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Sleeve lobectomy in patients with non-small-cell lung cancer: a report from the European Society of Thoracic Surgery database 2021

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Key question

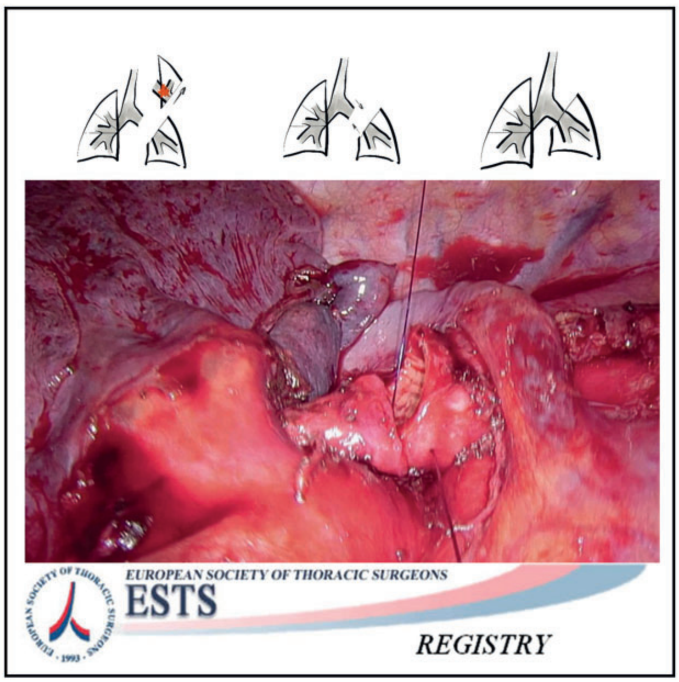
What is the current practice in sleeve lobectomy for lung cancer among ESTS members?

Key finding(s)

Morbidity and mortality rates are 40.6% and 2.2% respectively
Early bronchial anastomotic dehiscence rate is low (1.8%)
VATS associated with shorter length of stay and decreased overall complications

Take-home message

Sleeve lobectomy is safe, despite its potential technical difficulty. Complication rates are acceptable and VATS presents some advantages for patients



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†The first 2 authors contributed equally to this study.

Abstract

OBJECTIVES: For centrally located lung tumours, sleeve lobectomy is preferred over pneumectomy. We report on the surgical practices and perioperative outcomes of sleeve resections based on data from the European Society of Thoracic Surgeons database.

METHODS: We retrieved data of patients undergoing sleeve lobectomy or bilobectomy from 2007 to 2021. We evaluated baseline characteristics, surgical approach, neoadjuvant treatments, morbidity and postoperative outcomes of open and video-assisted thoracoscopic surgery (VATS) procedures.

RESULTS: In total, 1652 patients (median age: 63 years; females/males: 446/1206) underwent sleeve lobectomy (n = 1536) or bilobectomy (n = 116) by open thoracotomy (n = 1491; 90.2%) or VATS (n = 161; 9.8%) with a thoracotomy conversion rate of 21.1% (n = 34); 398 (24.1%) patients received neoadjuvant treatment. Overall morbidity and 30-day mortality were 40.6% and 2.2%, respectively. Bronchial anastomotic complications occurred in 29 patients (1.8%) with conservative treatment in 6 cases (20.7%) and operative management in 23 (79.3%). On multivariable analysis, factors related to the elevated risk of cardiopulmonary complications were body mass index < 20 [odds ratio (OR): 2.26; $P < 0.001$] and bilobectomy (OR : 2.28, $P < 0.001$). Age <60 years (OR: 0.71, $P = 0.013$), female sex (OR: 0.54, $P < 0.001$) and VATS (0.64, $P < 0.001$) were associated with decreased risk. Neoadjuvant treatment was not associated with increased risks of cardiopulmonary complications (OR: 1.05; $P = 0.664$). Compared to open thoracotomy, VATS was associated with significantly decreased overall morbidity (30.4% vs 41.7%, $P = 0.006$) and length of stay (median: 5 days vs 8 days; $P < 0.001$).

CONCLUSIONS: Sleeve lobectomies can be safely performed after neoadjuvant treatment. The VATS approach fosters shorter length of stay and decreased morbidity.

Keywords: Sleeve lobectomy • lung cancer • video-assisted thoracoscopic surgery • neoadjuvant treatment • bronchopleural fistula

ABBREVIATIONS AND ACRONYMS

ATT	average treatment effect
BMI	body mass index
ESTS	European Society of Thoracic Surgeons
IQR	interquartile range
NSCLC	non-small-cell lung cancer
OR	odds ratio
VATS	video-assisted thoracoscopic surgery

INTRODUCTION

Sleeve lobectomy is a standard surgical approach for central pulmonary tumours requiring lobectomy and necessitating a bronchoplastic procedure [1, 2]. Several studies and meta-analyses have reported better postoperative outcomes of sleeve lobectomy compared to pneumonectomy with comparable oncological outcomes [3–7]. More recent studies suggest that patients having sleeve lobectomies performed by video-assisted thoracoscopic surgery (VATS) have shorter lengths of stay and decreased morbidity without increasing bronchial anastomotic complications [8–10]. However, the VATS approach requires advanced surgical skills and should be performed by experienced surgeons in high-volume centres. In parallel, induction therapy by chemotherapy or radiotherapy has been used extensively to manage non-small-cell lung cancers (NSCLC), notably before a sleeve lobectomy, to reduce the size of the tumour and avoid pneumonectomy [7, 11], but the impact of neoadjuvant treatment before a bronchoplastic procedure remains controversial, notably regarding airway healing [12, 13].

The European Society of Thoracic Surgeons (ESTS) database is an online platform containing detailed data on thoracic procedures performed across 270 thoracic surgery units in 25 European countries. The database has been managed by ESTS since 2007 and represents current practices in thoracic surgery across Europe.

The objective of this study was to describe these current practices and the postoperative outcomes of sleeve lobectomy and to describe the impact of neoadjuvant treatment and of the introduction of VATS.

MATERIALS AND METHODS

Ethics statement

The ESTS database committee reviewed the project and defined it as an audit or service evaluation. As such, the need for formal approval by the ethics committee was waived. This study is reported according to the STROBE criteria for observational studies.

Data extraction

We retrospectively reviewed data from all patients undergoing sleeve lobectomy or bilobectomy for NSCLC identified in the ESTS database and operated on between July 2007 and January 2021. The data were cleaned before analysis. Records with missing information on the surgical procedure or postoperative outcomes were excluded from the analysis. We limited our analysis to variables with a combined completeness or reliability rate of at least 80% established following a standardized method [14].

We evaluated patient demographics; comorbidities; body mass index (BMI) (categorized as < or > 20); pulmonary functions; predicted postoperative forced expiratory volume in 1 s (categorized with a cut-off at 70% of the predicted postoperative value); operative characteristics (type of lobectomy, surgical approach); clinical outcomes during hospitalization and for up to 30 days after discharge, including length of stay and cardiopulmonary complications, defined as respiratory failure, need for reintubation, prolonged mechanical ventilation >24 h, pneumonia, atelectasis requiring bronchoscopy, pulmonary oedema, pulmonary embolism, acute respiratory distress syndrome/acute lung injury, arrhythmia requiring treatment and acute myocardial infarction. The administration of neoadjuvant chemotherapy with or without radiotherapy was recorded.

A bronchial anastomosis complication was considered in the case of a bronchopleural fistula or an anastomotic defect requiring either conservative treatment or reoperation. Complications were defined according to the joint ESTS–Society of Thoracic Surgeon definitions [15]. Mortality was defined as death in-hospital or within 30 days from the operation if the patient was discharged.

Finally, we compared the surgical practices and postoperative outcomes between sleeve (bi-) lobectomy by open thoracotomy and VATS and analysed the data for descriptive end points (gender, age, BMI, numbers and types of procedures), presence and types of comorbidities, surgical procedures, neoadjuvant treatment, postoperative outcomes, complications and number of deaths.

Statistical analyses

Continuous data are expressed as mean and standard deviation if normally distributed or median and interquartile range (IQR) if not normally distributed whereas categorical data are expressed as frequencies with percentages. Continuous variables were tested with the unpaired Student *t*-test for normally distributed variables or the Mann–Whitney U test. The normal distribution of continuous variables was assessed with the Shapiro-Wilk normality test. Categorical variables were tested using the χ^2 test. Using univariable and multivariable analyses, we assessed association with postoperative cardiopulmonary complications. Univariable analysis was performed to assess model convergence and linearity assumptions. Following a step-wise regression, multivariable analysis was used on variables returning a possible association with a postoperative outcome ($P < 0.1$). Postoperative outcomes were compared between patients operated on with VATS and open/thoracotomy. Finally, a propensity-case matched analysis was performed to compare postoperative outcomes of patients (i) benefiting from neoadjuvant therapy and (ii) patients operated on by VATS compared to those having the thoracotomy approach. The propensity scores were computed using a caliper of 0.2 with no replacement. The logistic regression used for the propensity score included the following variables: age, sex, BMI, predicted postoperative forced expiratory volume in 1 s, coronary arterial disease, cerebral vascular disease, diabetes, American Society of Anesthesiologists score >1, VATS approach, and pT and pN stages of the tumour >1. Results of the propensity score matching analysis are displayed as average treatment effect (ATT) among those treated. All statistical analyses were two-tailed, with a *P*-value of less than 0.05 considered significant. STATA (16.0) software (StataCorp LP, College Station, TX, USA) was used to perform the statistical analyses.

RESULTS

Between July 2007 and January 2021, a total of 1652 patients (female/male: 446/1206; median age: 63 years; IQR: 56–70) underwent a sleeve lobectomy ($n = 1536$) or bilobectomy ($n = 116$). Figure 1 shows the inclusion process whereas Table 1 summarizes the patient characteristics and surgical outcomes. A majority of patients presented with an ASA score < 2 (64%), and half of them (50%) presented with cardiac comorbidities. The majority

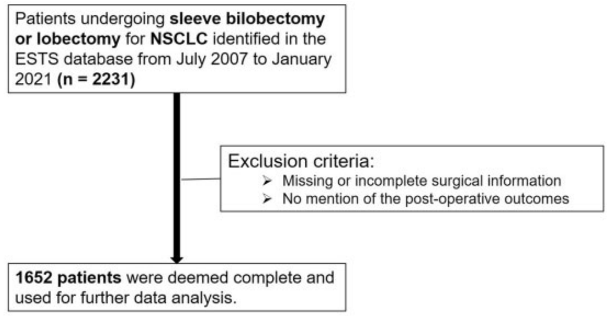

Figure 1: Flow chart of the inclusion process for patients. ESTS: European Society of Thoracic Surgeons; NSCLC: non-small-cell lung cancer.

Table 1: Patient demographics and outcomes

Baseline Characteristics	Total (n = 1652)	Percentage (%)
Sex (females/males)	446/1206	27/73
Age, median (IQR)	63 (56-70)	
Age < 60 years	646	39.2
BMI, mean (SD)	26.2 (4.9)	
BMI < 20	137	8.3
ASA score (mean)	2.15 (0.74)	
1	297	18
2	700	42.4
3	474	28.7
4	21	1.3
Unknown	160	9.7
No comorbidities	674	40.8
Overall comorbidities	976	59.2
Cardiac comorbidities	746	50
Coronary artery disease	187	12.5
Arterial hypertension	598	40.1
Atrial fibrillation	82	5.5
Insulin-dependent diabetes	67	4.8
CVD	43	3.1
CKD	66	4.8
Ppofev1, mean (SD)	68.3 (17.1)	
Ppofev1 < 70 %	820	55.7
Neoadjuvant treatment	398	24.1
None	1254	75.9
Chemotherapy	305	18.5
Radiotherapy	2	0.1
Chemoradiotherapy	91	5.5
Open	1491	90.2
VATS	161	9.8
Conversion	34	21.1
Lobectomy	1536	93
- RUL	792	48
- RML	36	2.2
- RLL	76	4.6
- LUL	454	27.5
- LLL	178	10.8
Bilobectomy	116	7
- Upper	63	3.8
- Lower	53	3.2
Resection margin		
R0	1393	92.9
R1-2	107	7.1
Pathological stage		
T0	106	6.4
T1	403	24.4
T2	737	44.6
T3	327	19.8
T4	79	4.8
N0	877	53.1
N1	501	30.3

Continued

Table 1: Continued

Baseline Characteristics	Total (n = 1652)	Percentage (%)
N2	269	16.3
N3	6	0.4
M0	1624	98.3
M1	28	1.7
Overall morbidity	671	40.6
30-day deaths	36	2.2
Cardiopulmonary complications	558	33.7
Pneumonia	164	9.9
Atelectasis	141	8.5
Bronchial complications	29	1.8
Prolonged air leak (> 5 days)	181	11
Atrial fibrillation	127	7.7
Length of stay (median) (IQR)	8 (7-12)	

ASA: American Society of Anesthesiologists; BMI: body mass index; CKD: chronic kidney disease; CVD: cerebrovascular disease; IQR: interquartile range; LLL: left lower lobe; LUL: left upper lobe; Ppofev: predicted preoperative forced expiratory volume; RLL: right lower lobe; RML: right middle lobe; RUL: right upper lobe; SD: standard deviation; VATS: video-assisted thoracoscopic surgery.

of patients did not undergo neoadjuvant treatment (1254, 75.9%). Among the 398 patients receiving induction therapy, 305 patients received chemotherapy alone (18.5%), 91 received chemoradiotherapy (5.5%) and only 2 patients received radiotherapy alone (0.1%). Final histopathological analysis showed pT > 1 in 1183 patients (71.6%) and positive pN status in 775 patients (46.9%). Open surgery was the most frequent approach (1491 patients, 90.2%) whereas 161 patients (9.8%) were operated on with VATS. Conversion to open thoracotomy was necessary in 34 patients (21.1%) for anatomical reasons ($n = 12$), lymph node invasion ($n = 8$), technical difficulties ($n = 12$) or vascular problems ($n = 2$). Upper sleeve lobectomies were predominantly realized (75.5% of all cases), 48% in the right upper lobe and 27.5% in the left upper lobe. Overall morbidity and 30-day mortality were 40.6% and 2.2%, respectively. Cardiopulmonary complications were predominantly pneumonia (9.9% of cases), atelectasis requiring bronchoscopy (8.5%) and atrial fibrillation (7.7%). Bronchial anastomotic complications within 30 days occurred in 29 patients (1.8%) split into anastomotic dehiscence requiring surgery in 23 patients (79.3%) or conservative management in 6 patients (20.7%). In-hospital mortality was 30.4% (7/23) of patients requiring surgery for bronchial complications. The median length of stay was 8 days (IQR: 7–12).

Univariable analysis of risk factors for cardiopulmonary complications is reported in Table 2. Female sex [odds ratio (OR) 0.52, $P < 0.001$], age < 60 years old (OR 0.75, $P = 0.007$) and the VATS approach (OR 0.64, $P = 0.020$) were associated with a decreased risk of postoperative cardiopulmonary complications following a sleeve lobectomy. Conversely, BMI < 20 (OR 1.62, $P = 0.009$) and bilobectomy (OR 2.23, $P < 0.001$) were associated with poorer outcomes. Multivariable analysis confirmed the decreased risk of complications in female patients (OR: 0.54), those under 60 years of age (OR: 0.64) and operated on by VATS (OR: 0.72). A BMI < 20 (OR: 2.26) and bilobectomy (OR: 2.28) were associated with postoperative complications (Table 2). We did not detect an association with induction therapy and postoperative cardiopulmonary complications. A propensity score matching analysis was performed (Supplementary Table 1) between patients with or without neoadjuvant treatment. No significant differences in terms of postoperative complications or length of hospitalization were found among 269 paired patients.

When comparing surgical approaches (Table 3), we observed that VATS operations were performed in older patients [66 (IQR: 57–71) vs 61.7 (IQR : 56–69) years, $P = 0.036$] with significantly more comorbidities (73.3% vs 64.5%, $P = 0.028$). We also observed that oncological cases were less advanced [pT > 1 (57.1% vs 70.5%, $P = 0.001$) and pN > 1 (35.4% vs 48.2%, $P = 0.002$)] in patients who had VATS than in patients who had an open approach.

Patients operated on by VATS presented significantly fewer overall complications (30.4% vs 41.7%, $P = 0.006$), cardiopulmonary complications (25.5% vs 34.7%, $P = 0.020$) and instances of atelectasis (1.9% vs 9.3%, $P = 0.004$) compared to patients operated on with the open approach. The length of stay was also shorter following VATS [median 5 (IQR: 3–8) vs 8 (IQR : 7–12) days, $P < 0.001$)]. The propensity matching analysis (Supplementary Table 2) paired 107 patients and confirmed a statistical difference in terms of decreased postoperative complications (ATT: -0.205; $P = 0.001$) and shorter length of hospitalization (ATT: -4.28; $P < 0.001$) in favour of a VATS approach. Three centres performed >10 VATS cases, which represented (94/161, 58%) the majority of cases presented in this series.

DISCUSSION

This study analyses a large data set of sleeve lobectomies, representing an overview of the daily practice of European thoracic surgeons over the past decade.

Sleeve lobectomy is a safe approach, currently preferred over pneumonectomy for centrally located NSCLCs [3–7]. Its reported mortality and morbidity rates are low, at 2–5% and 15–47%, respectively [16–19]. These results are congruent with our data, which show overall morbidity and 30-day mortality rates of 40.6% and 2.2%, respectively. Most complications were cardiopulmonary (33.7%), a majority of which remain common and manageable [prolonged air leak (11%), pneumonia (9.9%), atelectasis (8.5%) and atrial fibrillation (7.7%)]. We identified female sex, age less than 60 years and a VATS approach to be the postoperative outcomes associated with decreased frequency of complications, whereas a BMI < 20 and sleeve bilobectomies were associated with an elevated risk of complications.

Bilobectomies are complex resections and are thus associated with higher morbidity and mortality rates (50% and 5%, respectively), especially when the resection involves the lower lobe [20]. In the immediate postoperative period, bilobectomy patients presented a higher risk of cardiopulmonary complications [21].

Sleeve bilobectomy is a relatively infrequent procedure, with a known risk of postoperative residual pleural space infection [22] but with outcomes similar to those of a lobectomy [23]. In our series, sleeve bilobectomy has been associated with elevated rates of complications (OR = 2.28, $P < 0.001$), with 58.6% (68/116) morbidity following sleeve bilobectomy compared to 39.3% (603/1536) after sleeve lobectomy.

Complications related to bronchial anastomosis were rare, with an occurrence of 1.8%. The database was restricted to 30 days postoperatively and reported only dehiscence managed with/without surgical intervention. We observed a 79.3% (23/29) reintervention rate in cases of dehiscence. Mortality was 30.4% in this group of patients, underlining the importance of recognizing

Table 2: Univariable and multivariable analyses of risk factors for postoperative complications

	Odds ratio	95% CI	*P*-Value	Odds ratio	95% CI	*P*-Value
	Univariable analysis			*Multivariable analysis*		
Sex (female)	0.52	0.41-0.67	<0.001	0.54	0.40-0.673	<0.001
Age < 60	0.75	0.61-0.92	0.007	0.72	0.55-0.93	0.013
BMI <20	1.62	1.13-2.31	0.0087	2.26	1.49-3.44	<0.001
ASA score ≤2	0.84	0.67-1.05	0.129			
Cardiac comorbidities	1.22	0.99-1.52	0.065	1.21	0.93-1.54	0.145
Diabetes	1.26	0.76-2.08	0.377			
pT <1	0.99	0.79-1.23	0.904			
pN > 0	1.07	0.87-1.31	0.539			
Ppofev1 < 70	1.21	0.98-1.51	0.082	1.10	0.86-1.40	0.461
Neoadjuvant treatment	1.05	0.83-1.34	0.664			
VATS	0.64	0.44-0.93	0.020	0.64	0.42-0.98	<0.001
Bilobectomy	2.23	1.52-3.26	<0.001	2.28	1.55-3.79	<0.001
Upper	1.19	0.91-1.55	0.192			

ASA: American Society of Anesthesiologists; BMI: body mass index; CI: confidence interval; Ppofev: predicted preoperative forced expiratory volume; VATS: video-assisted thoracoscopic surgery.

and promptly managing this complication. In a recent meta-analysis of 1204 sleeve resections, bronchial complications were reported in 63 patients (5.2%) [13]. However, late stenoses were included in the analysis, a complication that was not analysed in our series. Bronchial dehiscence was reported in only 2.3% of patients. Studies also reported similar rates of bronchial complications, with occurrence rates around 3% among a smaller population of patients [24, 25].

Induction therapy has been associated with increased morbidity and potential anastomotic complications. Indeed, neoadjuvant treatment is frequently proposed to reduce the size of the tumour, increase the rate of resectability and avoid pneumonectomy. However, the impact of induction therapy, notably radiotherapy, on the outcomes of a procedure requiring healthy tissue for safe anastomosis is often debated. Yamamoto *et al.* observed impaired healing of tissues following radiotherapy [12]. Previous studies compared patients undergoing surgery alone to patients undergoing neoadjuvant treatment and surgery in terms of the occurrence of bronchial complications following a sleeve lobectomy. Although the rates between groups were similar, Comacchio *et al.* [26] reported mediastinal radiotherapy as a risk factor for anastomotic complications. Other authors also reported a higher incidence of airway complications following induction treatment with radiotherapy [16, 25, 27]. We did not observe increased morbidity rates after neoadjuvant treatment in our series (OR : 1.05, $P = 0.664$).

The VATS approach has changed the practice of thoracic surgery by becoming widely accepted as the first-intention approach for early stage lung cancer [8]. However, because sleeve lobectomy is a complex procedure, its realization through VATS remains challenging [10]. In a recent meta-analysis comparing the VATS approach to a thoracotomy for sleeve resections, Deng *et al.* reported a decrease in postoperative morbidity and in blood loss in the VATS group, leading to significantly shorter hospital stays [10]. Another review by Zhong *et al.* corroborated these results [28]. By comparing patients benefiting from a VATS sleeve lobectomy to patients having open surgery, we observed a decreased occurrence of overall complications (30.4% vs 41.7%, $P = 0.006$), of cardiopulmonary complications and of atelectasis in the VATS group despite the fact that the patients were older and had more comorbidities, suggesting a less morbid effect of VATS. Additionally, length of stay was shorter in the VATS group (5 vs 8 days, $P < 0.001$). Interestingly, no difference was observed in the rate of complications related to the anastomosis (1.2 vs 1.8%, $P = 0.604$). However, these results should be interpreted cautiously because the majority of the cases (58%) were realized in only 3 centres, suggesting that the VATS approach should be performed by experienced surgeons in high-volume centres. Moreover, unidentified confounders between VATS and thoracotomy may remain and thus result in biases. We observed a conversion rate of 21.1% (34/161), which was more elevated than the reported conversion rate after VATS lobectomy [29]. This finding may be explained by the technical issues and skills needed to successfully perform a sleeve lobectomy. This question remains open because the data set did not include details on the reasons for failure or on the experience of the surgeons performing the operations.

LIMITATIONS

Several limitations to our study can be identified: The ESTS database is a voluntary database that gathers data from a large number of institutions. However, data collection is not entirely standardized and only a minority of the data is audited. Voluntary data collection design limits inferences made from the database as a representative sample of the current European thoracic surgical practice.

Some risk factors/confounders that may be important for risk stratification have not been factored in the analysis due to under-representation and missing values such as diffusion lung capacity for carbon monoxide or the maximum rate of oxygen the body is able to use during exercise (VO_2 max). These may have played a role in the association with postoperative outcome.

Important pieces of information related to the surgical approach that can lead to recommendations for the most appropriate approach were missing from the database: endobronchial lesion, histological diagnosis of the cancer, central location of the lesion, size of the lesion, direct invasion by a local lymph node,

Table 3: Patient characteristics and comorbidities between video-assisted thoracoscopic surgery and open thoracotomy groups

Baseline characteristics	*Open (%)*	*VATS (%)*	*P-value*
Number	1491	161	
Sex (females/males)	379/1112 (25.4/74.6)	67/94 (41.6/58.4)	<0.001
Age, median (IQR)	61.7 (56-69)	66 (57-71)	0.036
Age < 60 years	594 (39.8)	52 (32.3)	0.059
BMI, mean (SD)	26.2 (4.8)	26.5 (6.4)	0.396
BMI < 20	121 (8.7)	16 (10.1)	0.546
ASA score ≤2	903 (67.2)	94 (63.1)	0.308
No comorbidities	473 (35.5)	43 (26.7)	0.028
Overall comorbidities	858 (64.5)	118 (73.3)	
Cardiac comorbidities	652 (49)	94 (58.4)	0.025
Coronary artery disease	168 (12.6)	19 (11.8)	0.764
Arterial hypertension	519 (39)	79 (49.1)	0.015
Atrial fibrillation	72 (5.4)	10 (6.2)	0.675
Insulin-dependant diabetes	60 (4.5)	7 (4.3)	0.770
CVD	39 (2.9)	4 (2.5)	0.639
CKD	64 (4.8)	2 (1.2)	0.042
Ppofev1, mean (SD)	68.3 (17.2)	69 (15.7)	0.617
Ppofev1 < 70 %	749 (56.3)	71 (49.7)	0.151
Neoadjuvant treatment	381 (25.6)	17 (10.6)	<0.001
None	1110 (74.4)	144 (89.4)	
Chemotherapy	297 (19.9)	8 (5)	
Radiotherapy	1 (0.06)	1 (0.6)	
Chemoradiotherapy	83 (5.6)	8 (5)	
Lobectomy	1380 (92.6)	156 (96.9)	0.048
- RUL	720 (48.3)	72 (44.7)	0.061[a]
- RML	30 (2)	6 (3.7)	
- RLL	65 (4.4)	11 (6.8)	
- LUL	413 (27.7)	41 (25.5)	
- LLL	152 (10.2)	26 (16.1)	
Bilobectomy	111 (7.4)	5 (3.1)	
- Upper	61 (4.1)	2 (1.2)	0.659[a]
- Lower	50 (3.2)	3 (1.9)	
Pathological stage			
pT > 1	1051 (70.5)	92 (57.1)	0.001
pN1-2	719 (48.2)	57 (35.4)	0.002
M0	1465 (98.3)	159 (98.8)	0.641
R0	1304 (92.6)	88 (94.6)	0.418
Overall morbidity	622 (41.7)	49 (30.4)	0.006
Deaths	36 (2.4)	0	NA
Cardiopulmonary complications	517 (34.7)	41 (25.5)	0.020
Pneumonia	149 (10)	15 (9.3)	0.785
Atelectasis	138 (9.3)	3 (1.9)	0.004
Bronchial complications	27 (1.8)	2 (1.2)	0.604
Prolonged air leak (> 5 days)	164 (11)	16 (10)	0.663
Atrial fibrillation	116 (7.8)	11 (6.8)	0.668
Length of stay (median) (IQR)	8 (7-12)	5 (3-8)	<0.001

[a]Fisher test.

ASA: American Society of Anesthesiologists; BMI: body mass index; CKD: chronic kidney disease; CVD: cerebrovascular disease; IQR: interquartile range; LLL: left lower lobe; LUL: left upper lobe; Ppofev: predicted preoperative forced expiratory volume; RLL: right lower lobe; RML: right middle lobe; RUL: right upper lobe; SD: standard deviation; VATS: video-assisted thoracoscopic surgery.

concomitant vascular resection and reconstruction potentially associated with increased complexity and different patterns of approach or complications. No data on the type of bronchial anastomotic technique were provided: absorbable or non-absorbable thread, interrupted or continuous suture and covering the anastomosis with a local flap.

Regarding the impact of neoadjuvant therapy, only a small number of patients received radiotherapy alone, which precluded the assessment of the consequences of radiotherapy alone. Data on survival were missing as well as data on the completeness of resection and the decision for adjuvant chemotherapy. No late follow-up data were given regarding late bronchial complications (stenosis or late dehiscence), which certainly underestimates the rate of bronchial anastomotic complications.

During the long study period, the evolution of the surgical techniques and the implementation of new technologies have occurred over the period. This missing information could have a significant impact on the outcomes of the resection and on the management of patients.

The relatively small size of the VATS group may generate large type II errors.

CONCLUSION

We reviewed the ESTS database of sleeve lobectomies and bilobectomies performed on more than 1500 patients representing a good overview and benchmarking for these procedures. We found that a majority of patients undergoing a sleeve resection were males (70.1%) with a median age of 63 years. Comorbidities were present in a majority of patients (59.2%), and half of them had cardiopulmonary comorbidities (50%). Morbidity and mortality rates (40.6% and 2.2%, respectively) were acceptable and manageable after sleeve lobectomies. A neoadjuvant treatment was administrated in 24.1% of patients without associated increased morbidity. The early bronchial anastomotic dehiscence rate was low (1.8%) and was managed by surgery in a substantial number of cases (79.3%). The VATS approach was associated with decreased postoperative complications and length of stay, but the conversion thoracotomy rate was >20%, suggesting technical difficulties.

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Data availability

All relevant data are within the manuscript and its supporting information files. The data underlying this article will be shared upon reasonable request to the corresponding author.

Author contributions

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