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Research

Optimizing lung cancer surgery in the elderly: sublobar resection versus lobectomy for early-stage non-small cell lung cancer patients aged 80 and above

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Abstract
The optimal surgical approach for elderly patients with early-stage non-small cell lung cancer (NSCLC) remains a topic of debate. A retrospective analysis was conducted on patients who underwent pulmonary resection for early-stage NSCLC at our single institution between January 2018 and December 2022. Propensity score matching was used to balance baseline characteristics between the sublobar resection and lobectomy groups. Perioperative outcomes, pulmonary function recovery, postoperative quality of life, and survival were compared between the two groups. A total of 151 patients were included, with 42 undergoing sublobar resection and 109 undergoing lobectomy. After propensity score matching, baseline characteristics were well-balanced between the two groups. Sublobar resection was associated with shorter operative time (125.83 ± 33.56 min vs. 161.14 ± 61.54 min, $p = 0.048$), less intraoperative blood loss [65 (30, 75) ml vs. 120 (70, 170) ml, $p < 0.001$], shorter drainage duration [3 (2, 5) days vs. 5 (3, 6) days, $p < 0.001$], shorter hospital stay [6 (4, 8) days vs. 10 (7, 13) days, $p < 0.001$], and fewer postoperative complications (11.9% vs. 47.6%, $p < 0.001$), compared to lobectomy. Moreover, sublobar resection led to better pulmonary function recovery and higher postoperative quality of life scores, with no significant difference in overall and disease-free survival between the groups. Sublobar resection in patients aged 80 and above with early-stage NSCLC offered comparable oncological outcomes to lobectomy while preserving more lung function and providing better postoperative recovery and long-term quality of life. These findings have important implications for treatment decision-making in elderly NSCLC patients.

Keywords Elderly · Non-small cell lung cancer · Sublobar resection · The quality of life · Long-term survival

1 Background

Lobectomy with lymph node dissection or sampling is the standard surgical approach for non-small lung cancer (NSCLC) [1, 2]. However, recent findings from the multicenter randomized controlled trial, the Japan Clinical Oncology Group 0802/West Japan Oncology Group 4607L (JCOG0802/WJOG4607L) trial, suggested that for clinically stage Ia, tumor

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diameter ≤ 2 cm NSCLC, segmentectomy yielded comparable 5-year survival rates to standard lobectomy, indicating that segmentectomy should be considered the standard surgical procedure for this patient population [3]. Moreover, research by Takahiro Mimae et al. [4] indicated that patients with peripheral early-stage NSCLC tumors measuring 2–4 cm who are suitable for lobectomy may have equivalent overall survival (OS) outcomes with sublobar resection with adequate surgical margins. This suggests that a smaller extent of resection may achieve comparable long-term survival for early-stage lung cancer, a crucial consideration for elderly patients requiring preservation of pulmonary function [5].

Elderly patients with NSCLC, particularly those over the age of 80, often exhibit hesitancy and reluctance towards surgery. Firstly, there is a perception that surgery for lung cancer may not significantly increase life expectancy. Secondly, surgery may entail greater risks of complications due to age being a risk factor for postoperative complications even death [6, 7]. Thirdly, surgery may substantially impact the quality of life postoperatively. Therefore, when considering lobectomy in patients over 80 years of age, a careful and thorough assessment of patient tolerability is essential [8]. However, there is currently limited research on sublobar resection in lung cancer patients over 80 years, and the long-term survival and quality of life after sublobar resection remains unclear.

This study aimed to investigate the postoperative recovery, long-term quality of life, and prognosis of elderly patients over 80 years undergoing sublobar resection for early-stage NSCLC.

2 Materials and methods

2.1 Patient selection

Patients diagnosed with early-stage NSCLC who underwent lobectomy or sublobar resection at the Department of Thoracic Surgery, Daping Hospital, Army Medical University, between January 2018 and December 2022 were collected. Inclusion criteria were as follows: (I) age 80 years or older; (II) tumor diameter less than 3 cm (Fig. 1); (III) Video-assisted thoracoscopic surgery (VATS) lobectomy or sublobar resection; (IV) postoperative pathological diagnosis of NSCLC; (V) no prior treatment such as radiotherapy, chemotherapy, or ablation; (VI) surgical margin greater than 2 cm or tumor diameter; (VII) signed informed consent. Exclusion criteria were as follows: (I) poor cardiopulmonary function unable to tolerate surgery; (II) history of treatment for other malignancies within 5 years; (III) postoperative pathology indicating atypical adenomatous hyperplasia (AAH) or carcinoma in situ (AIS); (IV) small cell lung cancer; (V) conversion to open thoracotomy; (VI) refusal of follow-up. Ultimately, 151 patients were included in this study, as illustrated in Fig. 2.

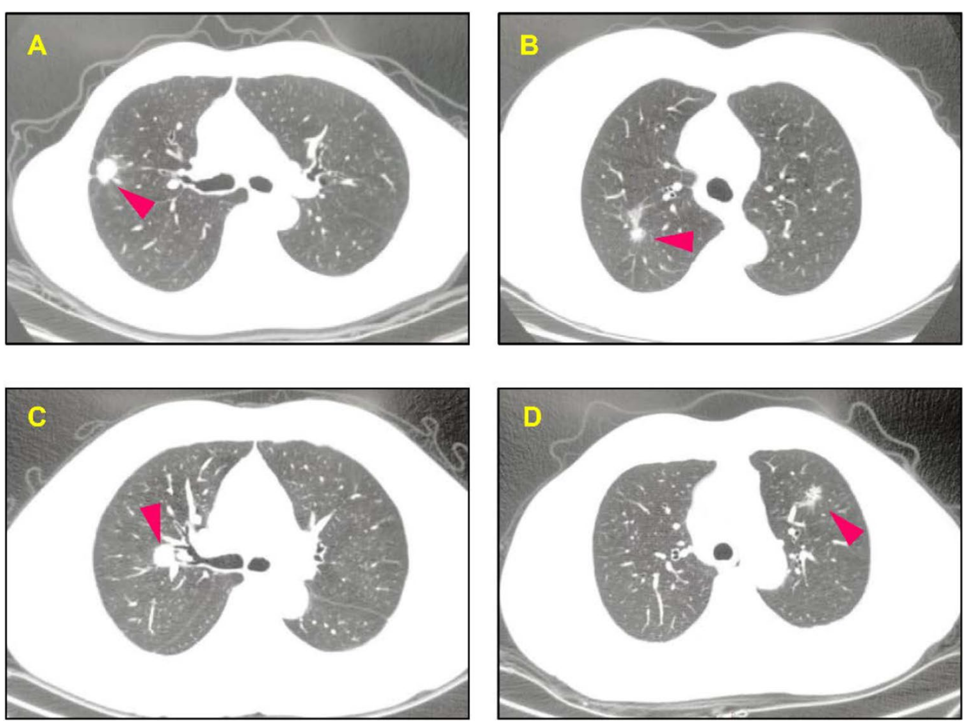

Fig. 1 Typical radiological images of the included cases. **A** Right upper pulmonary nodule located in the outer 1/3 of the lung. **B** Right upper pulmonary nodule located in the middle 1/3 of the lung. **C** Right upper pulmonary nodule located in the inner 1/3 of the lung. **D** Left upper pulmonary nodule located in the middle 1/3 of the lung. Wedge resection was done in case **A**. Segmentectomy was done in **B**. Lobectomy was done in **C** and **D**. Red arrows indicate pulmonary nodules

Clinical and pathological data were collected, including age, gender, pulmonary function, BMI (Body mass index), preoperative comorbidity index (CCI), smoking history, tumor size, tumor location, surgical approach, operative duration, postoperative pathology, postoperative complications, drainage volume, drainage duration, and length of hospital stay. Postoperative pathological staging was determined according to the eighth edition of the AJCC TNM staging system. The age-adjusted Charlson comorbidity index (aCCI) was used to assess preoperative comorbidities and predict disease-related mortality [9, 10].

2.2 Surgical procedure

According to the NCCN guidelines [11] and the Chinese guidelines for the diagnosis and treatment of lung cancer [12], video-assisted thoracoscopic surgery (VATS) lung resection was performed. All patients underwent general anesthesia with double-lumen endotracheal intubation for single-lung ventilation in the lateral decubitus position. Surgery was performed through two or single ports, with incisions placed at the fourth or fifth intercostal space along the anterior axillary line, approximately 3–5 cm in length.

In the lobectomy group, lobectomy with hilar and mediastinal lymph node dissection was performed. In the sublobar resection group, segmentectomy, or wedge resection with hilar and mediastinal lymph node dissection was performed. Intraoperatively, the distance from the margin to the tumor edge was evaluated, and intraoperative frozen section analysis was performed if the distance was less than 20 mm. In cases where lymph node metastasis or positive margins were suspected, the procedure was converted to lobectomy. Finally, 9 cases were converted from sublobar resection to lobectomy (all excluded according to the exclusion criteria).

2.3 Postoperative management

Postoperatively, patients were managed according to standard thoracic surgery protocols and monitored in the thoracic surgery ward (patients were observed in the post-anesthesia care unit before being transferred to the thoracic surgery

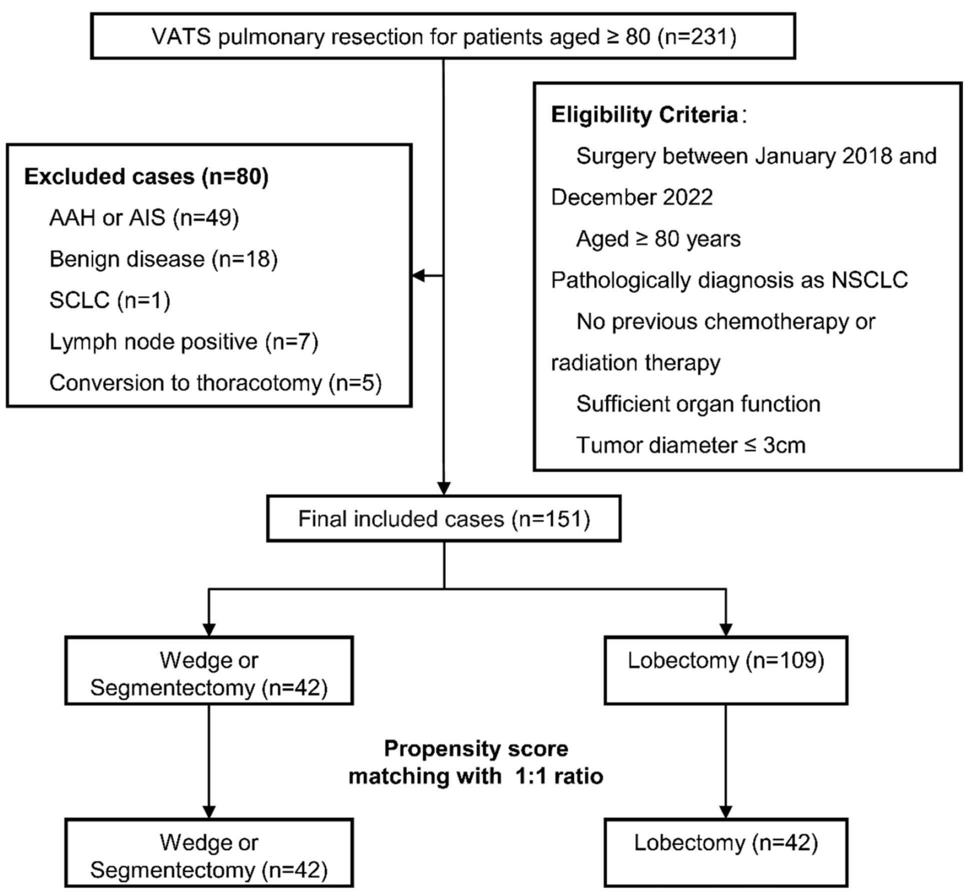

Fig. 2 Flowchart summarizing the patient selection. *VATS* video-assisted thoracoscopic surgery, *AAH* atypical adenomatoid hyperplasia, *AIS* adenocarcinoma in situ, *SCLC* small cell lung cancer, *NSCLC* non-small cell lung cancer

ward). Vital signs, 24-h drainage volume, urine output, and fluid replacement were closely monitored and recorded. Patients were encouraged to actively cough and expectorate to promote drainage and lung expansion, and early mobilization was encouraged. Chest X-rays, complete blood counts, and electrolyte tests were performed on the first post-operative day. Chest tubes were removed if there was no air leakage, drainage volume was less than 200 ml in 24 h, and chest X-ray showed no significant pneumothorax. Patients were discharged with regular follow-up appointments.

2.4 Follow-up

Patients were followed up regularly in the outpatient clinic after discharge. Typically, patients were followed up twice in the first 6 months, followed by biannual visits from 6 months to 3 years, and annual visits thereafter. Follow-up assessments included routine physical examination, laboratory tests (including complete blood count, hepatic and renal function, electrolytes, and tumor markers), and chest CT scans. PET-CT scans were performed based on clinical indications.

Outpatient records documented patient follow-up information and tumor recurrence. CT or PET-CT scans, along with pathological examinations (including biopsies and bronchoscopy), were used to confirm tumor recurrence. At the 1-year follow-up visit, patients completed the EORTC QLQ-C30 [13] and EORTC QLQ-LC13 [14] quality of life questionnaires, and pulmonary function tests were performed. Overall survival (OS) was defined as the time from primary tumor resection (date of surgery) to death. Disease-free survival (DFS) was defined as the time from primary tumor resection (date of surgery) to diagnosis of recurrence or metastasis.

2.5 Statistical analysis

Data were analyzed using SPSS 26.0 software (Statistical Package for the Social Sciences, Chicago, IL, USA), with $p < 0.05$ considered statistically significant. Propensity score (PS) analysis was carried out using logistic regression to create a propensity score for individual patients using demographic and clinical variables. Categorical variables were expressed as frequencies and percentages (%) and compared between groups using the chi-square test or Fisher's exact test. Normally distributed continuous variables were presented as mean ± standard deviation and compared using independent sample t-tests. Non-normally distributed continuous variables were presented as median, 25th (Q1) percentile, and 75th (Q3) percentile and compared using the Wilcoxon rank-sum test. OS and DFS were estimated using Kaplan–Meier curves, and differences between the two groups were compared using univariable log-rank analyses.

2.6 Ethical approval

The study was conducted in accordance with the Declaration of Helsinki. It was approved by the Ethics Committee of the Army Medical Center of the Chinese People's Liberation Army (Approval No.: Medical Research Ethics Review 2023(303)), while the need for informed consent was waived by the Ethics Committee of the Army Medical Center of the Chinese People's Liberation Army for this retrospective analysis.

3 Results

3.1 Clinical characteristics

A total of 151 eligible cases were included, with 42 (42/151, 27.8%) in the sublobar resection group and 109 (109/151, 72.2%) in the lobectomy group. The baseline clinical characteristics of all cases are presented in Table 1. There were no significant differences between the two groups in terms of age, gender, BMI, and smoking history. However, compared to the lobectomy group, patients in the sublobar resection group had a higher aCCI (percentage of patients with a score of aCCI ≥ 5: 64.3% vs. 43.1%, $p = 0.020$), poorer performance status ($p = 0.012$), lower FVC (74.81 ± 9.35% vs. 83.86 ± 16.80%, $p < 0.001$), lower FEV1 (71.72 ± 10.03% vs. 79.06 ± 16.61%, $p = 0.001$), lower DLCO (75.83 ± 9.50% vs. 83.59 ± 16.11%, $p = 0.004$), and smaller tumor diameter (2.12 ± 0.49 cm vs. 2.42 ± 0.44 cm, $p < 0.001$).

Table 1 demographic and clinical characteristics of patients aged ≥ 80 years

Variables	Before PSM			After PSM		
	Sublobar resection (n = 42)	Lobectomy (n = 109)	*P* Value	Sublobar resection (n = 42)	Lobectomy (n = 42)	*P* value
Age (years)	83 (80–85)	82 (80–84)	0.564	83 (80–85)	84 (81–86)	0.773
Gender (n [%])			0.676			0.208
Male	13 (31.0%)	30 (27.5%)		13 (31.0%)	8 (19.0%)	
Female	29 (69.0%)	79 (72.5%)		29 (69.0%)	34 (81.0%)	
BMI (kg/m^2)	24.22 ± 2.49	23.75 ± 3.11	0.385	24.22 ± 2.49	23.42 ± 2.81	0.171
Smoking history			0.543			0.178
Yes	7 (16.7%)	14 (12.8%)		7 (16.7%)	3 (7.1%)	
No	35 (83.3%)	95 (87.2%)		35 (83.3%)	39 (92.9%)	
aCCI			0.020			0.125
< 5	15 (35.7%)	62 (56.9%)		15 (35.7%)	23 (54.8%)	
≥ 5	27 (64.3%)	47 (43.1%)		27 (64.3%)	19 (45.2%)	
Performance status			0.012			0.147
0	11 (26.2%)	61 (56.0%)		11 (26.2%)	20 (47.6%)	
1	27 (64.3%)	43 (39.4%)		27 (64.3%)	21 (50.0%)	
2	4 (9.5%)	5 (4.6%)		4 (9.5%)	1 (2.4%)	
FVC%	74.81 ± 9.35	83.86 ± 16.80	< 0.001	74.81 ± 9.35	76.01 ± 11.74	0.654
FEV1%	71.72 ± 10.03	79.06 ± 16.61	0.001	71.72 ± 10.03	73.52 ± 14.29	0.506
DLCO %	75.83 ± 9.50	83.59 ± 16.11	0.004	75.83 ± 9.50	79.94 ± 9.83	0.117
Tumor size (cm)	2.12 ± 0.49	2.42 ± 0.44	< 0.001	2.12 ± 0.49	2.26 ± 0.42	0.073
Tumor location			0.720			0.507
Right lung	26 (61.9%)	64 (58.7%)		26 (61.9%)	23 (54.8%)	
Left lung	16 (38.1%)	45 (41.3%)		16 (38.1%)	19 (45.2%)	

PSM propensity score matching, *CCI* Charlson comorbidity index, *FVC* forced vital capacity, *FEV1* forced expiratory volume at timed intervals of 1.0, *DLCO* diffusing capacity of the lungs for carbon monoxide. Matching with a 1:1 propensity score was used with a caliper value set = 0.1, and 42 pairs of samples were eventually matched

3.2 Propensity score matching

After 1:1 propensity score matching, 42 pairs of patients were selected (Table 1). Patients in both groups were well-balanced in terms of age, gender, body mass index, performance status, pulmonary function, preoperative comorbidity, tumor size, and tumor location. There were more female patients (69.0% and 81.0%, respectively), and more non-smokers (35/42, 83.3% vs. 39/42, 92.9%, respectively).

3.3 Perioperative outcomes

All cases in both groups achieved R0 resection. In the lobectomy group, one patient died of postoperative pulmonary embolism. After propensity score matching, compared to lobectomy, the sublobar resection group had shorter operative duration (125.83 ± 33.56 min vs. 161.14 ± 61.54 min, p = 0.048), less intraoperative blood loss [65 (30, 75) ml vs. 120 (70, 170) ml, p < 0.001], less total drainage volume [320 (210, 430) ml vs. 450 (360, 600) ml, p < 0.001], shorter drainage time [3 (2, 5) days vs. 5 (3, 6) days, p < 0.001], shorter hospital stay [6 (4, 8) days vs. 10 (7, 13) days, p < 0.001], fewer postoperative complications (11.9% vs. 47.6%, p < 0.001), but fewer lymph nodes removed [7 (4, 10) vs. 10 (8, 14), p < 0.001]. There was no significant difference in the rate of local recurrence between the sublobar group and lobectomy group [4 (9.5%) vs. 8 (7.3%), p = 0.657]. See Table 2.

Table 2 The comparison of perioperative results between the sublobar resection group and the lobectomy group

Variables	Before PSM			After PSM		
	Sublobar resection (n = 42)	Lobectomy (n = 109)	*P* Value	Sublobar resection (n = 42)	Lobectomy (n = 42)	*P* Value
Operative time (min)	125.83 ± 33.56	158.47 ± 47.08	0.012	125.83 ± 33.56	161.14 ± 61.54	0.048
Blood loss (mL)	65 (30, 75)	120 (70, 145)	< 0.001	65 (30, 75)	120 (70, 170)	< 0.001
Station of lymphadenectomy	4 (3, 6)	6 (4, 9)	< 0.001	4 (3, 6)	6 (4, 8)	< 0.001
Number of lymphadenectomy	7 (4, 10)	11 (8, 15)	< 0.001	7 (4, 10)	10 (8, 14)	< 0.001
Volume of drainage (ml)	320 (210, 430)	490 (350, 610)	< 0.001	320 (210, 430)	450 (360, 600)	< 0.001
Drainage duration (days)	3 (2, 5)	5 (3, 7)	< 0.001	3 (2, 5)	5 (3, 6)	< 0.001
Hospital stay (days)	6 (4, 8)	8 (5, 11)	< 0.001	6 (4, 8)	10 (7, 13)	< 0.001
Total complications	5 (11.9%)	33 (30.3%)	0.020	5 (11.9%)	20 (47.6%)	< 0.001
Postoperative mortality	0	1	0.320	0	1	0.320
Histologic type			0.303			0.560
Adenocarcinoma	27 (64.3%)	77 (70.6%)		27 (64.3%)	30 (71.4%)	
Squamous	9 (21.4%)	25 (22.9%)		9 (21.4%)	9 (21.4%)	
Others	6 (14.3%)	7 (6.4%)		6 (14.3%)	3 (7.2%)	
Received adjuvant therapy	14 (33.3%)	61 (56.0%)	0.013	14 (33.3%)	16 (38.1%)	0.649
Local recurrence	4 (9.5%)	8 (7.3%)	0.657	4 (9.5%)	3 (7.1%)	0.983

PSM propensity score matching. Sublobar resection, including wedge resection and segmentectomy

3.4 Pulmonary function and quality of life

One month post-surgery, the patient underwent a follow-up chest CT scan. Notably, a hyperdense strip was observed following sublobar resection but not in lobectomy. Furthermore, sublobar resection cases exhibited a smaller diaphragm elevation and a larger residual volume of the thoracic cavity compared to lobectomy cases (Fig. 3).

To analyze the long-term pulmonary function and quality of life of patients postoperatively, pulmonary function tests were performed, and EORTC QLQ-C30 and EORTC QLQ-LC13 quality of life questionnaires were collected at the 1-year follow-up visit. The results showed that compared to the lobectomy group, the sublobar resection group had significantly higher postoperative pulmonary function indicators, including FVC: 2.05 ± 0.72 L vs. 1.51 ± 0.70 L, p = 0.006; FEV1: 1.85 ± 0.45 L vs. 1.51 ± 0.41 L, p = 0.001; DLCO: 6.38 ± 1.87 ml/mmHg.min vs. 4.98 ± 1.06 ml/mmHg min, p < 0.001; MVV: 71.05 ± 20.21 L/min vs. 57.24 ± 15.77 L/min, p = 0.022 (Table 3). This suggests that sublobar resection results in less loss of pulmonary function, preserving more lung parenchyma and function.

The long-term (1-year postoperative) quality of life in the sublobar resection group, including global health status/QoL, physical function, dyspnea, and coughing scores, was significantly superior to that in the lobectomy group (Table 4). However, there were no significant differences between the two groups in terms of role, emotional, social, and cognitive functions. This indicates that patients undergoing sublobar resection have higher quality of life and fewer symptoms burden postoperatively.

3.5 Survival analysis

The last follow-up was in October 2023, with a median follow-up time of 46 months overall. The median follow-up time in the sublobar resection group was 37 months (4–66 months), with 1-year survival rate of 90.2%, 3-year survival rate of 56.6%, and 5-year survival rate of 48.1%. In the lobectomy group, the median follow-up time was 49 months (1–75 months), with 1-year survival rate of 97.2%, 3-year survival rate of 72.0%, and 5-year survival rate of 51.1%. There were no significant differences in DFS and OS between the two groups (Fig. 4). After propensity score matching, there were still no significant differences in 5-year DFS (43.8% vs. 45.4%, p = 0.423) and 5-year OS (48.1% vs. 51.1%, p = 0.612) between the two surgical approaches (Fig. 4).

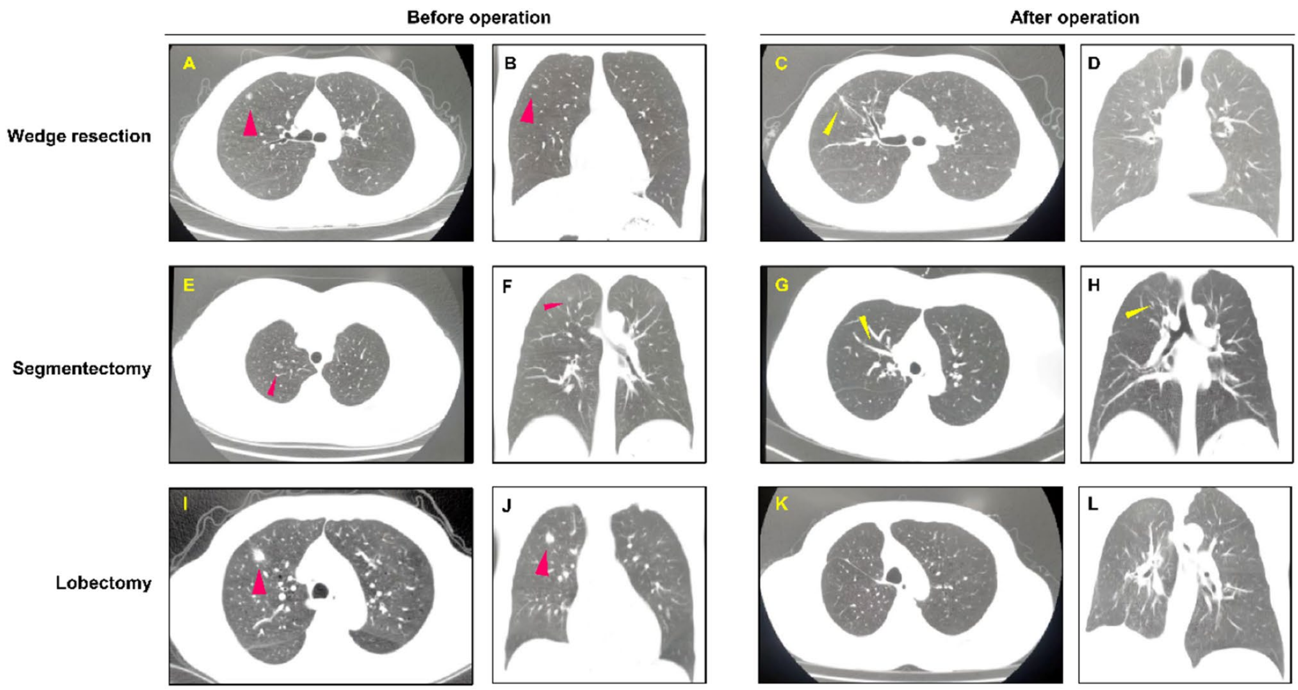

Fig. 3 Typical pre- and postoperative radiographic images of the three surgical approaches. **A** and **B**, preoperative pulmonary nodule in case 1. **C** and **D**, horizontal and coronal CT after wedge resection. **E** and **F**, preoperative pulmonary nodule in case 2. **G** and **H**, horizontal and coronal CT after segmentectomy. I and **J**, preoperative pulmonary nodule in case 3. **K** and **L**, horizontal and coronal CT after lobectomy. Red arrows indicate the pulmonary nodules. Yellow arrows indicate the cut edge hyperdense areas left after surgery

Table 3 The comparison of pulmonary function 1 year postoperatively between the sublobar resection group and the lobectomy group

Variables	Before PSM			After PSM		
	Sublobar resection (n = 34)	Lobectomy (n = 97)	*P* Value	Sublobar resection (n = 34)	Lobectomy (n = 34)	*P* Value
FVC (L)	2.05 ± 0.72	1.66 ± 0.68	0.003	2.05 ± 0.72	1.51 ± 0.70	0.006
Percentage of FVC (%)	69.93 ± 15.95	67.25 ± 14.01	0.545	69.93 ± 15.95	57.85 ± 12.01	0.014
FEV1 (L)	1.85 ± 0.45	1.58 ± 0.46	0.002	1.85 ± 0.45	1.51 ± 0.41	0.001
Percentage of FEV1 (%)	75.66 ± 16.06	69.95 ± 14.83	0.047	75.66 ± 16.06	64.12 ± 13.87	< 0.001
DLCO (ml/(mmHg.min))	6.38 ± 1.87	5.74 ± 1.50	0.051	6.38 ± 1.87	4.98 ± 1.06	< 0.001
Percentage of DLCO (%)	73.43 ± 20.85	70.40 ± 18.45	0.385	73.43 ± 20.85	61.76 ± 12.97	0.003
MVV (L/min)	71.05 ± 20.21	63.87 ± 18.81	0.189	71.05 ± 20.21	57.24 ± 15.77	0.022
Percentage of MVV (%)	73.62 ± 16.87	63.17 ± 18.70	0.053	73.62 ± 12.87	62.07 ± 11.56	0.002

Eight of the patients in the sublobar resection group and 12 of the patients in the lobectomy group died within 1 year without pulmonary function tests and quality of life scales being collected

PSM propensity score matching, *FVC* forced vital capacity. *FEV1* forced expiratory volume at timed intervals of 1.0, *DLCO* diffusing capacity of the lungs for carbon monoxide, *MVV* maximum voluntary ventilation

4 Discussion

This study demonstrated that sublobar resection, including wedge resection and segmentectomy, yields comparable DFS and OS outcomes to lobectomy in patients aged 80 and above with early-stage NSCLC. Moreover, sublobar resection presented lower perioperative risks in the short term and offered superior long-term recovery of pulmonary function and postoperative quality of life. These findings have significant implications for treatment strategies in elderly NSCLC patients.

Table 4 The comparison of quality of life 1 year postoperatively between the sublobar resection group and the lobectomy group

Variables	Sublobar resection (n = 34)	Lobectomy (n = 97)	Statistical value	*P* Value
EORTC QLQ-C30				
Global health status/QoL	70.9 (47.9–77.1)	58.3 (41.7–75.0)	3.090	0.002
Physical function	73.3 (66.7–93.3)	75.0 (53.3–80.0)	2.501	0.012
Role function	75.0 (33.3–83.3)	66.7 (33.3–83.3)	1.096	0.273
Emotional function	75.0 (41.7–91.7)	66.7 (41.7–83.3)	0.161	0.872
Cognitive function	66.7 (66.7–83.3)	66.7 (50.0–83.3)	0.800	0.424
Social function	83.3 (66.7–100)	83.3 (66.7–83.3)	0.534	0.593
Fatigue	33.3 (22.2–55.6)	33.3 (11.1–50.0)	1.539	0.124
Nausea/vomiting	16.7 (0–33.3)	16.7 (0–33.3)	0.712	0.476
Pain	33.3 (16.7–33.3)	16.7 (16.7–33.3)	1.058	0.290
Dyspnea	0 (0–33.3)	33.3 (0–66.7)	2.601	0.009
Insomnia	0 (0–33.3)	0 (0–33.3)	0.878	0.380
Appetite loss	0 (0–33.3)	0 (0–33.3)	0.156	0.876
Constipation	33.3 (0–66.7)	33.3 (0–33.3)	0.381	0.703
Diarrhea	0 (0–33.3)	0 (0–33.3)	0.770	0.441
Financial problem	16.7 (0–33.3)	33.3 (0–33.3)	0.157	0.876
EORTC QLQ-LC13				
Dyspnea	11.1 (0–33.3)	44.4 (11.1–55.6)	4.686	< 0.001
Coughing	0 (0–33.3)	33.3 (0–66.7)	2.795	0.005
Hemoptysis	0 (0–33.3)	0 (0–33.3)	0.566	0.572
Sore mouth	33.3 (0–66.7)	33.3 (0–66.7)	0.195	0.845
Dysphagia	0 (0–33.3)	0 (0–33.3)	0.890	0.374
Peripheral neuropathy	0 (0–33.3)	0 (0–33.3)	1.113	0.266
Alopecia	0 (0–33.3)	33.3 (0–33.3)	2.096	0.036
Overall pain*	11.1 (0–33.3)	22.2 (0–33.3)	0.989	0.323

Eight of the patients in the sublobar resection group and 12 of the patients in the lobectomy group died within 1 year without pulmonary function tests and quality of life scales being collected

QLQ quality of life questionnaire, *EORTC* European Organisation for the Research and Treatment of Cancer

*This entry is a combination of three pain-related items including pain in chest, pain in arm or shoulder and pain in other parts

It is well-known that patients undergoing lobectomy typically have higher cardiopulmonary demands compared to those undergoing sublobar resection [15]. Lobectomy demands a higher level of cardiopulmonary reserve due to the extensive nature of the procedure, including the removal of an entire lobe of the lung, which can significantly impact postoperative pulmonary function. In contrast, patients undergoing sublobar resection, such as segmentectomy or wedge resection, may have compromised baseline cardiopulmonary function, often associated with advanced age or comorbidities. In our study, this made the direct comparison of data between the two groups challenging. Therefore, through propensity score matching, we were able to balance the baseline data between the two groups, enabling a more rigorous statistical analysis and discussion of the study [16].

Previous studies have indicated that compared to lobectomy, sublobar resection is associated with shorter operative times, less intraoperative blood loss, and lower rates of complications [17, 18]. Although our study focused on patients aged 80 and above, similar conclusions can be drawn [19]. Shorter operative times and less intraoperative blood loss are generally believed to result in faster and better postoperative recovery, which is particularly crucial for elderly patients aged 80 and above. Prolonged operative times significantly reduce the tolerance of elderly patients to surgery, leading to delayed extubation and removal of drainage tubes [20, 21]. Similarly, increased intraoperative blood loss can slow down the postoperative recovery process, reduce mobility, and increase the risk of thrombosis [22, 23]. Especially after propensity score matching, there were no statistically significant differences in the impact of the two surgical approaches on patient prognosis.

Sublobar resection has a smaller resection range than lobectomy, preserving more lung parenchyma and thus having less impact on lung function compared to lobectomy [24]. This is more beneficial for postoperative pulmonary function

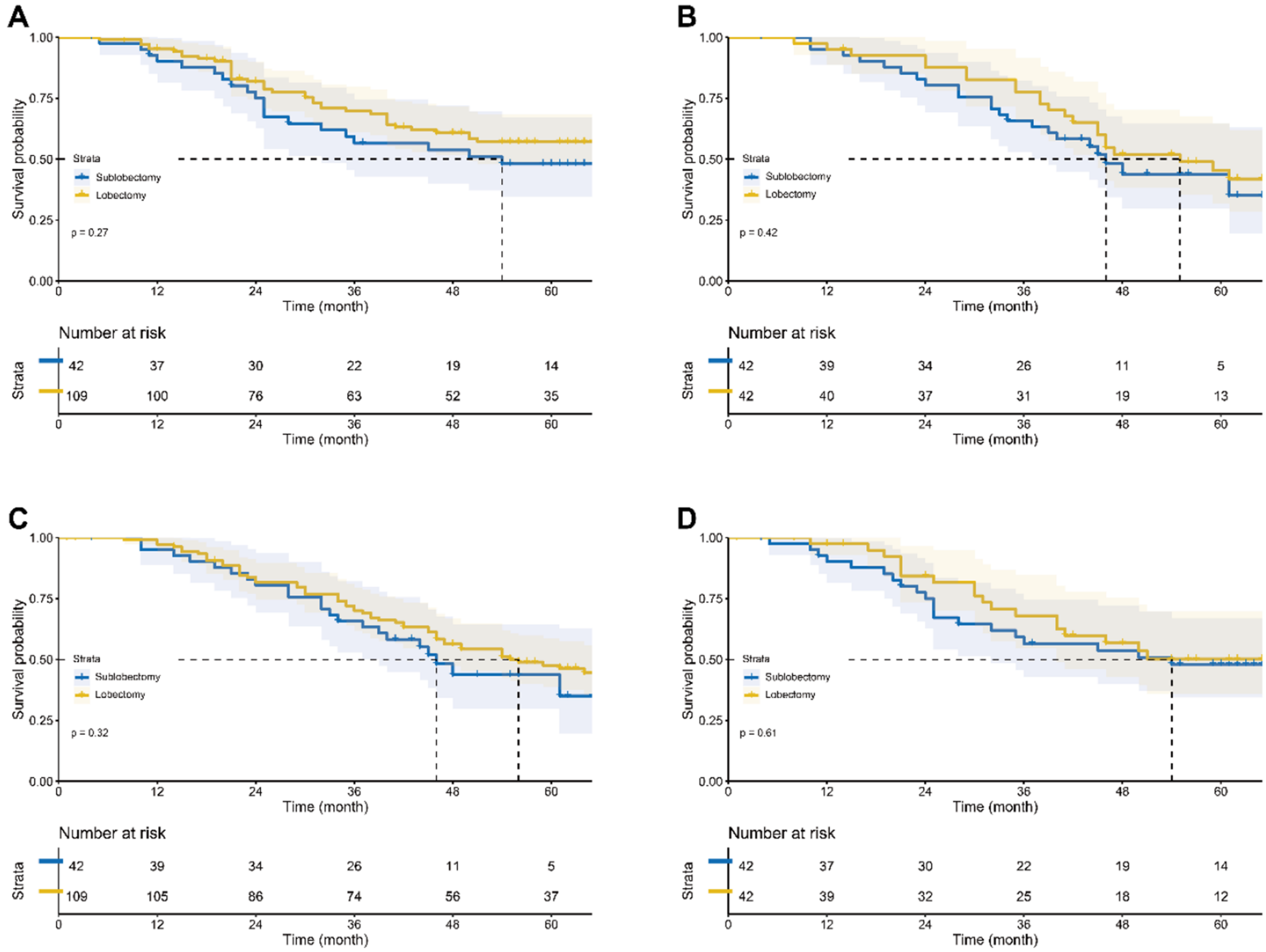

Fig. 4 Kaplan–Meier curves for survival before and after propensity score matching between sublobar resection and lobectomy. **A** DFS between sublobar resection and lobectomy before PSM. **B** DFS between sublobar resection and lobectomy after PSM. **C** OS between sublobar resection and lobectomy before PSM. **D** OS between sublobar resection and lobectomy after PSM. *DFS* disease free survival, *OS* overall survival, *PSM* propensity score matching

recovery. In our study, at the 1-year postoperative follow-up, pulmonary function indicators in the sublobar resection group were superior to those in the lobectomy group. Particularly for patients aged 80 and above, preserving more pulmonary function allows for better management of lung-related diseases postoperatively. Furthermore, better pulmonary function implies better quality of life and greater self-care ability. However, there were no significant differences between the two groups in terms of role, emotional, social, and cognitive functions. One potential explanation could be attributed to the resilience and adaptability of elderly patients, in coping with the challenges posed by lung cancer surgery [25]. Additionally, the comprehensive multidisciplinary care provided to elderly patients undergoing lung cancer surgery, including preoperative assessments, perioperative support, and postoperative rehabilitation, may contribute to the preservation of functional status and quality of life across both surgical groups. In summary, compared to lobectomy, sublobar resection may result in superior postoperative long-term quality of life for elderly patients [26, 27].

Our study showed that the overall DFS and OS in the sublobar resection group were lower than those in the lobectomy group among elderly patients. However, there was no statistically significant difference between the two groups. Similar to some previous studies, although the range of sublobar resection was smaller than that of lobectomy, and the number of lymph node dissections was lower in the sublobar resection group, the overall survival rate was not inferior to that of standard lobectomy [28, 29]. The emergence of these statistical results may be because the expected lifespan of elderly patients is much lower than that of younger patients. Regardless of whether lobectomy or sublobar resection is performed, there is a certain degree of decrease in overall quality of life postoperatively for elderly patients. The decrease in quality of life is more pronounced in the lobectomy group than in the sublobar resection group. Adapting to the postoperative state requires a longer time and more human and material resources to help elderly patients adapt to their new life situations. However, the adaptability of patients aged 80 and above is often lower, and some may even be unable to adapt, resulting in no difference in postoperative survival rates among these patients [30–32]. Additionally, these patients have a greater fear of disease progression than younger patients. Due to a certain degree of bias in their understanding of the disease, it is difficult for them to obtain correct disease knowledge through scientific channels. This has an impact on the recovery process and quality of life postoperatively, which may, in turn, have a certain impact on the overall prognosis [19, 33, 34].

Our study has some limitations. It is a retrospective analysis that requires more systematic and in-depth statistical analysis. However, this study also provides effective evidence for future research. Additionally, the sample size of this study is small, and more multicenter, large-sample studies and data are needed to support the results of this study. Although some elderly patients choose to undergo surgery, there are still many patients aged 80 and above who do not undergo surgery for various reasons such as economic reasons, underlying diseases, or surgical risks. Especially with the emergence of genetic testing and targeted therapy, it provides another treatment option for elderly patients [35]. We will continue to work on this study to provide more powerful evidence.

In conclusion, sublobar resection in patients aged 80 and above preserves more pulmonary function, achieves a better quality of life and has a similar prognosis compared to lobectomy, making it a safe, reliable, and practical surgical approach.

Author contributions JL and HZ were responsible for data collection and writing the first draft; NL, WZ and FD were responsible for data collection, collation, and analysis; HZ, FD, XW and XW were responsible for perioperative management and follow-up and assisted in data collection and collation; XW and XW was responsible for topic selection, design, paper review and revision.

Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate 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.

Competing interests No conflict of interest exists in the submission of this manuscript, and the manuscript is approved by all authors for publication.

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