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Video-Assisted Thoracoscopic Sleeve Lobectomy Versus Open Approach in Non-Small Cell Lung Cancer: A Single-Center Study with Propensity Score Matching

Küçük Hücreli Dışı Akciğer Kanserinde Video Yardımlı Torakoskopik Sleeve Lobektomi ve Açık Yaklaşım: Propensity Skor Analizi ile Tek Merkezli Çalışma

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ABSTRACT

Aim: It was aimed to compare the outcomes of sleeve lobectomy with video-assisted thoracoscopic surgery (VATS) and thoracotomy in patients with centrally located non-small cell lung cancer (NSCLC).

Materials and Methods: Between January 2020 and February 2024, 127 patients who underwent sleeve lobectomy for NSCLC were retrospectively analyzed. Thoracotomy was used in 105 (82.6%) sleeve lobectomy cases while VATS was used in 22 (17.4%) cases. Subgroups were created according to pathology stages using propensity score analysis. Both groups were compared in terms of perioperative and early postoperative complications.

Results: No significant differences were found between the thoracotomy and VATS groups in operation time or perioperative bleeding (4.3±0.9 hours vs 4.5±0.9, 467±385 mL vs 370±70 mL, p=0.474, 0.525, respectively). However, drainage time and hospital stay were significantly shorter in the VATS group (4.5±4 days vs 3.6±3.3 days, 7.1±7.9 days vs 5.1±3.4 days, respectively, (p=0.014, 0.005). In terms of oncological principles, there was no statistically significant difference between the groups regarding the number of sampled lymph nodes, pathological tumor sizes, pathological stages, and histopathological cell types (p=0.349, 0.106, 0.709, 0.066, respectively). There was no significant difference between the groups in terms of early postoperative complications (30.5% vs 40.9%, p: 0.341). After propensity score analysis, it was found that the VATS group had shorter drainage and hospital stay (p=0.023, 0.043, respectively).

Conclusion: In NSCLC cases, sleeve lobectomies performed with the VATS approach are superior to open surgery with shorter drainage times and hospital stays without compromising oncological principles.

Keywords: Video-assisted thoracoscopic surgery, lung cancer, sleeve resection

ÖZ

Amaç: Santral yerleşimli küçük hücreli dışı akciğer kanseri (KHDAK) olgularında video yardımlı torakoskopik cerrahi (VATS) ile sleeve lobektomi ve torakotomi ile sleeve lobektomi yaklaşımında sonuçlarımızı karşılaştırdık.

Gereç ve Yöntem: Ocak 2020 ve Şubat 2024 yılları arasında, KHDAK tanısıyla sleeve lobektomi yapılan 127 olgu retrospektif olarak incelendi. Sleeve lobektomi yapılan olguların 105'ine (%82,6) torakotomi, 22 (%17,4) olguya VATS uygulandı. Alt gruplar, patoloji evrelerine göre propensity skor analizi ile oluşturuldu. Her iki grup perioperatif ve erken postoperatif komplikasyonlar açısından karşılaştırıldı.

Bulgular: Torakotomi grubu ve VATS grubu arasında, operasyon süresi ve peroperatif kanama miktarları açısından istatistiksel olarak anlamlı bir fark görülmedi (4,3±0,9 saat vs 4,5±0,9, 467±385 mL vs 370±70 mL, sırasıyla p=0,474, 0,525). Fakat, VATS grubunda, drenaj süresi ve hastanede

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kalış süresi istatistiksel olarak anlamlı şekilde daha kısaydı (4,5±4 gün vs 3,6±3,3 gün, 7,1±7,9 gün vs 5,1±3,4 gün, sırasıyla p=0,014, 0,005). Onkolojik prensipler açısından gruplar arasında; örneklenen lenf nodu sayısı, patoloji tümör boyutları, patolojik evreler ve histopatolojik hücre tipleri arasında, gruplar arası istatistiksel anlamlı fark saptanmadı (sırasıyla p=0,349, 0,106, 0,709, 0,066). Gruplar arasında, postoperatif erken dönem komplikasyonlar açısından anlamlı fark yoktu (%30,5 vs % 40,9, p: 0,341). Propensity skor analizi sonrası gruplar arasında VATS grubunda daha kısa süre drenaj ve hastane yatışı olduğu saptandı (p=0,023, 0,043).

Sonuç: KHDAK olgularında VATS yaklaşımı ile yapılan sleeve lobektomiler, onkolojik prensiplerden ödün vermeden, daha kısa drenaj süreleri ve daha kısa hastanede kalış süreleri ile açık cerrahiye üstünlük göstermektedir.

Anahtar Kelimeler: Video yardımlı torakoskopik cerrahi, akciğer kanseri, sleeve rezeksiyon

INTRODUCTION

Surgery is the accepted treatment modality for early and locally advanced non-small cell lung cancer (NSCLC)[1]. The standard approach in centrally located tumors has been pneumonectomy for years[2]. Since 1956, when Dr. Thomas first described sleeve resection in a case of lung cancer, this procedure has been accepted as an alternative to pneumonectomy for centrally located tumors, preserving more lung parenchymal tissue without compromising oncological principles[3]. Bronchoplastic resections are required in 3%-19% of NSCLC cases[4]. Sleeve resections have been performed with open surgery in experienced centers for years since they are technically challenging and require significant experience in operations. As a result of the experience developed in minimally invasive surgery in recent years, complex and extended surgeries such as sleeve resection can be performed by experienced centers and physicians with video-assisted thoracoscopic surgery (VATS) approaches[5].

In our study, we compared the perioperative and early postoperative results of patients who underwent VATS sleeve lobectomy for NSCLC with the open surgical method in terms of the safety of the method and its compliance with oncological principles.

MATERIALS AND METHODS

Patient Selection

We retrospectively analyzed 127 patients who underwent sleeve lobectomy for lung cancer between January 2020 and February 2024. To determine the compliance of VATS sleeve resections with oncological principles, patients who underwent sleeve resection for non-tumor reasons were not included in the study. The study was approved by the ethics/scientific committee of University of Health Sciences Türkiye, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital and (decision no: 2023-462.28, date: 12.2023) was conducted by the principles of the Declaration of Helsinki.

Surgical Technique

All cases were evaluated with positron emission-computed tomography (PET-CT) in the preoperative period. Mediastinoscopy or endobronchial ultrasonography was performed for mediastinal staging in cases with no distant metastasis detected on PET-CT and suspicious mediastinal lymph node invasion findings. In patients with single and non-bulky N2, 3 cycles of platinum-based chemotherapy (3 cycles of nivolumab were added to neoadjuvant CT in 3 patients in the VATS group) and surgery was performed in patients with downstaging in terms of N2. Direct surgery was performed in cases without suspicion of mediastinal lymph node invasion. In cases with multiple N2, bulky N2, or no downstage after neoadjuvant treatment, surgery was not considered, and these cases were referred to oncology clinics for definitive treatment. T0 cases reflect complete pathological response post-neoadjuvant the therapy.

Indications for sleeve resection were often established preoperatively by radiological and bronchoscopic evaluations. However, in some cases, it was also decided based on perioperative findings during the operation. Indications for sleeve resection were tumor extension from the lobe bronchus to the secondary carina, progression to the main bronchus and/or invasion of the secondary carina outside the lobe bronchus by a metastatic interlobar (#11) lymph node.

Bronchovascular (double sleeve) lobectomy was performed in cases with simultaneous pulmonary artery invasion and carinal sleeve lobectomy in cases invading the carina. These cases were defined as extended sleeve resections in this study.

Bronchopleural fistulas (BPF) that developed after sleeve anastomosis were defined as early BPF if they developed within the first 7 days, intermediate BPF if they developed between 7-30 days, and late BPF if they developed >30 days later. Postoperative complications were graded according to the extended Clavien-Dindo classification of surgical complications established by the Japan Clinical Oncology Group.

In this study, VATS sleeve resections performed between 2020-2022 were defined as the first period while VATS sleeve resections performed after January 2023 were defined as the second period. This process was carried out by a single surgical team, utilizing an established and experienced team for VATS lobectomy and VATS segmentectomy procedures. The initiation of extended surgical procedures was used to divide the timeline into two periods, and a retrospective evaluation was conducted to compare the first and second periods.

Technical Consideration in VATS Sleeve Lobectomy

To provide more space for manipulation and to avoid unnecessary traction of the anastomosis, a systematic lymphadenectomy was routinely performed before the anastomosis. During anastomosis, care should be taken to ensure that the cartilage and membranous faces are opposite. A continuous suture technique with a 3/0 prolene needle is used in our clinic. The frequently preferred anastomosis technique is to start suturing from the proximal bronchus from the inside out at the junction of the cartilage and membranous structure. To avoid tangling the sutures during the procedure, it is beneficial to pass this first suture through the parietal pleura of the chest wall and out of the thorax and continue the anastomosis with the other needle tip. After anastomosis, air leakage is checked, and the surgeon may place additional sutures if deemed necessary. Especially in cases where sleeve resection is performed after neoadjuvant treatment, the anastomosis line can be supported with a live flap (parietal pleura, pericardial fatty tissue) if the surgeon deems it necessary. Images of the patient on whom we performed VATS right upper sleeve lobectomy are shown in Figure 1.

Statistical Analysis

While the data were analyzed retrospectively through patient files, there was no missing data since the patients in the study belonged to the last years. Windows Office Excel 2020 and Word 2019 versions were used to create the database. IBM SPSS Statistics Version 26 program was used for statistical calculations. The descriptive results of the study are presented together with the corresponding percentages in the case of nominal or ordinal variables. Continuous variables are presented with mean and standard deviation values. Pearson's chi-square test and Fisher's exact test were used for categorical variables, and the Mann-Whitney U test was used for non-categorical variables. Propensity score analysis was used to make peer groups according to pathological staging. The data were matched in a 1:1 ratio using logistic regression with the nearest method. "p" value below 0.05 was considered significant.

RESULTS

In 105 (82.6%) sleeve resection cases, posterolateral/anterolateral thoracotomy was performed (Thoracotomy group), while sleeve resection was performed by VATS in 22 (17.4%) cases (VATS group). While 22.7% (n=5) of VATS cases were performed uniportal, 77.3% (n=17) cases were performed with the biportal technique. Among 32 cases in which surgery was initiated with a VATS approach, conversion to thoracotomy was required in 10 cases and the conversion rate was 10/32 (31.2%). The reasons for conversion to thoracotomy were technical difficulty in five cases, severe adhesion in two cases and vascular hemorrhage in three cases.

Mean age of all patients was 58.6±11.6 years (range: 16-78), and the majority of the patients were male (n=106, 83.5%). There were no statistically significant differences between the groups in age, gender, smoking and forced vital capacity in 1st second (p=0.339, 0.390, 0.894, 0.087, respectively).

The operation time was 4.3±0.9 (range: 2.5-6) hours in the Thoracotomy group and 4.5±0.9 (range: 3-6) hours in the VATS group. Perioperative bleeding was 467±385 mL (range: 350-3000 mL) in the Thoracotomy group and 370±70 mL (range: 350-650 mL) in the VATS group. No statistically significant difference was found between the groups (p: 0.474, 0.525, respectively). Perioperative bleeding exceeding 2 liters was observed in a single case and was attributed to vascular hemorrhage in the Thoracotomy group. In the Thoracotomy group, drainage time was 4.5±4 days (range: 1-30 days) and hospital stay was 7.1±7.9 days (range: 2-68 days), while in the VATS group, drainage time was 3.6±3.3 days (range: 2-18 days) and hospital stay was 5.1±3.4 days (range: 3-19 days). These differences between the groups were statistically significant (p: 0.014, 0.005, respectively) (Figure 2). The demographic characteristics of the patients and details of the preoperative and postoperative processes are summarized in Table 1.

There was no statistically significant difference between the groups in the number of sampled lymph nodes, pathological tumor sizes, pathological stages, and histopathological cell types (p=0.349, 0.106, 0.709, 0.066, respectively). The oncological features of the cases are provided in detail in Table 2. In both the Thoracotomy group (n=1, 0.9%) and VATS Group (n=1, 4.5%), the bronchial surgical margin was reported as R1 in two cases. In the Thoracotomy group, the bronchial surgical margin was identified as R1 in one case, and due to the detection of perioperative N2 positivity, further extension of the surgical margin was not performed. In the VATS group, the R1 margin was accepted owing to the patient's history of contralateral thoracic surgery, which limited further resection.

Between January 2020 and December 2022, 6 (50%) of the 12 patients started with VATS in the period we defined as the first period were switched to open. BPF was developed in one case (16.7%). VATS was not performed after neoadjuvant treatment in this period. In the first period, only 6.1% (n=6) of the patients who underwent sleeve resection in our clinic were performed via VATS.

In the second period after January 2023, when our experience developed, 20 cases were started with VATS and only 4 cases (20%) were switched to open. Out of 16 cases completed with VATS, BPF developed in only 2 cases (12.5%). In 3 cases (18.7%), VATS sleeve resection was performed after neoadjuvant treatment. With increasing experience, 3 sleeve lower bilobectomies and one case of broncho-vascular sleeve resection were performed in this period. In 55% (n=16) of the

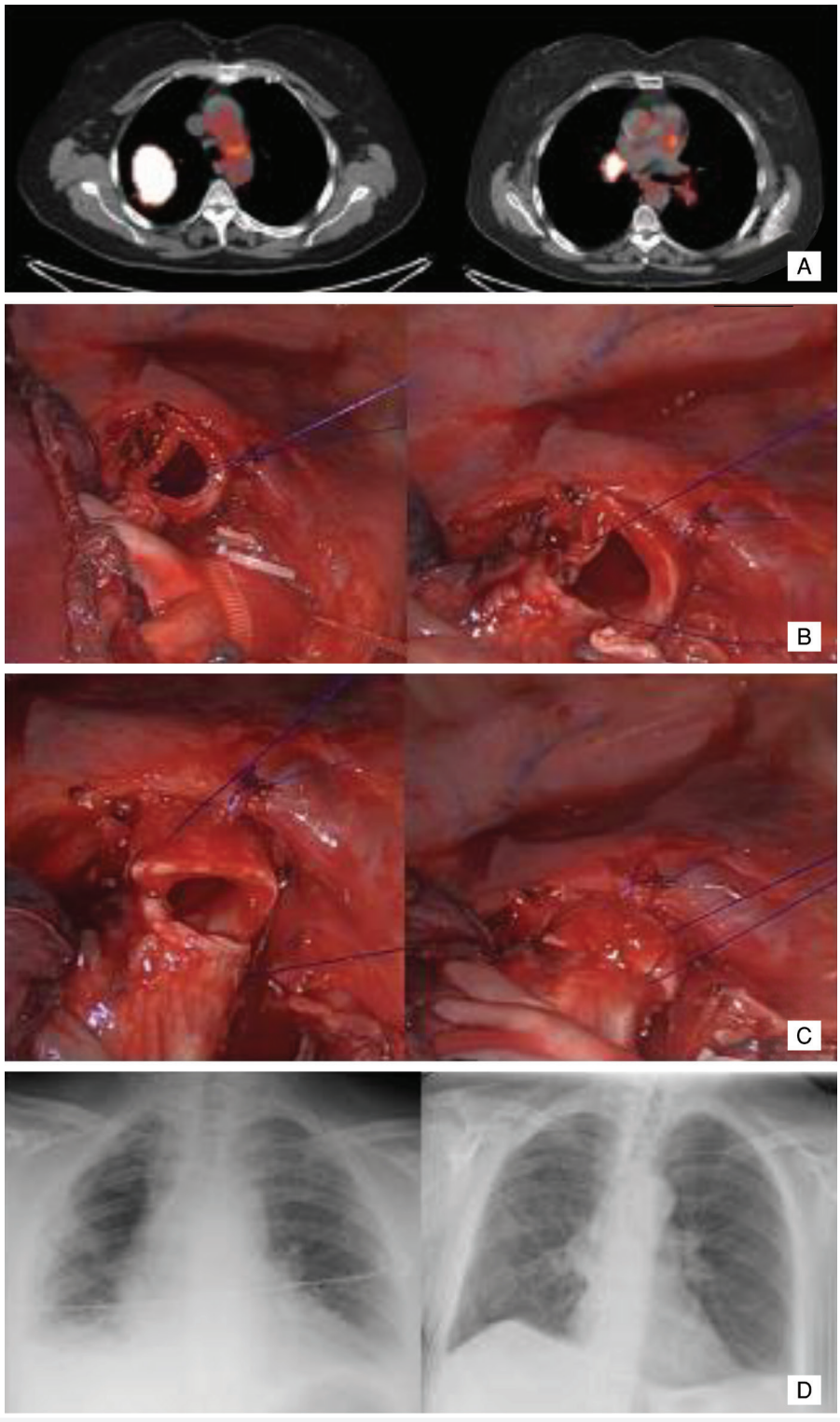

Figure 1. A) The patient, who was evaluated due to a complaint of cough, was found to have a right upper lobe mass. Subsequently, a PET-CT scan was performed, and the sections demonstrating the involvement of the mass and the right hilar lymph node are presented. B, C) After transection of the right upper lobe bronchus and removal of the specimen, the perioperative images demonstrate the anastomosis of the right main bronchus to the interlobar bronchus, initiated from the posterior membranous wall. D) Postoperative first-day and postoperative fifth-day chest radiographs are shown in the images

PET-CT: Positron emission-computed tomography

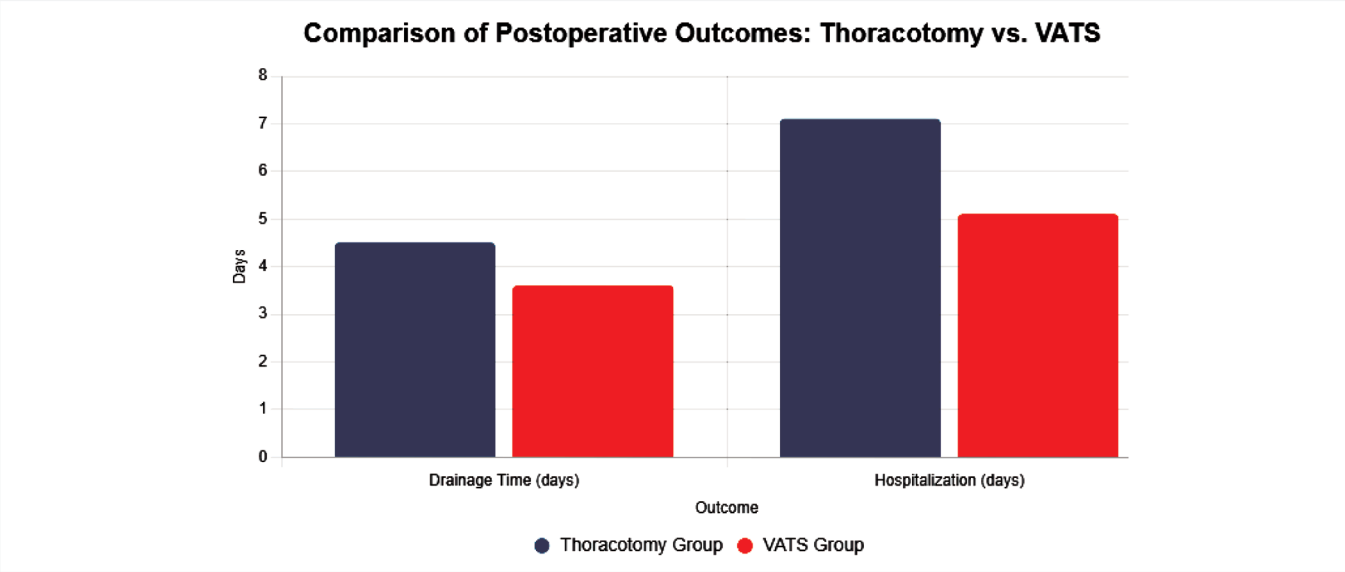

Figure 2. Comparison of postoperative outcomes

In the thoracotomy group, drainage time was 4.5 days, while in the VATS group, drainage time was 3.6 days (p=0.014). In the thoracotomy group, hospital stay was 7.1 days, while in the VATS group, hospital stay was 5.1 days (p=0.005)

VATS: Video-assisted thoracoscopic surgery

Table 1. Demographic characteristics of the patients, preoperative and postoperative process details

Variables	Units	All patients (n=127)	Thoracotomy group (n=105)	VATS group (n=22)	p-value
Age ± SD	Years	58.6±11.6 (R: 16-78)	58.2±11.5 (R: 16-77)	60.7±11.9 (R: 27-78)	p=0.339
Male (n/%) Female (n/%)	Sex	106 (83.5%) 21 (16.5%)	89 (84.8%) 16 (15.2%)	17 (77.3%) 5 (22.7%)	p=0.390
Smoking ± SD	Pack/year	30.7±16.5 (R: 0-50)	30.9±16.4 (R: 0-50)	30±17.4 (R: 0-50)	p=0.894
FEV1 (n/%) <50 50-60 60-80 >80	%	 7 (5.5%) 18 (14.2%) 59 (46.5%) 43 (33.9%)	 5 (4.8%) 16 (15.2%) 53 (50.5%) 31 (29.5%)	 2 (9.1%) 2 (9.1%) 6 (27.3%) 12 (54.5%)	p=0.087
Operation time ± SD	Hours	4.4±0.9 (R: 2.5-6)	4.3±0.9 (2.5-6)	4.5±0.9 (3-6)	p=0.474
Amount of perioperative bleeding ± SD	mL	450±353 (R: 350-3000)	467±385 (350-3000*)	370±70 (350-650)	p=0.525
Drainage time ± SD	Days	4.4±3.9 (R: 1-30)	4.5±4 (1-30)	3.6±3.3 (2-18)	**p=0.014**
Duration of hospitalization ± SD	Days	6.7±7.3 (R: 2-68)	7.1±7.9 (2-68)	5.1±3.4 (3-19)	**p=0.005**

*Perioperative bleeding exceeding 2 liters was observed in a single case and was attributed to vascular hemorrhage in the thoracotomy group

FEV1: 1. forced vital capacity per second, n: Number, R: Range, SD: Standard deviation, VATS: Video-assisted thoracoscopic surgery

patients who underwent sleeve resection in our clinic during the second period, the procedure was performed by VATS. The periodical development of our clinic in VATS sleeve resections is summarized in Table 3.

Complications were seen in 41 (32.3%) of all sleeve resection cases. Early postoperative complications were observed in 32 (30.5%) patients in the Thoracotomy group and 9 (40.9%) patients in the VATS group. No significant difference was observed between the groups in terms of complication development (p: 0.341). In the Thoracotomy group, 12 (11.4%) cases were revised early or late, while 4 (18.2%) cases were revised in the VATS group (p=0.477). Postoperative 30-day mortality was 2 (1.9%) in the Thoracotomy group, while there was no early mortality in the VATS group (p=0.682).

Complication details and 30-day mortality are summarized in Table 4. The characteristics of the patients after propensity score analysis are shown in Table 5 and the VATS group had shorter drainage and hospital stay (p=0.023, 0.043, respectively).

DISCUSSION

Sleeve resections have been performed as parenchyma-sparing surgery in lung cancer treatment with the open surgical method by experienced centers for years[6]. Protection of patients from pneumonectomy brings with it advantages such as better quality of life, better survival, lower mortality, morbidity, and recurrence rates[6-8].

The VATS approach in thoracic surgery has been shown to reduce morbidity, shorten drainage duration, and decrease the length of hospital stay. Additionally, it contributes to improved postoperative quality of life[8]. However, the place and

Table 2. Oncological features of the cases

Variables	All patients (127) n (%)	Thoracotomy (105) n (%)	VATS (22) n (%)	p-value
Resection side				
Right	84 (66.1%)	71 (67.6%)	13 (59.1%)	p=0.442
Left	43 (33.9%)	34 (32.4%)	9 (40.9%)	
Neoadjuvant treatment	17 (13.4%)	14 (13.3%)	3 (13.6%)	p=0.970
Extended surgery	12 (9.4%)	11 (10.4%)	1 (4.5%)	p=0.690
Double sleeve	9 (7.1%)	8 (7.6%)	1 (4.5%)	p=0.516
Carinal sleeve	3 (2.4%)	3 (2.9%)	--	p=1
Upper lobectomy	75 (59.1%)	60 (57.1%)	15 (68.2%)	
Upper bilobectomy	5 (3.9%)	5 (4.8%)	--	
Middle lobectomy	3 (2.4%)	3 (2.9%)	--	p=0.133
Lower lobectomy	34 (26.8%)	30 (28.6%)	4 (18.2%)	
Lower bilobectomy	10 (7.9%)	7 (6.7%)	3 (13.6%)	
Number of lymph node stations sampled	6.8±1 (R: 6-10)	6.8±0.9 (R: 6-10)	7±1.1 (R: 6-10)	p=0.349
Squamous cell carcinoma	85 (66.9%)	75 (71.4%)	10 (45.5%)	
Carcinoid tumor	21 (16.5%)	14 (13.3%)	7 (31.8%)	p=0.066
Adenocarcinoma	12 (9.4%)	10 (9.5%)	2 (9.1%)	
Other*	9 (7.1%)	6 (5.7%)	3 (13.6%)	
Pathology T size (cm)	3.6±1.9 (R: 0-15)	3.7±2 (R: 0-15)	3±1.5 (R: 0-6.5)	p=0.106
Pathology T staging				
T0	2 (1.6%)	1 (1%)	1 (4.5%)	
T1	43 (33.9%)	35 (33.3%)	8 (36.4%)	p=0.793
T2	52 (40.9%)	44 (41.9%)	8 (36.4%)	
T3	24 (18.9%)	20 (19%)	4 (18.2%)	
T4	6 (4.7%)	5 (4.8)	1 (4.5%)	
Pathology lymph node staging				
N0	77 (60.6%)	64 (61%)	13 (59.1%)	p=0.363
N1	37 (29.1%)	32 (30.5%)	5 (22.7%)	
N2	13 (10.2%)	9 (8.6%)	4 (18.2%)	
Pathology staging				
Stage 0	2 (1.6%)	1 (1%)	1 (4.5 %)	
Stage 1A	33 (26%)	28 (26.7%)	5 (22.7 %)	
Stage 1B	24 (18.9%)	20 (19%)	4 (18.2 %)	p=0.709
Stage 2B	46 (36.2%)	38 (36.2%)	8 (36.4 %)	
Stage 3A	16 (12.6%)	14 (13.3%)	2 (9.1 %)	
Stage 3B	6 (4.7%)	4 (3.8%)	2 (9.1 %)	
R0 resection	125 (98.4%)	104 (99%)	21 (%95.5)	p=0.318
R1 resection	2 (1.6%)	1 (1%)	1 (%4.5)	

*Adenosquamous carcinoma, mixed neuroendocrine tumor, pleomorphic carcinoma, inflammatory myofibroblastic tumor and unspecified type

VATS: Video-assisted thoracoscopic surgery, T: Tumor, n: Number, R: Range

Table 3. Periodical development in VATS sleeve resections

	First period (year 2020-2022) n=6	Second period (after January 2023) n=16
Conversion rate (VATS /initiated with VATS)	6/12 (50%)	4/20 (20%)
After neoadjuvant therapy n (%)	--	3 (100%)
Complication rate	2 (33.3%)	7 (43.8%)
BPF n (%)	1 (16.7%)	2 (12.5%)

BPF: Bronchopleural fistula, VATS: Video-assisted thoracoscopic surgery, n: Number

Table 4. Early postoperative morbidity and 30-day mortality

Variables	All patients (127) n (%)	Thoracotomy group (105) n (%)	VATS group (22) n (%)	p-value
Complications	41 (32.3%)	32 (30.5%)	9 (40.9%)	p=0.475
BPF	9 (7%)	6 (5.7%)	3 (13.6%)	
Early (1-7 days)	2	2	--	
Medium (7-30 days)	6	3	3	p=0.188
Late (>30 days)	1	1	--	
BPF Treatment				
Complementary pneumonectomy	6 (66.6%)	5 (83.3%)	1 (33.3%)	
- Omentum support available	2	2	--	
- Omentum support not available	4	3	1	
- Addition of middle lobectomy	1	--	1	
- Primary repair	2	1	1	
Revised cases	16 (12.6%)	12 (11.4%)	4 (18.2%)	
- BPF	9	6	3	
- Hemorrhage/hematoma	1	1	--	p=0.477
- Middle lobe syndrome	1	1	--	
- Wound site infection	5	4	1	
Grade II	15 (36.6%)	13 (40.6%)	2 (22.2%)	
AF/cardiac problems	5	4	1	
Metabolic problems	2	1	1	
Pneumonia	2	2	--	
PAL	6	6	--	
Grade IIIA*	6 (14.6%)	5 (15.6%)	1 (11.1%)	
Empyema	1	1	--	
Secretion retention	3	2	1	
PAL (requiring revision)	2	2	--	
Grade IIIB**	16 (39%)	12 (37.5%)	4 (44.4%)	
BPF	9	6	3	
Hemorrhage/hematoma	1	1	--	
Middle lobe syndrome	1	1	--	
Wound infection	5	4	1	
Grade IV	2 (4.8%)	1 (3.1%)	1 (11.1%)	
Pulmonary embolism	1	--	1	
Pneumonia (tracheotomy opened)	1	1	--	
Grade V	2 (1.57%)	2 (1.9%)	--	p=0.682
Mortality (30-days)	2	2	--	

*: Grade, IIIA: Intervention under local anesthesia, **: Grade,VATS: Video-assisted thoracoscopic surgery, BPF: Bronchopleural fistula, AF: Atrial fibrillation, PAL: Prolonged air leak, IIIB: Intervention under general anesthesia, n: Number

benefits of the VATS approach in more extended and complex cases such as sleeve resections is a controversial issue.

As a result of the developments in the field of minimally invasive surgery, in 2002, Santambrogio et al.[9] performed sleeve resection with VATS for the first time in a 15-year-old patient diagnosed with mucoepidermoid carcinoma and in the following years, sleeve resection with VATS was performed in experienced centers with large series. VATS sleeve resection operations, which have started in our clinic in recent years, have increased over the years and today most cases requiring sleeve anastomosis can be performed by VATS. In a study by Huang et al.[10] in 2016, 118 VATS bronchial sleeve cases were approached with 3 ports. Similarly, Acar and Ceylan[11] defined the technique as 3 ports in their VATS sleeve resection series. On the other hand, Gonzalez-Rivas et al.[12] published their first case of uniportal VATS sleeve lobectomy in 2013 and published a large series in the following years[13]. In our clinic, the three-port approach was not used in any case. Although biportal approach was the preferred method, 22.7% of the cases were performed by uniportal approach.

Zhang et al.[14] underlined that at least 100 standard lobectomies by VATS and at least 10 sleeve lobectomies by thoracotomy are required to gain sufficient experience and expertise in VATS sleeve resections. Imai and Weksler[5] also emphasized that applying VATS in such complex procedures requires meticulous planning and considerable technical expertise. In a series of 201 cases of sleeve resection between 2010-15 using the National Cancer Data Base (NCDB), the rate of patients who underwent VATS was reported to be 21%[15]. Although this rate was 17.4% in our study, this rate has reached 55% with increasing experience in recent years. However, despite all this experience, surgeons should always keep in mind the decision criteria and timing for conversion to thoracotomy[16].

When the literature is analyzed, conversion to thoracotomy rates, European Society of Thoracic Surgeons (ESTS) database and the US NCDB, these values were 24.5% and 20.5%, respectively[17-19]. Despite these high rates[19], conversion to thoracotomy rates have been reported to be quite low in Chinese studies, ranging from 2.9% to 4.5%[19]. Although our conversion rate was as high as 31.2% in our study, this rate decreased to 20% in the second period with the experience we gained, according to the ESTS database. In the initial period, a higher rate of conversion to thoracotomy was observed due to the preference for initiating surgery with VATS in cases where preoperative thoracic CT imaging did not allow for a definitive decision. With the accumulation of experience, the conversion rate has subsequently decreased. As a result of increasing experience, more extended sleeve resections can be performed in experienced centers. In our clinic, broncho-vascular sleeve resection in one case, sleeve bilobectomy in 3 cases and sleeve resection after neoadjuvant treatment in 3 cases were performed in the advanced period.

Table 5. After propensity score matching

	Thoracotomy group n=22 (%)	VATS group n=22 (%)	p-value
Age ± SD	59.3±11.7	60.7±11.9	p=0.707
Male Female	20 (90.9) 2 (9.1)	17 (77.3) 5 (22.7)	p=0.412
Smoking (pack/year) ± SD	32±15.7	30±17.4	p=0.774
Neoadjuvant treatment	4 (18.2)	3 (13.6)	p=1
Right zone Left zone	14 (63.6) 8 (36.4)	13 (59.1) 9 (40.9)	p=0.757
Extended surgery (double sleeve)	1 (4.5)	1 (4.5)	p=1
Operation time (hours) ± SD	4.5±1 (R: 3-6)	4.5±0.9 (R:3-6)	p=0.962
Amount of perioperative bleeding (mL) ± SD	459±356 (R: 350-1700)	370±70 (R: 350-650)	p=0.925
Drainage time (days) ± SD	5.3±5.8 (R: 2-29)	3.6±3.3 (R:2-18)	p=0.023
Duration of hospitalization (days) ± SD	7.7±7.7 (R: 3-34)	5.1±3.4 (R:3-19)	p=0.043
Complication Minor Major	8 (36.4) 1 (4.5) 7 (31.8)	9 (40.9) 2 (9.1) 7 (31.8)	p=0.951
Bronchopleural fistula	2 (9.1)	3 (13.6)	p=1
Mortality (30-days)	--	--	p=1

VATS: Video-assisted thoracoscopic surgery, SD: Standard deviation, n: Number, R: Range

Although the VATS sleeve resection technique provides the advantages of a minimally invasive approach, it is an important issue whether the method provides oncological principles compared to open surgery. In their meta-analysis, Deng et al.[19] have reported that VATS has similar oncological outcomes to open surgery. Yang et al.[20] have also demonstrated comparable short- and long-term outcomes in their propensity score matched analysis of VATS versus open thoracotomy sleeve lobectomy cases. In the present study, we did not observe any difference between the groups in terms of oncological results from the literature.

In the NCDB, the duration of hospital stay after open surgery and VATS sleeve resection was reported to be 6 days in both groups[16]. In their evaluation using the ESTS database, Gonzalez et al.[17] evaluated 1652 sleeve lobectomy patients performed by 270 thoracic surgery units from 25 different European countries between 2007 and 2021 and showed a significant difference in hospital stay between open surgery and VATS patient groups (5 vs 8 days). In the same study, VATS sleeve resection was associated with significantly decreased overall morbidity (30.4% vs 41.7%, p=0.006). In our case series, there was no statistically significant difference between the groups in terms of postoperative complications. Similar to the Gonzalez review, we observed that patients were discharged faster in the VATS group and this difference was statistically significant (7.1 vs 5.1 days).

Xie et al.[18] reported that thoracic drains were terminated more rapidly in patients undergoing sleeve resection by VATS. (6 vs 5 days). In our study, we found statistically significantly shorter drainage times in the VATS group (4.5 vs 3.6).

According to the meta-analysis results of 5 studies with a total of 436 patients comparing the preoperative findings of both groups, less blood loss and longer operation time were observed in the VATS sleeve group[21]. Geropoulos reported this time as 45 minutes longer in the VATS group in his case series[22]. In our study, we observed less blood loss in the VATS sleeve group, although not statistically significant. Also, we did not observe a significant difference between the groups in terms of operative times.

The most important problems that may develop in sleeve resections are those related to anastomosis lines. Tapias et al.[23] reported this rate as 4.3% in VATS sleeve resection cases. The rate of BPF in our patient cohort is higher than in the literature. However, with increasing experience, this rate has reached levels compatible with the literature in the advanced period (6.2%). In the literature, many studies, mainly from China, have been published in recent years on the results of VATS sleeve resections and/or comparisons with open surgery (Table 6)[15,17,18,20,21,23,24,25].

Study Limitations

There are some limitations to the study. First, our study is retrospective. Although we are a high-volume hospital and have experience in sleeve resections in open surgery, our VATS experience in these cases has increased in recent years. Therefore, our number of patients is considerably lower than similar studies in the literature and our outcomes have reached levels compatible with the literature only in recent years. Another limitation of our study is that we cannot state whether the method provides a survival advantage over open surgery because the patient results have not yet reached sufficient time for survival analyses. One of the biggest advantages of minimally invasive surgery compared to open surgery is its effects on early pain and quality of life. Unfortunately, no evaluation of these parameters was made in our study. However, our study is the first study in our country in which VATS sleeve resections were compared to open surgery. The importance of surgical education and transmission of advanced minimally invasive techniques to the next generation has been underlined in recent literature as well[16].

In comparative studies, it is generally expected that the number of cases in both groups be similar. However, VATS sleeve lobectomy is performed in a limited number of centers, and the case numbers remain lower compared to other surgical approaches. This is a key limitation; however, due to the limited literature, the study may still offer valuable contributions. The initial analysis aimed to compare the general features of the two techniques, and thus, downstaging data after neoadjuvant therapy were not included.

CONCLUSION

VATS sleeve resections in NSCLC cases provide advantages over open surgery with shorter hospital stays and drainage times without compromising oncological principles. VATS sleeve resections are surgical procedures that require experience and can be preferred as an alternative to open surgery by experienced centers and physicians.

Table 6. Studies on VATS sleeve resections

Author/country/year	VATS (n) VATS-Thr (%)	Conversion (%)	Complication rate VATS (%)-Thr (%) p-value	Hospitalization VATS-Thr (days) p-value	The mean operation time (minimum) p-value	Blood loss (mL) VATS-Thr p-value	The mean postoperative drainage duration VATS-Thr (day) p-value
Zhong Y, China 2020 (Meta-analysis of 6 studies)[21]	281 43.2%	2.9%-4.5%		SMD -0.24, 95% CI: -0.51 to 0.03, p=0.078	SMD 0.59, 95% CI: 0.14 to 1.03, p=0.010		
Mayne NR, USA, 2021[15]	44.21%	20%		6-6 p=0.36			
Zhu XY, China 2021[25]				10.5	247.8±73.1	300.4±321.8 mL	
Geropoulos G, Greece-London 2022 6 studies[22]	229.35%				45.85 minimum less in VATS, p=0.01	37 mL less in VATS p<0.001	
Xie D, China 2021[18]	112 30.8%			6-7		100-200 p<0.1	5-6 p<0.1
Yang Y, China 2020[20]	44 23.5%		20.3%-30.2% p=0.028				
Ceylan KC, Türkiye 2020[24]				6.4±1.9	288.2±77.1		5.5±1.9
Gonzalez M, Thoracic Surgery database 2021[17]	161 9.8%	21.1%	30.4%-41.7% p=0.006	5-8 p<0.001			
Demirkol EY. (this study)	22 17.3%	33%	40.9%-30.5% p=0.475	5.1±3.4 7.1±7 p=0.005	4.5 0.9 p=0.474	370±70-467±385 p=0.525	3.6±3.3-4.5±4 p=0.014

VATS: Video-assisted thoracoscopic surgery, Thr: Thoracotomy, SMD: Standardized mean difference, CI: Confidence interval

Ethics

Ethics Committee Approval: The study was approved by the ethics/scientific committee of University of Health Sciences Türkiye, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital and (decision no: 2023-462.28, date:12.2023) was conducted by the principles of the Declaration of Helsinki.

Informed Consent: It is a retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: V.E., M.M., Concept: M.Ü., Design: V.E., M.Ü., Data Collection or Processing: N.Y., E.K., Analysis or Interpretation: M.E.F., C.B.S., Literature Search: V.E., M.Ü., Writing: E.Y.D.

Conflict of Interest: No conflict of interest was declared by the authors.

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