Thoracoscopic segmentectomy versus lobectomy: A propensity score–matched analysis

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ABSTRACT

Objectives: The aim of this study is to compare the postoperative complications, perioperative course, and survival among patients from the multicentric Spanish Video-assisted Thoracic Surgery Group database who received video-assisted thoracic surgery lobectomy or video-assisted thoracic surgery anatomic segmentectomy.

Methods: From December 2016 to March 2018, a total of 2250 patients were collected from 33 centers. Overall analysis (video-assisted thoracic surgery lobectomy = 2070; video-assisted thoracic surgery anatomic segmentectomy = 180) and propensity score–matched adjusted analysis (video-assisted thoracic surgery lobectomy = 97; video-assisted thoracic surgery anatomic segmentectomy = 97) were performed to compare postoperative results. Kaplan–Meier and competing risks method were used to compare survival.

Results: In the overall analysis, video-assisted thoracic surgery anatomic segmentectomy showed a lower incidence of respiratory complications (relative risk, 0.56; confidence interval, 0.37–0.83; P = .002), lower postoperative prolonged air leak (relative risk, 0.42; 95% confidence interval, 0.23–0.78; P = .003), and shorter median postoperative stay (4.8 vs 6.2 days; P = .004) than video-assisted thoracic surgery lobectomy. After propensity score–matched analysis, prolonged air leak remained significantly lower in video-assisted thoracic surgery anatomic segmentectomy (relative risk, 0.33; 95% confidence interval, 0.12–0.89; P = .02). Kaplan–Meier and competing risk curves showed no differences during the 3-year follow-up (median follow-up in months: 24.4; interquartile range, 20.8–28.3) in terms of overall survival (hazard ratio, 0.73; 95% confidence interval, 0.45–1.17; P = .2), tumor progression–related mortality (subdistribution hazard ratio, 0.41; 95% confidence interval, 0.11–1.57; P = .2), and disease-free survival (subdistribution hazard ratio, 0.73; 95% confidence interval, 0.35–1.51; P = .4) between groups.

Conclusions: Video-assisted thoracic surgery segmentectomy showed results similar to lobectomy in terms of postoperative outcomes and midterm survival. In addition, a lower incidence of prolonged air leak was found in patients who underwent video-assisted thoracic surgery anatomic segmentectomy. (JTCVS Open 2022;9:268-78)
Parenchymal-sparing resections could be important in patients with small pulmonary lesions, decreased pulmonary reserve, poor performance, or previous lung resections.1-3 Over time, improvements in imaging and wider use of screening have allowed earlier detection of treatable lung lesions.7 As video-assisted thoracic surgery (VATS) continues to expand, a special interest in thoracoscopic sublobar procedures has naturally arisen among thoracic surgeons.5-8 There are still few and limited studies that compare the postoperative outcomes of VATS anatomic segmentectomy versus VATS lobectomy.9-13 The main advantage previously described is the value of lung preservation after segmentectomy but at the cost of prolonged air leaks.9,10 This study aims to compare the postoperative outcomes and midterm survival between VATS anatomic segmentectomy and lobectomy in 2250 patients from the prospective multicentric Spanish Video-assisted Thoracic Surgery Group database.

MATERIALS AND METHODS

Patients
In 2016, the Spanish Society of Thoracic Surgery developed a prospective multicentric database with the participation of 33 certified Spanish thoracic surgery centers, all of them members of the Spanish Video-assisted Thoracic Surgery Group.14 This project was approved by the ethics committees of all the participating centers, and informed consent was obtained from the recruited patients to use their clinical data for scientific purposes (PI15/0072, 20/05/2015). Each center included all consecutive patients undergoing VATS anatomic lung resections from December 20, 2016, to March 20, 2018. Inclusion criteria were patients aged more than 18 years undergoing VATS anatomic lung resections (lobectomy or segmentectomy). Wedge resections, bilateral procedures, pneumonectomies, bilobectomies, non-VATS interventions, and those VATS procedures that required conversion to thoracotomy were excluded. Patients were then included in the VATS lobectomy group (VLG) or the VATS anatomic segmentectomy group (VASG).

Surgical Technique
VATS cases were defined as the absence of rib separation (regardless number of incisions) and the visualization performed via the optic system alone (Video 1). Anatomic segmentectomy was defined as any sublobar resection following the intersegmental plane with individual division of arterial, venous, and bronchial branches from the involved segment. In lung cancer cases, lymphadenectomy was performed by sampling or systematic lymph node dissection.15

Descriptive, Explicative, and Outcome Variables
All descriptive and outcome variables were adapted from the standardization documents of the Society of Thoracic Surgeons and the European Society of Thoracic Surgeons.16 Cases of postoperative morbidity and mortality included those occurring during the first 30 days after surgery. Two composite dependent variables were defined: Severe complications included death or any complication considered IIIb or worse in the Clavien-Dindo classification,17 and respiratory complications were defined as the presence of any respiratory complication listed in Table 1. In a 3-year follow-up, overall survival, tumor-progression survival, and disease-free survival were also evaluated. The explanatory predictive variable was the type of VATS resection (anatomic segmentectomy vs lobectomy).

Patients’ Follow-up
Patients’ follow-up included computed tomography every 3 months for the first year, every 6 months for second year, and yearly thereafter.

Statistical Analysis
Data were processed and explored. Variables with more than 10% missing values were deleted. For descriptive analysis, continuous variables were tested for normal distribution (Shapiro–Wilk test) and homoscedasticity (Levene test). Normally distributed variables were reported as mean and standard deviation, and non-normal variables were reported as median and interquartile range (IQR). Mean differences were assessed with a t test. Categorical variables were reported as absolute (count) and relative (percentage) frequencies and compared with a chi-square test. Dependent variables were postoperative complications and perioperative course (Table 1). The remaining descriptive variables were considered for statistical adjustment. An unadjusted analysis was performed for outcome variables. Risk ratio
was used as association measure for categorical variables. Continuous and multivariate variables were tested for mean or frequency differences. For adjusted analysis, a propensity score–matched 1:1 sample was selected using logistic regression with the nearest neighbor method and a caliper of 0.1. All descriptive variables showing significant differences between groups was included in the model. Baseline characteristics were checked again in the matched sample. A risk ratio confidence interval (CI) excluded the value one. Survival analysis was performed with the resulting groups after propensity matching. For the univariate analysis of survival, the Kaplan–Meier method was used. Global survival curves were compared with log-rank test. Mortality by a specific cause and recurrences were analyzed by competing risks method because other-cause mortality is a competing risk for relapse and disease-related mortality. Survival between groups was assessed with the Gray test. Stata 14 Statistical Software: Release 14 (StataCorp LP) was used for the analysis.

RESULTS

The analysis identified 2070 patients in the VLG, 1404 male and 666 female, with a median age of 66 years (IQR, 59-73); and 180 patients in the VASG, 124 male and 56 female, with a median age of 67 years (IQR, 59-74).

Overall Results

Preoperatively (Table 2), the VLG showed less frequency of previous thoracic surgery (4.7% vs 10%; $P = .001$), previous oncological history (37.8% vs 49.4%; $P < .001$), and better predicted postoperative diffusion capacity for carbon monoxide (72.9% vs 65.7%; $P = .001$), whereas the VASG exhibited better predicted postoperative forced expiratory volume in 1 second (75.2% vs 72.2%; $P = .001$). Upper lobectomies were the most frequent procedures in the VLG,

| TABLE 1. Unadjusted analysis of results |
|-----------------------------------------|
|                                  | VLG (N = 2070) | VASG (N = 180) | RR/MD | 95% CI          | $P$ value |
|-----------------------------|----------------|----------------|-------|-----------------|----------|
| Severe complications*       | 73 (3.5%)      | 4 (2.2%)       | 0.63  | 0.23-1.70       | .36      |
| Postoperative mortality     | 22 (1.1%)      | 2 (1.1%)       | 1.05  | 0.25-4.41       | .95      |
| Clavien–Dindo IIIb          | 30 (1.5%)      | 0              | 0     |                 | .1       |
| Clavien–Dindo IVa           | 24 (1.2%)      | 3 (1.7%)       | 1.44  | 0.44-4.73       | .55      |
| Clavien–Dindo IVb           | 7 (0.3%)       | 0              | 0     |                 | .43      |
| Respiratory complications   | 455 (21.0%)    | 22 (12.2%)     | 0.56  | 0.37-0.83       | .002     |
| Prolonged intubation        | 2 (0.1%)       | 0              | 0     |                 | .68      |
| Reintubation                | 23 (1.1%)      | 1 (0.6%)       | 0.50  | 0.07-3.68       | .49      |
| Prolonged air leak (>5 d)   | 272 (13.1%)    | 10 (5.6%)      | 0.42  | 0.23-0.78       | .003     |
| Pleural effusion/pneumothorax| 49 (2.4%)      | 2 (1.1%)       | 0.47  | 0.12-1.91       | .28      |
| Atelectasis                 | 71 (3.4%)      | 7 (3.9%)       | 1.13  | 0.53-2.43       | .75      |
| Pneumonia                   | 72 (3.5%)      | 4 (2.2%)       | 0.64  | 2.24-1.73       | .37      |
| ARDS                        | 18 (0.9%)      | 0              | 0     |                 | .21      |
| Bronchopleural fistula      | 8 (0.4%)       | 0              | 0     |                 | .40      |
| Empyema                     | 13 (0.6%)      | 0              | 0     |                 | .27      |
| Chylothorax                 | 3 (0.1%)       | 1 (0.6%)       | 3.83  | 0.4-36.7        | .21      |
| Pulmonary thromboembolism   | 5 (0.2%)       | 0              | 0     |                 | .51      |
| Other respiratory complications| 42 (2.0%)   | 1 (0.6%)       | 0.27  | 0.04-1.98       | .17      |
| Reintervention              | 60 (2.9%)      | 4 (2.2%)       | 0.77  | 0.28-2.08       | .6       |
| Wound infection             | 23 (1.1%)      | 2 (1.1%)       | 1     | 0.24-4.21       | 1        |
| Cardiovascular complications| 108 (5.2%)     | 8 (4.4%)       | 0.85  | 0.42-1.72       | .65      |
| Blood transfusion           | 21 (1.0%)      | 4 (2.2%)       | 2.19  | 0.76-6.39       | .14      |
| Other complications         | 114 (5.5%)     | 11 (6.1%)      | 1.11  | 0.61-20.2       | .73      |

Perioperative outcomes

| Type of care | Surgical time (min) | 180 | 177 | 3.7 | $-6.5$ to $13.9$ | .47 |
|--------------|---------------------|-----|-----|-----|-----------------|-----|
| Basic care   | 278 (13.4%)         | 20  | 11.1%|     |                 | .32 |
| Intermediate care | 668 (32.3%) | 70 | 38.9%|     |                 |    |
| Intensive care unit | 1123 (54.3%) | 90 | 50.0%|     |                 |    |
| Intraoperative death | 1 (0.1%) | 0  | 0   |     |                 | .76 |
| Postoperative stay (d) | 6.2 | 4.8 | 1.4 | 0.43-2.31 | .904 |
| Readmission | 109 (5.5%)         | 6 (3.5%) | 0.64 | 0.28-1.43 | .26 |
| Intermediate care or ICU readmission | 69 (3.3%) | 7 (3.9%) | 1.17 | 0.54-2.50 | .69 |
### TABLE 2. Patient demographics and baseline characteristics

| Variables: Median (IQR) or No. (%) | VLG (N = 2070) | VASG (N = 180) | P value |
|-----------------------------------|----------------|---------------|---------|
| Age (y)                           | 66 (59, 73)    | 67 (59, 74)   | .9678   |
| Sex (male)                        | 1404 (67.8%)   | 124 (68.9%)   | .77     |
| BMI (kg/m²)                       | 26.6 (23.7, 29.7) | 26.6 (24.2, 29.7) | .65 |
| Smokers (current or ex-smokers)   | 1707 (82.5%)   | 136 (75.5%)   | .04     |
| Previous thoracic surgery         |                |               |         |
| Ipsilateral                       | 96 (4.7%)      | 18 (10.0%)    | .001    |
| Contralateral                     | 32 (1.6%)      | 4 (2.2%)      |         |
| Bilateral                         | 53 (2.6%)      | 14 (7.8%)     |         |
| Previous oncological disease      |                |               | <.001   |
| Previous lung cancer              | 53 (2.9%)      | 14 (11.1%)    | <.001   |
| Predicted postoperative FEV1 (%)  | 72.2 (61.2, 84.5) | 75.2 (62.6, 90.9) | .002   |
| Predicted postoperative DLCO (%)  | 65.7 (54.7, 78.1) | 72.9 (59.9, 85.9) | .001   |
| Diagnosis                         |                |               | .001    |
| Lung carcinoma                    | 1819 (87.9%)   | 126 (70.0%)   |         |
| Lung metastases                   | 141 (6.8%)     | 31 (17.2%)    |         |
| Other                             | 110 (5.3%)     | 23 (12.8%)    |         |
| Pathologic stage                  |                |               | <.001   |
| 0                                 | 14 (0.8%)      | 5 (4.0%)      |         |
| I                                 | 1178 (56.9%)   | 101 (56.1%)   |         |
| II                                | 344 (16.6%)    | 8 (4.4%)      |         |
| III                               | 216 (10.4%)    | 7 (3.9%)      |         |
| IV                                | 27 (1.3%)      | 3 (1.7%)      |         |
| Tumor location                    |                |               | <.001   |
| Central                           | 501 (27.6%)    | 15 (11.9%)    |         |
| Peripheral                        | 1317 (72.4%)   | 111 (88.10%)  |         |
| ASA                               |                |               | .57     |
| I                                 | 50 (2.4%)      | 5 (2.8%)      |         |
| II                                | 907 (43.9%)    | 70 (38.9%)    |         |
| III                               | 1066 (51.6%)   | 102 (56.7%)   |         |
| IV                                | 44 (2.1%)      | 3 (1.7%)      |         |
| Hemithorax                        |                |               | <.001   |
| Right                             | 1302 (62.9%)   | 54 (30.0%)    |         |
| Left                              | 768 (37.1%)    | 126 (70.0%)   |         |
| No. of incisions                  |                |               | <.001   |
| 1                                 | 176 (8.5%)     | 34 (18.9%)    |         |
| 2                                 | 1349 (65.2%)   | 114 (63.3%)   |         |
| Multiportal (≥3)                  | 545 (26.3%)    | 32 (17.8%)    |         |
| Lobes or segments resected        |                |               | N/A     |
| Right upper lobectomy             | 2070 (100.0%)  | 180 (100.0%)  |         |
| Middle lobectomy                  | 775 (36.6%)    |               |         |
| Right lower lobectomy             | 393 (19.0%)    |               |         |
| Left upper lobectomy              | 444 (21.5%)    |               |         |
| Left lower lobectomy              | 326 (15.8%)    |               |         |
| S1                                |                | 15 (8.3%)     |         |
| S2                                |                | 9 (5.0%)      |         |
| S3                                |                | 8 (4.4%)      |         |
| S6                                |                | 31 (17.2%)    |         |
| Basal pyramid                     |                | 10 (5.6%)     |         |
| Nonbasal pyramid lower segmentectomies (S7, S8, S9, S10 or combination) | | | |
| S1 + S2                           |                | 5 (2.8%)      |         |
| Left S1 + S2 + S3                 |                | 5 (2.8%)      |         |
| Left S4 + S5                      |                | 59 (32.8%)    |         |
| Other combination                 |                | 24 (13.3%)    |         |

IQR, Interquartile range; VLG, VATS lobectomy group; VASG, VATS anatomic segmentectomy group; BMI, body mass index; FEV1, forced expiratory volume in 1 second; DLCO, diffusing capacity for carbon monoxide; ASA, American Society of Anesthesiologists; N/A, not applicable.
| Variables | VLG (N = 97) | VASG (N = 97) | P value |
|-----------|-------------|--------------|---------|
| Age (y)   | 67 (61, 72) | 69 (61, 74)  | .5998   |
| Sex (male)| 97 (62.9%)  | 97 (66.0%)   | .653    |
| BMI (kg/m²)| 27.7 (25.0, 30.8) | 26.7 (24.2, 30.0) | .1521   |
| Smokers (current or ex-smoker)| 82 (84.5%) | 81 (83.5%) | .957    |
| Previous thoracic surgery | | | .747 |
| No | 86 (88.9%) | 88 (90.7%) |
| Ipsilateral | 3 (3.1%) | 2 (2.1%) |
| Contralateral | 7 (7.2%) | 7 (7.2%) |
| Bilateral | 1 (1.0%) | 0 |
| Previous oncological disease | 30 (38.1%) | 41 (42.3%) | .558 |
| Predicted postoperative FEV1 (%) | 75.9 (63.4, 86.8) | 72.47 (59.7, 86.8) | .8019 |
| Predicted postoperative DLCO (%) | 70.7 (61.6, 82.5) | 73.1 (56.4, 85) | .90 |
| Diagnosis | | | 1 |
| Lung carcinoma | 97 (100%) | 97 (100%) |
| Histology | | | .5 |
| Adenocarcinoma | 63 (64.9%) | 55 (56.7%) |
| Epidermoid | 22 (22.7%) | 26 (26.8%) |
| Others | 12 (12.4%) | 16 (16.5%) |
| Tumor size (mm) | 17 (12, 25) | 15 (12, 20) | .09 |
| Pathologic stage | | | .97 |
| 0 | 5 (5.2%) | 4 (4.1%) |
| IAI | 15 (15.5%) | 16 (16.5%) |
| IA2 | 38 (39.2%) | 41 (42.3%) |
| IA3 | 6 (6.2%) | 9 (9.3%) |
| IB | 12 (12.4%) | 13 (13.4%) |
| IIA | 1 (1.0%) | 1 (1.0%) |
| IIB | 10 (10.3%) | 5 (5.6%) |
| IIIA | 8 (8.3%) | 6 (6.2%) |
| IIIB | 1 (1.0%) | 1 (1.0%) |
| IVB | 1 (1.0%) | 1 (1.0%) |
| Lymph nodes resected | 6 (4, 10) | 4 (2.5, 8) | .001 |
| Hilar-mediastinal* stations resected | 3 (3, 4) | 3 (2, 3) | .01 |
| Patients with pathological hilar-mediastinal lymph node involvement | 11 (11.3%) | 9 (9.3%) | .22 |
| Patients with pathological Intrapulmonary lymph node involvement | 4 (4.1%) | 2 (2.1%) | .407 |
| Previous lung cancer | 9 (9.3%) | 8 (8.3%) | .8 |
| ASA | | | .741 |
| I | 2 (2.1%) | 1 (1.03%) |
| II | 41 (42.3%) | 35 (36.1%) |
| III | 52 (53.6%) | 59 (60.8%) |
| IV | 2 (2.1%) | 2 (2.1%) |
| Hemithorax | | | .869 |
| Right | 24 (24.7%) | 25 (25.8%) |
| Left | 73 (75.3%) | 72 (74.2%) |
| No. of incisions | | | .22 |
| 1 | 8 (8.3%) | 16 (16.5%) |
| 2 | 66 (68.0%) | 61 (62.8%) |
| Multiportal (≥3) | 23 (23.7%) | 20 (20.6%) |

IQR, Interquartile range; VLG, VATS lobectomy group; VASG, VATS anatomic segmentectomy group; BMI, body mass index; FEV1, forced expiratory volume in 1 second; DLCO, diffusing capacity for carbon monoxide; ASA, American Society of Anesthesiologists. *Hilar-mediastinal: N2 stations or 10 station.
whereas left upper trisegmentectomy was the most frequent in the VASG. Primary lung cancer was the most frequent diagnosis in both groups but more prevalent in VLG (87.9% vs 70%; \( P = .001 \)). The majority of cases were performed by the biportal or multiportal VATS approach (91.3% of all cases) (Videos 1 and 2).

In the postoperative data analysis (Table 1), VASG showed less respiratory complications (RR, 0.56; 95% CI, 0.37-0.83; \( P = .002 \)), less postoperative prolonged air leak (RR, 0.42; 95% CI, 0.23-0.78; \( P = .003 \)), and shorter postoperative stay (4.8 vs 6.2 days; \( P = .004 \)). Severe complications were lower in VASG, but this difference did not reach statistical significance (RR, 0.63; 95% CI, 0.23-1.70; \( P = .36 \)). No other significant differences were found.

### Table 4. Propensity-matched analysis of results

|               | VLG (97) | VASG (97) | RR/MD | 95% CI          | \( P \) value |
|---------------|----------|-----------|-------|----------------|--------------|
| Severe complications* | 3 (3.1%) | 3 (3.1%) | 1     | 0.21-4.8       | 1            |
| Postoperative mortality | 1 (1.0%) | 2 (2.1%) | 2     | 0.18-21.7      | .56          |
| IIb            | 1 (1.0%) | 0 (0%)    | 0     | N/A            | .31          |
| Iva            | 2 (2.1%) | 2 (2.1%) | 1     | 0.14-6.96      | 1            |
| Ivb            | 0 (0%)   | 0 (0%)    | N/A   | N/A            | .56          |

**Respiratory complications**

|               | VLG (97) | VASG (97) | RR/MD | 95% CI          | \( P \) value |
|---------------|----------|-----------|-------|----------------|--------------|
| Prolonged intubation | 0 (0%)  | 0 (0%)    | 0 (0%) | N/A            | .07          |
| Reintubation   | 0 (0%)   | 1 (1.0%)  | N/A   | N/A            | .02          |
| Prolonged air leak (>5 d) | 16 (16.5%) | 6 (6.2%) | 0.38  | 0.15-0.92      | 1            |
| Pleural effusion/pneumothorax | 1 (1.0%) | 1 (1.0%) | 1     | 0.06-15.8      | 1            |
| Atelectasis    | 2 (2.1%) | 4 (4.1%)  | 2     | 0.38-10.7      | .41          |
| Pneumonia      | 3 (3.1%) | 3 (3.1%)  | 1     | 0.21-4.8       | 1            |
| ADRS           | 0 (0%)   | 0 (0%)    | N/A   | N/A            | .56          |
| Bronchopleural fistula | 0 (0%)  | 0 (0%)    | N/A   | N/A            | .56          |
| Empyema        | 0 (0%)   | 0 (0%)    | N/A   | N/A            | .56          |
| Chylothorax    | 2 (2.1%) | 1 (1.0%)  | 0.5   | 0.05-5.42      | 1            |
| Pulmonary thromboembolism | 0 (0%)  | 0 (0%)    | N/A   | N/A            | .56          |
| Other respiratory complications | 2 (2.1%) | 1 (1.0%) | 0.5   | 0.05-5.42      | 1            |

**Reintervention**

|               | VLG (97) | VASG (97) | RR/MD | 95% CI          | \( P \) value |
|---------------|----------|-----------|-------|----------------|--------------|
| Wound infection| 0 (0%)  | 2 (2.1%)  | N/A   | N/A            | .07          |
| Cardiovascular complications | 6 (6.2%) | 7 (7.2%)  | 1.17  | 0.41-3.35      | .77          |
| Blood transfusion | 2 (2.1%) | 3 (3.1%)  | 1.5   | 0.26-8.78      | .65          |
| Other complications | 6 (6.2%) | 6 (6.2%)  | 1     | 0.33-2.99      | 1            |

**Perioperative outcomes**

|               | VLG (97) | VASG (97) | RR/MD | 95% CI          | \( P \) value |
|---------------|----------|-----------|-------|----------------|--------------|
| Surgical time (min) | 191     | 179       | 12    | -6.7 to 30.8   | .2           |
| Basic care     | 11 (11.3%) | 4 (4.1%)  | 3.8   | 0.01-27.8      | 1            |
| Intermediate care | 33 (34.0%) | 38 (39.2%) | 1.17  | 0.41-3.35      | .77          |
| Intensive care unit | 53 (54.6%) | 55 (56.7%) | 1.17  | 0.41-3.35      | .77          |
| Intraoperative death | 0 (0%)  | 0 (0%)    | N/A   | N/A            | .56          |
| Postoperative stay | 5.7     | 5.3       | 0.4   | -0.75 to 1.58  | .49          |
| Readmission    | 7 (7.2%) | 6 (6.2%)  | 0.86  | 0.30-2.45      | .56          |
| Intermediate care or ICU readmission | 0 (0%)  | 0 (0%)    | N/A   | N/A            | .56          |

VLF, VATS lobectomy group; VASG, VATS anatomic segmentectomy; RR, relative risk; MD, mean difference; CI, confidence interval; N/A, not applicable; ADRS, acute respiratory distress syndrome; ICU, intensive care unit. *Severe complications: death or any complication considered IIb or superior in the Clavien-Dindo classification.

**Matched Results**

After propensity score–matching analysis, a sample of 97 VASG patients were 1:1 matched to 97 VLG patients (Table 3) according to the following variables: smokers, previous thoracic surgery, previous oncological disease, previous lung cancer, postoperative predicted forced expiratory volume in 1 second, postoperative predicted diffusing capacity for carbon monoxide, diagnosis, stage, tumor location, hemithorax, and number of incisions. All patients in both groups had a diagnosis of primary lung cancer, and there were no significant differences in the preoperative variables, including staging. The VLF showed a greater number of lymph nodes resected (6 [IQR, 4-10] vs 4 [IQR, 2.5-8]; \( P = .001 \)) and a greater number of hilar-mediastinal stations resected (3 [IQR, 3-4] vs 3 [IQR, 2-3]; \( P = .01 \)).
However, neither intrapulmonary (4.1% vs 2.1%; $P = .407$) nor hilar mediastinal (10.3% vs 8.3%; $P = .39$) lymph nodes involvement showed differences between groups.

After adjusted analysis (Table 4), the only postoperative difference between groups was a significantly lower incidence of prolonged air leak in the VASG (RR, 0.33; 95% CI, 0.12-0.89; $P = .02$). No other differences were found in terms of postoperative complications and perioperative outcomes between groups.

The 36-month follow-up (24.4; IQR, 20.8-28.3) time curve analysis for overall survival (HR, 0.73; 95% CI, 0.45-1.7; $P = .2$) (Figure 1), tumor progression–related survival (loco-regional or distant metastasis) (subdistribution Log-Rank test = 0.25 ($P = .62$) $HR = 0.73 (0.45-1.17) P = .2$) (Figure 1), and relapse-related mortality (Multiple Decrements) (SHR = 0.41 (0.11-1.57) $P = .2$) (Figure 2) showed no significant differences between the two groups.

**FIGURE 1.** Overall survival in the VASG versus VLG. CI, Confidence interval; HR, hazard ratio.

**FIGURE 2.** Relapse-related mortality in the VASG versus VLG. CI, Confidence interval; SHR, subdistribution hazard ratio.
hazard ratio, 0.41; 95% CI, 0.11-1.57; *P* = .2) (Figure 2), and disease-free survival (subdistribution hazard ratio, 0.73; 95% CI, 0.35-1.51; *P* = .4) (Figure 3) showed no differences between groups.

### DISCUSSION

Postoperative results and midterm survival after VATS anatomic segmentectomy have been explored by different authors showing postoperative results similar to those for VATS lobectomy, but studies are mostly retrospective, focusing on patients with limited functional reserve or very small lung lesions, with occasional attempts of patient matching. Although our study is retrospective, it is characterized by a reasonably large cohort of patients (2250 VATS patients) and the application of propensity score–matching methodology. A significant postoperative finding in the present study is the lower incidence of prolonged air leak in VATS segmentectomies that have been greater in previous studies. We suspect this is due to greater apposition of the remaining lung parenchyma; however, there was no homogeneous way to construct the intersegmental plane in all centers, so future studies will be necessary to confirm this finding.

In the survival analysis, we did not find differences between groups, which is consistent with previous studies. Although there were differences in lymphadenectomy patterns, the definitive pathological lymph node involvement did not show differences between groups. Despite the inherent diversity of stages, histology, and lymphadenectomy technique of a multicentric study, midterm survival results were similar when comparing thoracoscopic anatomic segmentectomy with lobectomy (Figures 1-3). Midterm survival and recurrence were tested in 3 years of follow-up (24.4; IQR, 20.8-28.3) because the median time from surgical resection of the primary lung cancer to loco-regional recurrent disease or distant recurrence is less than 15 months.

Not limited to VATS approaches only, there are currently 2 randomized trials being conducted to compare lobectomy versus sublobar resections in terms of survival and disease-free survival: the Cancer and Leukemia Group B (140503) and the Japan Clinical Oncology Group (0802). It is hoped that the future results will provide strong, sufficient evidence to overcome the limitations not only in our study but also in the available literature. However, the issue of adopting the VATS approach for sublobar resections, even in the absence of strong randomized studies, seems to have been overcome by clinical evolution of surgical units toward noninvasive approaches.

### Study Limitations

This study has several limitations. Although the entry of data was made in a prospective manner, the decision to perform each procedure was not randomized and was left up to the individual clinician’s judgment. This supposes a risk of selection bias and a lack of control of confounding factors with the need of statistical adjustment techniques. In addition, this is not an intention-to-treat analysis. Moreover, the nature of the multicenter collaboration implies that some units would be more versed in performing more...
complex or unusual segmentectomies than others. Missing is higher than 10% in the variable tumor location. We acknowledge that accurate information about the location of the tumors, peripheral versus central, might have an effect, depending on the surgeon’s experience, on having more prolonged air leaks. In addition, there was no requirement to disclose the method of lung parenchyma division, although is assumed that this was performed by the use of endo-staplers in the majority of cases.

CONCLUSIONS

VATS anatomic segmentectomy has similar postoperative results when compared with VATS lobectomy in terms of postoperative morbidity, midterm overall survival, and disease-free survival. As a newly reported finding, VATS segmentectomy decreases the risk of postoperative prolonged air leak compared with VATS lobectomy (Figure 4).

Conflict of Interest Statement

The authors reported no conflicts of interest.

The Journal policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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**Key Words:** anatomic segmentectomy, lobectomy, lung cancer, sublobar resection, thoracoscopic, VATS
APPENDIX E1
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