult and challenging, particularly by junior surgeons and (ii) there was, until recently, some concern about their real rate of postoperative complications since there are very few data in the literature [2]. Although it is admitted that sublobar resections are beneficial for patients with comorbidities and/or reduced pulmonary reserve [3], is not clear whether complications such as prolonged air leaks (PALs) or pulmonary infection could be higher and eventually counterbalance their functional benefit. This has prompted us to investigate our data in order to evaluate the morbidity of this technique. The aim of this work was 2-fold, first, to evaluate the global rate of postoperative complications and second, to search for the predictors of complications.

PATIENTS AND METHODS

The records of a consecutive series of 228 anatomic pulmonary segmentectomies performed in our department between January 2007 and December 2011 were reviewed. The study was approved by our Institutional Review Board (N° 2012-10). Data were collected by review of hospital records and by direct contact with patients and/or referring physicians. Preoperatively, all patients underwent the same diagnostic and staging procedures. Whenever possible, specimens for cytological and histological examination were obtained via bronchoscopy or computed tomography (CT)-guided fine needle aspiration. Chest roentgenogram and CT of the brain, chest and abdomen were performed for non-invasive preoperative staging in patients with confirmed or suspected lung cancer. All patients underwent pulmonary function tests and calculation of predicted postoperative function to assess the surgical risk.

The approach was a posterolateral thoracotomy (Group PLT) in 146 patients (64%)—Group PLT—and a thoracoscopy in 82 (36%)—Group TS.

Technical aspects

Patients in the PLT group were operated on through a standard Group PLT. Patients in the TS group had a full thoracoscopic approach according to a previously reported technique [4]. Briefly, we used a deflectable scope housing a charged coupled device at its tip (LTF, Olympus, Tokyo, Japan) connected to a high definition camera (HDTV) (Exera II, Olympus, Tokyo, Japan). Only endoscopic instruments were used. These were inserted through 3–4 trocars, according to the necessity of dissection or exposure. No utility incision was used. On completion of the pulmonary resection, the specimen was placed into an endobag and retrieved through one of the port sites that were enlarged to a length of 2–4 cm, depending on the specimen size.

In both groups, the control of large vessels was accomplished with endostaplers while haemostasis of small-calibre vessels was performed with clips or with a bipolar vessel-sealing device (LigaSure™, Covidien, Boulder, CO, USA). The intersegmental veins were preserved and used as a landmark for the identification of the intersegmental plane. Demarcation between the resected and preserved segments was made possible by reventilation. In most patients, the intersegmental plane was divided by stapling using 4.8 mm staples (Endo-GIA II, Norwalk, CT, USA). Division of the fissure was made using a stapler in most patients or by peeling (alone or in combination with stapling) in some.

For patients operated on for lung cancer, intersegmental lymph nodes, if present, were analysed by frozen section to confirm segmentectomy (if malignant, the procedure was changed into a lobectomy). An additional radical mediastinal lymphadenectomy was performed in all these patients. The bronchus stump and portion of the staple line adjacent to the nodule were also examined by frozen section if close to the tumour. If any of those were positive, the procedure was transformed into lobectomy. Those patients are not included in this study.

One or two chest tubes were placed through the port sites. Their removal was decided according to usual rules, i.e. no air leakage and output inferior to 150 cc per day.

Postoperative data

Operative complications were classified as minor or major. Minor complications were the following: clinically defined pneumonia, PALs (defined as an air leak lasting >6 days), pneumothorax, empyema, bronchial fistula and atrial fibrillation. Major complications were defined as complications requiring either reoperation or any other invasive treatment or complications followed by patient death (haemothorax, active bleeding and segmental ischaemia, wound infection with thoracotomy dehiscence, acute respiratory failure requiring reintubation, myocardial infarction and massive haemoptysis).

Postoperative mortality included all deaths within 90 days of surgery. The patients were discharged after fulfilling the following criteria: no fever, no infection, haemodynamic stability, oxygenation returned to baseline, patient able to resume ambulation, eating and drinking, minimal chest pain, no chest tube and off parenteral therapy for >12–24 h, no effusion on chest X-ray, no or minimal pneumothorax stable for >24 h.

Follow-up data were obtained from follow-up examinations or by direct contact with the patient or referring physicians.

Statistical study

A descriptive quantitative and qualitative evaluation of morbidity and mortality was done. We tested postoperative complications and mortality distributions by age, sex, smoking history, previous diseases, respiratory function and type of surgery (thoracotomy or thoracoscopy).

Descriptive analysis was performed and we obtained central (mean and median) and dispersion (standard deviation (SD), interquartile range) measures depending on whether there was a normal distribution (Kolmogorov–Smirnov test). For quantitative variables, the Student *t* or Mann–Whitney *U*-tests were used to compare baseline characteristics and complications by type of approaches. For differences in proportions, the χ^2 test or Fisher test was used when needed. Odds ratios (ORs) using Mantel–Haenszel methods were calculated for risk factors for the presence of complications. Multivariate conditional logistic regression analysis was conducted using variables with $P < 0.05$ on univariate analysis. Likelihood ratio tests were used with a significance level of $P = 0.05$ to guide sequential exclusion of covariates from the model. Interaction terms were tested to assess for effect modification. All statistical tests were two-tailed and P-value ≤ 0.05 was deemed significant. Results were analysed using SPSS, version 12.0 (Chicago, IL, USA).

RESULTS

Between 2007 and 2011, 1453 major pulmonary resections (MPR) (1054 lobectomies, 171 pneumonectomies and 228 segmentectomies) were performed in our department. Segmental resections accounted for 16% of all resections.

We performed 228 segmentectomies on 221 patients. There were 99 females (45%) and 122 males (55%). The mean age was 61 years (range 18–86 years) and 57 (25%) patients were 70 years old or older. One hundred thirty-nine patients (61%) had a history of smoking and 66 (29%) were current smokers. The mean forced expiratory volume in 1 s (FEV1) was 87% (SD = 21.25) and 30 patients (13%) had an FEV1 of ≤60%. A total of 57 patients had a history of pulmonary resection (a lobectomy in most cases). Indications for segmentectomy were as follows: primary lung cancer (111 cases), metastases (71 cases), benign non-infectious lesions (25 cases) and infection (21 cases) (Table 1). The surgical approach was a PLT group in 146 patients (64%) and a thoracoscopy (TS group) in 82 (36%). Among primary lung cancer only 22 patients (10%) had preoperative definitive cytological diagnosis. In the other patients, a diagnosis was obtained either by wedge resection or by needle biopsy with frozen section.

Resected segments were: 60 apical segments of the lower lobe (S6), 46 apicoposterior segments (S1 + S2), 42 lingula-sparing upper lobectomy (S1 + S2 + S3), 38 basilar segments (S7 + S8 + S9 + S10),

Table 1: Description of demographic characteristics (221 patients)

Variable	*n*	%
Age (in years)		
Mean = 61 (SD = 11.54)		
Median = 62 (18–86)		
<70	171	75
≥70	57	25
Sex		
Female	103	45
Male	125	55
Smoker status		
Active	66	29
Former >6 month	73	32
Non-smoker	89	39
Comorbidities		
Cardiovascular	22	10
Diabetes mellitus	24	11
Previous thoracic resection	57	25
Preoperative		
FEV1		
Mean = 87% (21.25)		
Median = 88% (25–135)		
FEV1 ≤ 60%	30	13
Indication for surgery		
Non-small-cell lung cancer	111	49
Metastasis	71	31
Benign non-infectious lesion	25	11
Benign infectious lesion	21	9

FEV1: forced expiratory volume in 1 s.

Table 2: Description of resections by location (228 segmentectomies)

Location	*n*
Right = 78 resections	
Upper	
Apicoposterior	31
Anterior	6
Lower	
Basilar segments	13
Superior	24
Other	4
Left = 150 resections	
Upper	
Apicoposterior	15
Lingula-sparing upper lobectomy	42
Lingula	22
Lower	
Basilar segments	25
Superior	36
Other	10

22 lingula (S4 + S5), 6 right anterior segments (S2) and 14 other segmentectomies (Table 2).

Complications

The mortality rate at 3 months was 1.3% (3 cases). One patient had a massive myocardial infarction and another had an acute respiratory failure with refractory hypoxaemia. The third patient, who presented with major malnutrition, had a bronchial fistula at Day 2, complicated by an intrapulmonary abscess. He died at Day 17 from a massive haemoptysis.

Table 3: Description of complications ($n = 77$)

Complications	Patients, *n* (%)
Major	14 (6%)
Massive haemoptysis	1
Myocardial infarction	1
Reoperation	10 (4.4%)
Haemothorax	4
Segmental ischaemia	3
Prolonged air leak (28 days)	1
Active bleeding	1
Thoracotomy dehiscence	1
Reintubation for acute respiratory failure	2
Minor	63 (28%)
Clinically defined pneumonia	29 (12.7%)
Pneumothorax	21 (9.2%)
Air leak >6 days	21 (9.2%)
Empyema	8 (3.5%)
Atrial fibrillation	7 (3%)
Bronchial fistula	2 (0.9%)
Global complications	77 (34%)

A total of 77 (34%) patients had one ore more complications. There were 14 major complications: 2 reintubations for acute respiratory failure, 10 complications requiring reoperation, 1 massive haemoptysis and 1 massive myocardial infarction. Minor complications occurred in 63 patients (27.5%) and were mainly of respiratory order: 25 pneumonia (50% of minor complications), 21 pneumothorax, 21 PALs and other complications (Table 3).

A reoperation was necessary in 10 patients. There were 3 cases of segmental ischaemia, i.e. 2 torsions and 1 venous infarction requiring resection of the infarcted segment. Four patients were reoperated on for haemothorax. The other complications were: 1 case of early onset of bleeding in a patient operated on while on curative anticoagulation, 1 case of PAL (28 days) and 1 case of diffuse subcutaneous emphysema secondary to the dehiscence of the thoracotomy. In 3 cases, reoperation was done by thoracoscopy, and by thoracotomy in the other 7. The postoperative course for all of these patients was uneventful.

The overall median chest tube duration for all patients was 3 days (range 1–24 days), and the overall median postoperative stay was 6 days (range 3–126 days).

There was only 7 (3%) atelectasis requiring bronchoscopy. All of them had other complications too: 4 had a bronchopneumopathy, 1 had a PAL and 2 had major complications: 1, a reoperation for haemothorax and 1 died after a myocardial infarction.

In patients with altered pulmonary function tests (preoperative FEV1 < 80%, $n = 76$ patients), the overall complication rate was 50%. Among those, in patients with an FEV1 of ≤60% the overall complication rate (70%) was significantly higher than in patients with 60% < FEV1 < 80% ($P < 0.001$). Most complications (41%) were of pulmonary order and were significantly more frequent in patients with an FEV1 of ≤60% ($P < 0.001$). The hospitalization was significantly longer in patients with FEV1 ≤ 60% with a mean of 16 days vs 9.5 days for patients with 60% < FEV1 < 80% ($P < 0.001$). The mean duration of drainage was not statistically different (5.7 vs 5.0 days) in the two groups (Table 4).

Table 4: Univariate analysis for FEV1 parameter (*n* = 228 patients)

	FEV1						*P*-value
	≤60%		60% < FEV1 < 80%		≥80%		
	n	%	*n*	%	*n*	%	
Global complications							
No	9	30	29	63	113	74	<0.001
Yes	21	70	17	37	39	26	
Mean hospital stay (SD)	16.13 (23.34)		9.45 (8.1)		7.6 (6.27)		<0.001
Mean drainage duration (SD)	5.7 (3.2)		5.04 (5.2)		4.67 (4.74)		0.53

SD: standard deviation; FEV1: forced expiratory volume in 1 s.

Table 5: Univariate analysis for surgical approach (*n* = 228 patients)

	Approach				*P*-value
	Thoracotomy		Thoracoscopy		
	n	%	*n*	%	
Global complications					
No	85	58.2	66	80.5	<0.001
Yes	61	41.8	16	19.5	
Mean hospital stay (SD)	10.5 (13.0)		6.6 (3.87)		0.008
Mean drainage duration (SD)	5.7 (5.52)		3.5 (1.86)		0.001

SD: standard deviation.

There were fewer complications in the TS, (19%) than in the PLT, group (42%) ($P < 0.001$). Both the mean drainage duration and mean hospital stay were shorter in the TS group (3.5 vs 5.7 days, $P = 0.001$, and 6.6 vs 10.5 days, $P = 0.008$, respectively) (Table 5).

On univariate analysis, FEV1 ≤ 60%, male gender and surgical approach by a Group PLT were statistically significant risk factors for complications (Table 6).

On multivariate analysis, independently of age, FEV1 ≤ 60% ($P = 0.001$), male gender ($P = 0.013$) and surgical approach by a Group PLT [OR = 0.324, 95% confidence interval (0.149–0.704), $P = 0.001$], remained predictive factors for complications (Table 7).

DISCUSSION

For years, sublobar resections have been proposed as parenchymal sparing procedures and were reserved for those patients with impaired pulmonary function. For most patients with normal lung function, it was thought that lobectomy—not only for oncological reasons, but also because it was easier and more standardized—should be the best option [5].

Among the factors explaining why surgeons are reluctant to perform segmentectomy are: prolonged operative time, more complex anatomy with difficult identification of vessels and bronchi, management of the intersegmental plane with potential postoperative PALs, fear of venous injury that can lead to postoperative ischaemic complications and—in case of carcinoma—inability to achieve a complete lymph node dissection [5, 6]. Recently, reports about the video-assisted approach and totally thoracoscopic approach have portrayed an image of segmentectomies that is associated with technical challenges [4, 7].

Pulmonary function

Evaluating the risks of MPR partly relies on pulmonary functional tests (PFTs), and particularly on FEV1 and diffusing capacity of carbon monoxide (DLCO). It is usually admitted that patients with preoperative FEV1 and/or DLCO < 60% of what is predicted are at increased risk of postoperative pulmonary complications [8]. In our series, impaired FEV1 was one of the most important predictive factors for complications. When FEV1 was <60%, the complication rate was significantly higher (70%) than in patients with 60% < FEV1 < 80% (34.8%). The impact of low FEV1 on postoperative morbidity of MPR has been demonstrated. However, some recent papers have stressed the fact that PFTs could not be as important as a predictive factor when patients are operated on via thoracoscopy. Thus, in a series of 340 lobectomies with FEV1 or DLCO < 60% who were operated on by thoracotomy (167 patients) or thoracoscopy (173 patients), FEV1 appeared as a significant predictor of pulmonary complication for patients undergoing thoracotomy but not thoracoscopy [9]. In a series of 70 patients with FEV1 < 40% who underwent MPR, Kachare *et al.* [10] showed that patients undergoing thoracoscopic resection had a much lower incidence of pneumonia than those undergoing open resection (4.3 vs 21.7%, $P < 0.05$). These authors concluded that traditional PFTs guidelines for operability should most likely be reassessed for thoracoscopic surgery. In our series, a comparison

Table 6: Univariate analysis for complications

	Global complications		
	No, *n* = 151, *n* (%)	Yes, *n* = 77, *n* (%)	*P*-value
Age			
<70	115 (67.3)	56 (32.7)	0.573
≥70	36 (63.2)	21 (36.8)	
Gender			
Female	77 (75.8)	26 (25.2)	0.013
Male	74 (59.2)	51 (40.8)	
Smoker status			
Active	38 (57.6)	29 (42.4)	0.078
Former >6 month	48 (65.8)	26 (34.2)	0.918
Never	63 (74.1)	22 (25.9)	0.052
Comorbidities			
Cardiovascular	12 (54.5)	10 (45.5)	0.224
Diabetes mellitus	12 (50.0)	12 (50.0)	0.076
Previous pulmonary resection	37 (64.9)	20 (35.1)	0.809
No comorbidities	36 (76.6)	11 (23.4)	0.092
FEV1			
FEV1 ≤ 60%	9 (30.0)	21 (70.0)	<0.001
60% < FEV1 < 80%	30 (65.2)	16 (34.8)	
FEV1 ≥ 80%	113 (74.3)	39 (25.7)	
Indication			
Cancer	73 (65.8)	38 (34.2)	0.886
Metastasis	45 (63.4)	26 (36.6)	0.543
Benign non-infectious	20 (80.0)	5 (20.0)	0.124
Benign infectious	13 (61.9)	8 (38.1)	0.662
Surgical approach			
Thoracotomy	85 (58.2)	61 (41.8)	0.001
Thoracoscopy	66 (80.5)	16 (19.5)	
Mean duration of surgery (min)	142.2	142.7	0.337

FEV1: forced expiratory volume in 1 s.

Table 7: Multivariate analysis for overall complications (*n* = 77 patients)

	Overall complications	
	Adjusted OR (95% CI)[a]	*P*-value
Male gender	2.04 (1.2–3.6)	0.013
Preoperative FEV1 < 60%	5.9 (2.5–13.7)	<0.001
Thoracotomy	2.14 (1.33–3.46)	0.001

[a]OR adjusted by age.
FEV1: forced expiratory volume in 1 s.

of both groups did not permit reaching a significant difference, but there were fewer complications in the TS group with low FEV1 while more than half of these patients in the PLT group had a complication.

Type of approach

Many series of video-assisted and thoracoscopic segmentectomies have been recently published. Those comparing video-assisted thoracic surgery (VATS) to open approaches [11, 12] have come to the same conclusion as ourselves, i.e. VATS compares favourably with thoracotomy. In our series, the overall complication rate was 19% in the TS group vs 42% in the PLT group. In a series of 225 segmentectomies for stage I lung cancer comprising 104 VATS and 121 thoracotomies, Schuchert *et al.* [12] reported a morbidity rate of 15.4% for VATS vs 29.8% for thoracotomy. In a series of 77 segmentectomies for stage I lung cancer comprising 48 VATS and 29 thoracotomies, Atkins *et al.* [11] reported a significantly reduced length of stay in the TS group compared with the thoracotomy group, as in our own series (11 days vs 7 days). In a series of 47 thoracoscopic segmentectomies with limited pulmonary reserve, Kachare *et al.* [10] showed a significantly lower incidence of pneumonia when compared with 23 segmentectomies by open surgery (4.3 vs 21.7%).

Specific postoperative complications

Postoperative PALs are one of the complications that have contributed to the poor reputation to segmentectomies. However, the incidence of PAL is not higher after segmentectomy than after lobectomy. In some studies, PAL rates after lobectomy range from 9 [13] to 15% [14]. In our series of segmentectomies, the rate of PAL was 9.2%. In the series of Jones *et al.* [2], it was 8%. The analyses of 24 113 pulmonary resections from the French national thoracic database found a PAL rate of 8.3% after lobectomy and 8.0% after segmentectomy [15]. Eventually, despite the issue of intersegmental plane division, segmentectomies are not responsible for more PAL than lobectomies.

Segmental torsions seem even scarcer and are not described as a common complication in large series of segmentectomies. There is only one case report of lingular torsion following a segmentectomy of the left upper division [16]. In a recent series of 49 segmentectomies performed by thoracotomy, 1 patient (2%) was reoperated on for an infarction of the lingula [17]. In our series, the 2 cases belonged to the TS group. This raises the question of whether there could be a relation between thoracoscopy and this complication. Although the thoracoscopic approach offers a clear and magnified view, one of its limitations is the difficulty in obtaining a global vision of the operative field, especially as the lung is reinflated. Therefore, a wrong positioning of the remaining lobe or segment can be overlooked. In addition, securing the lobe or segment to the adjacent lobe by thoracoscopy is not very easy. When performed by thoracotomy, it is usually done by applying anchoring stitches on a partially reventilated parenchyma. This is almost impossible to perform by thoracoscopy due to the lack of space caused by reinflation of the lung. We have overcome this difficulty by applying one or two cartridges of staples, using an endostapler with no knife (Endo-TA, Covidien Mansfield, MA, USA).

Does the complexity of anatomical segmentectomy result in increased morbidity?

As mentioned by Oizumi *et al.* [18], segmentectomy raises some specific challenges to surgeons because—even when done via thoracotomy—the procedure is reputed to be complex. Not only are the anatomical relationships difficult to grasp, particularly for the young and less- experienced surgeons, but also the identification and division of the intersegmental plane are a concern. The study of preoperative CT three-dimensional reconstructions helps assert the number, size and direction of these arteries without doubt. Having the vascular pattern in mind helps the surgeon perform a safer dissection of the branches of the pulmonary artery, particularly when the fissure is fused and/or when lymph nodes are present. In a series of 49 patients selected for VATS lobectomy, Fukuhara *et al.* [14] found that preoperative three-dimensional (3-D) computed pulmonary angiography was identifying the pulmonary artery branches in 95% of the cases. In their series, only some small branches (<2 mm in diameter) were missed. For junior or less-experienced surgeons, preoperative 3-D reconstruction of the vascular anatomy can be a helpful adjunct.

Another difficulty faced during thoracoscopic segmentectomy is the identification and division of the intersegmental plane. When performed through a thoracotomy, this step is facilitated by the use of manual palpation, which is not possible via thoracoscopy. Several methods have been described. The most common is the creation of a ventilated-deflated line by reventilating the operated lung once the segmental bronchus has been stapled. This technique has two drawbacks: (i) reventilation obscures the vision, a much more troublesome problem than during thoracotomy, (ii) the segments to be resected can be partly reventilated through the collateral canals, leading to an unclear demarcation line. Therefore, some authors have suggested acting reverse, i.e. reventilating the whole lung before the segmental bronchus has been divided and then collapsing it, so that only the diseased segments remain inflated [19]. Others have suggested using selected jet ventilation in the segmental bronchi to be divided. In emphysematous patients, we have used a similar method by injecting air through the channel of a bronchofibrescope, after selective endoscopy of the segmental bronchus [20].

Once the intersegmental plane has been determined, the last issue is the choice of the division method. Some authors have used a combination of blunt dissection, electrocautery and application of fibrin sealant [19]. When air leaks were observed, some surgeons applied mattress suture with pledgets [20]. These methods have the advantage of sparing the parenchyma, but bear a risk of postoperative air leak. Actually, most authors use staplers. Stapling is, however, not very easy. First, it may require using many cartridges, up to five in the series of Watanabe. Secondly, the limited opening of the endostaplers and the thickness of the parenchyma cause exposure to disruption of the staples line, an adverse event that occurred twice in our series. The consequences were not serious, but led to troublesome blood loss and required hand suturing.

In spite of these specific difficulties related to segmentectomy, there is no evidence of increased morbidity or mortality compared with lobectomy. In our study, we found a global complication rate of 34% and a major complication rate of 6%. Our findings are comparable with those of other series. Allen *et al.* [21] find, in a prospective randomized study, a morbidity rate of 46%, but in this study only non-small-lung cancer patients were included, and one could presume that those patients admitted for segmentectomy were more at risk of postoperative complications. In the same study, the complication rate after lobectomy was 37%, similar to the complication rate after segmentectomy in our study. Jones *et al.* [2]—in a retrospective series of 62 segmentectomies—found an overall complication rate of 39%, but in their series, most patients had preoperative FEV1 values of ≤55%. The incidence of supraventricular dysrhythmias in our study is lower than that seen after lobectomy [21, 22].

Finally, the mortality rate in our series was 1.3%, i.e. close to the mortality rate of lobectomies. Wada *et al.*, [23] in a series of 2044 patients from a single institution, reported a 1.2% operative mortality after lobectomy. In the American College of Surgery Oncology Group Z0030 randomized, multi-institutional, prospective trial, the reported mortality after lobectomy was 1% [21].

In conclusion, our series demonstrates that the morbidity and the mortality of segmentectomies are acceptable. Patients with FEV1 < 60% should be systematically considered for a segmentectomy, and if feasible, the segmentectomy should be performed by a thoracoscopic approach, which reduces the rate of postoperative complications and allows the lowering of the threshold of preoperative FEV1 [10]. Thoracoscopic anatomical segmentectomy could become the operation of choice, not only for clinical T1aN0 lung carcinomas [24], but also for metastases or other benign lesions that are not amenable to wedge resection because of their close relationship to bronchovascular elements.

Conflict of interest: none declared.

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