Original Article

Single-center clinical experience of extended sleeve lobectomy (ESL) versus standard sleeve lobectomy (SL)

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Background: Sleeve lobectomy (SL) and extended SL (ESL), which aim to preserve pulmonary function and enhance the quality of life of patients while ensuring oncological outcomes, are valuable surgical options for the treatment of centrally located non-small cell lung cancer (NSCLC). This study aimed to compare perioperative adverse events and long-term survival between SL and ESL in NSCLC patients, providing a comprehensive review of surgical outcomes, complications, and survival to assess the roles of SL and ESL in thoracic oncology.

Methods: This single-center retrospective study assessed the outcomes of NSCLC patients who underwent SL or ESL from June 2014 to January 2022. The patients were selected based on specific inclusion criteria, and statistical analyses were conducted to examine the postoperative outcomes, overall survival (OS), and disease-free survival (DFS) of the patients.

Results: A total of 218 patients met the inclusion criteria. Among 218 patients, 33 underwent ESL and 185 underwent SL. Compared to SL, ESL was associated with longer operative times and higher R0 resection rates (93.9% *vs*. 78.8%, P=0.047). Despite the higher complexity of ESL compared to SL, there were no significant differences in the perioperative complications or mortality rates between the groups. Survival analysis was conducted on the propensity score matching (PSM) data, the results demonstrated superior OS and DFS in the ESL group compared to the SL group. Advanced age, more advanced nodal (N) status, and non-R0 resection were significant predictors of poorer prognosis.

Conclusions: ESL is a feasible and effective alternative for treating centrally located NSCLC, with better R0 resection rates and comparable survival outcomes to SL, without increasing the risk of grade III–IV complications. Further studies with larger cohorts need to be conducted to validate these findings and refine the surgical techniques.

Keywords: Non-small cell lung cancer (NSCLC); sleeve lobectomy (SL); extended sleeve lobectomy (ESL); overall survival (OS); postoperative complications

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Introduction

Over the past several decades, the surgical management of non-small cell lung cancer (NSCLC), particularly for patients with centrally located tumors, has evolved significantly. Pneumonectomy (PN), while effective, often result in significant declines in patients' pulmonary function and quality of life (1,2), limiting their ability to undergo adjuvant therapies or resections for recurrent disease (3). To mitigate these adverse outcomes, sleeve lobectomy (SL) has been increasingly implemented in clinical practice, demonstrating favorable clinical outcomes (4-7).

The origin of SL can be traced back to the 1950s, but it was not until the late 20th century that the procedure gained widespread acceptance due to advancements in surgical techniques, perioperative care, and a better understanding of the biology of lung cancer (8,9). As an alternative to PN, SL not only effectively removes the tumor but also enables more lung parenchyma to be preserved, thus maintaining pulmonary function, improving quality of life, and reducing risk of postoperative complications. Extended SL (ESL), which is defined as an atypical bronchoplasty involving additional resection and anastomosis of lobar bronchus or segmental bronchus beyond the standard SL, further extends the benefits of SL (10). However, ESL is technically more complex than SL, especially in cases involving multi-lobar atypical bronchoplasty. This complexity is primarily manifested in the management of the bronchial anastomosis site, where a meticulous technique is required to ensure the quality of the anastomosis and the success of the surgery (11,12). Moreover, in relation to perioperative management, the patient's pulmonary function status, and specific tumor characteristics are critical factors determining the success of the operation (13-16). The purpose of this study is to compare the perioperative adverse events and long-term survival of patients undergoing standard SL and ESL at our center, in order to clarify the benefits and postoperative risks that ESL may offer to NSCLC patients. In this article, we seek to provide a comprehensive review of our experience with SL and ESL in patients with NSCLC. By meticulously analyzing the surgical outcomes, complications, and long-term survival following these approaches, we endeavored to delineate the role of SL and ESL in contemporary thoracic oncology. We present this article in accordance with the STROBE reporting checklist (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-24-546/rc).

Highlight box

Key findings

- Extended sleeve lobectomy (ESL) can achieve a higher R0 resection rate compared to sleeve lobectomy (SL) without increasing the incidence of perioperative complications.

What is known, and what is new?

- As an alternative to pneumonectomy (PN), SL not only effectively removes tumors but also helps to preserve more lung tissue, enabling patients to maintain better lung function and a better quality of life, while reducing the risk of postoperative complications.
- ESL has a better R0 resection rate than SL and provides significant clinical benefits.

What is the implication, and what should change now?

- With developments in surgical technology and the accumulation of more clinical data, the role and significance of ESL in the treatment of central and locally advanced non-small cell lung cancer will become more important.

Methods

Study design and patient selection

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Liaoning Cancer Hospital & Institute Medical Ethics Committee (approval No. KY20231203). This study was a retrospective study and did not bring any adverse effects to the participants' treatment. Requirement for informed consent has been waived by the ethics committee. The inclusion criteria were patients diagnosed with malignant lung tumors and who underwent surgery between 2014 and 2022. The exclusion criteria were patients who had simple lobectomy, sublobar resection, or PN, lacked follow-up information, had metastatic malignant tumors, small cell lung cancer, or a history of other malignancies within the past year.

Preoperative assessment

We follow the National Comprehensive Cancer Network (NCCN) and China Society of Clinical Oncology (CSCO) guidelines for preoperative assessment. All patients underwent comprehensive preoperative evaluation, which included detailed medical history, physical examination, cardiac function tests, pulmonary function tests (vital capacity, forced expiratory volume in one second, and radiological staging assessments [chest computed tomography (CT), positron emission tomography (PET)-CT, and brain magnetic resonance imaging (MRI)]. Bronchoscopy was performed to assess the extent of intrapulmonary tumor invasion. Mediastinal staging was conducted via PET-CT, mediastinoscopy, or endobronchial ultrasound-guided transbronchial needle aspiration. A multidisciplinary team consultation was held preoperatively to evaluate the surgical indications and potential risks. Before the surgery, the researchers performed 3D reconstruction of the pulmonary vessels and bronchi based on thin-slice enhanced chest CT scans to better understand the individual's anatomical structure. This study adopted the eighth edition of Union for International Cancer Control (UICC)/American Joint Committee on Cancer (AJCC) lung cancer tumor-node-metastasis (TNM) staging criteria.

Perioperative assessment and management

The surgical approach was determined based on the location and size of the tumor, and its relationship with the surrounding structures. We routinely employed the hybrid thoracoscopic surgical approach [hybrid video-assisted thoracoscopic surgery (VATS)], which is a minimally invasive approach lying between standard thoracotomy and video-assisted surgery. The surgical incision length ranges from 5 to 10 cm, typically around 8 cm. The incision is located in the fourth or fifth intercostal space according to the location of the tumor. An additional 1 cm long incision is made in the seventh or eighth intercostal space as a camera port, which is also used for drainage after surgery. An incision protection retractor is routinely used without rib spreading. The advantages of hybrid VATS are direct visualization of the surgical field and flexible maneuverability. More specific details about this surgical method have been published by our center in previous papers. The objective of surgery was to achieve complete tumor resection while preserving as much lung parenchyma as possible. After the removal of the tumor along with its bronchus and pulmonary artery, end-to-end anastomoses were performed. We used 4-0 prolene suture for bronchial anastomosis and 5-0 prolene sutures for vascular anastomosis. The anastomosis technique involved direct end-to-end anastomosis of the bronchi or vessels using twin needles in a bi-directional continuous manner. According to the Okada classification (3), our ESL surgeries included the following five types: Type A: involving resection of the right upper lobe (RUL) and right middle lobe (RML), with or without resection of segment 6 (S6), followed by reconstruction between the right main bronchus and the remaining bronchus; Type B: involving resection of the left upper lobe and S6, with bronchial reconstruction between the left main bronchus and the remaining bronchus; Type C: involving resection of the left lower lobe and segments 4+5, with reconstruction between the bronchus of segments 1+2+3 and the left main bronchus; Type D: resection of the RML and right lower lobe, with reconstruction between segments B1+2+3 and the right main bronchus; Type E: resection of the RUL and S6, with reconstruction between the right main bronchus and the RML and the basal segment (*Figure 1*). Systematic mediastinal lymph node dissection was performed intraoperatively in all patients. R0 resection is defined as having negative surgical margins, including the bronchus, blood vessels, and surrounding tissues, with the highest lymph node removed also being negative under microscopy.

Post-operatively, patients were monitored in the Intensive Care Unit or Postoperative Care Unit. Focus was given to managing chest drainage, monitoring vital signs, and encouraging early mobilization. Postoperative complications were classified and analyzed according to the Clavien-Dindo classification. Complications such as hemoptysis, bronchopleural fistula, atelectasis, or chylothorax were appropriately addressed.

Follow up

The outcome variables included postoperative complications, 90-day mortality, overall survival (OS), and disease-free survival (DFS). Postoperative complications were categorized as follows. The 90-day mortality rate was defined as death within 90 days after surgery, or at any time post-surgery if the patient died during the initial hospitalization. OS was defined as the time from surgery to death from any cause. DFS was defined as the time from surgery to the recurrence of the disease or death from the disease. The last follow up was conducted in June 2023. Post-operatively, patients regularly underwent clinical evaluations, chest CTs, and pulmonary function tests. The initial follow-up occurred one month post-surgery, followed by quarterly surveillance CT scans for the first two years, with PET-CTs or MRIs as needed, and then bi-annually thereafter. Any signs of recurrence or metastasis were promptly investigated.

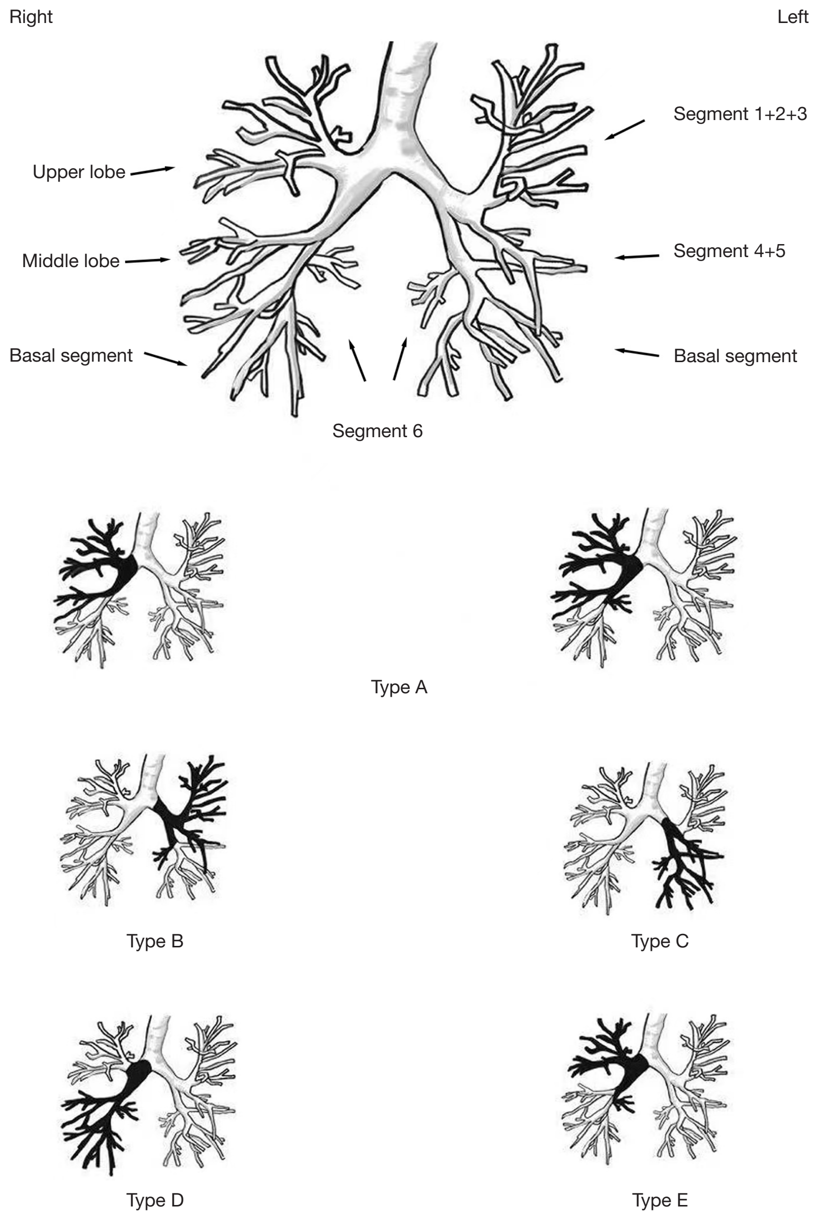

Figure 1 The five types of ESL according to the Okada classification. ESL, extended sleeve lobectomy.

Statistical analysis

Data analysis was conducted using SPSS software (version 27, Chicago, IL, USA). Using propensity score matching (PSM) with a 1:3 ratio to balance the differences between the groups (Caliper =0.2), the variables included in the propensity score-matched model were age, gender, smoke, pathologic type neoadjuvant therapy, and TNM stage. The continuous variables were expressed as mean ± standard deviation (SD), and categorical variables are represented by the frequency and percentage. Continuous variables were compared using the *t*-tests. Categorical variables were compared using Chi-squared test or Fisher's exact test. The survival analysis was conducted using the Kaplan-Meier method, and differences between the groups were assessed using the log-rank test. A Cox proportional hazards regression model (Enter) was used to evaluate the independent risk factors for OS and DFS. In the multivariate analysis, variables from the univariate analysis with a P value <0.05 were considered suitable for inclusion in the multivariate model. In all tests,

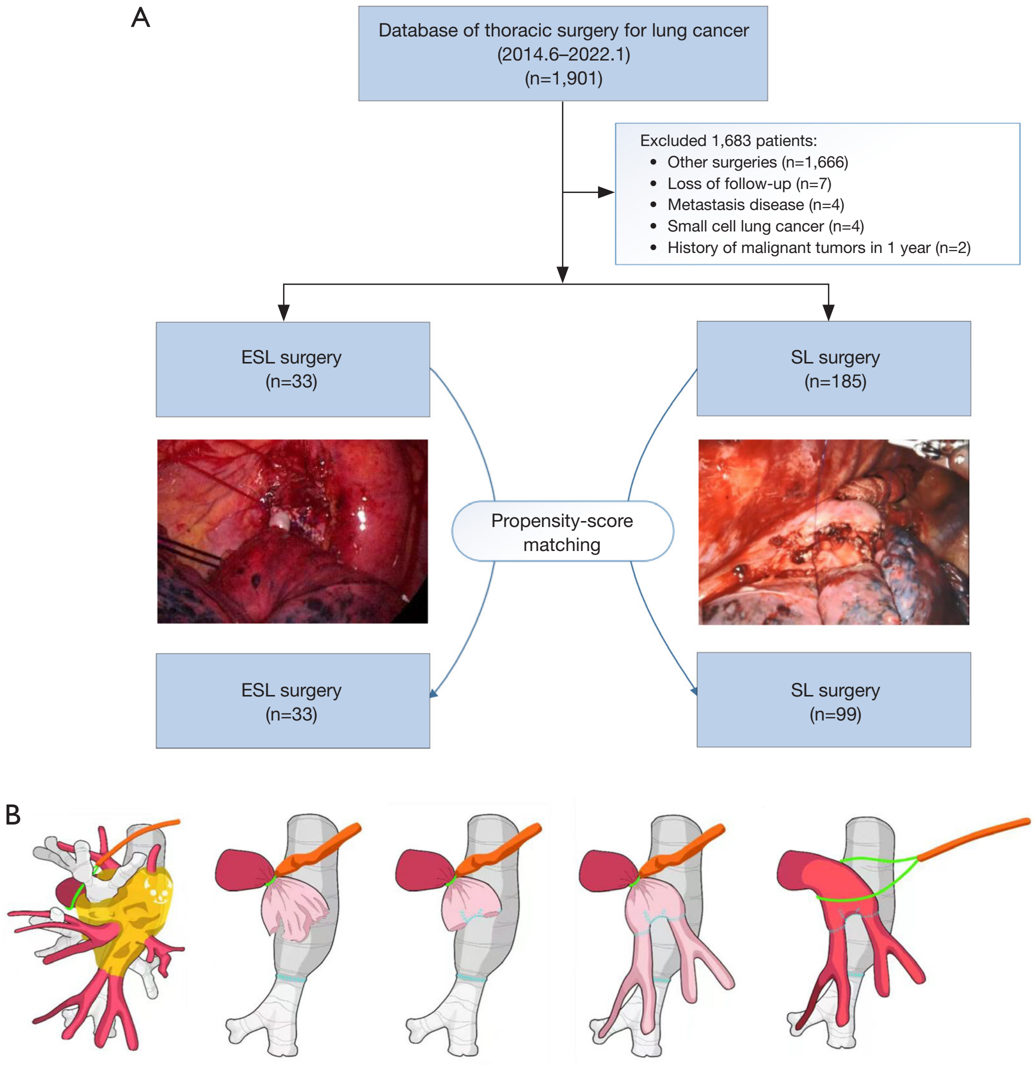

Figure 2 Research design plan. (A) Flowchart of the study, including the inclusion and exclusion criteria, group assignments, and intraoperative anastomosis images for SL and ESL. (B) ESL schematic diagram. Bronchus: resection of the left upper lobe and segment B6, and anastomosis between the left main bronchus and basal segment bronchus. Pulmonary artery: occlusion of the main trunk of the left pulmonary artery, followed by distal resection, and anastomosis between the main trunk with A7+8 and A9+10. ESL, extended sleeve lobectomy; SL, sleeve lobectomy.

a P value <0.05 was considered statistically significant.

Results

Baseline characteristics of patients

From June 2014 to January 2022, surgical procedures were performed on 1,901 lung cancer patients at Liaoning Cancer Hospital & Institute. A total of 1,666 patients who underwent simple lobectomy or PN were excluded from the study, as were with 7 patients with no follow up, 4 patients with pathologically confirmed metastatic tumors, 4 patients with small cell lung cancer, and 2 patients with a history of malignant tumors within the past year. Among the remaining 218 patients, 33 (15.13%) underwent ESL and 185 (84.86%) underwent SL (*Figure 2*). The mean follow-up period was 50 months (range, 14–80 months). The ESL group had a higher proportion of smokers (93.9% *vs.* 76.2%, P=0.02) and more advanced stage (stage III

Table 1 Baseline characteristics of the patients before and after matching

Baseline characteristics	Unmatched cohort			Propensity score matched cohort		
	ESL	SL	Unadjusted P value	ESL	SL	PSM-adjusted P value
Number of patients	33	185		33	99	
Age, years	60.15±7.26	61.05±8.12	0.55	60.15±7.26	61.13±8.71	0.56
Gender			0.26†			0.36†
Male	31 (93.9)	157 (84.9)		31 (93.9)	85 (85.9)	
Female	2 (6.1)	28 (15.1)		2 (6.1)	14 (14.1)	
Smoke			0.02†*			0.09†
Never	2 (6.1)	44 (23.8)		2 (6.1)	18 (18.2)	
Current or former	31 (93.9)	141 (76.2)		31 (93.9)	81 (81.8)	
Pathologic type			0.38			0.35
Squamous	29 (87.9)	151 (81.6)		29 (87.9)	80 (80.8)	
Others	4 (12.1)	34 (18.4)		4 (12.1)	19 (19.2)	
Neoadjuvant therapy			0.19			0.19
No	20 (60.6)	133 (71.9)		20 (60.6)	72 (72.7)	
Yes	13 (39.4)	52 (28.1)		13 (39.4)	27 (27.3)	
Pathologic T stage			0.13‡			0.18‡
T1	6 (18.2)	18 (9.7)		6 (18.2)	8 (8.1)	
T2	18 (54.5)	131 (70.8)		18 (54.5)	67 (67.7)	
T3	3 (9.1)	20 (10.8)		3 (9.1)	14 (14.1)	
T4	6 (18.2)	16 (8.6)		6 (18.2)	10 (10.1)	
Pathologic N stage			0.09			0.23
N0	12 (36.4)	40 (21.6)		12 (36.4)	24 (24.2)	
N1	11 (33.3)	97 (52.4)		11 (33.3)	49 (49.5)	
N2	10 (30.3)	48 (25.9)		10 (30.3)	26 (26.3)	
pTNM stage			0.04			0.11
I	11 (33.3)	32 (17.3)		11 (33.3)	17 (17.2)	
II	8 (24.2)	81 (43.8)		8 (24.2)	38 (38.4)	
III	14 (42.4)	72 (38.9)		14 (42.4)	44 (44.4)	

Data are n (%) or mean ± standard deviation. †, continuity correction; ‡, Fisher's exact test; *, P<0.05. ESL, extended sleeve lobectomy; SL, sleeve lobectomy; PSM, propensity score matching; pTNM, pathological tumor-node-metastasis.

patients, 42.4% *vs.* 38.9%, P=0.04) than the SL group. The remaining clinical characteristics of the study cohort are presented in *Table 1*.

Surgical outcomes

All the data are the results after PSM. In terms of intraoperative bleeding loss {median 200 [interquartile range (IQR): 100–260] *vs.* 100 (IQR: 50–200) mL for the ESL group and the SL group, respectively, P=0.049}, operative time [median: 330 (IQR: 302.5–360) *vs.* 240 (IQR: 180–310) minutes for the ESL group and the SL group, respectively, P<0.001], and length of postoperative hospitalization [median: 12 (IQR: 9–14) *vs.* 9 (IQR: 7–12)

Table 2 Surgical outcomes after matching

Surgical outcomes	Propensity score matched cohort		
	ESL	SL	P value
Estimated bleeding loss, mL	200 [100–260]	100 [50–200]	0.049*
Operative time, min	330 [302.5–360]	240 [180–310]	<0.001*
Tube drainage time, days	8 [6.5–12.5]	8 [6–11]	0.195
Length of hospitalization, days	12 [9–14]	9 [7–12]	0.007*
90-day mortality			0.736
Alive	33 (100.0)	96 (97.0)	
Dead	0 (0)	3 (3.0)	
Resection margins			0.047*
R0	31 (93.9)	78 (78.8)	
Others	2 (6.1)	21 (21.1)	
Complication grade			0.90
Grade I–II	26 (78.8)	79 (79.8)	
Grade III–IV	7 (21.1)	20 (20.2)	

Data are n (%) or median [interquartile range]. *, P<0.05. ESL, extended sleeve lobectomy; SL, sleeve lobectomy.

days for the ESL group and the SL group, respectively, P=0.007], the ESL group performed worse than the SL group. The overall 90-day mortality rate of the SL group was 3%, while no deaths occurred within the 90-day post-operation period in the ESL group (P=0.74). The ESL group had a higher rate of complete resection (R0) resection than the SL group (93.9% *vs.* 78.8%, P=0.047). In the ESL group, 2 non-R0 patients had pathological positivity in the highest mediastinal lymph nodes. In the SL group, among the 21 non-R0 patients, 12 had residual metastatic lymph nodes in the interlobar region, and 9 had pathological positivity in the highest mediastinal lymph nodes. In the ESL group, there were 7 grade III–IV perioperative complications, including 1 case of chylothorax, 2 cases of severe pneumonia, 2 cases requiring mechanical ventilation, 2 cases of persistent air leak from the chest drain for more than 15 days (non-bronchopleural fistula), and 1 case of bronchopleural fistula. In the SL surgery group, there were 20 grade III–IV perioperative complications, including 2 cases of chylothorax, 9 cases of severe pneumonia, 5 cases requiring mechanical ventilation, 2 cases of persistent air leak from the chest drain for more than 15 days (non-bronchopleural fistula), and 2 cases of bronchopleural fistula. There were no statistically significant differences between the two groups in terms of intraoperative bleeding, duration of postoperative drainage, postoperative discharge time, or perioperative complications (*Table 2*).

Survival analysis

The Kaplan-Meier survival analysis demonstrated that after PSM, the ESL group showed superior OS (log-rank P=0.02) and DFS (log-rank P=0.01) than the SL group (*Figure 3*). In the univariate Cox regression analysis (*Table 3*), higher age {hazard ratio (HR) 1.06 [95% confidence interval (CI): 1.02–1.10]}, non-squamous histology (HR 2.20; 95% CI: 1.10–4.42), N1 stage (HR 3.57; 95% CI: 1.47–8.66), and N2 stage (N2, HR 4.94; 95% CI: 1.87–13.02), and non-R0 resection (HR 3.02; 95% CI: 1.57–5.82) were associated with poorer OS, while undergoing ESL surgery (HR 0.44; 95% CI: 0.21–0.92) was associated with better OS. Smoking status (HR 0.38; 95% CI: 0.20–0.73), non-squamous histology (HR 2.44; 95% CI: 1.33–4.48), T4 stage (HR 3.37; 95% CI: 1.07–10.61), N1 stage (HR 2.91; 95% CI: 1.43–5.92) and N2 stage (N2, HR 3.74; 95% CI: 1.68–8.34), and non-R0 resection (HR 3.90; 95% CI: 2.12–7.18) were associated with poorer DFS, while undergoing ESL surgery (HR 0.43; 95% CI: 0.22–0.83) was associated with better DFS.

The significant variables in the univariate analysis were advanced forward as variables for the further multivariate

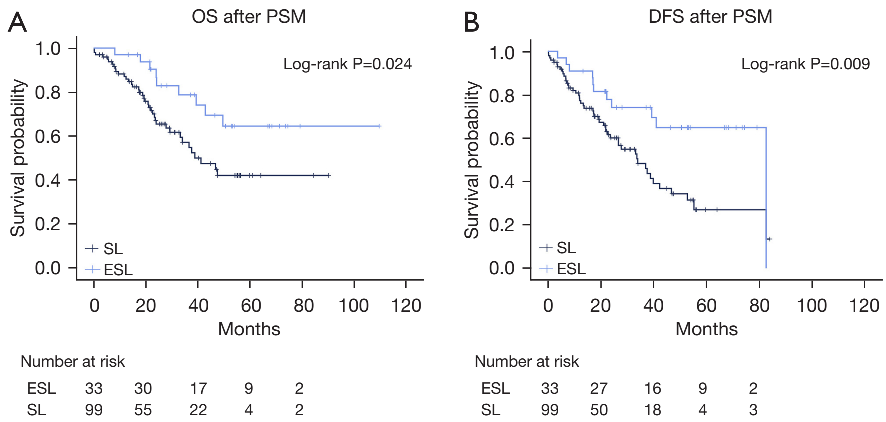

Figure 3 After PSM, the ESL group had significantly better OS and DFS than the SL group. (A) OS analysis chart of SL and ESL treatment groups after PSM. (B) DFS analysis chart of SL and ESL treatment groups after PSM. OS, overall survival; PSM, propensity score matching; ESL, extended sleeve lobectomy; SL, sleeve lobectomy; DFS, disease-free survival.

regression analysis (*Table 4*). For OS, the significant predictors were age (HR 1.08; 95% CI: 1.04–1.13; P<0.001), N staging (N1, HR 4.04; 95% CI: 1.63–10.04; P=0.003; N2, HR 5.13; 95% CI: 1.86–14.0; P=0.001), and non-R0 resection (HR 2.69; 95% CI: 1.38–5.22; P=0.004). For DFS, the significant predictors included smoking history (HR 0.31; 95% CI: 0.16–0.60; P=0.001), N staging (N1, HR 3.00; 95% CI: 1.50–6.15; N2, HR 2.79; 95% CI: 1.20–6.49; P=0.02), and non-R0 resection (HR 3.48; 95% CI: 1.81–6.67; P<0.001).

Discussion

Historically, PN has been the standard surgical approach for central NSCLC. However, this procedure is associated with significant morbidity and mortality, especially in patients with compromised lung function. For patients with centrally located NSCLC involving the main bronchus or pulmonary artery, ESL has emerged as a viable surgical option (16). In fact, ESL has demonstrated comparable five-year recurrence-free survival (RFS) and overall survival (OS) rates to PN. One study reported that the ESL group had a five-year RFS rate of 46.67% and an OS rate of 63.33%, while the PN group had an RFS rate of 29.03% and an OS rate of 38.71% (11). These findings underscore the potential advantages of ESL in preserving lung function and enhancing survival rates. The primary objective of this procedure is to achieve a higher R0 rate through a wider resection and a lower lung sparing technique, which is significantly related with better survival. The results of this study indicate that the ESL procedure can significantly increase the R0 resection rate in patients with early-stage lung cancer. Although the operation time, length of hospitalization and intraoperative blood loss are higher compared to the SL procedure, the complication rate does not show a significant difference.

Studies, including that of Magouliotis *et al.* (3), have shown that SL and ESL are comparable to PN in terms of oncological outcomes, but offer the advantages of better postoperative pulmonary function and fewer complications. In our study, we observed complications such as persistent air leaks, chylothorax, pleural effusion, and pulmonary infections. The ESL group had a perioperative grade III–IV complication rate of 21.1%, while that of the SL group was 20.2%. As reported by others, such complications are not uncommon following SL and ESL procedures. For instance, Voltolini *et al.* reported a grade III–IV complication rate of 9.1% (12), Berthet *et al.* reported a complication rate of 25% (2), and Hong *et al.* reported an overall complication rate of 16% (10). Our findings are consistent with these previous reports, indicating that most complications can be conservatively managed with timely diagnosis and appropriate treatment, without the need for re-operation.

The successful conduct of SL and ESL requires precise surgical techniques intraoperatively; however, appropriate patient selection, accurate tumor staging, and meticulous intraoperative assessment are also crucial (17,18). Given that this study is a retrospective analysis, certain confounding factors also need to be taken into account during the survival analysis. For example, ESL may be prioritized in specific situations, such as when it is determined preoperatively that SL surgery cannot achieve

Table 3 Univariate analyses of the overall survival and disease-free survival of the matched cohort

Variables	Prognostic factors for overall survival		Prognostic factors for disease-free survival	
	HR (95% CI)	P value	HR (95% CI)	P value
Age	1.06 (1.02–1.10)	0.005*	1.03 (0.99–1.06)	0.12
Gender				
Female	Reference		Reference	
Male	0.51 (0.21–1.24)	0.14	0.70 (0.48–1.03)	0.07
Smoke				
Never	Reference		Reference	
Current or former	0.53 (0.26–1.11)	0.09	0.38 (0.20–0.73)	0.004*
Pathologic type				
Squamous	Reference		Reference	
Others	2.20 (1.10–4.42)	0.03*	2.44 (1.33–4.48)	0.004*
Neoadjuvant therapy				
No	Reference		Reference	
Yes	0.58 (0.27–1.25)	0.17	0.81 (0.44–1.51)	0.51
Pathologic T stage				
T1	Reference		Reference	
T2	2.01 (0.62–6.59)	0.25	1.92 (0.68–5.40)	0.22
T3	2.11 (0.53–8.45)	0.29	1.83 (0.54–6.26)	0.34
T4	2.80 (0.74–10.60)	0.13	3.37 (1.07–10.61)	0.04*
Pathologic N stage				
N0	Reference		Reference	
N1	3.57 (1.47–8.66)	0.005*	2.91 (1.43–5.92)	0.003*
N2	4.94 (1.87–13.02)	0.001*	3.74 (1.68–8.34)	0.001*
Resection margins				
R0	Reference		Reference	
Others	3.02 (1.57–5.82)	0.001*	3.9 (2.12–7.18)	<0.001*
Approach				
SL	Reference		Reference	
ESL	0.44 (0.21–0.92)	0.03*	0.43 (0.22–0.83)	0.01*

*, P<0.05. HR, hazard ratio; CI, confidence interval.

complete tumor resection, or intraoperatively when positive bronchial margins or locally invasive positive lymph nodes are detected during SL surgery. The above-mentioned factors may lead to differences in clinical characteristics (e.g., TNM staging) between the ESL and SL groups. To eliminate the impact of baseline differences on survival time between the two groups, we employed the PSM method, ensuring that the survival analysis results are more objective and reliable. Intraoperative bronchoscopy and a frozen-section analysis are instrumental in ensuring clear surgical margins (19-22). In this study, all patients underwent frozen-section pathological diagnosis of the bronchial

Table 4 Multivariate analyses of the overall survival and disease-free survival of the matched cohort

Variables	Prognostic factors for overall survival		Prognostic factors for disease-free survival	
	HR (95% CI)	P value	HR (95% CI)	P value
Age	1.08 (1.04–1.13)	<0.001*	–	–
Smoke				
Never	–	–	Reference	
Current or former	–	–	0.31 (0.16–0.60)	0.001
Pathologic N stage				
N0	Reference		Reference	
N1	4.04 (1.63–10.04)	0.003*	3.00 (1.50–6.15)	0.003*
N2	5.13 (1.86–14.0)	0.001*	2.79 (1.20–6.49)	0.02*
Resection margins				
R0	Reference		Reference	
Others	2.69 (1.38–5.22)	0.004*	3.48 (1.81–6.67)	<0.001*

*, P<0.05. HR, hazard ratio; CI, confidence interval.

margins before anastomosis. Only when the bronchial margins were confirmed to be negative, the anastomosis was performed. However, in certain cases, such as when intrapulmonary metastatic lymph nodes are not completely dissected, bronchial anastomosis is still performed. In the SL group, 12 patients had intrapulmonary metastatic lymph nodes that were not completely dissected, while no corresponding cases were observed in the ESL group. Through multivariate regression analysis, we concluded that the R0 resection status is a significant predictor of both OS and DFS, whereas the ESL surgical technique itself is not. The key to surgery is ensuring R0 resection status, not necessarily performing ESL surgery. Considering that ESL achieves a higher R0 resection rate through more extensive resection and less lung tissue preservation, SL surgery is sufficient for patient treatment when the margins (including the bronchus, blood vessels, and surrounding tissues) are negative.

In the survival analysis, we found that after PSM, the ESL group had superior OS and DFS than the SL group. Considering that the majority of patients requiring ESL surgery have centrally located and more invasive lung cancers, there is a possibility that SL alone may not achieve R0 resection in this population, which was confirmed by our findings. The results of the multivariate regression analysis indicated that while the surgical approach of ESL was not a significant predictor of OS and DFS ESL did increase the rate of R0 resections, and R0 resection status is a significant predictor of both OS and DFS.

Another noteworthy result is that in the multivariate regression analysis of DFS, smoking status emerged as a beneficial predictor for patients, which contradicts the results of previous studies (23,24). This discrepancy might have been affected by two factors. First, our findings indicated that patients with squamous cell carcinoma had better OS and DFS compared to those with non-squamous cell carcinoma. Considering that smoking is a known predictor of squamous cell carcinoma, this might have led to a confounding conclusion that smoking status is a beneficial predictor for DFS. Second, our sample size was relatively small, especially after performing PSM, which might have introduced a degree of selection bias.

Limitation

Additionally, this study is a retrospective analysis, with the time span for surgeries in both the ESL and SL groups ranging from 2014 to 2022. However, due to the greater complexity of the ESL procedure, 66.7% (22/33) of the enrolled patients were admitted after 2019. Due to advancements in chemotherapy and immunotherapy, patients enrolled later are more likely to achieve better prognoses, which partly confounds the outcomes of the ESL procedure and represents another limitation of this study. Therefore, large-scale prospective studies in the future are warranted to eliminate this influence. Moreover, to eliminate the impact of baseline differences on survival time between the two groups, we employed the PSM method. However, due to the incomplete data collection, some important potential confounders that could affect prognosis (e.g., comorbidities, preoperative spirometry results) were not balanced between the two groups. We hope that future large-scale prospective studies will consider including these factors in their research design. In terms of data analysis, we attempted to conduct subgroup analyses based on whether vascular sleeve resections and anastomoses were performed, whether neoadjuvant treatment was administered, and whether adjuvant therapy was received. However, due to the small sample size, the subgroup analyses could not yield valid conclusions and thus were not presented in the article. Future research with an increased sample size is needed to further explore these aspects.

Conclusions

In summary, ESL can achieve a higher R0 resection rate compared to SL without increasing the incidence of perioperative complications. However, ESL is considerably complex and risky, and therefore, it should only be performed when an R0 resection cannot be achieved with SL. In the future, as surgical techniques evolve and more clinical data are accumulated, the role and significance of ESL in treating centrally located and locally advanced NSCLC will become further established.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-24-546/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-24-546/coif). M.B.A. receives consulting fees from Merck, astrazeneca, ethicon, and BMS. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Liaoning Cancer Hospital & Institute Medical Ethics Committee (approval No. KY20231203). This study was a retrospective study and did not bring any adverse effects to the participants' treatment. Requirement for informed consent has been waived by the ethics committee.

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