

Original Article

Clinical efficacy and safety of video-assisted thoracoscopic lobectomy versus wedge resection in elderly patients with early-stage non-small cell lung cancer

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Abstract: Objective: To compare the clinical efficacy and safety of video-assisted thoracoscopic surgery (VATS) lobectomy and VATS wedge resection in elderly patients with early-stage non-small cell lung cancer (NSCLC). Methods: A retrospective analysis was conducted on the clinical data of 156 elderly patients with early-stage NSCLC who underwent surgical treatment at our hospital between January 2019 and December 2023. According to the surgical procedure, the patients were divided into a lobectomy group (n = 88) and a wedge resection group (n = 68). Perioperative outcomes, inflammatory markers, changes in pulmonary function, tumor marker levels, postoperative complications, quality of life, and survival outcomes were compared between the two groups. Results: There were no statistically significant differences in baseline characteristics between the two groups (P > 0.05). Compared with the lobectomy group, the wedge resection group had less intraoperative blood loss, shorter postoperative drainage duration, lower drainage volume, and shorter hospital stay, and all these differences were statistically significant (P < 0.001), whereas operative time was comparable between the two groups (P > 0.05). Serum C-reactive protein (CRP) and procalcitonin (PCT) levels on postoperative days 1 and 3 were significantly increased in both groups compared with preoperative levels, but the increase was significantly smaller in the wedge resection group. At 3 months after surgery, forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), and maximal voluntary ventilation (MVV) were all decreased in both groups compared with preoperative values, but the decline was less pronounced in the wedge resection group (P < 0.001). Postoperative tumor marker levels, including carcinoembryonic antigen (CEA) and cytokeratin 19 fragment (CYFRA21-1), were reduced in both groups compared with pretreatment levels, but no significant differences were found between the groups (P > 0.05). The overall incidence of postoperative complications was lower in the wedge resection group than in the lobectomy group (4.41% vs. 12.50%), although the difference was not statistically significant (P > 0.05). Survival analysis was exploratory only and limited by the small number of events and relatively short follow-up duration; therefore, no definitive conclusions can be drawn (P > 0.05). At 12 months after surgery, quality-of-life scores in physical functioning, role functioning, and emotional functioning were significantly higher in the wedge resection group than in the lobectomy group (P < 0.001). Multivariate logistic regression analysis showed that TNM stage was an independent risk factor for poor prognosis in elderly patients with early-stage NSCLC (OR = 6.087, P = 0.001), whereas age ≤ 70 years was independently associated with a better prognosis (OR = 0.135, P < 0.001). A nomogram prediction model was further established based on these variables, and the area under the receiver operating characteristic curve (AUC) was 0.810, indicating good predictive performance. Conclusion: Both VATS lobectomy and VATS wedge resection are safe and effective surgical options for elderly patients with early-stage NSCLC. Wedge resection shows certain advantages in reducing perioperative trauma, alleviating inflammatory response, preserving pulmonary function, and improving postoperative quality of life, whereas no statistically significant difference was observed between the two procedures in short-term oncological outcomes or survival prognosis. TNM stage and age were independent prognostic factors. The prediction model constructed based on these two variables may have good clinical value for individualized prognostic assessment in elderly patients with early-stage NSCLC.

Keywords: Non-small cell lung cancer, elderly patients, VATS lobectomy, VATS wedge resection, prognosis, nomogram

Introduction

Non-small cell lung cancer (NSCLC) is the predominant histological type of lung cancer, accounting for approximately 80%-85% of all cases [1, 2]. In recent years, with the ongoing acceleration of population aging and the widespread adoption of high-resolution imaging-based screening, the detection rate and overall disease burden of this condition have shown a corresponding increase [3]. For patients with early-stage disease, the tumor is confined to a very limited anatomical region and could be potentially curable [4]. Surgical resection is still regarded by most clinicians as the standard first-line treatment for lung cancer and, compared with non-surgical therapies, can provide patients with more substantial long-term survival benefits [5].

Although the conventional thoracotomy provides very satisfactory oncologic outcomes, it is associated with greater surgical trauma, prolonged recovery, and more likely to develop complications, posing particular challenges for the elderly patients with limited physiological reserve [6]. In recent years, with the rapid development of minimally invasive techniques, video-assisted thoracoscopic surgery (VATS) has played an increasingly important role in the treatment of lung cancer. VATS lobectomy has become the standard surgical treatment for early-stage non-small cell lung cancer (NSCLC) [7, 8], as it allows complete tumor resection while enabling systematic lymph node dissection. However, elderly patients often endure the disease of multiple comorbidities and diminished cardiopulmonary function, and extensive surgical trauma may adversely affect postoperative recovery and quality of life [9].

In contrast, VATS wedge resection is less invasive, involves a smaller extent of the lung parenchymal removal, and may better preserve the pulmonary function. Some studies have suggested that in the selected patients who have small peripheral tumors, wedge resection can achieve the satisfactory oncologic control while reducing the perioperative risk [10, 11]. Nevertheless, concerns remain regarding the potential for the increased local recurrence after the sublobar resection, and the long-term survival benefit remains controversial. Therefore, in the elderly patients who have early-stage NSCLC, balancing the oncologic radicality

with the surgical safety remains a critical clinical issue. Currently, the evidence that compares the efficacy and safety of the VATS lobectomy and the VATS wedge resection specifically in the elderly patients remains inconclusive.

Therefore, we conducted a retrospective analysis to investigate the clinical outcomes of elderly patients with early-stage NSCLC treated with either VATS lobectomy or VATS wedge resection. The perioperative parameters, the changes of the pulmonary function, the postoperative complications, and the survival outcomes were compared by systematically analyzing the differences between the two procedures across multiple clinical observation indicators. This study aimed to provide a more comprehensive and objective evaluation of their clinical efficacy and safety, thereby offering evidence to guide surgical decision-making in this population.

Materials and methods

Study design and participants

A retrospective observational study was conducted in elderly patients with early-stage non-small cell lung cancer (NSCLC) who underwent the surgical treatment at our institution between January 2019 and December 2023, and their clinical data were consecutively collected and analyzed. Eligible cases have been identified through the hospital electronic medical record system. All patients were pathologically confirmed as having the stage I (Ia or Ib) NSCLC according to the 8th edition of the TNM staging system. The inclusion criteria were as follows: (1) Age \geq 65 years; (2) Postoperative pathological confirmation of stage I NSCLC; (3) Treatment with the video-assisted thoracoscopic surgery (VATS) lobectomy or VATS wedge resection; and (4) Complete the clinical and follow-up data. The exclusion criteria included: (1) Coexistence of other malignancies; (2) Previous lung surgery or receipt of the neoadjuvant therapy; (3) Severe cardiac, hepatic, or renal dysfunction precluding surgery; (4) Loss to follow-up within 30 days after surgery; and (5) Incomplete the clinical records.

According to the surgical procedure, the patients were assigned to a lobectomy group (n = 88) and a wedge resection group (n = 68). Because this was a retrospective, nonrandom-

ized study, treatment allocation was determined by clinical judgment rather than random assignment, which may have introduced selection bias. This study was approved by the Ethics Committee of Shandong Provincial Third Hospital Ethics Committee (Approval No. KYYL-2026010). The study was conducted in accordance with the Declaration of Helsinki and relevant regulations. The ethics committee confirmed that the investigators were qualified and that the study design was scientifically sound with an appropriate risk-benefit profile. Due to the retrospective nature of the study, the requirement for informed consent was waived.

Surgical procedures

Preoperative assessment: All patients underwent the routine preoperative evaluations, including complete blood count, coagulation profile, liver and renal function tests, electrolyte panel, and urinalysis. Cardiopulmonary function has been assessed to ensure that there were no contraindications to surgery. All patients underwent chest radiography and chest computed tomography (CT) examination to determine the tumor location, size, extent, and characteristics. In addition, further assessments were performed when necessary, such as diaphragmatic motion and pulmonary function testing, were conducted when it was necessary to guide surgical planning.

Operative techniques: All procedures were performed under general anesthesia with double-lumen endotracheal intubation to enable single-lung ventilation. Patients were placed in the lateral decubitus position.

In the lobectomy group, anatomical lobectomy was performed via a thoracoscopic approach. The pulmonary vein, pulmonary artery branches, and bronchus were sequentially dissected and divided, followed by complete removal of the affected lobe. Systematic hilar and mediastinal lymph node dissection was routinely performed in accordance with the International Association for the Study of Lung Cancer (IASLC) lymph node map to ensure oncologic radicality.

In the wedge resection group, thoracoscopic wedge resection was performed using a linear stapling device. Surgical margins were maintained at least 2 cm from the tumor edge or

satisfied the principle of a margin distance greater than or equal to the tumor diameter. Based on the intraoperative findings and the patient's actual disease condition, hilar or mediastinal lymph node sampling was performed as appropriate, and further lymph node dissection was carried out when necessary. Given the inherent differences between the two surgical procedures, systematic lymph node dissection was routinely performed in the lobectomy group, whereas lymph node sampling or selective dissection was generally adopted in the wedge resection group. All procedures in the wedge resection group were non-anatomic wedge resections, and no anatomic segmentectomy was included in this study.

Follow-up and outcomes: Postoperative follow-up was conducted through outpatient visits, telephone interviews, and hospital record review. All patients underwent staged regular follow-up after surgery, with follow-up performed every 3 months during the first postoperative year, every 6 months in the second year, and annually thereafter. Follow-up assessments included the physical examination and chest CT scans, with additional examinations being performed when clinically indicated.

Overall survival (OS) was defined as the time during from the date of surgery to death from any cause or last follow-up. Patients were followed through the outpatient visits, telephone interviews, and hospital records to obtain information on the survival status and tumor recurrence. Poor prognosis was defined as the occurrence of disease progression events during follow-up, including tumor recurrence, metastasis, or death. Poor prognosis events were used as the outcome variable for regression analysis to increase the number of clinical events and improve the robustness of the statistical model. The follow-up period was continued until in December 2025. The follow-up duration ranged from the 2 to 75 months and its median follow-up time was 49 months.

Data collection and outcome measures

Clinical data were extracted from the medical records and included: Baseline characteristics: age, sex, smoking history, tumor location, histological subtype, tumor diameter, and clinical stage; Perioperative variables: operative time,

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intraoperative blood loss, postoperative drainage duration, drainage volume, length of hospital stay, and hospitalization costs; Inflammatory markers: serum C-reactive protein (CRP) and procalcitonin (PCT) levels measured preoperatively and on postoperative days 1 and 3; Pulmonary function parameters: forced vital capacity (FVC), forced expiratory volume in one second (FEV_{1}), and maximal voluntary ventilation (MVV), measured preoperatively and at 3 months postoperatively; Postoperative complications; Follow-up data: recurrence and survival outcomes. Quality of life was assessed preoperatively and at 12 months after surgery using validated quality-of-life questionnaires.

Statistical analysis

All statistical analyses were performed using the SPSS or R software. All continuous variables were first tested for normality. Data conforming to a normal distribution were described as mean \pm standard deviation ($\bar{x} \pm s$), and differences between the two groups were further compared using the independent-samples t-test. For data that did not follow a normal distribution, the median and interquartile range were used for description, and intergroup comparisons were performed using the Mann-Whitney U test. Categorical variables were expressed as frequencies and percentages, and comparisons between groups were conducted using the chi-square test or Fisher's exact test according to the sample size and expected cell counts. Paired t-tests were used for the preoperative and postoperative comparisons within groups. Survival curves were generated using the Kaplan-Meier method and compared using the log-rank test. All statistical tests were two-sided, and a P value < 0.05 was considered statistically significant.

Results

Baseline characteristics

Comparing with the baseline characteristics between the lobectomy group and the wedge resection group, it revealed that there was no statistically significant differences in sex distribution, age, tumor location (left vs. right lung), histological subtype (squamous cell carcinoma vs. adenocarcinoma), TNM stage (Ia vs. Ib), or tumor diameter (all $P > 0.05$). These findings indicate that the two groups were comparable

at the baseline. Although no statistically significant differences were observed in the measured baseline variables, unmeasured confounders may still exist because treatment allocation was not randomized. Given the inherent procedural differences, systematic hilar and mediastinal lymph node dissection was routinely performed in the lobectomy group, whereas lymph node sampling or selective assessment was generally adopted in the wedge resection group. However, the number of dissected lymph nodes and nodal stations was not quantitatively compared in this retrospective study.

However, detailed quantitative data regarding the number of dissected lymph nodes and nodal stations were not systematically recorded in this retrospective study and therefore could not be included in the baseline comparison. Given the inherent differences in the lymph node management between lobectomy (systematic dissection) and wedge resection (sampling or selective dissection), this factor may have introduced potential confounding. Detailed data are presented in **Table 1**.

Comparison of perioperative outcomes

Comparison of perioperative parameters between the two groups demonstrated that the wedge resection group had significantly lower intraoperative blood loss, shorter postoperative drainage duration, reduced postoperative drainage volume, and shorter length of hospital stay compared with the lobectomy group (all $P < 0.001$). The operative duration was generally comparable between the two groups, with no statistically significant difference observed on intergroup comparison ($P > 0.05$). Detailed results are shown in **Figure 1**.

Comparison of inflammatory markers

Preoperative serum C-reactive protein (CRP) and procalcitonin (PCT) levels were generally comparable between the two groups, with no statistically significant differences observed on intergroup comparison ($P > 0.05$). Postoperatively, both CRP and PCT levels increased significantly compared with preoperative values in each group ($P < 0.05$). Intergroup comparison demonstrated that postoperative CRP and PCT levels were significantly higher in the lobectomy group than those of the wedge resection group ($P < 0.05$) (**Figure 2**).

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Table 1. Baseline characteristics of the study population

Group	n	Male/Female (n)	Age (years)	Smoking history (n)	Tumor location (n)			Histological type (n)		TNM stage		Tumor size (cm)		
					Upper lobe	Middle lobe	Lower lobe	Squamous cell carcinoma	Adenocarcinoma	Ia	Ib	< 2	2-4	> 4
Lobectomy group	88	51/37	68.3 ± 9.7	73	45	24	19	28	60	45	40	16	40	31
Wedge resection group	68	37/31	69.5 ± 8.2	60	43	11	14	28	40	33	31	19	30	18
t/ χ^2		0.078	0.834	0.483		3.119			1.028		0.000		2.581	
P		0.780	0.406	0.487		0.210			0.298		1.000		0.276	

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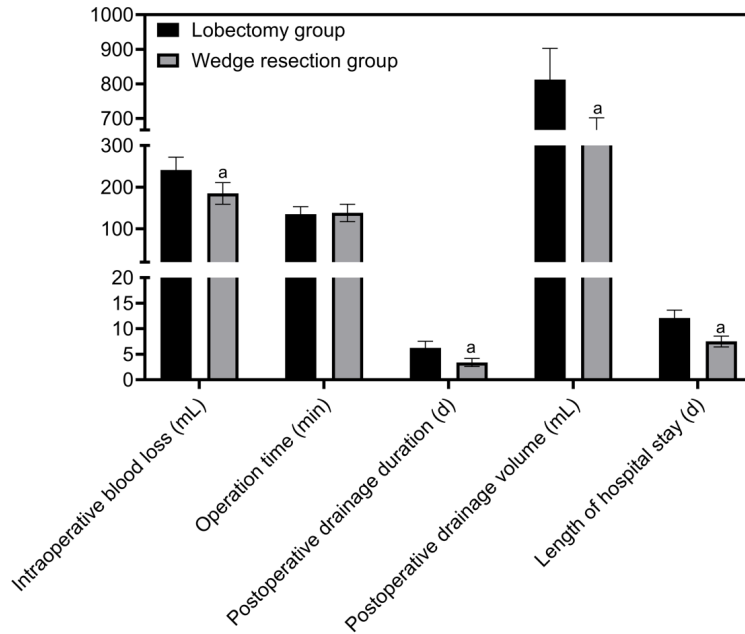


Figure 1. Comparison of perioperative outcomes between the lobectomy group and the wedge resection group. Perioperative indicators included intraoperative blood loss, operative time, postoperative drainage duration, postoperative drainage volume, and length of hospital stay. Data are presented as mean \pm standard deviation (mean \pm standard deviation (SD)). ^a $P < 0.05$ compared with the lobectomy group.

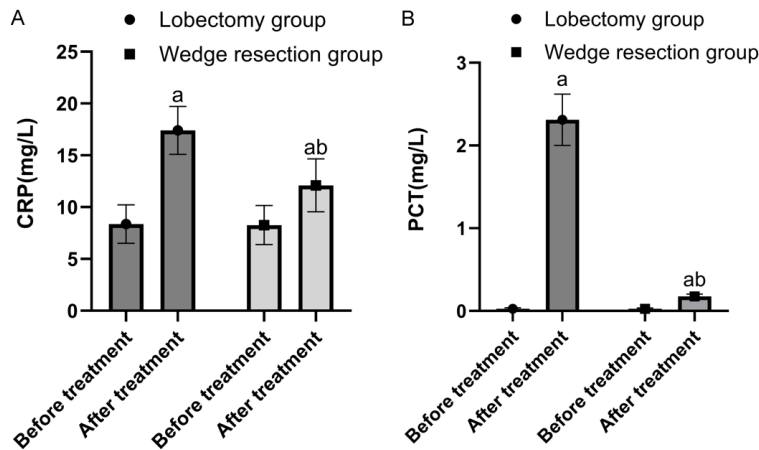


Figure 2. Comparison of perioperative serum CRP and PCT levels between the lobectomy group and the wedge resection group. A. Changes in serum C-reactive protein (CRP) levels before and after treatment in the two groups; B. Changes in serum procalcitonin (PCT) levels before and after treatment in the two groups. Data are presented as mean \pm standard deviation (mean \pm SD). ^a $P < 0.05$ versus the preoperative value within the same group; ^b $P < 0.05$ versus the wedge resection group at the same time point.

Comparison of tumor marker levels

There were no significant differences in preoperative serum carcinoembryonic antigen (CEA) or cytokeratin 19 fragment (CYFRA21-1) levels

between the two groups (both $P > 0.05$), indicating baseline comparability. After surgery, serum carcinoembryonic antigen (CEA) and cytokeratin 19 fragment (CYFRA21-1) levels in both groups showed a marked downward trend compared with the preoperative levels. However, further intergroup analysis revealed that the differences in postoperative CEA and CYFRA21-1 levels between the two groups did not reach statistical significance ($P > 0.05$, presented in **Table 2**).

Comparison of pulmonary function

There were no significant differences in preoperative forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), or maximal voluntary ventilation (MVV) between the two groups ($P > 0.05$), indicating baseline comparability.

At 3 months postoperatively, FVC, FEV_1 , and MVV levels significantly decreased in both groups compared with preoperative values (all $P < 0.05$). Intergroup comparison demonstrated that, at 3 months after surgery, FVC and MVV levels were significantly lower in the lobectomy group than in the wedge resection group ($P < 0.001$). Similarly, postoperative FEV_1 was also significantly lower in the lobectomy group compared with the wedge resection group ($P < 0.001$). Presented in **Table 3**.

Comparison of postoperative complications

The overall incidence of postoperative complications was 12.50% in the lobectomy group and 4.41% in the wedge resection group. However, the difference between the two groups was not statistically significant ($\chi^2 = 3.072$, $P = 0.080$). Regarding individual complications, the lobec-

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Table 2. Comparison of tumor marker levels between the lobectomy group and the wedge resection group

Group	n	CEA (ng/mL)		CYFRA21-1 (ng/mL)	
		Preoperative	3 Months Postoperatively	Preoperative	3 Months Postoperatively
Lobectomy group	88	7.82 ± 2.10	4.38 ± 1.62	4.62 ± 1.35	2.78 ± 1.02
Wedge resection group	68	7.65 ± 2.06	4.12 ± 1.71	4.55 ± 1.31	2.91 ± 1.08
t		0.517	0.994	0.333	0.788
P		0.606	0.322	0.740	0.432

CEA: carcinoembryonic antigen; CYFRA21-1: cytokeratin 19 fragment.

Table 3. Comparison of the pulmonary function

Group	n	FVC (L)		FEV ₁ (L)		MVV (L/min)	
		Preoperative	3 Months Postoperatively	Preoperative	3 Months Postoperatively	Preoperative	3 Months Postoperatively
Lobectomy group	88	4.04 ± 0.42	2.69 ± 0.47 ^a	2.86 ± 0.28	1.12 ± 0.54 ^a	73.25 ± 10.61	51.26 ± 8.21 ^a
Wedge resection group	68	3.97 ± 0.37	2.69 ± 0.47 ^a	2.95 ± 0.33	1.78 ± 0.51 ^a	71.43 ± 11.55	62.09 ± 8.32 ^a
t		1.108	6.841	1.892	7.921	1.048	8.312
P		0.270	< 0.001	0.060	< 0.001	0.296	< 0.001

Note: ^aP < 0.05 versus the preoperative value within the same group. FVC: forced vital capacity; FEV₁: forced expiratory volume in one second; MVV: maximal voluntary ventilation.

Table 4. Comparison of postoperative complications between the lobectomy and wedge resection groups

Group	n	Pleural effusion	Pulmonary infection	Atelectasis	Pneumothorax	Bronchopleural fistula	Total incidence
Lobectomy group	88	2 (2.27%)	2 (2.27%)	4 (4.45%)	2 (2.27%)	1 (1.14%)	11 (12.50%)
Wedge resection group	68	1 (1.47%)	0 (0%)	2 (2.94%)	0 (0%)	0 (0%)	3 (4.41%)
t							3.072
P							0.080

tomy group demonstrated higher or comparable incidences of pleural effusion, pulmonary infection, atelectasis, pneumothorax, and bronchopleural fistula compared with the wedge resection group; nevertheless, none of these differences reached statistical significance (all $P > 0.05$). Presented in **Table 4**.

Comparison of laboratory parameters

The preoperative levels of GLU, WBC, and PA were comparable between the two groups, with no statistically significant differences observed ($P > 0.05$). Compared with preoperative values, postoperative GLU and WBC levels increased significantly in both groups, whereas PA levels decreased significantly (all $P < 0.05$). Intergroup comparison demonstrated that the magnitude of postoperative changes in laboratory parameters in the wedge resection group was smaller than those of lobectomy group, suggesting a relatively milder perioperative stress response

in patients undergoing wedge resection. Presented in **Table 5**.

Survival outcomes

Throughout the entire follow-up period, deaths were observed in both groups, including 4 cases in the lobectomy group and 6 cases in the wedge resection group. Kaplan-Meier survival analysis showed no statistically significant difference between the two groups; however, given the limited number of death events ($n = 10$), the survival analysis should be interpreted as exploratory and insufficient to draw definitive conclusions (log-rank test, $P > 0.05$) (**Figure 3**).

Comparison of quality of life

There were no significant differences in baseline scores for physical functioning, role functioning, or emotional functioning between

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Table 5. Comparison of laboratory parameters before and after surgery between the lobectomy and wedge resection groups

Group	n	GLU (mmol/L)		WBC ($\times 10^9/L$)		PA (mmol/L)	
		Preoperative	Postoperative Day 1	Preoperative	Postoperative Day 1	Preoperative	Postoperative Day 1
Lobectomy group	88	5.39 \pm 0.95	8.53 \pm 1.48 ^a	7.81 \pm 1.95	14.72 \pm 6.22 ^a	220.25 \pm 60.53	151.72 \pm 38.65 ^a
Wedge resection group	68	5.17 \pm 0.88	7.12 \pm 2.15 ^a	7.67 \pm 1.72	11.51 \pm 4.51 ^a	223.43 \pm 51.65	192.09 \pm 29.77 ^a
t		1.512	5.007	0.477	3.642	0.353	7.247
P		0.133	< 0.001	0.634	< 0.001	0.725	< 0.001

Note: ^aP < 0.05 versus the preoperative value within the same group. GLU: glucose; WBC: white blood cell count; PA: prealbumin.

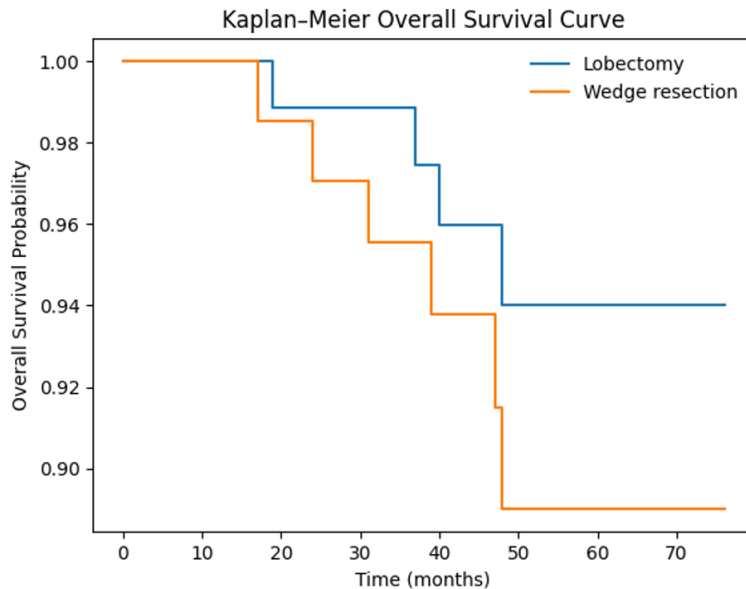


Figure 3. Kaplan-Meier overall survival curves comparing lobectomy (n = 88) and wedge resection (n = 68) in patients with early-stage non-small cell lung cancer. Although no statistically significant difference was observed, the survival analysis was limited by the small number of events and should be interpreted as exploratory, and no definitive conclusions can be drawn (log-rank test, $P > 0.05$).

Lobectomy group and Wedge resection group ($P > 0.05$), which is comparability prior to treatment. At 12 months after surgery, quality-of-life scores in all domains were significantly higher than the preoperative levels in both groups. Intergroup analysis demonstrated that physical functioning, role functioning, and emotional functioning scores were significantly higher in the wedge resection group than in the lobectomy group. The results are presented in **Table 6**.

Multivariate logistic regression analysis

Using the patient prognosis as the outcome variable, the results showed that age, TNM stage, and tumor size were significantly associ-

ated with patient prognosis ($P < 0.05$), whereas sex, FVC, FEV₁, MVV, smoking history, tumor location, histological type, and surgical procedure were not significantly associated with prognosis ($P > 0.05$, **Table 7**).

Further multivariate logistic regression analysis showed that TNM stage was clearly associated with poor prognosis in elderly patients with early-stage non-small cell lung cancer and was confirmed to be an independent risk factor (OR = 6.087, 95% CI: 2.063-17.960, $P = 0.001$). This finding suggests that, compared with patients with stage Ia disease, those with stage Ib disease were more likely to have a poor prognosis. Age was identified as an independent protective factor (OR = 0.135, 95% CI:

0.044-0.413, $P < 0.001$). Other variables, including sex, pulmonary function indices, smoking history, tumor location, histological type, tumor size, and surgical procedure, were not significantly associated with prognosis (all $P > 0.05$, **Table 8**).

Construction and validation of the prognostic nomogram

By integrating these independent prognostic factors, a nomogram prediction model was ultimately established to assess the risk of poor prognosis in elderly patients (**Figure 4A**). Each predictor was assigned a corresponding score according to the regression coefficient and the

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Table 6. Comparison of quality-of-life scores

Group	n	Physical Functioning		Role Functioning		Emotional Functioning	
		Preoperative	12 Months After Surgery	Preoperative	12 Months After Surgery	Preoperative	12 Months After Surgery
Lobectomy group	88	60.35 ± 4.14	74.32 ± 3.87 ^a	64.62 ± 3.79	71.57 ± 4.22 ^a	62.35 ± 3.71	70.09 ± 4.66 ^a
Wedge resection group	68	61.22 ± 4.36	79.22 ± 5.17 ^a	63.55 ± 3.81	76.26 ± 4.78 ^a	61.28 ± 3.93	78.32 ± 5.12 ^a
t		1.303	6.981	1.785	6.667	1.774	10.745
P		0.195	< 0.001	0.076	< 0.001	0.078	< 0.001

Note: ^aP < 0.05 versus the preoperative value within the same group.

Table 7. Univariate analysis of factors associated with prognosis

Variable	Good prognosis group (n = 116)	Poor prognosis group (n = 40)	Statistic	P value
FVC (L)	75.09 ± 10.22	76.22 ± 9.73	t = -0.625	0.534
FEV ₁ (L)	82.09 ± 12.35	81.29 ± 11.57	t = 0.366	0.716
MVV (L/min)	73.25 ± 10.61	71.43 ± 11.55	t = 0.873	0.386
Sex (Male/Female)	67/49	21/19	χ ² = 0.155	0.694
Age (≤ 70/> 70 years)	73/43	8/32	χ ² = 20.274	< 0.001
Smoking history (Yes/No)	99/17	34/6	χ ² = 0.000	1.000
Tumor location (Upper/Middle/Lower lobe)	69/25/22	19/10/11	χ ² = 1.939	0.379
Histological type (Squamous/Adenocarcinoma)	42/74	14/26	χ ² = 0.000	1.000
TNM stage (Ia/Ib)	78/38	7/33	χ ² = 27.704	< 0.001
Tumor size (< 2/2-4/> 4 cm)	32/53/31	3/17/20	χ ² = 8.533	0.014
Surgical procedure (Lobectomy/Wedge resection)	62/54	26/14	χ ² = 1.179	0.278

FVC: forced vital capacity; FEV₁: forced expiratory volume in one second; MVV: maximal voluntary ventilation.

Table 8. Multivariate logistic regression analysis of prognostic factors

Variable	B	SE	Wald	df	P value	OR (Exp(B))	95% CI (Lower)	95% CI (Upper)
Age (≤ 70 years)	-2.003	0.571	12.304	1	< 0.001	0.135	0.044	0.413
TNM stage (Ib)	1.806	0.552	10.704	1	0.001	6.087	2.063	17.96

OR: odds ratio; CI: confidence interval; SE: standard error.

total score was calculated by summing the points for each variable. The corresponding probability of the poor prognosis was estimated using the risk scale of the nomogram. Among the included predictors, TNM stage contributed the greatest weight to the overall score, followed by the age.

As shown in **Figure 4B**, the AUC, to discriminate the ability of the nomogram, was 0.810 (95% CI: 0.741-0.879), which indicates that the predictive performance can be considered acceptable. Calibration of the model was assessed using a calibration curve, as shown in **Figure 4C**. The predicted probabilities were generally consistent with the observed outcomes, and the bias-corrected curve closely approximated the ideal reference line, suggesting the satisfactory calibration performance. Decision curve

analysis (DCA) was performed to evaluate the clinical utility of the model, as shown in **Figure 4D**. Within a threshold probability range of approximately 0.05-0.55, the nomogram demonstrated a greater net benefit than both the “treat-all” and “treat-none” strategies, indicating the potential clinical applicability within this range.

Discussion

Previous studies have shown that the elderly patients diagnosed with NSCLC are less likely to receive the curative treatment compared with the younger patient. Age is often overemphasized in the clinical decision-making [12]. However, multivariate analyses have demonstrated that After incorporating performance status (PS) and comorbidities as adjustment

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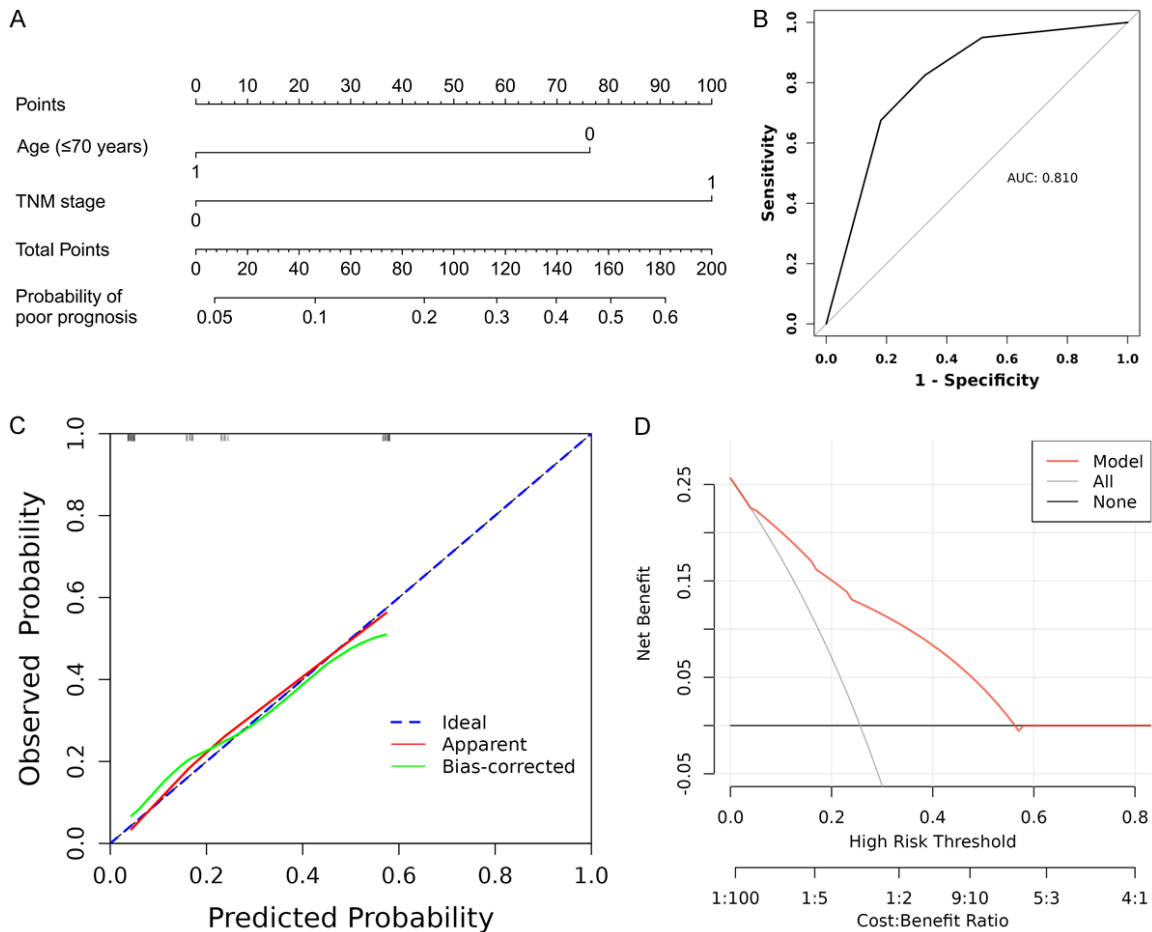


Figure 4. Development and validation of the prognostic nomogram for predicting poor prognosis. A. Nomogram for predicting poor prognosis. B. Receiver operating characteristic (ROC) curve evaluating the discrimination ability of the nomogram. C. Calibration curve showing the agreement between predicted and observed probabilities. D. Decision curve analysis (DCA) demonstrating the clinical utility of the nomogram.

factors, chronological age itself is not an independent prognostic factor, and elderly patients with the good functional status may still benefit from active surgical intervention [13, 14]. Compared with the younger individuals, elderly patients suffering with NSCLC frequently present with a poorer performance status and a higher burden of comorbidities. Age-related physiological decline and the presence of the chronic diseases can reduce tolerance to surgical trauma and perioperative stress, which may influence the surgical selection and the postoperative outcomes [15, 16]. It has been reported that patients with age ≥ 70 years have relatively limited overall prognosis, with a 2-year survival rate of approximately 35.6%, and that surgical modality may affect the long-term survival outcomes [17].

With the rapid development of minimally invasive techniques, video-assisted thoracoscopic surgery (VATS) has become the mainstream surgical approach for early-stage NSCLC. Both VATS lobectomy and VATS wedge resection are commonly performed procedures [18, 19]. Nevertheless, the comparative efficacy and safety of these two techniques specifically in elderly patients remain unclear. In the present retrospective study, we compared perioperative parameters, inflammatory response, pulmonary function changes, tumor marker levels, postoperative complications, survival outcomes, and quality of life between elderly patients undergoing VATS lobectomy and VATS wedge resection. Our findings indicate that the two procedures achieved no definitive conclusion regarding survival differences can be

drawn due to limited statistical power. Therefore, the improvement of postoperation observed in patients may partly reflect the recovery from disease-related distress rather than the direct beneficial effects of the surgical procedure itself. Furthermore, the results of multivariate logistic regression analysis indicated that the TNM stage may represent an independent risk factor which affect patient prognosis. In particular, patients with stage Ib disease demonstrated a significantly higher risk of the poor prognosis compared with those with stage Ia disease, suggesting that the tumor stage remains a key determinant of prognosis in the early-stage NSCLC population.

Large randomized controlled trials, such as CALGB 140503 and JCOG0802, have reported long-term outcomes with follow-up durations exceeding 7 years, providing more robust evidence for survival comparisons [20, 21]. In contrast, the current study, with a median follow-up of 49 months and limited survival events, is insufficient to support definitive conclusions regarding long-term survival outcome.

Further analysis indicated that age ≤ 70 years was also an important factor associated with patient prognosis and was significantly correlated with a more favorable outcome (OR = 0.135, $P < 0.001$). However, this finding should be interpreted with a certain degree of caution. Because this study was designed as a retrospective analysis and included only patients who underwent surgical treatment, elderly individuals who were able to receive surgery were likely subjected to stricter preoperative evaluation and selection criteria. Consequently, the observed statistical association may partly reflect selection bias or residual confounding rather than a direct protective effect of younger age. Moreover, important baseline characteristics, such as performance status and comorbidity burden, were not included in the current analysis; therefore, the possibility of unmeasured confounding cannot be excluded.

Notably, the results of this study indicated that surgical procedure was not an independent prognostic factor ($P > 0.05$). This finding suggests that, under carefully selected indications, thoracoscopic wedge resection may provide oncological safety comparable to that of lobectomy in elderly patients with early-stage NSCLC. Meanwhile, systematic or selective lymph node

sampling or dissection should still be considered during surgery to evaluate lymph node metastasis, thereby improving the accuracy of staging and ensuring appropriate oncological management. Because lymph node dissection or sampling was not compared in the present study, this limitation may have influenced the evaluation of oncological outcomes and might partly explain why no significant difference between the two surgical procedures was observed. Combined with the perioperative indicators and pulmonary function changes observed in this study, wedge resection demonstrated certain advantages in reducing surgical trauma and promoting postoperative recovery, while showing no obvious inferiority in short-term tumor control or survival outcomes.

In summary, for elderly patients with early-stage NSCLC, compared with thoracoscopic lobectomy, thoracoscopic wedge resection was associated with better perioperative recovery, a milder inflammatory response, improved preservation of pulmonary function, and higher postoperative quality-of-life scores.

The absence of significant differences in tumor marker levels (CEA, CYFRA21-1) and short-term survival outcomes between the lobectomy and wedge resection groups can be explained by several factors. First, all patients included in this study had early-stage NSCLC (stage I), with relatively low tumor burden, allowing complete resection in both surgical approaches. Second, wedge resection was performed in carefully selected patients with small, peripheral tumors, minimizing potential oncological disadvantage. Third, the follow-up period was relatively short, and the number of death events was limited, which may have reduced the statistical power to detect small differences in survival outcomes. Therefore, under appropriate patient selection, wedge resection may provide oncologic outcomes comparable to lobectomy in the short term. These findings are consistent with previous studies reporting similar short-term oncologic outcomes between lobectomy and sublobar resection in selected early-stage NSCLC patients.

Pulmonary function assessment at 3 months postoperatively demonstrated significantly better preservation of FVC, FEV₁ and MVV in the wedge resection group. Since the extent of lung resection directly affects postoperative pulmo-

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nary function, preservation of lung parenchyma is crucial in elderly patients with limited functional reserve. Our findings are consistent with previous reports indicating that sublobar resection offers advantages in pulmonary function preservation.

Although the overall complication rate was numerically higher in the lobectomy group, the difference did not reach statistical significance. The limited sample size may have reduced statistical power; however, the overall trend supports the potential safety advantage of wedge resection.

Quality-of-life scores at 12 months after surgery were higher than preoperative levels in both groups, with significantly higher postoperative scores observed in the wedge resection group. However, this finding should be interpreted cautiously. Preoperative quality-of-life scores may have been influenced by disease-related symptoms and psychological burden at the time of cancer diagnosis. Therefore, the observed postoperative improvement may partly reflect recovery from disease-related distress rather than a direct beneficial effect of the surgical procedure itself.

Furthermore, to further clarify the factors influencing prognosis in elderly patients with early-stage non-small cell lung cancer, this study established a multivariate logistic regression model. The results showed that TNM stage was an important indicator in prognostic assessment and could serve as an independent risk factor for poor prognosis. Further comparison revealed that patients with stage Ib disease had a markedly higher risk of poor prognosis than those with stage Ia disease (OR = 6.087, 95% CI: 2.063-17.960, $P = 0.001$). This finding suggests that tumor stage remains a key determinant of prognosis in early-stage NSCLC. As tumor stage progresses, tumor burden increases and local invasiveness becomes more pronounced, which may elevate the risk of recurrence or metastasis and consequently affect long-term survival outcomes. These findings are consistent with previous studies, indicating that TNM stage retains important prognostic value even among patients of early-stage NSCLC.

In the present study, multivariate analysis demonstrated that age (≤ 70 years) was demon-

strated to be significantly correlated with prognosis (OR = 0.135, $P < 0.001$). This finding should be interpreted with caution. Given the retrospective design and the inclusion of only surgically treated patients, older individuals who underwent surgery were likely subject to stricter preoperative evaluation and selection criteria. Those deemed eligible for surgery generally had better overall physical condition and may represent a relatively favorable, highly selected subgroup. Therefore, the observed statistical association may partly reflect selection bias or residual confounding rather than a direct protective effect of younger age. In addition, important factors such as performance status and comorbidity burden were not included in the current analysis, and the possibility of unmeasured confounding cannot be excluded.

Notably, the results of this study indicated that surgical procedure was not an independent prognostic factor ($P > 0.05$). This finding suggests that, under carefully selected indications, thoracoscopic wedge resection may provide oncological safety comparable to that of lobectomy in elderly patients with early-stage NSCLC. Combined with the perioperative indicators and pulmonary function outcomes observed in this study, Wedge resection offers certain clinical advantages in reducing surgical trauma and improving postoperative recovery; meanwhile, compared with lobectomy, it does not appear to show any obvious disadvantage in terms of short-term tumor control or survival outcomes.

In summary, for elderly patients with early-stage NSCLC, VATS wedge resection was associated with more favorable perioperative recovery, a milder inflammatory response, better preservation of pulmonary function, and higher postoperative quality-of-life scores compared with VATS lobectomy. Based on the data currently available from this study, no statistically significant differences were observed between the two groups in the short-term oncologic outcomes or survival outcomes included in the analysis. However, it should be noted that, as this was a retrospective, non-randomized controlled study, the findings may still have been influenced by selection bias and potential confounding factors. Therefore, these results should be interpreted with caution and further validated by higher-quality prospective studies. Therefore, in carefully selected elderly patients,

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wedge resection may represent a feasible alternative surgical strategy.

Nevertheless, several limitations of this study should be acknowledged: First, this was a single-center retrospective study with a nonrandomized design. Treatment allocation was based on clinical judgment rather than random assignment, and the unequal group sizes may reflect underlying treatment-selection bias. Although no statistically significant differences were observed in measured baseline characteristics, unmeasured confounders may still have influenced between-group comparability. In addition, propensity score matching or inverse probability weighting was not performed, which may limit the ability to fully adjust for baseline differences.

Second, an important source of potential confounding was the difference in lymph node management between the two procedures. Lobectomy routinely involves systematic hilar and mediastinal lymph node dissection, whereas wedge resection often includes only lymph node sampling or selective dissection. Because the number and extent of nodal assessment were not quantitatively analyzed or adjusted for, this factor may have influenced perioperative indicators as well as oncologic comparisons.

Third, although the median follow-up time was 49 months, the limited number of survival events in this cohort may have substantially reduced the statistical power to detect potential between-group differences in overall survival. Longer follow-up and larger cohorts are required to further validate the oncologic efficacy of these procedures in elderly patients.

One important limitation of this study is that the number of dissected lymph nodes was not recorded and therefore could not be included in the analysis. As lymph node assessment is closely related to tumor staging and prognosis, this may have introduced potential bias. In addition, lymph node management differed between the two groups, with systematic dissection in the lobectomy group and sampling or selective dissection in the wedge resection group, which may have affected the comparison of oncological outcomes. Furthermore, subgroup analysis based on the number of lymph nodes (e.g., ≥ 4 nodes) could not be per-

formed. Therefore, the interpretation of the results should be made with caution, and future studies are needed to include more detailed lymph node data to reduce confounding.

This study was retrospective and non-randomized, and propensity score matching or inverse probability weighting was not performed. Therefore, potential confounding factors may not have been fully adjusted, and residual bias cannot be excluded. Future studies using more rigorous statistical methods such as propensity score matching are needed to further validate these findings.

In the present study, all cases in the wedge resection group were non-anatomic wedge resections, and no segmentectomy was included. Therefore, the results should not be directly compared with studies evaluating segmentectomy. Given that segmentectomy and wedge resection are different procedures with distinct oncologic outcomes, as demonstrated in trials such as JCOG0802 and CALGB 140503, this distinction should be noted when interpreting the results.

Disclosure of conflict of interest

None.

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