Article

Clinical Application of Surgical Methods Based on Different Lung Segments and Pathological Subtypes in the Treatment of T1b Lung Adenocarcinoma

Ann. Ital. Chir., 2026 97, 6: 1034–1041
https://doi.org/10.62713/aic.4485

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AIM: This study aimed to explore the clinical application of surgical methods based on different lung segments and pathological subtypes in the treatment of T1b lung adenocarcinoma.
METHODS: A total of 207 patients with T1b lung adenocarcinoma admitted to the hospital between December 2019 and December 2022 were included in a retrospective analysis. According to the different surgical treatment strategies, all patients were divided into two groups: control group (n = 117) and experimental group (n = 90). The surgical methods for the control group were based on consolidation-to-tumour ratio (CTR), and the experimental group were according to lung segments and pathological subtypes. All patients were followed up for three years. Kaplan–Meier curve and Cox proportional hazard analysis were adopted to analyze the 3-year overall survival (OS) and recurrence-free survival (RFS) of two groups.
RESULTS: Compared with the control group, the proportion of lobectomy, lymph node management strategy, total nodes retrieved, number of stations, blood loss and operation time in the experimental group were decreased ($p < 0.05$), and the forced expiratory volume in 1 second (FEV_1) after surgery was increased. During the 3-year follow-up, there were 15 cases of recurrence (12.82%) and 6 cases of death (5.13%) in the control group; there were 9 cases of recurrence (10.00%) and 4 cases of death (4.44%) in the experimental group. There was no significant difference in recurrence or mortality between the two groups ($p > 0.05$). Kaplan-Meier curves showed no significant differences in 3-year disease-free survival (DFS) rate or 3-year overall survival (OS) rate between the two groups (p = 0.456, 0.623). Cox univariate analysis showed that the risk factors affected RFS were micropapillary pathological subtype (hazard ratio (HR) = 4.125, 95% confidence interval (CI) = 1.241–13.709, p = 0.021) and middle and lower lobes (HR = 2.633, 95% CI = 1.092–6.350, p = 0.031).
CONCLUSIONS: For T1b lung adenocarcinoma, incorporating tumor location and pathological subtype into surgical decisions may be beneficial to patient outcomes. This study may provide a reference for personalized treatment of small-sized lung cancer.

Keywords: T1b lung adenocarcinoma; lung segments; pathological type; sublobar resection; surgical decision-making

Introduction

Lung cancer is the leading cause of cancer-related deaths worldwide [1,2]. Among them, lung adenocarcinoma is a common type of lung cancer and falls under the category of non-small cell lung cancer (NSCLC), accounting for approximately 50% of NSCLC cases [3]. As health awareness increases and lung cancer screening methods expand, an increasing number of lung nodules ≤2 cm are being detected [4–6]. Previously, lobectomy was the standard surgical method for small-sized NSCLC patients [7]. In recent years, a study has reported that compared to lobectomy, segmentectomy could better preserve parenchymal tissue and potentially minimize postoperative complications [8]. Based on these results, researchers suggested that segmentectomy should be the standard surgical procedure for peripheral NSCLC with a small size. Considering the differences in patient populations, it is unclear whether these conclusions are applicable to Chinese populations.

Lymph node involvement is a significant factor affecting treatment outcomes and prognosis in lung adenocarcinoma [9]. However, radical lymph node dissection results in damage to peripheral tissues, such as chylothorax and recurrent laryngeal nerve injury [10]. The pattern of lymph node metastasis in patients with lung cancer has the characteristic of lung lobe specificity. The incidence of lower mediastinal lymph node metastases in upper lobe tumors is lower than that of upper mediastinal lymph node metastases in lower lobe tumors [11]. Therefore, lymph node dissection surgical methods targeting specific tumor locations may mini-

Submitted: 10 December 2025 Revised: 18 March 2026 Accepted: 13 May 2026 Published: 10 June 2026
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Editor: Andrea Bondurri

mize the surgery-induced damage to patients to the greatest extent. Lung adenocarcinoma includes multiple pathological subtypes. Among these subtypes, the lepidic type has the best prognosis [12]. Micropapillary and solid subtypes were more prone to lymph node metastasis and poor prognosis [13,14]. Pani *et al*. [15] analyzed NSCLC $\leq$2.0 cm and found that micropapillary predominant tumors were more likely to exhibit lymph node metastases in the adenocarcinoma subgroup, whereas all invasive mucinous and minimally adenocarcinomas were classified as N0 stage. This research also reminds us that whether surgical procedures for patients with $\leq$2.0 cm lung adenocarcinoma can be determined based on pathological subtypes. However, research exploring this issue remains limited.

The surgical procedure is closely related to perioperative safety, postoperative quality of life, and long-term oncological outcomes. According to the National Comprehensive Cancer Network (NCCN) guidelines, the standard surgery for lung cancer with a tumor diameter $\leq$2 cm is lobectomy, and sublobar resection is also acceptable [16]. For pure ground-glass opacity (GGO) nodules, lymph node dissection may not be required; but for nodules with a consolidation-to-tumour ratio (CTR) >0.5, lymph node dissection should be considered [17,18]. However, these strategies did not take into account tumor location and pathological subtype. Overall, although multiple surgical options are currently available in clinical practice for small-sized lung adenocarcinoma, there is considerable variability and controversy regarding specific surgical choices, as well as a lack of personalized treatment strategies that integrate both pathological subtype and tumor location. Based on this, we speculate whether pathological subtypes and tumor location in lung lobes can be taken into account in surgical decisions for small-sized lung adenocarcinoma. Therefore, this study aimed to explore the clinical application of surgical strategies based on different lung segments and pathological subtypes in the treatment of T1b lung adenocarcinoma. The study may provide a reference for the surgical treatment of small-sized lung cancer.

Methods

Patients

This study was a retrospective analysis. A total of patients (n = 207) with T1b lung adenocarcinoma admitted to Zhejiang Rongjun Hospital between December 2019 and December 2022 were included in the study. The clinical information was collected. According to the different surgical treatment strategies for T1b lung adenocarcinoma, all patients were divided into two groups: a control group (n = 117) and an experimental group (n = 90). It should be clarified that the grouping was based on the surgical strategies applied in clinical practice, rather than predefined interventions determined by the study design. The surgical methods for the control group were mainly based on the CTR: for CTR $\leq$0.5, sublobar resection and lymph node sampling were adopted; for CTR >0.5, lobectomy and lymph node dissection were adopted. The surgical methods for the experimental group: for lepidic-predominant pathological subtypes, sublobar resection was adopted; for acinar-, papillary-, micropapillary-, and solid-predominant pathological subtypes, if lung nodules were located on the upper lobes, sublobar resection following lymph node sampling was performed; if they were on the middle and lower lobes, lobectomy with lymph node dissection was conducted. Pathological subtypes were determined based on preoperative biopsy and intraoperative frozen sections. This study was approved by the ethics committee of Zhejiang Rongjun Hospital (No.2024-4). All programs comply with the Declaration of Helsinki. All patients signed informed consent forms.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) aged 18–75 years old; (2) diagnosed as lung adenocarcinoma before surgery, through cytological or histological examination; (3) computed tomography (CT) showed that tumor diameter >1 cm and $\leq$2 cm; (4) there was at least one measurable lesion in the GGO on lung CT imaging; (5) TNM stage IA; previously untreated and underwent surgical treatment; (6) Eastern Cooperative Oncology Group (ECOG) score of 0–1; (7) the patients have adequate organ function to withstand surgical trauma; (8) adherence to the treatment plan and procedures; (9) complete clinical information with no loss to follow-up.

Exclusion criteria were as follows: (1) combined with other cancers; (2) received preoperative chemotherapy, radiotherapy, targeted therapy, or immunotherapy; (3) patients with active autoimmune diseases that require systemic treatment, such as glucocorticoid, immunosuppressant; (4) allogeneic organ transplantation (excluding corneal transplantation) or allogeneic hematopoietic stem cell transplantation; (5) pregnant or lactating women; (6) patients suffered any serious or uncontrollable systemic diseases, such as ventricular arrhythmia, atrial fibrillation, chronic heart failure, active tuberculosis, uncontrolled infection, diabetes with poor blood glucose control; (7) incomplete clinical data or loss to follow-up.

Preoperative CT Image

The preoperative low-dose spiral CT images were collected. The tumor size, location, GGO and solid component were determined by experienced radiologists. GGO is defined as an area of slight, homogeneous increase in density that does not obscure the underlying vascular and bronchial structures. A solid component is defined as an area of significantly increased density that obscures the underlying vascular and bronchial structures. CTR = solid component diameter / tumor diameter.

Table 1. Comparison of general information between the two groups.

General information	Control group (n = 117)	Experimental group (n = 90)	t/χ^2	p
Gender (n, %)			0.001	0.971
Male	66 (56.41%)	51 (56.67%)		
Female	51 (43.59%)	39 (43.33%)		
Age (years)	61.68 ± 6.36	60.37 ± 4.72	1.637	0.103
BMI (kg/m^2)	25.2 (23.1, 27.8)	24.7 (22.2, 27.2)	1.286	0.198
Tumor diameter (mm)	16 (14, 17)	15 (14, 17)	1.165	0.244
Tumor location (n, %)			0.523	0.470
Left lung	50 (42.74%)	43 (47.78%)		
Right lung	67 (57.26%)	47 (52.22%)		
Involved lung segments (n, %)			0.215	0.643
Upper lobes	61 (52.14%)	44 (48.89%)		
Middle and lower lobes	56 (47.86%)	46 (51.11%)		
ECOG (n, %)			1.032	0.310
0	101 (86.32%)	73 (81.11%)		
1	16 (13.68%)	17 (18.89%)		
CTR (n, %)			0.002	0.961
≤0.5	62 (52.99%)	48 (53.33%)		
>0.5	55 (47.01%)	42 (46.67%)		
Pathological subtype (n, %)			2.872	0.579
Lepidic	70 (59.83%)	44 (48.89%)		
Acinar	17 (14.53%)	18 (20.00%)		
Papillary	14 (11.97%)	15 (16.67%)		
Micropapillary	8 (6.84%)	7 (7.78%)		
Solid	8 (6.84%)	6 (6.67%)		
Smoking history (n, %)			0.077	0.781
Yes	75 (64.10%)	56 (62.22%)		
No	42 (35.90%)	34 (37.78%)		

BMI, body mass index; ECOG, Eastern Cooperative Oncology Group; CTR, consolidation-to-tumour ratio.

Clinical Data Collection

The clinical data of patients were obtained from clinical records. The general information included age, gender, body mass index (BMI), tumor diameter, tumor location, involved lung lobes, ECOG, CTR, pathological subtype, and smoking history.

Operation Methods

Before treatment, Mimics 3D (Version 22.0, Materialise Dental, Leuven, Belgium) software was applied to reconstruct the tumor morphology and location. The surgical methods were decided by a multidisciplinary team at a professional meeting, including thoracic surgeons, oncologists, and pathologists. The surgical approach for the control group was primarily based on the CTR value detected on preoperative CT images, while also taking into account tumor size, anatomical location, pulmonary function, and the surgeons' experience. In the experimental group, pathological subtypes were determined based on preoperative biopsy and intraoperative frozen-section analysis, and tumor location was detected by imaging. The surgery strategies were determined by first considering the tumor location and then the patient's pathological subtypes.

According to the operation methods, lobectomy/sublobar resection was conducted. The distance from the dissection margin to the tumor edge must be evaluated during lobectomy and sublobar resection. If the distance was shorter than the maximum tumor diameter, cytological examination was conducted to ensure the absence of tumour cells at the resection margin before completing the surgery. If the results showed positive for tumour cells, additional partial resection was mandatory. Lymph node dissection included hilar and mediastinal lymph nodes. Lymph node sampling should remove at least three N2 and representative N1 nodes, and pathological examination showed negative of tumor cells.

Observation Indicators and Follow-Up

The blood loss, operation time, and length of stay were recorded. Pulmonary function was evaluated by the forced expiratory volume in 1 second (FEV_1) before surgery and 3 months after surgery.

Patients were followed up every 3–4 months, lasting for 3 years. The follow-up method was either outpatient or telephone. The procedure of follow-up included routine physical examination and chest radiography test. Moreover, pa-

Table 2. Comparison of perioperative indicators between the two groups.

Perioperative indicators	Control group (n = 117)	Experimental group (n = 90)	$t/Z/\chi^2$	p
Video-assisted thoracic surgery (n, %)			0.796	0.372
Yes	102 (87.18%)	82 (91.11%)		
No	15 (12.82%)	8 (8.89%)		
Operation method (n, %)			11.087	<0.001
Lobectomy	55 (47.01%)	22 (24.44%)		
Sublobar resection	62 (52.99%)	68 (75.56%)		
Lymph node dissection (n, %)			72.648	<0.001
No dissection	0 (0%)	44 (48.89%)		
Lymph node sampling	62 (52.99%)	24 (26.67%)		
Lymph node dissection	55 (47.01%)	22 (24.44%)		
Total nodes retrieved	8 (6, 20)	5 (0, 11)	6.811	<0.001
Number of stations	5 (4, 7)	4 (0, 6)	5.952	<0.001
Blood loss (mL)	30 (25, 40)	25 (15, 35)	4.584	<0.001
Operation time (min)	176 (164, 191)	171 (155, 184)	2.091	0.037
Length of stay (days)	9 (8, 11)	9 (7, 11)	1.404	0.160
FEV_1 (L)				
Before surgery	1.78 ± 0.38	1.80 ± 0.25	0.432	0.666
After surgery	1.53 ± 0.29	1.62 ± 0.33	2.084	0.038

FEV_1, forced expiratory volume in 1 second.

tients undergo chest and abdominal CT tests at least once a year. The survival status of patients was also collected. The primary endpoint was 3-year overall survival (OS) and 3-year disease-free survival (DFS). DFS was defined as the period from surgical treatment to tumor local or distant recurrence. The overall survival was defined as the period from surgical treatment to any cause of death.

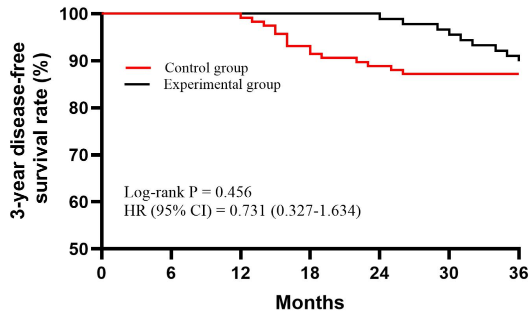
Statistical Analysis

Data were statistically analyzed by SPSS software (27.0, IBM, Armonk, NY, USA). Quantitative data were tested for normality using a Shapiro-Wilk test. Normal data were represented by mean and standard deviation, and an independent t-test was used for intergroup comparison. Non-normal data were presented as median and quartiles, Mann-Whitney U test was used for comparison. The Kaplan–Meier method was used for survival analysis, and the Log-rank method for the comparison between two groups. Cox proportional hazard analysis was used to analyze the influencing factors on the survival data. Due to the small number of events, Cox analysis was only conducted using univariate analysis to avoid overfitting. A $p < 0.05$ was defined as statistically different.

Results

Comparison of General Information Between the Two Groups

There were no significant differences between the control group and experimental group in gender, age, BMI, tumor diameter, tumor location, involved lung lobes, ECOG, CTR, pathological subtype, or smoking history ($p > 0.05$) (Table 1).



Number at risk

Control group	117	117	117	109	104	102	102
Experimental group	90	90	90	90	90	86	81

Fig. 1. Kaplan–Meier curves of 3-year DFS for two groups. HR, hazard ratio; DFS, disease-free survival.

Comparison of Observation Indicators Between the Two Groups

There were no significant differences between the two groups in video-assisted thoracic surgery, length of stay, or FEV_1 before surgery ($p > 0.05$). Compared with the control group, the proportion of lobectomy, lymph node management strategy, total nodes retrieved, number of stations, blood loss and operation time of the experimental group were decreased ($p < 0.05$), and the FEV_1 after surgery was increased ($p < 0.05$) (Table 2).

Kaplan–Meier Curves of 3-Year DFS and 3-Year OS

During the 3-year follow-up period, there were 15 cases of recurrence (12.82%) and 6 cases of death (5.13%) in the

Table 3. Cox proportional hazard analysis of RFS.

Indicator	Univariate analysis	
	HR (95% CI)	*p*
Male	1.312 (0.574–2.998)	0.520
Age	1.014 (0.944–1.088)	0.703
BMI	1.069 (0.952–1.201)	0.257
Tumor diameter	1.065 (0.888–1.278)	0.496
Tumor location (left lung)	0.488 (0.202–1.177)	0.110
Involved lung segments (middle and lower lobes)	2.633 (1.092–6.350)	0.031
ECOG (1)	2.299 (0.953–5.545)	0.064
CTR (>0.5)	1.981 (0.867–4.528)	0.105
Pathological subtype		
Lepidic	1.000 (Reference)	/
Acinar	2.105 (0.689–6.435)	0.192
Papillary	2.133 (0.642–7.084)	0.216
Micropapillary	4.125 (1.241–13.709)	0.021
Solid	3.439 (0.911–12.977)	0.068
Smoking history	1.427 (0.592–3.441)	0.429
Video-assisted thoracic surgery	0.591 (0.202–1.729)	0.337
Lobectomy	2.106 (0.943–4.701)	0.069
Lymph node dissection		
No dissection	1.000 (Reference)	/
Lymph node sampling	0.936 (0.274–3.196)	0.915
Lymph node dissection	2.017 (0.658–6.188)	0.220
Total nodes retrieved	1.038 (0.990–1.088)	0.122
Number of stations	1.122 (0.949–1.327)	0.179
Blood loss	1.004 (0.998–1.010)	0.154
Operation time	1.004 (0.986–1.023)	0.664
Length of stay	1.025 (0.868–1.212)	0.768
FEV_1 before surgery	1.908 (0.534–6.817)	0.320

Note: HR, hazard ratio; RFS, recurrence-free survival.

control group; there were 9 cases of recurrence (10.00%) and 4 cases of death (4.44%) in the experimental group. No significant differences in recurrence or mortality were observed between the two groups ($p > 0.05$). Kaplan–Meier curves showed no significant differences in 3-year DFS rate or 3-year OS rate between the two groups ($p = 0.456, 0.623$) (Figs. 1,2).

Cox Proportional Hazard Analysis of Recurrence-Free Survival (RFS)

Cox univariate analysis showed that the risk factors affected RFS were micropapillary pathological subtype (hazard ratio (HR) = 4.125, 95% confidence interval (CI) = 1.241–13.709, $p = 0.021$) and middle and lower lobes (HR = 2.633, 95% CI = 1.092–6.350, $p = 0.031$) (Table 3).

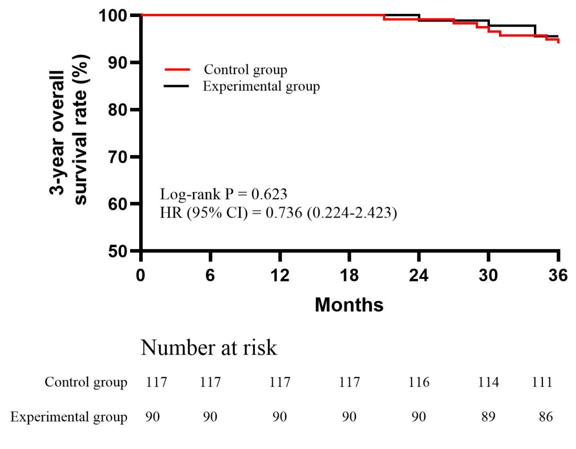


Fig. 2. Kaplan–Meier curves of 3-year OS for two groups. OS, overall survival.

Discussion

For T1b lung adenocarcinoma, surgery is a preferred treatment option. Previous clinical trials suggested that segmentectomy should be the standard surgical procedure for small-sized peripheral NSCLC (tumour diameter ≤2 cm and CTR >0.5) [8]. However, CTR is an indicator based on two-dimensional images; it cannot reflect the three-dimensional structure of tumors. Moreover, this standard did not consider the location and pathological subtype of pulmonary nodules. In this study, compared to surgical strategies based on CTR, surgical strategies based on tumor location and pathological subtype had comparable survival outcomes, and did not affect OS and DFS. The recurrence and mortality rates of the experimental group were slightly lower than those in the control group, but the difference was not significant. The experimental group had lower blood loss and operation time, and better FEV_1 indicator. The Cox univariate analysis showed that the risk factors affecting RFS were micropapillary pathological subtype and middle and lower lobes; lobectomy/sublobar resection, or lymph node dissection/sampling did not affect the RFS of patients. These results suggested that compared with the control group, the experimental group had lower surgical trauma and a comparable prognosis. The surgical methods based on tumor location and pathological subtype can not only address measurement errors in CT through three-dimensional software, but also mitigate the impact of intraoperative pathology. It enables surgeons to formulate surgical plans using familiar anatomical structures and pathological features. This approach may help to develop precise surgical plans for small-sized lung adenocarcinoma.

The selection of surgical methods for lung cancer should balance multiple factors such as surgical injury, efficacy, and prognosis. Although some guidelines have been published to assist clinicians in determining surgical procedures, the choice of surgical method remains controversial. The efficacy of sublobar resection for small-sized lung adenocarcinoma has been reported in some clinical studies [8,19]. Compared with lobectomy, sublobar resection has smaller lung parenchymal damage, which is crucial for preserving lung function, reducing surgical trauma, and minimizing postoperative complications [20]. This is also in line with the fact that the recovery of FEV_1 was greater in the experimental group. In our clinical surgical methods, sublobar resection remains the predominant surgical procedure for T1b lung adenocarcinoma. But for patients with acinar, papillary, micropapillary, and solid pathological subtypes and tumors in the middle and lower lobes, lobectomy was performed. The lobectomy or sublobar resection was selected according to the different tumor locations. The primary reason was that lymph node drainage routes in the middle and lower lobes were complex, with a high risk of tumor metastasis and recurrence. Lobectomy effectively clears the lesion and removes the lymph node drainage area, thereby reducing the risk of recurrence. A meta-analysis revealed that for stage I–III NSCLC, the patients with lower lobe tumors had poor 3-year survival, and those with upper lobes had a higher 5-year survival rate than those in non-upper lobes [21]. A possible reason for this is related to the fact that tumors in the lower lobe are more likely to metastasize to subcarinal, paraesophageal, or inferior pulmonary ligament lymph nodes. From an anatomical perspective, the upper lobe exhibits well-defined boundaries. In contrast, the middle and lower lobes present greater anatomical variability in bronchial and vascular structures, and the boundaries between lung segments are unclear. These features increase the surgical difficulty of sublobar resection and may lead to insufficient or excessive surgical margins [22,23]. In addition, the drainage routes of lymph nodes in the lower lobe were complex, leading not only to the pulmonary but also to mediastinal lymph nodes, which increase the risk of tumor metastasis [24]. Given these challenges, lobectomy can ensure the removal of potential lesions for tumors in the lower lobes.

Additionally, it should be noted that, in addition to tumor location, the pathological subtype of lung adenocarcinoma is also a crucial factor in determining the surgical methods. For patients with lepidic small-sized nodules, sublobar resection was performed even if they were located in the middle and lower lobes. For other pathological subtypes of T1b lung adenocarcinoma, lobectomy was performed if the tumor was located in the middle and lower lobes. Overall, pathological subtypes and tumor location were used together to determine the surgical methods for T1b lung adenocarcinoma. The pathological type is closely related to prognosis. The risk of lymph node metastasis and recurrence was higher in acinar, papillary, micropapillary, and solid lung adenocarcinoma than that of lepidic [12]. Lepidic pathological subtype exhibits low malignant behavior and aggressiveness, with a low probability of lymph node metastasis. Acinar, papillary, micropapillary and solid have higher aggressiveness and risk of lymph node metastasis [25]. Previous research has suggested that lobectomy is associated with longer DFS and OS than sublobar resection in solid-type clinical stage IA NSCLC [26]. These findings suggest that for mediate- and high-grade small-sized lung adenocarcinoma, lobectomy is a reliable approach to improve patient prognosis.

In lymph node management, comprehensive decisions were made based on tumor location and pathologic subtype. For low-grade pathologic subtypes, no additional lymph node sampling or dissection was performed. Patients with Mediate- and high-grade T1b lung adenocarcinoma undergo lymph node sampling/dissection. These considerations were primarily based on the biological characteristics of tumor cells in these different subtypes. The goal was to minimize surgical trauma as much as possible while ensuring therapeutic efficacy and prognosis. In previous studies, the GGO component was used to predict the invasiveness of tumor cells, and a CTR $>$0.5 was used as a criterion for lymph node dissection [17,18]. Pure GGO lesions have been shown not to exhibit lymph node involvement, and only very few patients with semisolid GGO (CTR $\leq$0.5) present with lymph node involvement [17]. Although a link between CTR and lymph node involvement has been found, CTR is a two-dimensional imaging indicator that cannot represent the biological characteristics of tumor cells or their spatial growth patterns. It is noted that the CTR correlates with pathological subtypes of lung adenocarcinoma. Meanwhile, it enables rapid and intuitive assessment of the risk of lymph node metastasis based on pathological subtype. Based on this, pathological subtypes were used in this study to determine the lymph node sampling/dissection. However, the significant differences in lymph node handling methods between the two groups make it difficult to completely distinguish whether differences in oncological outcomes are attributable to the surgical strategy or to lymph node handling methods, thereby introducing potential confounding factors.

Our study also has some limitations. Firstly, the sample size was relatively small in this study, which may introduce bias into the results due to a large fluctuation range of the inter-individual variability or the limited statistical difference in some indicators (such as blood loss). Large-scale clinical studies are required to validate the conclusions further. Additionally, the follow-up period was only 3 years. Long-term follow-up (at least five years) should be conducted to track the impact of treatment strategies on recurrence and survival outcomes in patients with T1b lung adenocarcinoma. Moreover, due to the role of the tumor location in the surgical decision-making process, even when the correction was included in the Cox model, it was still difficult to completely eliminate its confounding effect on the survival outcome. Finally, this study developed surgical strategies aligned with clinical practice based on the tumor location and pathology, in order to explore individualized treatment plans. However, as an exploratory study, the surgical decision-making process was relatively simplified. Other factors, such as the anatomical complexity of lung segments, adequacy of surgical margins, and patient preference, are also important considerations in surgical plans, but were not included in this study. Therefore, it is necessary to develop surgical plans based on this study while comprehensively considering the above factors. Future research will incorporate additional clinical decision-related factors for refined stratified analysis.

Conclusions

For patients with T1b lung adenocarcinoma, the surgical strategies based on tumor location and pathological subtype show advantages over the surgical strategies based on CTR in terms of blood loss, operation time, and postoperative FEV_1 indicator. There were no significant differences in 3-year recurrence-free survival or overall survival between the two strategies. In general, incorporating tumor location and pathological subtype into surgical decisions may be a beneficial approach for T1b lung adenocarcinoma in the short term. This study may provide a reference for personalized treatment of small-sized lung cancer.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

ZQZ and YCZ designed the research study and wrote the first draft. GL and LCH performed the experiments. YG and PC collected raw data, and conducted formal data analysis. YHM, HFC and XFL participated in research implementation and data acquisition. YY conceptualized the study and provided critical academic guidance. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was approved by the ethics committee of Zhejiang Rongjun Hospital (No.2024-4). All programs comply with the Declaration of Helsinki. All patients signed informed consent forms.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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