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Does the Uniportal VATS Approach Affect Patient Safety and Oncologic Principles? Analysis of Anatomic Resections and Recent Results

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Abstract

Background and Objectives

Minimally invasive techniques have revolutionized lung cancer surgery by reducing morbidity while preserving oncologic principles. Uniportal Video-Assisted Thoracoscopic Surgery (U-VATS) has gained prominence for its balance of surgical precision and enhanced recovery. This study presents the outcomes of patients who underwent anatomic lung resection via U-VATS for primary lung cancer.

Materials and Methods

A retrospective review was conducted on patients undergoing U-VATS anatomical lung resections at our center between May 2020 and December 2022. Demographic data, tumor characteristics, surgical details, and postoperative outcomes were analyzed. Survival analysis and prognostic factors affecting survival were also evaluated.

Results

A total of 115 patients were included (mean age: 65±8.5 years; 78.3% male). Lobectomy was performed in 81.7% and segmentectomy in 11.3% of cases. R0 resection was achieved in all, with a median of 5 lymph node stations and 9 lymph nodes dissected. The complication rate was 15.7%, most commonly prolonged air leak. Adenocarcinoma was the most frequent histology (56.5%). Pathological staging revealed 1A in 23.5%, 1B in 36.5%, 2A in 5.2%, 2B in 25.2%, and 3A in 8.7%. Thirty-day mortality was 0.87%. The mean follow-up was 35.1±10.7 months, and overall survival was 87%. T stage (p=0.046) and lymphovascular invasion (p=0.002) were significant prognostic factors.

Conclusions

U-VATS anatomic lung resection is a safe and effective approach that provides oncologic adequacy with low complication and mortality rates. Our findings support its utility in achieving minimally invasive lung cancer surgery goals.

Keywords: anatomical resection, lung cancer, uniportal, video-assisted thoracoscopic surgery.

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Introduction

Minimally invasive surgery aims to achieve less pain, faster recovery, and shorter hospitalization. In line with this principle, video-assisted thoracoscopic surgery (VATS) has become a routine approach for thoracic surgeons worldwide. VATS is now widely utilized not only for routine procedures and early-stage lung cancer but also for the most complex intrathoracic surgeries. Consequently, current guidelines recommend that lung cancer surgery should be performed using VATS by experienced surgeons while adhering to oncologic principles (1). Although VATS anatomical lung resection for lung cancer lacks a standardized technique, the approach has evolved significantly over the years—from the conventional two- to four-port method to the uniportal approach (2). Since 2004, uniportal VATS (U-VATS) has gained increasing importance in thoracic surgery units, including our center (3). The development of specialized instruments has further facilitated the widespread adoption of this technique. The fundamental geometric concept of U-VATS enables a sagittal approach to intrathoracic lesions, resembling the exposure achieved through open thoracotomy, while simultaneously providing enhanced visualization for hand-eye coordination (4). However, unlike conventional VATS, some studies suggest that U-VATS may present challenges regarding safety and oncologic efficacy (5). In this study, we aimed to present our recent outcomes of U-VATS anatomical lung resections for lung cancer and compare them with the current literature. In addition, we aimed to evaluate them in terms of patient safety and oncologic principles.

Material And Methods

Patient Selection

This retrospective, single-center study was conducted at the Department of Thoracic Surgery, XXX University Faculty of Medicine, between May 2020 and December 2022. A total of 137 patients who underwent U-VATS anatomical lung resection in our clinic were retrospectively analyzed. Patients aged 18 years or older with a diagnosis of primary lung malignancy were included in the study. Patients diagnosed with secondary lung malignancy or benign tumors based on histopathological examination, as well as those who underwent conversion to open thoracotomy due to intolerance to single-lung ventilation, were excluded from the study. After applying the inclusion criteria, 115 patients (90 males, 25 females; mean age: 65 ± 8.48 years; IQR: 58–70 years) were included in the final analysis (Figure 1). Informed consent was obtained preoperatively from all patients.

The data of the patients included in the study were retrospectively obtained from the hospital's digital information system, including demographic and medical records. A comprehensive review of the records was conducted to collect demographic data (age, sex, etc.), etiology, tumor size, lesion localization, harvested lymph node localization and count, histopathological findings, pathological staging, intraoperative complications, chest tube removal time, length of hospital stay, survival, and malignancy recurrence status. Prolonged air leakage (PAL) was defined as air leakage lasting more than five days. Early postoperative complications included atrial fibrillation, PAL, and surgical site infection, while late complications consisted of moderate to severe dyspnea, empyema, and bronchopleural fistula. The safety of the surgical technique was evaluated based on perioperative complications, chest tube duration, and length of hospital stay. Compliance with oncologic principles was assessed by R0 resection status, mediastinal lymph node dissection, number of harvested lymph nodes, locoregional recurrence, and survival outcomes.

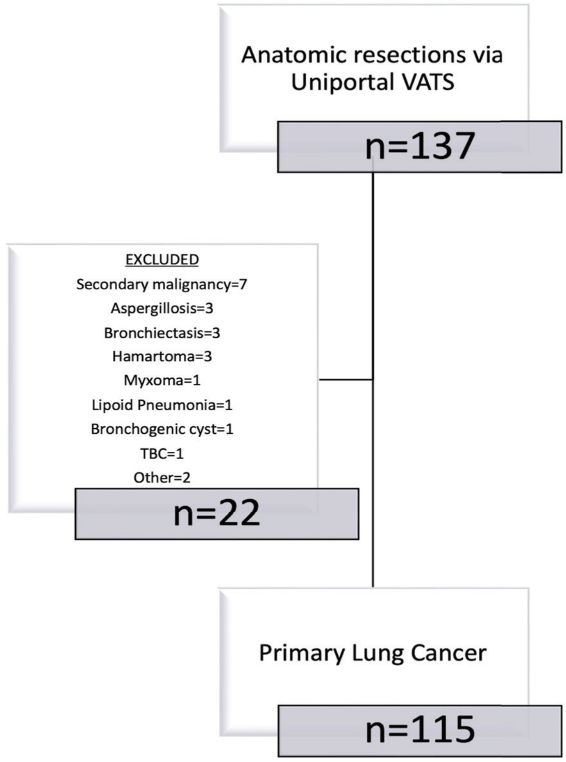


Figure -1: Flowchart of the study.

Surgical Technique

The patient was intubated with a double-lumen endotracheal tube for single-lung ventilation and placed in the lateral decubitus position. Although there are differing opinions in the literature regarding the optimal incision site and intercostal entry, we determined our incision approach based on the technique previously described in our study (6). A single 3–4 cm incision was made in the predetermined intercostal space, and a wound protector was used to facilitate instrument manipulation. A 10-mm, 30° thoracoscope (HOPKINS® Forward-Oblique 30° Telescope, Karl Storz, Tuttlingen, Germany) was used for visualization, while a LigaSure™ Maryland Jaw (Minneapolis, MN, USA) endoscopic sealing and dissection device was utilized for tissue dissection. Following a 360° dissection of the hilum, systematic mediastinal lymph node dissection (LND) was performed, and lobe-specific lymph nodes were analyzed using frozen section histopathology. For vascular and bronchial dissection, the preferred surgical instruments included a node grasper, dissector clamp, endovascular clamp, right-angled clamp, and suction device. Dissected vascular and bronchial structures were either transected using an endostapler or ligated with Hem-o-Lock clips and sealed with an energy device. Fissure separation was performed using either staplers or an energy device. In cases completed with the fissure-last technique, an average of four to five staplers was used for parenchymal division. For right upper lobectomies and left upper lobectomies with complete fissures, the fissure-first technique was preferred. At the end of the procedure, a 28Fr chest tube was placed through the same incision, and negative pressure was established using a closed underwater drainage system.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 for Windows. Data were presented as mean ± standard deviation (SD), median (interquartile range, IQR), and frequency (%). The Shapiro-Wilk test was used to assess the normality assumption of quantitative variables. For non-normally distributed data, the Mann-Whitney U test was applied. Pearson's chi-square test, continuity correction chi-square test, and Fisher's exact test were used for frequency comparisons. Survival analyses were conducted using the Kaplan-Meier method and Cox regression analysis. A p-value < 0.05 was considered statistically significant.

Results

In this study, the clinical and surgical data of 115 patients were analyzed. The mean age of the patients was 65 ± 8.48 years, with male patients comprising 78.3% (n=90) of the study population. The Charlson Comorbidity Index (CCI), which was used to assess the comorbidity burden, had a mean score of 4.78 ± 1.54. Additionally, the Morbidity Risk Score, which evaluates postoperative mortality risk, was calculated as 35.63 ± 29.18. Regarding surgical procedures, lobectomy was the most commonly performed operation (81.7%), followed by segmentectomy (11.3%) and bilobectomy (3.5%). In terms of laterality, 59.1% (n=68) of the procedures were performed on the right lung, while 40.9% (n=47) involved the left lung. Lymph node dissection data revealed that an average of 5.28 ± 1.92 lymph node stations were dissected, with a mean of 9.73 ± 5.69 lymph nodes harvested. The median postoperative chest tube removal time was 2 days (IQR: 1–4 days), while the median length of hospital stay was 4 days (IQR: 3–5 days). The intraoperative complication rate was 4.34% (n=5), with bleeding being the most common complication. Conversion to open thoracotomy due to bleeding was required in two patients (1.8%). The postoperative complication rate was 15.7% (n=18), with prolonged air leakage (13.04%) being the most frequently observed complication. Only one patient experienced

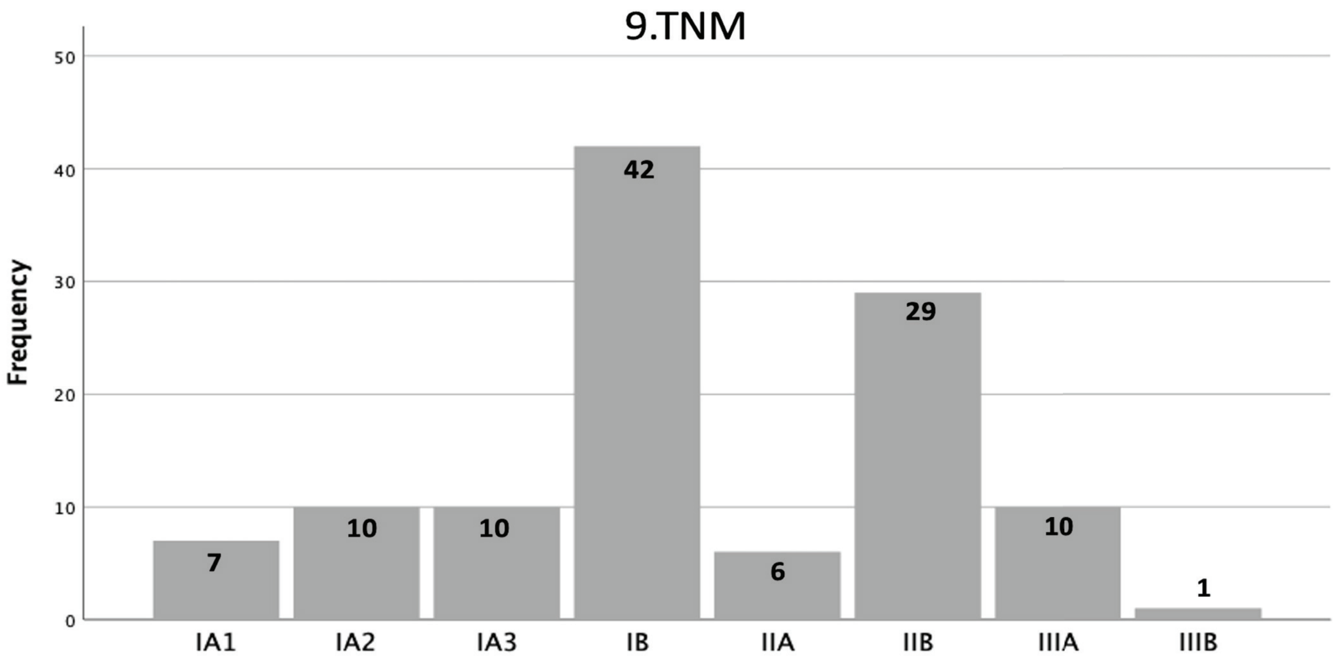
Table-1: Descriptive analysis of demographic and surgery-related variable

Variables	Total (n=115)
Age (mean±SD) year	65±8.48
Sex, n (%)	
Male	90 (78.3)
Female	25 (21.7)
Resection, n (%)	
Lobectomy	94 (81.7)
Bilobectomy	4 (3.5)
Segmentectomy	13 (11.3)
Lobectomy+Segmentectomy	2 (1.7)
Pneumonectomy	1 (0.9)
Lobectomy+TWR	1 (0.9)
Side, n(%)	
Right	68 (59.1)
Left	47 (40.9)
Charlton Comorbidity Score	4.78±1.54
Mortality Risk Score	35.63±29.18
Number of Lymph Node Station (mean±SD)	5.28±1.92
Number of Lymph Node, (mean±SD)	9.73±5.69
Tube removal [median(IQR)] day	2 (1-4)
Postoperative LOS [median(IQR)] day	4 (3-5)
Intraoperative complication, n(%)	
No	110 (95.66)
Yes	5 (4.34)
Postoperative complication, n(%)	
No	97 (84.3)
Yes	18 (15.7)
Follow-up (mean±SD) month	35.1±10.7
Malignancy (Recurrens/Seconder) n(%)	
No	100 (87)
Yes	15 (13)
Survival, n(%)	
Alive	100 (87)
Death	15 (13)

(IQR: Interquartiler range; LOS: Lenght of stay; SD: Standart deviation; TWR: Thoracic Wall resection)

30-day mortality due to COVID-19. The mean postoperative follow-up period was 35.1 ± 10.7 months. At the last follow-up, 87% of patients (n=100) remained event-free, whereas 13% (n=15) developed malignancy (recurrence or secondary organ involvement). The overall survival rate during the follow-up period was 87% (n=100), and the total mortality rate was 13% (n=15). A detailed descriptive analysis of demographic and surgical variables is presented in Table 1.

According to the 9th TNM classification of the World Health Organization (WHO), the distribution of cases based on the T factor and disease stage is presented in Figures 2 and 3. The most frequently observed T stage was T2a (40%, n=46), followed by T3 (24.3%, n=28). Among the cases, Stage IB was the most common disease stage (36.5%), followed by Stage IIB (25.2%). Early-stage tumors (IA1, IA2, IA3) were observed at lower frequencies (6.1% to 8.7%).

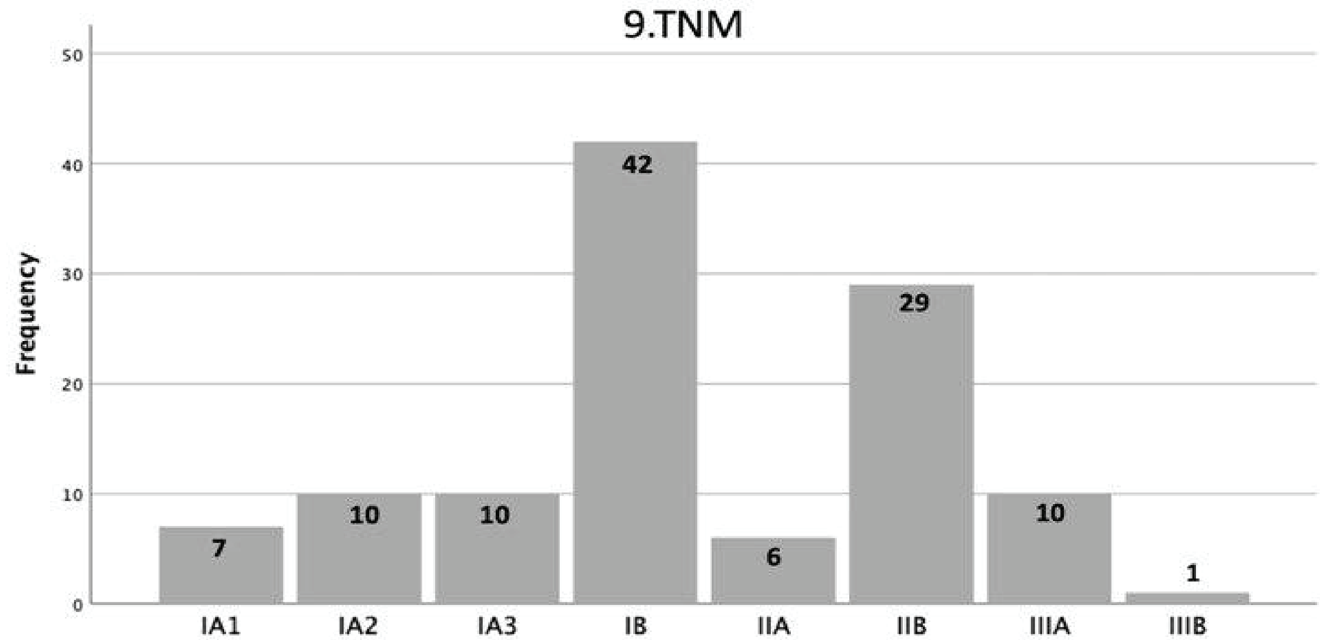


Stage	%	Stage	%
IA1	6,1	IA2	8,7
IA3	8,7	IB	36,5
IIA	5,2	IIB	25,2
IIIA	8,7	IIIB	0,9

Figure -2: Distribution of patients according to T stage.

In this study, the most frequently identified histopathological tumor type was adenocarcinoma (56.5%, n=65). Squamous cell carcinoma was detected in 35.7% (n=41) of cases, while neuroendocrine tumors were identified in 7.8% (n=9). The mean tumor diameter was 31.16 ± 17.43 mm. Lymphovascular invasion was detected in 10.4% (n=12) of patients, and perineural invasion was observed in 7% (n=8) of cases. Regarding visceral pleural invasion (VPI), PL0 was identified in 45.2% (n=52) of patients, indicating no pleural invasion. PL1, PL2, and PL3 were observed in 29.6% (n=34), 20.9% (n=24), and 4.3% (n=5) of cases, respectively. Spread through air spaces (STAS) was found in 11.3% (n=13) of patients. An analysis of lymph node involvement revealed that 81.7% (n=94) of patients had no lymph node metastasis, while 18.3% (n=21) exhibited lymph node involvement (Table 2).

In this study, the relationship between survival status and clinical and histopathological variables is presented in Table 3. No statistically significant difference in survival was observed in terms of sex or surgical procedures. Similarly, survival did not differ significantly among histopathological subgroups. Among patients with adenocarcinoma, 86.2% (n=56) survived, while the mortality rate was 13.8% (n=9). The survival rate for squamous cell carcinoma (SCC) was 85.4% (n=35), whereas all patients with neuroendocrine tumors (100%, n=9) survived. No



Stage	%	Stage	%
IA1	6,1	IA2	8,7
IA3	8,7	IB	36,5
IIA	5,2	IIB	25,2
IIIA	8,7	IIIB	0,9

Figure -3: Distribution of patients according to the 9th TNM staging system.

Table-2: Descriptive analysis of tumor histopathology results of the patients.

Histopathologic Results	**Total (n=115)**
Pathology, n(%)	
Adenocarcinoma	65 (56.5)
Squamous Cell Carcinoma	41 (35.7)
Neuroendocrine Carcinoma	9 (7.8)
Tumor size (mean±SD) mm	31.16±17.43
Lymphovascular invasion, n (%)	
No	103 (89.6)
Yes	12 (10.4)
Perineural invasion, n (%)	
No	107 (93)
Yes	8 (7)
Pleural invasion, n (%)	
PL0	52 (45.2)
PL1	34 (29.6)
PL2	24 (20.9)
PL3	5 (4.3)
STAS, n(%)	
No	102 (88.7)
Yes	13 (11.3)
Lymph Node Metastasis, n (%)	
No	94 (81.7)
Yes	21 (18.3)

(PL: Pleural layer; SD: Standart deviation; STAS: Tumor spread through air spaces) statistically significant difference was found in survival analysis based on the 9th TNM staging system. In general, Stage IA patients had the highest survival rates, while patients with advanced-stage disease showed an increase in mortality. The poorest survival outcome was observed in Stage IIIB patients, with no survivors recorded in this group.

A statistically significant difference was found in T-stage survival analysis (p=0.046). Patients with T1-stage tumors had better survival rates, whereas mortality increased significantly in T3 and T4-stage patients. The presence of lymph node metastasis negatively impacted survival; however, the difference was not statistically significant. Among patients without lymph node metastasis, 88.3% (n=83) survived, whereas the survival rate in patients with metastasis was 81.0% (n=17). No significant association was found between visceral pleural invasion (VPI) and survival. However, among TPL-3 patients, the survival rate was the lowest, with a mortality rate of 40.0% (n=2).

Table -3: The effect of clinical, histopathologic and surgical factors on survival.

	Survival		p
	Alive	Death	
Sex			
Male	77	13	0.397
Female	23	2	
Resection			
Lobectomy	83	11	
Bilobectomy	10	3	
Segmentectomy	4	0	0.108
Lobectomy+Segmentectomy	1	0	
Pneumonectomy	2	0	
Lobectomy+TWR	0	1	
Pathology			
Adenocarsinoma	56	9	0.477
SCC	35	6	
NEC	9	0	
9.TNM Staging			
IA1	6	1	
IA2	9	1	
IA3	8	2	
IB	40	2	0.123
IIA	5	1	
IIB	23	6	
IIIA	9	1	
IIIB	0	1	
T Stage			
Tis	1	0	
1mi	1	0	
1a	4	2	
1b	11	1	
1c	8	2	0.046
2a	44	2	
2b	7	2	
3	22	6	
4	2	0	
Lymph Node Metastasis			
No	83	11	0.366
Yes	17	4	
Pleural invasion			
PL0	47	5	
PL1	30	4	0.254
PL2	20	4	
PL3	3	2	
Lymphovascular invasion			
No	93	10	0.002
Yes	7	5	
Perineural invasion			
No	94	13	0.298
Yes	6	2	
STAS			
No	90	12	0.254
Yes	10	3	
Complication			
No	85	12	0.619
Yes	15	3	
Malignancy at follow-up			
No	88	12	0.391
Yes	12	3	

(PL: Pleural layer; SD: Standart deviation; STAS: Tumor spread through air spaces; Tis: Insitu tumor; TWR: Thoracic Wall resection; 1mi: histopathology of minimally invasive tumor)

The presence of lymphovascular invasion (LVI) significantly affected survival (p=0.002). In patients without LVI, the survival rate was 90.3% (n=93), whereas in patients with LVI, the survival rate dropped to 58.3% (n=7). No significant relationship was found between survival and perineural invasion, STAS presence, or postoperative complications. Additionally, no statistically significant difference was observed between malignancy recurrence and survival (p=0.391).

The survival rate in patients without malignancy recurrence was 88.0% (n=88), while it was 80.0% (n=12) in those with recurrence. In the Kaplan-Meier survival analysis of T-stage, presented in Figure 4, a significant difference in survival rates among different T-stages was observed (Log-rank: 18.118, degrees of freedom (df): 9, p=0.034).

Similarly, in the Kaplan-Meier survival analysis based on lymphovascular (LV) invasion, shown in Figure 5, LV invasion was found to have a significant impact on survival rates (Log-rank: 8.596, df: 1, p=0.003). Notably, during the first 20–30 months of follow-up, a sharp decline in the survival curve was observed in patients with LV invasion.

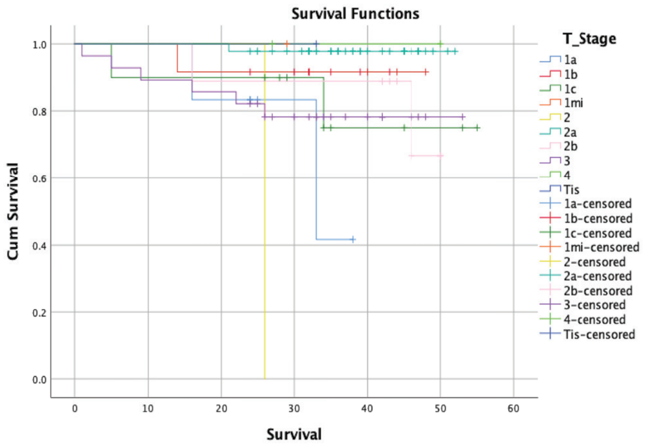


Figure -4: Survival analysis of patients included in the study according to T stage (Log-rank: 18.118, df: 9, p=0.034)

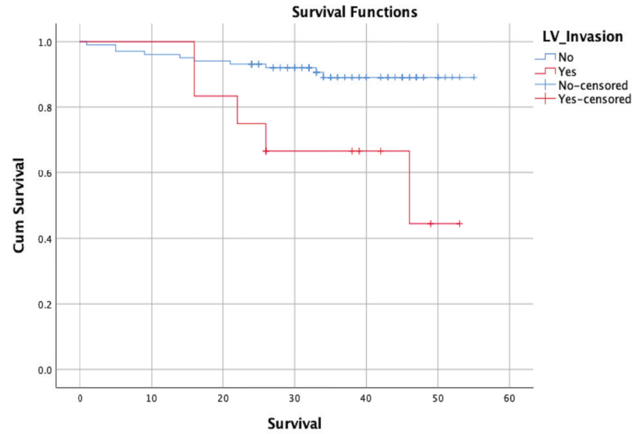


Figure-5: Survival analysis of patients included in the study according to lymphovascular invasion status (Log-rank: 8.596, df: 1, p=0.003)

Discussion

This retrospective, single-center study comprehensively analyzed the early postoperative outcomes and survival of patients who underwent anatomical resection via U-VATS for primary lung cancer. Surgical safety was assessed based on perioperative complications, chest tube duration, and length of hospital stay, while oncologic principles were evaluated using intraoperative staging criteria, histopathological characteristics, and survival analysis. With acceptable complication rates, this study highlights that U-VATS can be safely utilized in the surgical treatment of lung cancer. Additionally, a detailed evaluation of prognostic factors influencing survival after surgery has been emphasized, providing valuable clinical insights for future prospective studies.

Compared to open surgery and conventional VATS, U-VATS has been shown to be at least as safe as other techniques. Drevet et al. reported that U-VATS is a safe and feasible approach for both standard and complex lung surgeries (7). Similarly, AlShimali et al. reported that U-VATS provides comparable safety and postoperative outcomes to triportal VATS (8). The common aspect of these studies is that they evaluated perioperative parameters, morbidity, and mortality outcomes to assess surgical safety. In contrast, Nachira et al. focused on oncologic parameters, including lymph node dissection, R0 resection, and survival outcomes, and concluded that U-VATS is comparable to other techniques while offering advantages such as reduced postoperative pain and shorter hospital stays (9). In our study, we compared perioperative parameters and survival outcomes of anatomical resections performed with U-VATS to the existing literature. Harris et al., in a meta-analysis comparing U-VATS and M-VATS, reported an average conversion to open thoracotomy rate of 3.6% and 2.6%, respectively. Additionally, they found chest tube duration to be 4.5/5.3 days and hospital stay to be 6.2/6.7 days. Similarly, Savoie-White et al., in a systematic review of 12 studies, reported that chest tube duration and hospital stay were similar between U-VATS and other approaches, while U-VATS was associated with less intraoperative bleeding (10).

Furthermore, two different studies investigating surgical treatment of lung cancer demonstrated that U-VATS was associated with fewer complications and less postoperative pain (11, 12). In our study, the intraoperative complication rate was 4.34% and the conversion to open thoracotomy rate was 1.8%. Despite a postoperative complication rate of 15.7%, the median chest tube duration was 2 days, and the median hospital stay was 4 days. These findings, which indicate shorter durations compared to the literature, further support the safety of U-VATS in surgical treatment. Adherence to oncologic principles is the most critical factor influencing treatment success for all surgeons involved in cancer surgery (13). Tumor characteristics, lymph node involvement, and distant organ metastasis directly impact survival and serve as key determinants for disease staging (14). In addition to these oncologic factors, surgical parameters that directly influence survival include complete microscopic tumor resection, adequate lymph node dissection, and accurate pathological staging.

The Uniportal VATS Interest Group (UVIG) consensus of the European Society of Thoracic Surgery (ESTS) has endorsed the use of U-VATS in the surgical treatment of early-stage lung cancer (2). In lung cancer surgery, the extent of anatomical resection is determined based on the T factor. U-VATS has been shown to be a safe approach for all types of lung resections, including pneumonectomy and other complex procedures (15-18). In our study, the predominance of T2a-stage patients suggests that most cases were surgically operable. The low proportion of early-stage tumors (Tis, T1a, T1b, T1c) was attributed to restrictions imposed during the COVID-19 pandemic, which led to delays in surgery for early-stage disease or the preference for non-surgical treatment options. Furthermore, our study confirms, through T-stage-based survival analysis, that survival rates are significantly higher in early T-stages, whereas they decline substantially in advanced stages.

Adequate lymph node evaluation is crucial for accurate staging, which directly impacts treatment decisions. Several studies have demonstrated that VATS is an effective method for mediastinal lymph node dissection, achieving outcomes comparable to, or even superior to, those of thoracotomy (11, 19).

Moreover, studies comparing lymph node dissection performed via U-VATS and conventional VATS have reported no significant differences between the two techniques. Some studies have even suggested that U-VATS may be superior in terms of the number of harvested lymph nodes (20-23). In addition, Buz et al. stated that tumors involving lymph nodes may be associated with poor outcomes (24). Therefore, ipsilateral lymph node dissection is recommended during surgical treatment of lung cancer (2). In our study, systematic lymph node dissection was performed using the U-VATS approach, with an average of five lymph node stations dissected and a mean of nine lymph nodes harvested. The lymph node metastasis rate was 18.3%, yet no statistically significant association with survival was observed. However, among histopathological characteristics, lymphovascular invasion (LVI) was identified as a factor directly associated with survival. Lymphovascular invasion is a key prognostic factor, indicating the aggressive biological behavior of tumors. This study suggests that patients with LVI are at higher risk for disease recurrence and should be closely monitored. The presence of LVI may increase the need for adjuvant therapy and should be carefully considered in postoperative management. This study has several limitations. First, it has a retrospective design, which may introduce selection bias. Additionally, as a single-center study, the generalizability of the findings to larger patient populations is limited. The sample size was relatively small, which may have reduced the statistical power of survival analyses, particularly in advanced-stage tumors. The mean follow-up period was 35.1 ± 10.7 months, which may not be sufficient to evaluate long-term oncologic outcomes. Lastly, certain confounding factors, such as smoking status and pulmonary function, which could potentially influence survival, were not fully controlled. Considering these limitations, the findings of this study should be further validated through multi-center, prospective studies with larger patient cohorts.

In conclusion, U-VATS is a safe and feasible surgical approach for lung cancer treatment, adhering to oncologic principles while maintaining acceptable perioperative complication rates. A more comprehensive understanding of prognostic factors affecting survival after lung surgery requires large-scale, multi-center studies with long-term follow-up. This study highlights the effectiveness of U-VATS in lung cancer surgery and provides valuable clinical insights for future surgical strategies.

Funding statement

This research received no external funding.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethics Committee Approval:

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (approval number: 2025/146; approval date: 12 March 2025).

Peer-review: Externally peer-reviewed.

Conflict Of Interest: The authors declare that there are no conflicts of interest.

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