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Comparison of Wedge Resection and Anatomical Lung Resection in Elderly Patients With Early-Stage Nonsmall Cell Lung Cancer With Visceral Pleural Invasion: A Population-Based Study

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Keywords: anatomical resection | nonsmall cell lung cancer (NSCLC) | SEER database | the elderly | visceral pleural invasion | wedge resection

ABSTRACT

Background: As the global population ages, the prevalence of early-stage nonsmall cell lung cancer (NSCLC) among octogenarians is rising. This demographic frequently presents with comorbid conditions, diminished cardiopulmonary function, and increased frailty, which elevate the risks associated with standard treatments. While lobectomy combined with lymph node dissection is still considered the gold standard for managing NSCLC, octogenarians are at significantly higher risk of perioperative mortality. Although wedge resection has been suggested as a less invasive option, previous research has insufficiently explored the influence of visceral pleural invasion (VPI) on postoperative outcomes. This study seeks to evaluate whether wedge resection can provide survival outcomes equivalent to those of anatomical resection in this high-risk population.

Methods: We conducted a retrospective analysis using SEER data from 2010 to 2019, focusing on octogenarians diagnosed with stage I NSCLC and VPI. Propensity score matching, Kaplan–Meier survival analysis, log-rank testing, and Cox multivariate regression were employed to evaluate and compare the outcomes associated with two different surgical techniques.

Results: We identified 523 octogenarians with stage I NSCLC and VPI, from a cohort of 1587 patients. In this study cohort, 372 (71.1%) patients received anatomical resection, while 151 (28.9%) patients underwent wedge resection. Following multivariable adjustment and propensity score matching, there were no statistically significant differences in lung cancer-specific survival (CSS; HR 0.99, 95% CI: 0.57–1.73) or overall survival (OS; HR 1.02, 95% CI: 0.68–1.53) observed between the two surgical groups. Additionally, multivariate Cox regression analysis indicated that the choice of surgical approach was not an independent prognostic factor for either CSS (HR 1.29, 95% CI: 0.62–2.69) or OS (HR 1.50, 95% CI: 0.68–1.62).

Abbreviations: CSS, cancer-specific survival; CT, computed tomography; NSCLC, nonsmall cell lung cancer; OS, overall survival; SEER, Surveillance, Epidemiology, and End Results; VPI, visceral pleural invasion.

Shuyuan Li, Yong Ge, and Ran Ma contributed equally to this work.

Conclusions: This study demonstrates that wedge resection is a viable surgical option for octogenarians with stage I NSCLC and VPI. Notably, the addition of lymph node dissection to wedge resection significantly enhances survival outcomes compared to wedge resection performed without lymph node dissection.

1 | Introduction

Nonsmall cell lung cancer (NSCLC) remains a leading cause of cancer-related deaths worldwide [1, 2]. The widespread adoption of high-resolution computed tomography (CT) has significantly enhanced the early detection of NSCLC [3]. With the global population aging, the prevalence of early-stage NSCLC among octogenarians is steadily increasing [4]. This demographic often presents with multiple comorbidities, reduced cardiopulmonary function, and greater frailty compared to younger patients [5, 6]. While lobectomy, usually combined with lymph node dissection or sampling, is the gold standard for curative NSCLC treatment [7], octogenarians face elevated risks with this procedure. Perioperative mortality rates in older patients are more than twice as high as those in younger individuals [8, 9]. Studies have shown that sublobar resection, as an alternative to lobectomy, can minimize respiratory function loss and may also confer survival benefits [10, 11]. Additionally, evidence indicates that wedge resection provides a less invasive and feasible option for elderly patients [12].

Previous studies on early-stage NSCLC in patients over 80 have often failed to adequately address the role of visceral pleural invasion (VPI) as a significant risk factor. Evidence suggests that NSCLC with VPI exhibits more aggressive behavior and is associated with an increased likelihood of mediastinal lymph node metastasis [13, 14]. Patients with VPI are more prone to increased recurrence rates and higher disease-specific mortality compared to individuals lacking this characteristic [15]. Recognizing its clinical importance, the American Joint Committee on Cancer (AJCC) classifies VPI as a size-independent T2 factor, resulting in an upgrade of early-stage NSCLC ($\leq$ 3 cm) from T1 to T2a and from stage IA to stage IB, irrespective of tumor size [16]. While numerous studies have explored surgical options for early-stage NSCLC with VPI, findings suggest that sublobar resections, such as wedge resection and segmentectomy, can yield survival outcomes comparable to lobectomy. However, wedge resection is generally considered to offer less favorable survival benefits compared to lobectomy or other anatomical resections [17, 18].

With the aging global population, the number of individuals over 80 years old diagnosed with early-stage NSCLC with VPI is projected to rise significantly. To address the current research gap for this demographic, our study aimed to evaluate the surgical treatment options available, focusing on whether wedge resection offers survival outcomes comparable to those of anatomical resection. Leveraging data from the Surveillance, Epidemiology, and End Results (SEER) database, we aimed to evaluate long-term survival outcomes in patients treated with wedge resection compared to those undergoing anatomical resection. The results of this study are expected to offer valuable insights to inform clinical decision-making in the management of elderly patients with early-stage NSCLC with VPI.

2 | Patients and Methods

2.1 | Study Design, Ethics, and Patients

This research is a retrospective study based on data from the SEER database, examining individuals aged 80 and above diagnosed between 2010 and 2019 with stage I NSCLC, characterized by tumors $\leq$ 4 cm in size and exhibiting VPI. Managed by the National Cancer Institute, the SEER program serves as a prominent resource offering comprehensive details on demographics, tumor pathology, treatment approaches, and survival metrics, encompassing roughly 34.6% of the U.S. population. Patients who lacked surgical intervention or had incomplete records concerning VPI, tumor dimensions, TNM staging, surgical specifics, or survival data were excluded. This analysis complies with the updated Helsinki Declaration. As patient data within the SEER database are anonymized, neither individual consent nor separate ethical approval was required.

Baseline demographic and clinical data were collected, encompassing variables such as age, sex, race, marital status, tumor dimensions, TNM staging, histological classification, lesion site, tumor grade, surgical technique, interval from diagnosis to surgery, lymph node sampling and results, and the use of radiotherapy or chemotherapy. Information regarding survival outcomes and follow-up durations was also incorporated. This study evaluated patient prognosis using lung cancer-specific survival (CSS) and overall survival (OS). The SEER database categorized causes of death based on information from death certificates. For CSS analysis, deaths unrelated to lung cancer were treated as censored at the time of death. OS was defined as the time span from the initial diagnosis to death due to any cause.

2.2 | Statistical Analysis

Continuous variables were presented as medians accompanied by interquartile ranges (IQRs) or as means alongside standard deviations (SDs), while categorical variables were reported as frequencies and percentages. For comparisons involving continuous variables, Student's *t*-test was used for data meeting assumptions of normality and homogeneity of variance. When these assumptions were not satisfied, the Mann–Whitney U test was applied. Categorical variables were analyzed using Pearson's chi-square test or Fisher's exact test, depending on the context.

Unadjusted CSS and overall OS for patients undergoing wedge resection versus anatomical resection (segmentectomy or lobectomy) were evaluated using Kaplan–Meier survival curves. To further assess survival differences, a multivariate Cox proportional hazards model was employed. To minimize confounding, propensity score matching (PSM) was performed using logistic regression to calculate propensity scores, representing the

TABLE 1 | Baseline clinical characteristics of prematched patients.

Variables	Wedge	Anatomic	*p*
Total	151.00	372.00	
Age, *M* (Q1, Q3)	83.00 (81.00, 84.50)	82.00 (81.00, 84.00)	0.23
Sex, *n* (%)			0.49
Female	83 (54.97)	192 (51.61)	
Male	68 (45.03)	180 (48.39)	
Race, *n* (%)			0.65
Black	7 (4.64)	15 (4.03)	
White	132 (87.42)	318 (85.48)	
Others	12 (7.95)	39 (10.48)	
Marital status, *n* (%)			0.98
Married	75 (49.67)	191 (51.34)	
SDW	65 (43.05)	156 (41.94)	
Single	7 (4.64)	17 (4.57)	
Unknown	4 (2.65)	8 (2.15)	
Primary site, *n* (%)			0.57
Left-lower lobe	28 (18.54)	56 (15.05)	
Left-upper lobe	36 (23.84)	84 (22.58)	
Right-lower lobe	27 (17.88)	74 (19.89)	
Right-middle lobe	7 (4.64)	30 (8.06)	
Right-upper lobe	53 (35.10)	128 (34.41)	
Histology, *n* (%)			0.14
Adenomas and adenocarcinomas	70 (46.36)	201 (54.03)	
Squamous cell neoplasms	45 (29.80)	82 (22.04)	
Others	36 (23.84)	89 (23.92)	
Differentiation, *n* (%)			0.88
Grade I	22 (14.57)	53 (14.25)	
Grade II	85 (56.29)	210 (56.45)	
Grade III	40 (26.49)	103 (27.69)	
Grade IV	4 (2.65)	6 (1.61)	
LNs sampled, *n* (%)			< 0.01
No	67 (44.37)	23 (6.18)	
Yes	84 (55.63)	349 (93.82)	
Radiation, *n* (%)			0.01
No	139 (92.05)	362 (97.31)	
Yes	12 (7.95)	10 (2.69)	
Chemotherapy, *n* (%)			0.78
No	146 (96.69)	363 (97.58)	
Yes	5 (3.31)	9 (2.42)	
Tumor size (mm), *M* (Q1, Q3)	20.00 (15.00, 26.00)	25.00 (20.00, 32.00)	< 0.01
Tumor size (mm), *n* (%)			< 0.01
0–30	133 (88.08)	264 (70.97)	
31–40	18 (11.92)	108 (29.03)	
Months from diagnosis to treatment, *M* (Q1, Q3)	1 (0, 2)	1 (0, 2)	0.05

(Continues)

TABLE 1 | (Continued)

Note: Grade I: well differentiated; Grade II: moderately differentiated; Grade III: poorly differentiated; Grade IV: undifferentiated.
Abbreviation: SDW: marital status includes separated, divorced, and widowed.

likelihood of undergoing a specific surgical intervention. The covariates used in the logistic model were aligned with those applied in the Cox proportional hazards model. Matching was performed using a 1:1 nearest neighbor algorithm with a fixed caliper width of 0.05 to ensure balance between groups.

Survival outcomes in the matched dataset were evaluated using Kaplan–Meier survival curves and robust Cox regression analysis. Statistical significance was defined as a two-tailed *p* value below 0.05. All statistical analyses were conducted using R software (version 3.6.1) and relevant R packages, including tableone, MatchIt, Hmisc, rms, survival, and survminer.

3 | Results

3.1 | Demographic and Clinicopathological Characteristics

A total of 523 patients met the inclusion criteria, and their demographics are shown in Table 1. All patients underwent surgery, with 372 (71.1%) cases undergoing anatomical resection and 151 (28.9%) cases undergoing wedge resection. The median follow-up time for this study was 51 months, ranging from 35.16 to 66.84 months. None of the patients had lymph node or distant metastasis, and all had a maximum tumor diameter of ≤4 cm. Postoperative pathology confirmed VPI, classifying all patients as stage IB. The 3-year CSS and OS rates for anatomical resection (combining lobectomy and segmentectomy) were 95.6% [95% CI, 93.4%–97.8%] and 93.3% [95% CI, 90.6%–96.0%], respectively. For the wedge resection group, the 3-year CSS and OS rates were 92.7% [95% CI, 86.4%–99.0%] and 86.7% [95% CI, 78.5%–94.9%], respectively.

3.2 | CSS and OS Analysis

We performed Cox multivariate regression on the prematched population and found that the surgical method was not an

TABLE 2 | Multivariate Cox regression on the prematched population.

Variables	CSS			OS		
	HR	**95% CI**	***p***	**HR**	**95% CI**	***p***
Age, *M* (Q1, Q3)	1.03	0.96 ~ 1.11	0.35	1.02	0.96 ~ 1.07	0.54
Sex, *n* (%)						
Female	Reference			Reference		
Male	1.47	1.00 ~ 2.17	0.05	1.44	1.09 ~ 1.92	0.01
Race, *n* (%)						
Black	Reference			Reference		
White	1.28	0.51 ~ 3.26	0.60	1.35	0.65 ~ 2.80	0.43
Others	0.94	0.31 ~ 2.88	0.92	1.00	0.42 ~ 2.36	1.00
Marital status, *n* (%)						
Married	Reference			Reference		
SDW	1.28	0.86 ~ 1.92	0.23	1.32	0.99 ~ 1.77	0.06
Single	1.30	0.60 ~ 2.81	0.51	1.04	0.56 ~ 1.94	0.89
Unknown	1.83	0.71 ~ 4.73	0.21	0.97	0.41 ~ 2.26	0.94
Primary site, *n* (%)						
Left-lower lobe	Reference			Reference		
Left-upper lobe	1.84	0.95 ~ 3.56	0.07	1.29	0.83 ~ 2.01	0.27
Right-lower lobe	1.30	0.63 ~ 2.65	0.48	1.01	0.62 ~ 1.64	0.97
Right-middle lobe	2.25	1.01 ~ 5.03	0.05	1.28	0.72 ~ 2.28	0.39
Right-upper lobe	1.83	0.98 ~ 3.44	0.06	1.29	0.85 ~ 1.97	0.23
Histology, *n* (%)						
Adenomas and adenocarcinomas	Reference			Reference		
Squamous cell neoplasms	1.36	0.82 ~ 2.24	0.23	1.36	0.98 ~ 1.90	0.06
Others	1.57	1.01 ~ 2.47	0.05	1.19	0.81 ~ 1.74	0.37
Differentiation, *n* (%)						
Grade I	Reference			Reference		
Grade II	0.91	0.54 ~ 1.53	0.72	1.24	0.83 ~ 1.85	0.30
Grade III	1.06	0.59 ~ 1.90	0.85	1.36	0.86 ~ 2.13	0.19
Grade IV	2.46	0.93 ~ 6.51	0.07	2.26	0.96 ~ 5.33	0.06
LNs sampled, *n* (%)						
No	Reference			Reference		
Yes	0.85	0.52 ~ 1.38	0.51	0.75	0.53 ~ 1.07	0.11
Radiation, *n* (%)						
No	Reference			Reference		
Yes	1.97	0.93 ~ 4.16	0.08	1.37	0.75 ~ 2.51	0.31
Chemotherapy, *n* (%)						
No	Reference			Reference		
Yes	1.04	0.23 ~ 4.82	0.96	1.14	0.37 ~ 3.48	0.81

(Continues)

TABLE 2 | (Continued)

Variables	CSS			OS		
	HR	95% CI	*p*	HR	95% CI	*p*
Tumor size (mm), *M* (Q1, Q3)	1.04	1.01 ~ 1.08	0.05	1.03	1.01 ~ 1.06	0.02
Tumor size (mm), *n* (%)						
0–30	Reference			Reference		
31–40	1.04	0.56 ~ 1.96	0.89	0.83	0.52 ~ 1.32	0.42
Months from diagnosis to treatment, *M* (Q1, Q3)	1.09	0.98 ~ 1.21	0.13	1.08	1.00 ~ 1.17	0.06
Surgery						
Wedge	Reference			Reference		
Anatomic	0.82	0.52 ~ 1.30	0.40	0.83	0.59 ~ 1.16	0.28

Note: Grade I: well differentiated; Grade II: moderately differentiated; Grade III: poorly differentiated; Grade IV: undifferentiated.
Abbreviation: SDW: marital status includes separated, divorced, and widowed.

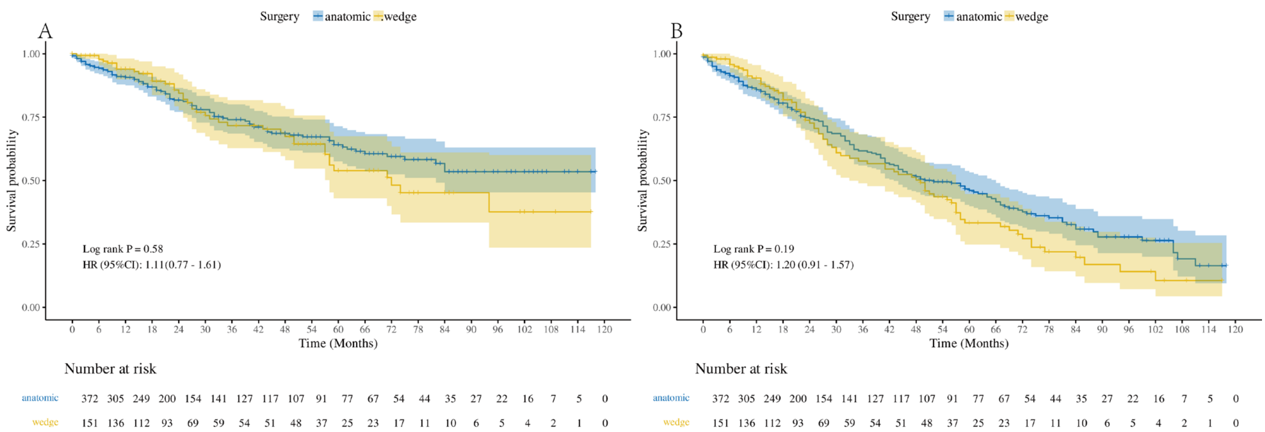

FIGURE 1 | The survival rates for patients before propensity score matching according to surgical procedures, (A) for CSS and (B) for OS. CSS: cancer-specific survival; OS: overall survival.

independent prognostic predictor for CSS and OS, with HRs of 0.82 [95% CI: 0.52–1.30] and 0.83 [95% CI: 0.59–1.16], respectively, as shown in Table 2. Kaplan–Meier (KM) curves were then plotted, revealing no significant differences in CSS and OS between the populations undergoing wedge resection and anatomical resection, with HRs of 1.11 [95% CI: 0.77–1.61]; $p = 0.58$ for CSS and HRs of 1.20 [95% CI: 0.91–1.57]; $p = 0.19$ for OS, as shown in Figure 1.

We performed 1:1 PSM using the surgical method as the grouping variable (wedge resection vs. anatomical resection), creating two closely matched groups comprising 102 patients each that underwent wedge resection and anatomical resection. Table 3 presents the distribution of characteristics between the two matched groups. KM curve analysis on the matched population revealed no significant differences in CSS and OS between patients undergoing wedge resection and those undergoing anatomical resection, with HRs of 0.99 [95% CI: 0.57–1.73]; $p = 0.98$ and 1.02 [95% CI: 0.68–1.53]; $p = 0.95$, respectively, as shown in Figure 2. Subsequently, we performed a robust multivariate Cox regression analysis on the matched population, finding that the surgical method was not an independent prognostic predictor for CSS and OS, with HRs of 1.01 [95% CI: 0.60 ~ 1.69] and 1.05 [95% CI: 0.68 ~ 1.62], respectively, as shown in Table 4.

3.3 | Subgroup Analysis

We compared the survival prognosis between patients undergoing lymph node dissection and those who did not within the wedge resection group. The findings indicated that patients who received wedge resection combined with lymph node dissection exhibited significantly improved OS compared to those who did not undergo lymph node dissection, with HR of 1.72 [95% CI: 1.09–2.72], as shown in Figure 3. Additionally, we compared the survival outcomes of wedge resection and anatomical resection, both combined with lymph node dissection, and found no significant difference between the two groups, even after PSM, as shown in Figures 4 and 5.

4 | Discussion

This study is the first to explore surgical treatment strategies for patients aged over 80 with stage I NSCLC and VPI, specifically assessing whether wedge resection achieves survival outcomes comparable to those of anatomical resection. Through a comprehensive nationwide analysis of this patient group, findings from unadjusted, multivariate-adjusted, and propensity score-matched analyses reveal that wedge resection yields CSS and OS

TABLE 3 | Baseline clinical characteristics of matched patients.

Variables	Wedge	Anatomic	*p*
Total	102.00	102.00	
Age, *M* (Q1, Q3)	82.00 (81.00, 84.00)	83.00 (81.00, 84.75)	0.60
Sex, *n* (%)			0.58
Female	53 (51.96)	49 (48.04)	
Male	49 (48.04)	53 (51.96)	
Race, *n* (%)			0.93
Black	3 (2.94)	3 (2.94)	
White	91 (89.22)	93 (91.18)	
Others	8 (7.84)	6 (5.88)	
Marital status, *n* (%)			0.66
Married	52 (50.98)	59 (57.84)	
SDW	42 (41.18)	37 (36.27)	
Single	5 (4.90)	5 (4.90)	
Unknown	3 (2.94)	1 (0.98)	
Primary site, *n* (%)			0.42
Left-lower lobe	20 (19.61)	16 (15.69)	
Left-upper lobe	22 (21.57)	23 (22.55)	
Right-lower lobe	20 (19.61)	31 (30.39)	
Right-middle lobe	5 (4.90)	3 (2.94)	
Right-upper lobe	35 (34.31)	29 (28.43)	
Histology, *n* (%)			0.23
Adenomas and adenocarcinomas	49 (48.04)	37 (36.27)	
Squamous cell neoplasms	28 (27.45)	35 (34.31)	
Others	25 (24.51)	30 (29.41)	
Differentiation, *n* (%)			1.00
Grade I	16 (15.69)	15 (14.71)	
Grade II	57 (55.88)	58 (56.86)	
Grade III	27 (26.47)	28 (27.45)	
Grade IV	2 (1.96)	1 (0.98)	
LNs sampled, *n* (%)			0.40
No	25 (24.51)	20 (19.61)	
Yes	77 (75.49)	82 (80.39)	
Radiation, *n* (%)			0.76
No	97 (95.10)	96 (94.12)	
Yes	5 (4.90)	6 (5.88)	
Chemotherapy, *n* (%)			1.00
No	98 (96.08)	97 (95.10)	
Yes	4 (3.92)	5 (4.90)	
Tumor size (mm), *M* (Q1, Q3)	21.50 (16.00, 27.00)	20.00 (15.00, 25.75)	0.41
Tumor size (mm), *n* (%)			0.84
0–30	88 (86.27)	89 (87.25)	
31–40	14 (13.73)	13 (12.75)	
Months from diagnosis to treatment, *M* (Q1, Q3)	1.00 (0.00, 2.00)	1.00 (0.00, 2.00)	0.50

Note: Grade I: well differentiated; Grade II: moderately differentiated; Grade III: poorly differentiated; Grade IV: undifferentiated.
Abbreviation: SDW: marital status includes separated, divorced, and widowed.

outcomes comparable to those observed with anatomical resections, such as segmentectomy and lobectomy.

According to Yu et al. patients with early-stage NSCLC with VPI undergoing sublobar resection exhibited poorer survival outcomes compared to those who underwent lobectomy [19]. Similarly, findings by Huang et al. suggested that lobectomy may offer better survival benefits than wedge resection, with the latter linked to reduced survival rates [17]. Given that VPI is a recognized risk factor, the prevailing approach has been to favor more extensive resections, such as lobectomy, to improve survival prospects. Nevertheless, the question of whether sublobar resection offers comparable survival outcomes to lobectomy in patients with early-stage NSCLC and VPI continues to be a subject of ongoing discussion. Elderly patients, particularly those over 80 years old, often face heightened risks associated with anatomical resection due to factors such as multiple comorbidities, diminished cardiopulmonary reserve, and increased frailty. These challenges make less invasive procedures, like wedge resection, a more viable option. The JACS1303 study demonstrated that in patients over 80 with early-stage NSCLC, wedge resection could achieve therapeutic outcomes comparable to those of anatomical resection, including lobectomy and segmentectomy [12]. However, the study did not consider VPI as a risk factor and limited tumor sizes to 2 cm or smaller. To address these gaps, we expanded the inclusion criteria to encompass tumors up to 4 cm, covering all stage I patients. Through multiple rounds of PSM, our analysis revealed that wedge resection in patients over 80 with stage I NSCLC and VPI can yield survival outcomes comparable to anatomical resection. These findings suggest that physiological changes associated with aging may influence tumor behavior and progression, potentially altering the risk–benefit balance of different surgical approaches [20].

VPI is strongly linked to a high likelihood of lymph node metastasis, and lobectomy has proven effective in achieving thorough lymph node clearance and sampling. According to research conducted by Kudo et al., the visceral pleura contains a substantial lymphatic network distributed across the lung surface, extending into the parenchyma, connecting with bronchial lymphatics,

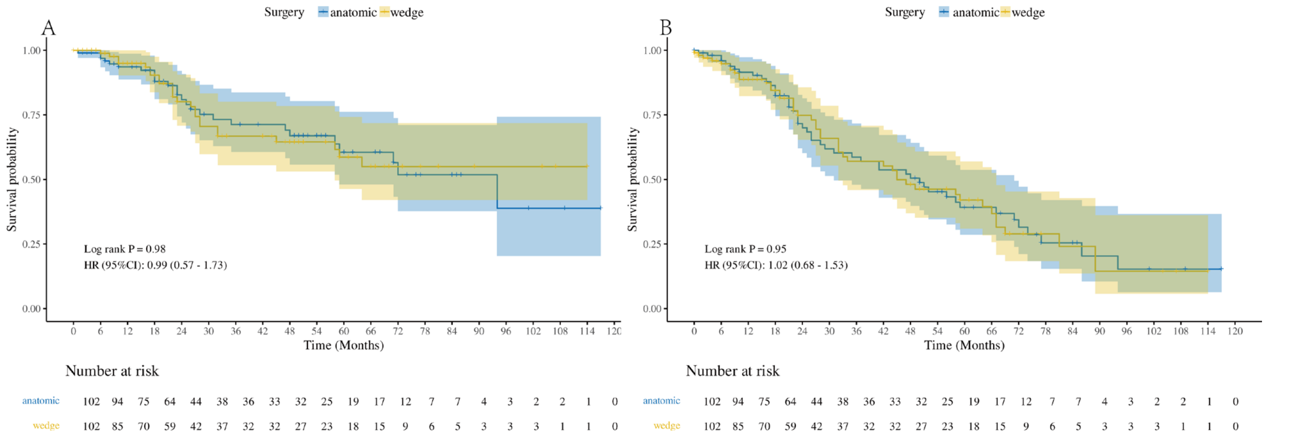

FIGURE 2 | The survival rates for patients after 1:1 propensity score matching according to surgical procedures, (A) for CSS and (B) for OS. CSS: cancer-specific survival; OS: overall survival.

TABLE 4 | Multivariate Cox regression on the matched population.

	CSS			OS		
Variables	**HR**	**95% CI**	***p***	**HR**	**95% CI**	***p***
Age, M (Q1, Q3)	1.05	0.94 ~ 1.18	0.40	1.19	1.06 ~ 1.33	< 0.01
Sex, *n* (%)						
Female	Reference			Reference		
Male	1.39	0.79 ~ 2.47	0.26	1.75	1.13 ~ 2.71	0.01
Race, *n* (%)						
Black	Reference			Reference		
White	0.54	0.13 ~ 2.30	0.40	1.72	0.31 ~ 9.54	0.54
Others	0.33	0.06 ~ 1.88	0.21	0.77	0.12 ~ 5.09	0.78
Marital status, *n* (%)						
Married	Reference			Reference		
SDW	1.68	0.99 ~ 2.86	0.05	2.12	1.33 ~ 3.37	< 0.01
Single	3.05	1.33 ~ 6.98	0.01	3.50	2.01 ~ 6.10	< 0.01
Unknown	2.44	0.75 ~ 7.94	0.14	1.70	0.49 ~ 5.91	0.40
Primary site, *n* (%)						
Left-lower lobe	Reference			Reference		
Left-upper lobe	0.81	0.28 ~ 2.35	0.70	0.91	0.43 ~ 1.95	0.81
Right-lower lobe	1.34	0.50 ~ 3.57	0.56	1.67	0.68 ~ 4.11	0.27
Right-middle lobe	2.02	0.49 ~ 8.34	0.33	3.07	1.25 ~ 7.57	0.02
Right-upper lobe	1.89	0.75 ~ 4.78	0.18	1.65	0.81 ~ 3.36	0.17
Histology, *n* (%)						
Adenomas and adenocarcinomas	Reference			Reference		
Squamous cell neoplasms	1.58	0.90 ~ 2.76	0.11	0.71	0.43 ~ 1.18	0.19
Others	1.95	0.98 ~ 3.89	0.06	0.97	0.42 ~ 2.26	0.95

(Continues)

TABLE 4 | (Continued)

Variables	CSS			OS		
	HR	**95% CI**	***p***	**HR**	**95% CI**	***p***
Differentiation, *n* (%)						
Grade I	Reference			Reference		
Grade II	1.42	0.63 ~ 3.24	0.40	1.75	0.84 ~ 3.64	0.14
Grade III	1.58	0.67 ~ 3.71	0.85	2.18	0.99 ~ 4.79	0.05
Grade IV	64.97	20.71 ~ 203.83	< 0.001	56.34	14.19 ~ 223.64	< 0.01
LNs sampled, *n* (%)						
No	Reference			Reference		
Yes	0.91	0.50 ~ 1.66	0.76	0.99	0.62 ~ 1.60	0.97
Radiation, *n* (%)						
No	Reference			Reference		
Yes	2.03	0.60 ~ 6.86	0.25	1.38	0.45 ~ 4.23	0.57
Chemotherapy, *n* (%)						
No	Reference			Reference		
Yes	2.28	0.32 ~ 16.01	0.41	0.89	0.17 ~ 4.74	0.89
Tumor size (mm), *M* (Q1, Q3)	1.03	1.01 ~ 1.07	0.05	1.03	0.99 ~ 1.07	0.12
Tumor size (mm), *n* (%)						
0–30	Reference			Reference		
31–40	1.84	0.97 ~ 3.49	0.06	1.07	0.49 ~ 2.33	0.87
Months from diagnosis to treatment, *M* (Q1, Q3)	1.20	1.03 ~ 1.41	0.02	1.19	1.06 ~ 1.33	0.00
Surgery						
Wedge	Reference			Reference		
Anatomic	1.01	0.60 ~ 1.69	0.98	1.05	0.68 ~ 1.62	0.81

Note: Grade I: well differentiated; Grade II: moderately differentiated; Grade III: poorly differentiated; Grade IV: undifferentiated.
Abbreviation: SDW: marital status includes separated, divorced, and widowed.

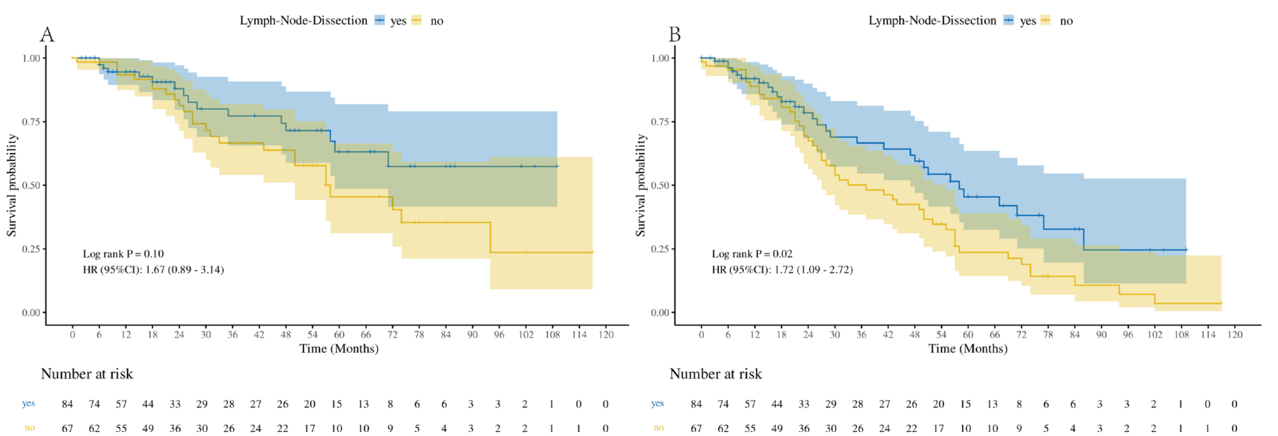

FIGURE 3 | The survival rates for patients undergoing wedge resection according to lymph node dissection, (A) for CSS and (B) for OS. CSS: cancer-specific survival; OS: overall survival.

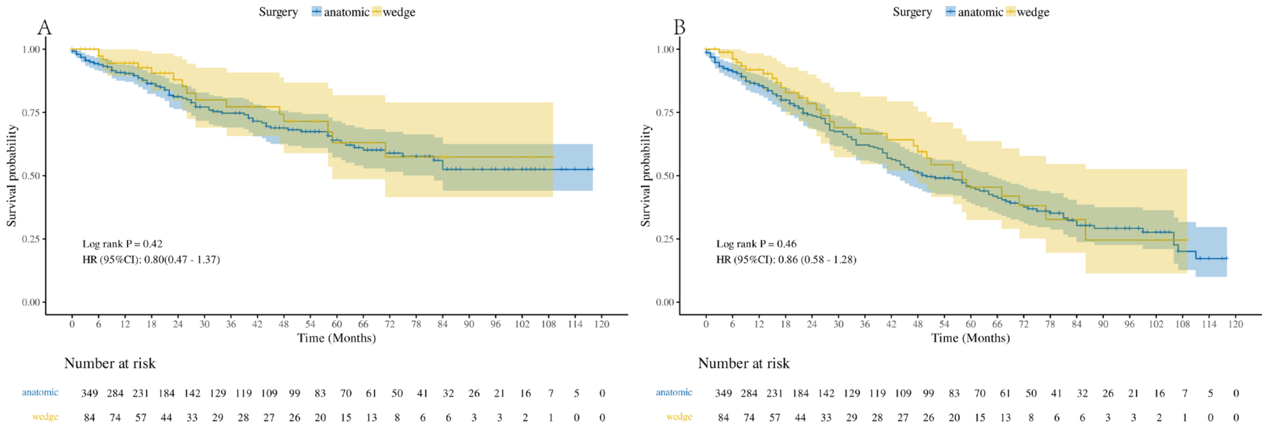

FIGURE 4 | The survival rates of patients before propensity score matching who underwent wedge resection combined with lymph node dissection compared to those who underwent anatomical resection combined with lymph node dissection, (A) for CSS and (B) for OS. CSS: cancer-specific survival; OS: overall survival.

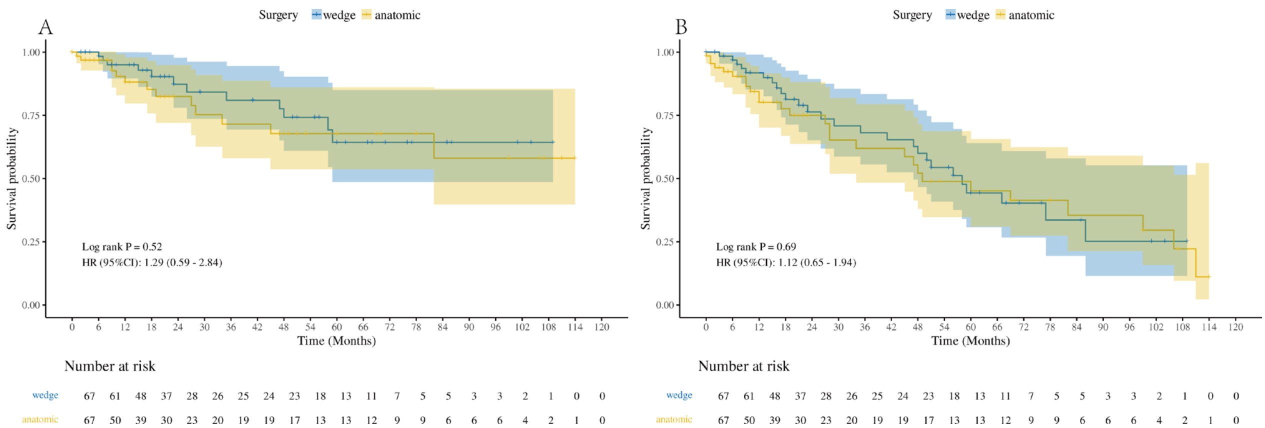

FIGURE 5 | The survival rates of patients after propensity score matching those who underwent wedge resection combined with lymph node dissection compared to those who underwent anatomical resection combined with lymph node dissection, (A) for CSS and (B) for OS. CSS: cancer-specific survival; OS: overall survival.

and ultimately draining into various hilar lymph nodes [21]. Furthermore, Imai et al. observed that lymphatic vessels beneath the pleura might bypass hilar lymph nodes entirely, directly draining into the mediastinum and potentially resulting in skip N2 metastasis [22]. Consequently, lymph node dissection is crucial for early-stage NSCLC patients presenting with VPI. In our study, the majority of patients who underwent wedge resection also received lymph node dissection. Although the lymph node sampling showed no evidence of metastasis, our analysis, which included all stage I patients, indicated potential benefits of lymph node dissection for those undergoing wedge resection. Prior research has highlighted that omitting lymph node dissection can lead to a threefold increase in local recurrence rates [12]. While certain clinical factors, such as advanced age and related intolerance, may justify avoiding lymph node sampling in specific cases, we advocate for routine lymph node dissection during wedge resection procedures.

The SEER database identifies VPI primarily through elastic fiber staining, a standard pathological method for evaluating tumor invasion into the visceral pleura. Specifically, a PL1 classification indicates tumor invasion into, but not through, the elastic fiber layer of the pleura, whereas PL2 signifies penetration of this layer, potentially extending into the pleural cavity. Although diagnosing VPI preoperatively or intraoperatively remains a significant challenge, this study focused exclusively on postoperative data. By analyzing such data, the study aimed to shed light on prognosis and guide treatment strategies for patients with confirmed VPI. While these findings may not directly inform preoperative or intraoperative decisions, they are essential for understanding VPI's role in the broader treatment framework, especially in determining the necessity of lymph node dissection and tailoring surgical approaches for elderly patients.

Our study has several limitations. First, its retrospective design introduces the possibility of confounding due to unmeasured variables. To address this issue and reduce bias, we employed multivariable Cox regression analysis along with stringent PSM techniques. Second, the SEER database itself has inherent limitations, notably the absence of detailed information such as recurrence timing, smoking history, and comorbidities. This lack of data constrains our ability to evaluate the comparative benefits of the three surgical approaches with respect to disease-free survival. Moreover, due to the limitations of the SEER database, which does not provide a clear differentiation between lymph node dissection and lymph node sampling, we have used the term "lymph node dissection" as a general term to refer to both lymph node dissection and lymph node sampling. Finally, In our study, the population did not receive adjuvant therapy. As a result, we are unable to conduct an analysis on the impact of adjuvant therapy on survival outcomes.

5 | Conclusion

This study revealed that wedge resection is a viable option for octogenarians with stage I NSCLC accompanied by VPI when compared to anatomical resection. Furthermore, combining wedge resection with lymph node dissection offers superior survival benefits compared to wedge resection alone in this patient population.

Author Contributions

Shuyuan Li, Yong Ge, and Jiayi Wang contributed equally as first authors. Study concept and design: Hao Zhang, Teng Sun, and Shoujie Feng. Acquisition of data: Shuyuan Li and Tianyue Ma. Statistical analysis: Shuyuan Li, Cheng Zhang and Ran Ma. Drafting of the manuscript: Shuyuan Li and Yong Ge. Revision of the manuscript: Hao Zhang. Study supervision: Hao Zhang.

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Ethics Statement

The data were sourced from the SEER. As information on patients is public and anonymized, ethical approval and informed consent were not required for this research.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The dataset utilized for analysis in this study can be accessed at https://seer.cancer.gov/.

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