Turkish Journal of Thoracic and Cardiovascular Surgery 2022;30(1):66-74
http://dx.doi.org/doi: 10.5606/tgkdc.dergisi.2022.20912

Original Article / *Özgün Makale*

Video-assisted thoracoscopic lobectomy and bilobectomy versus open thoracotomy for non-small cell lung cancer: Mortality and survival

Küçük hücreli dışı akciğer kanserinde video-yardımlı torakoskopik lobektomi ve bilobektomiye kıyasla açık torakotomi: Mortalite ve sağkalım

Ahmet Üçvet[1], Serkan Yazgan[1], Özgür Samancılar[1], Yunus Türk[1], Soner Gürsoy[1], Ahmet Emin Erbaycu[2]

Institution where the research was done:
Health Sciences University, Dr. Suat Seren Chest Diseases and Thoracic Surgery Training and Research Hospital, Izmir, Turkey

Author Affiliations:
[1]Department of Thoracic Surgery, Health Sciences University, Dr. Suat Seren Chest Diseases and Thoracic Surgery Training and Research Hospital, Izmir, Turkey
[2]Department of Chest Diseases, Izmir Bakırçay University, Izmir, Turkey

ABSTRACT

Background: In this study, we aimed to evaluate patients who had non-small cell lung cancer and underwent resection, to investigate our tendency to prefer video-assisted thoracic surgery or open thoracotomy, and to compare 30- and 90-day mortalities and survival rates.

Methods: Between January 2013 and January 2019, a total of 706 patients (577 males, 129 females; mean age: 61.9±8.6 years; range, 17 to 84 years) who underwent lobectomy or bilobectomy due to primary non-small cell lung cancer were retrospectively analyzed. The patients were divided into two groups as operated on through video-assisted thoracic surgery and through open thoracotomy. The 30- and 90-day mortality rates and survival rates were compared.

Results: Of the patients, 202 (28.6%) underwent video-assisted thoracic surgery and 504 (71.4%) underwent open thoracotomy. Lobectomy was performed in 632 patients (89.5%) and bilobectomy was performed in 74 patients (10.5%). Patients who were chosen for video-assisted thoracic surgery were statistically significantly older, did not require any procedure other than lobectomy, did not receive neoadjuvant therapy, had a small tumor, and did not have lymph node metastases. The 30- and 90-day mortality rates in the video-assisted thoracic surgery and open thoracotomy groups were 1.8% vs. 2% and 2.6% vs. 2.5%, respectively. The five-year survival rates of video-assisted thoracic surgery and open thoracotomy groups were 74.1% and 65.2%, respectively (p>0.05). The 30- and 90-day mortality and five-year survival rates were 2.1%, 2.6%, and 73.5% in the video-assisted thoracic surgery group and 2.1%, 2.1%, and 68.5% in the open thoracotomy group, respectively, indicating no statistically significant difference between the two groups.

Conclusion: Throughout the study period, video-assisted thoracic surgery was more preferred in patients with advanced age, in those who had a small tumor, who did not receive neoadjuvant therapy, did not have lymph node metastasis, and did not require any procedure other than lobectomy. In the video-assisted thoracic surgery and open thoracotomy groups, 30- and 90-day mortality and five-year survival rates were similar. Based on these findings, both procedures seem to be acceptable in this patient population.

Keywords: Lung cancer, mortality, survival, thoracotomy, video-assisted thoracic surgery.

ÖZ

Amaç: Bu çalışmada küçük hücreli dışı akciğer kanseri olan ve rezeksiyon yapılan hastalar değerlendirildi, video-yardımlı torasik cerrahi ve açık torakotomi için seçim kriterlerimiz incelendi ve 30 ve 90 günlük mortalite ve sağkalım oranları karşılaştırıldı.

Çalışma planı: Ocak 2013 - Ocak 2019 tarihleri arasında, primer küçük hücreli dışı akciğer kanseri nedeniyle lobektomi veya bilobektomi yapılan toplam 706 hasta (577 erkek, 129 kadın; ort. yaş: 61.9±8.6 yıl; dağılım, 17-84 yıl) retrospektif olarak incelendi. Hastalar video-yardımlı torasik cerrahi ve açık cerrahi ile ameliyat edilenler olmak üzere iki gruba ayrıldı. Otuz ve 90 günlük mortalite oranları ve sağkalım oranları karşılaştırıldı.

Bulgular: Hastaların 202'sine (%28.6) video-yardımlı torasik cerrahi ve 504'üne (%71.4) açık torakotomi yapıldı. Hastaların 632'sine (%89.5) lobektomi ve 74'üne (%10.5) bilobektomi uygulandı. Video-yardımlı torasik cerrahi grubuna alınan hastalar istatistiki olarak anlamlı düzeyde, daha yaşlı, lobektomiden başka bir işleme gerek duymayan, neoadjuvan tedavi almamış, küçük tümör boyutlu ve lenf nodu metastazı olmayan hastalar idi. Otuz- ve 90-günlük mortalite, video-yardımlı torasik cerrahi ve açık torakotomi grubunda sırasıyla %2'ye kıyasla %1.8 ve %2.5'e kıyasla %2.6 idi. Beş yıllık sağkalım oranları, video-yardımlı torasik cerrahi ve açık torakotomi gruplarında sırasıyla %74.1 ve %65.2 idi (p>0.05). Otuz- ve 90-günlük mortalite ve beş yıllık sağkalım oranları video-yardımlı torasik cerrahi grubunda sırasıyla %2.1, %2.6 ve %73.5 ve açık torakotomi grubunda %2.1, %2.1 ve %68.5 olup, iki grup arasında anlamlı bir fark yoktu.

Sonuç: Çalışma süresince, video-yardımlı torasik cerrahi ileri yaş, küçük tümörlü, neoadjuvan tedavi almamış, lenf bezi metastazı yapmamış ve lobektomiden başka bir işleme gerek duymayan hastalarda daha çok tercih edildi. Video-yardımlı torasik cerrahi ve açık torakotomi gruplarında, 30- ve 90-günlük mortalite ve beş yıllık sağkalım oranları benzerdi. Bu sonuçlara göre, her iki yöntem de bu hasta popülasyonunda kabul edilebilir görünmektedir.

Anahtar sözcükler: Akciğer kanseri, mortalite, sağkalım, torakotomi, video-yardımlı torasik cerrahi.

Received: October 08, 2020 *Accepted:* May 17, 2021 *Published online:* January 28, 2022

Correspondence: Serkan Yazgan, MD. SBÜ Dr. Suat Seren Göğüs Hastalıkları ve Göğüs Cerrahisi Eğitim ve Araştırma Hastanesi, Göğüs Cerrahisi Kliniği, 35110 Konak, İzmir, Türkiye. Tel: +90 536 - 583 50 85 e-mail: serkanyazgan@gmail.com

Cite this article as:
Üçvet A, Yazgan S, Samancılar Ö, Türk Y, Gürsoy S, Erbaycu AE. Video-assisted thoracoscopic lobectomy and bilobectomy versus open thoracotomy for non-small cell lung cancer: Mortality and survival. Turk Gogus Kalp Dama 2022;30(1):66-74

In early-stage primary non-small cell lung cancer (NSCLC), surgical treatment is essentially preferred as the standard practice. Although thoracotomy was used as a surgical intervention for many years, the frequency of use of video-assisted thoracic surgery (VATS) procedure has been increased gradually in recent years to reduce the adverse effects which are thought to occur due to thoracotomy.[1,2] The VATS stands out as an appealing alternative with less postoperative pain, shorter hospital stay, lower costs, and better cosmetic results.[3] It is thought to be an effective and safe method that can be an alternative to thoracotomy in selected patients.[4] There is still no clear consensus on which procedure is superior with regard to long-term outcomes.[5]

In the present study, we aimed to evaluate patients who had NSCLC and underwent resection, to investigate our tendency to prefer VATS or open thoracotomy, and to compare 30- and 90-day mortalities and survival rates.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Health Sciences University, Dr. Suat Seren Chest Diseases and Thoracic Surgery Training and Research Hospital Department of Thoracic Surgery between January 2013 and January 2019. A total of 1,139 patients who underwent lobectomy or wider parenchymal resection due to primary NSCLC were screened. Pneumonectomies, sleeve resections, incomplete resections, chest wall or diaphragmatic resections, and carcinoid tumors were excluded from the study. A total of 706 patients (577 males, 129 females; mean age: 61.9±8.6 years; range, 17 to 84 years) who underwent lobectomy or bilobectomy due to NSCLC and met the inclusion criteria were included in the study. A written informed consent was obtained from each patient. The study protocol was approved by the Health Sciences University, Dr. Suat Seren Chest Diseases and Thoracic Surgery Training and Research Hospital Institutional Review Board (IRB date/no: 15.11.2019/11516). The study was conducted in accordance with the principles of the Declaration of Helsinki.

The patients were divided into two groups as operated on through VATS and open thoracotomy. To compare the two procedures more objectively, the subgroup of patients was analyzed separately. The decision to perform VATS or open thoracotomy for tumor resection was made by a single surgical team, considering the characteristics of the patient and the disease. If the patient was initially treated through VATS, but it was converted to thoracotomy for various reasons, they were included in the group of thoracotomy.

Data regarding the patients, such as demographics, other applied treatments, pathology of the resected tumor, tumor size, and lymph node involvement, were recorded. In the preoperative evaluation, medical history, physical examination, radiological imaging (direct radiography of the chest, computed tomography [CT] of the thorax, positron emission tomography [PET]), routine laboratory tests, electrocardiography, cranial magnetic resonance imaging (MRI), fiberoptic bronchoscopy, and other required consultations were used. Patients who were treated for coexisting disease such as hypertension, coronary artery disease, heart failure, diabetes mellitus, chronic obstructive pulmonary disease, bronchial asthma, and patients who had previously active tuberculosis were grouped as patients with comorbidity.

Surgical procedure

All surgical procedures were performed under general anesthesia and patients were placed in the lateral decubitus position. During the operation, double-lumen intubation, invasive arterial blood pressure monitoring and epidural analgesia were performed by anesthesiologists as standard procedures.

The basic technique we use for VATS in our practice is as follows: we use single or two ports and a utility incision no greater than 4 cm in length without spreading the ribs. The incision for observation is 1.2 cm in length and is located at the anterior-axillary line of the seventh or eighth intercostal space. The utility incision for the main operation is usually located between the anterior-axillary line and mid-nipple line at the fourth or fifth intercostal space. Bronchial and vascular ligation was performed with an articulating endoscopic linear cutting stapler. Open thoracotomy was performed by means of a posterolateral thoracotomy incision, which was 10.0 to 15.0 cm in length and performed by preserving the serratus anterior muscle, and of a rib spreader. All patients underwent complete dissection of mediastinal lymph node and were staged according to the 8th Edition Lung Cancer Stage Classification.[6]

Data collection and follow-up

The patients were followed routinely in the postoperative period, and their current status was checked through the Turkish Civil Registration System in August 2019, when the study was completed. All patients were analyzed in terms of 30- and 90-day mortality rates and survival. Current status of the

patients was updated through Civil Registration System, and 30- and 90-day mortality and survival rates were calculated. The effects of age group, sex, comorbidity, neoadjuvant therapy, type of surgical intervention, type of resection, histology, tumor size and lymph node metastasis on these rates were examined.

The discharged patients were followed in the outpatient setting. They were checked every three months for the first year and, then, every six months through a physical examination and an imaging study (CT scan).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The groups were compared using chi-square test and mean values were compared using independent t-test. Binary logistic test was used for multivariate analysis. To calculate survival, mortality within the first 90-day was excluded and all deaths were taken into consideration. Expected survival rates were calculated using the Kaplan-Meier, and compared with log-rank and Cox regression analysis. A p value of <0.05 was considered statistically significant.

A propensity score-matched analysis was performed. Propensity scores were generated for all patients eligible to undergo either VATS or open thoracotomy lobectomy. The VATS versus open thoracotomy was the treatment indicator (dependent variable) and the covariates were age, sex, tumor size, and nodal status. Nearest neighbor matching method was used without replacement. The VATS and thoracotomy group covariates were compared by standardized differences. The patients were stratified by propensity score groupings to evaluate 30- and

Table 1. Baseline characteristics of the patients

	Total		VATS		Open thoracotomy		Univariate	Multivariate	
Patient characteristics	n	%	n	%	n	%	*p*	*p*	OR
Total	706	100	202	28.6	504	71.4	-	-	-
Age (year)							**0.001**	**0.008**	1.6
≤60	287	40.7	63	31.2	224	44.4			
>60	419	59.3	139	68.8	280	55.6			
Sex							**0.002**	-	-
Male	577	81.7	150	74.3	427	84.7			
Female	129	18.3	52	25.7	77	15.5			
Comorbidity							**0.001**	-	-
No	415	58.8	99	49.0	316	62.7			
Yes	291	41.2	103	51.0	188	37.3			
Neoadjuvant therapy							**<0.0001**	**<0.0001**	10.0
No	631	89.4	199	98.5	432	85.7			
Yes	75	10.6	3	1.5	72	14.3			
Type of resection							**0.001**	**0.037**	2.1
Lobectomy	632	89.5	193	95.5	439	87.1			
Bilobectomy	74	10.5	9	4.5	65	12.9			
Histology							**0.024**	-	-
Non-adenocarcinoma	376	53.3	94	46.5	282	56.0			
Adenocarcinoma	330	46.7	108	53.5	222	44.0			
Tumor size (cm)							**<0.0001**	**<0.0001**	2.6
≤3	380	53.8	141	69.8	239	47.4			
3-7	286	40.5	61	30.2	225	44.6			
>7	40	5.7	0	0	40	7.9			
Lymph node involvement (n)							**<0.0001**	**<0.0001**	2.8
No	526	74.5	180	89.1	346	68.7			
Yes	180	25.5	22	10.9	158	31.3			

VATS: video-assisted thoracic surgery; OR: Odds ratio; Bold values represent statistically significant outcomes.

90-days mortality and survival among the VATS and open thoracotomy groups.

RESULTS

The majority of the patients underwent lobectomy (89.5% lobectomy and 10.5% bilobectomy). A total of 504 (71.4%) of the operations were performed via open thoracotomy and 202 (28.6%) via VATS. In the VATS group, the rate of those patients who were older, did not receive preoperative oncological treatment, underwent lobectomy, had smaller tumor, and did not have lymph node metastasis was statistically significantly higher (Table 1).

Overall, 30-day mortality rate was found to be 1.8% (n=13) and 90-day mortality rate was 2.5% (n=18). The 30-day mortality rate was 2% in the VATS group and 1.8% in the open thoracotomy group, while the 90-day mortality was 2.5% and 2.6% in the VATS and open thoracotomy groups, respectively. There was no statistically significant difference between the two groups in terms of 30- and 90-day mortality rates. Furthermore, there was no significant difference between the groups in 30- and 90-day mortality in terms of sex, age, comorbidity, neoadjuvant therapy, type of resection, histology, tumor size, and lymph node metastasis (Table 2).

At the end of the mean follow-up period of 32.8±20.3 (range, 0 to 79) months, the five-year survival rate of all patients was 67% and the mean survival time was 62.3±1.2 months. This rate was 74.1% in the VATS group and 65.2% in the open thoracotomy group, and the difference was not

Table 2. Thirty- and 90-day mortality rates of patients

	30-day mortality			90-day mortality		
Variables	n	%	*p*	n	%	*p*
Treatment approach			1			1
VATS	4	2.0		5	2.5	
Open thoracotomy	9	1.8		13	2.6	
Age (year)			0.5			0.63
≤60	4	1.4		6	2.1	
>60	9	2.1		12	2.9	
Sex			0.48			0.22
Male	12	2.1		17	2.9	
Female	1	0.8		1	0.8	
Comorbidity			0.4			0.8
No	6	1.4		10	2.4	
Yes	7	2.4		8	2.7	
Neoadjuvant therapy			0.38			0.24
No	13	2.1		18	2.9	
Yes	0	0		0	0	
Type of resection			0.64			0.42
Lobectomy	11	1.7		15	2.4	
Bilobectomy	2	2.7		3	4.1	
Histology			0.59			0.63
Non-adenocarcinoma	8	2.1		11	2.9	
Adenocarcinoma	5	1.5		7	2.1	
Size (cm)			0.63			0.94
≤3	8	2.1		9	2.4	
3-7	5	1.7		8	2.8	
>7	0	0		1	2.5	
Lymph node involvement (n)			1			0.79
No	10	1.9		13	2.5	
Yes	3	1.7		5	2.8	

VATS: Video-assisted thoracic surgery.

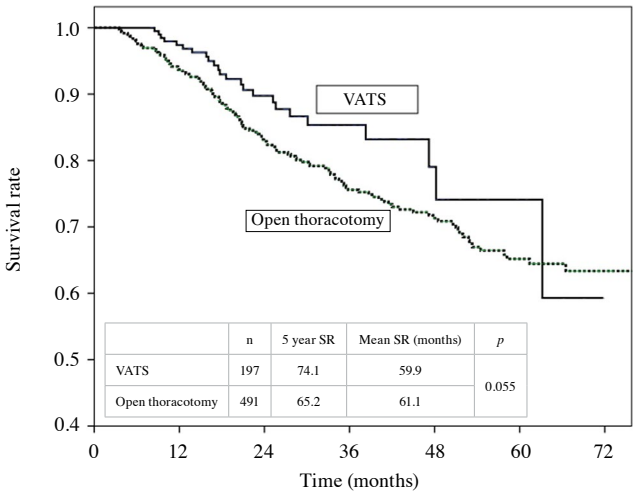

Figure 1. Survival curves of those undergoing VATS and open thoracotomy among all patients.
VATS: Video-assisted thoracic surgery; SR: Survival rate.

statistically significant (p=0.055) (Figure 1). Although the VATS group usually had better survival rates when the two groups were compared, the difference was found to be statistically significant only in those without comorbidity (77.9% *vs*. 65.7%, respectively; p=0.041) (Table 3).

In the Cox regression analysis of survival rates of all patients, male patients (p=0.011, odds ratio [OR]=2), patients with lymph node metastasis (p<0.0001, OR=2.3), and those with adenocarcinoma (p=0.034, OR=1.4) had a statistically significantly lower survival (Table 4).

To compare more homogeneous groups, VATS and open thoracotomy groups, both of which consisted of 193 patients, were formed by using propensity score-matching method. While the 30-day mortality rate was 2.1% (p=1.0) in both groups, the 90-day mortality

Table 3. Five-year survival rates of patients

	General		VATS	Open thoracotomy	
	5-year OS		5-year OS	5-year OS	VATS and Open thoracotomy
Variables	%	*p*	%	%	*p*
Total	67.0	-	74.1	65.2	0.055
Age (year)		0.31			
≤60	69.4		88.4	66.9	0.06
>60	65.3		69.0	63.7	0.24
Sex		**0.015**			
Male	65.0		68.8	63.9	0.25
Female	76.6		92.9	72.3	0.11
Comorbidity		0.35			
No	68.0		77.9	65.7	0.041
Yes	65.2		71.5	64.0	0.42
Neoadjuvant therapy		**0.024**			
No	68.7		74.7	66.9	0.094
Yes	54.5		50.0	55.1	0.49
Type of resection		0.84			
Lobectomy	66.8		73.5	64.9	0.086
Bilobectomy	76.8		100	67.8	0.23
Histology		0.063			
Non-adenocarcinoma	70.0		78.0	68.6	0.33
Adenocarcinoma	63.8		70.1	61.1	0.057
Size (cm)		0.094			
≤3	69.8		85.4	66.6	0.097
3-7	63.7		43.1	64.4	0.75
>7	63.1		-	63.1	-
Lymph node involvement		**<0.0001**			
(n)	73.1		76.2	71.7	0.2
No	48.8		65.7	48.9	0.72
Yes					

VATS: Video-assisted thoracic surgery; OS: Overall survival; Bold values represent statistically significant outcomes.

Table 4. Cox regression analysis

Variables	*p*	OR	SE
All patients			
Sex (Female/Male)	**0.011**	2.0	0.27
Lymph node metastasis (No/Yes)	**<0.0001**	2.3	0.17
Histology (Non-adenocarcinoma/Adenocarcinoma)	**0.034**	1.4	0.17

OR: Odd ratio; SE: Standard error; Bold values represent statistically significant outcomes.

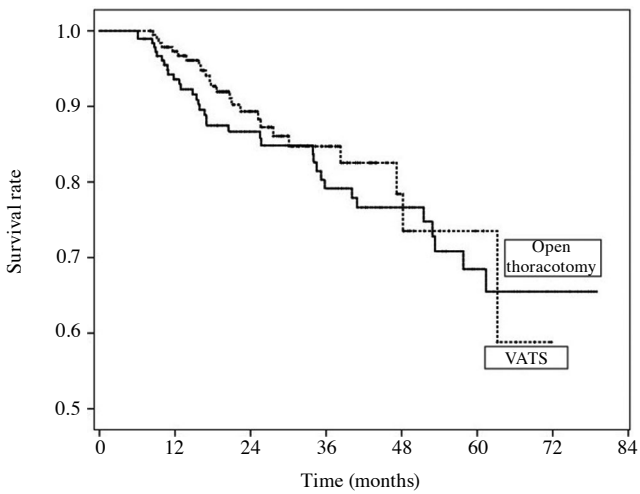

Figure 2. Comparison of the survival curves of VATS and open thoracotomy in propensity score groupings.
VATS: Video-assisted thoracic surgery.

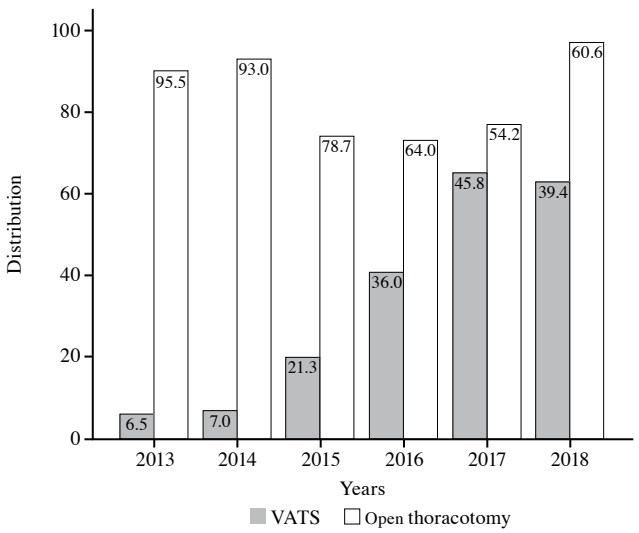

Figure 3. VATS (dark column) and open thoracotomy (white column) application rates by years.
VATS: Video-assisted thoracic surgery.

rates in the VATS and open thoracotomy groups were 2.6% and 2.1% (p=1.0), respectively. The five-year survival rates were 73.5% and 68.5% (p=0.4), respectively (Figure 2).

DISCUSSION

As in the whole world, the trend toward minimally invasive surgical methods in all surgical departments is quite high in Turkey, as well. These methods are particularly important in terms of patient comfort and quality of life after surgery. Minimally invasive surgical methods are used safely and with high efficiency in surgical cases of lung cancer in which oncological surgery principles are at the forefront. The minimally invasive surgical approach has almost become a standard procedure, particularly in early-stage lung cancer.[1] With the increasing experience in our center, anatomical resections via VATS are performed more and more every year (Figure 3). In terms of lung cancer, oncological efficiency refers to complete and proper application of anatomical resection and lymph node dissection. Improper anatomical dissection would result in local recurrence, incomplete lung cancer staging, remaining occult lymph node metastases, and local/systemic recurrences. Furthermore, lymph node dissection must be performed effectively.[1] This is an important discussion topic about VATS and the fact that the lymph node dissection may not be as effective as open thoracotomy raises concerns. However, in a study, Toker et al.[7] compared the patients undergoing robot-assisted thoracic surgery (RATS) and VATS with those operated through open thoracotomy, and found that there was no statistically significant difference in terms of the number of dissected lymph nodes. In this study, we found that the VATS procedure was more preferred in patients who were older, less likely to have lymph node metastasis, who had smaller tumor, who did not receive neoadjuvant treatment, and who did not require any procedure

other than lobectomy. The higher rate of involvement in the dissected lymph nodes in the open thoracotomy group can be explained by the preference of open thoracotomy in patients with suspected lymph node metastasis in the preoperative period.

Overall survival is a key index to assess the long-term effectiveness of the treatment. However, one of the most important problems in comparing VATS and open thoracotomy is the difficulty of studying homogeneous patient groups. As a matter of fact, histological type, stage and sex, age and comorbidity lead to significant differences between the groups. These conditions affecting survival may mask factors related to surgical technique. Taking this bias into account, Flores et al.[3] formed two balanced groups. In a prospective study involving early-stage NSCLC patients, 398 of whom underwent lobectomy via VATS and 343 via open thoracotomy, they reported using the Cox model that there was no significant difference in survival between the two groups. On the other hand, age, large tumor size, and advanced lymph node involvement were found to be associated with poor survival. Although the five-year survival of the two groups was similar, complications were less and hospital stay was shorter in the VATS lobectomy group. Based on the evaluation of all patients using Cox regression analysis in terms of survival, male sex, lymph node metastasis, and adenocarcinoma histology showed a significantly lower survival. No significant effect of VATS or open thoracotomy on survival was detected in univariate and multivariate analyses. In the comparison we made by forming two more homogeneous groups by means of propensity-score matching method, our results showed similar survival for VATS and open thoracotomy, as in the study of Flores et al.[3] On the other hand, it is a known fact that preoperative comorbidity has a negative prognostic effect on survival results. Therefore, in both procedures, we compared patients without preoperative comorbidity as a subgroup. In terms of survival, the difference was spectacularly statistically significant in favor of VATS for patients without comorbidity (77.9% *vs*. 65.7%, respectively; p=0.041). The numbers of patients with and without preoperative comorbidity in the VATS group were almost equal. The open thoracotomy group consisted mainly of patients with better preoperative condition. The difference in other subgroups compared in terms of survival was not statistically significant.

In their meta-analysis, Cheng et al.[8] reported the advantages of VATS in the early period, but emphasized that there was no statistically significant difference in the stage-specific five-year survival between the two groups. Yang et al.,[9] who analyzed long-term survival results of lobectomy performed on clinical Stage I NSCLC patients through RATS, VATS and open thoracotomy, emphasized that results of minimally invasive approach were similar to thoracotomy (77.6%, 73.5%, and 77.9%, respectively). In another experience consisting of 160 NSCLC patients, the rates in VATS group were not lower than in open thoracotomy in terms of five-year disease-free survival and overall survival.[10]

In another study comparing the two methods only for clinical Stage I NSCLC, hypertension, chronic renal failure, and prior history of malignancy were observed more in the VATS group, and that pathological stage, tumor size, histology or number of positive lymph nodes were not significantly different between the two methods.[11] However, it was shown that more lymph nodes were dissected through open thoracotomy. The operative time, blood loss, atrial fibrillation, number of ventilator days, and median survival of the two groups were similar. In another meta-analysis comparing only patients with clinical Stage I NSCLC according to the previous staging system, eight different studies on the five-year survival rate were examined.[12] In four of these studies, which reported five-year survival between 75% and 94.9%, the survival rate of the VATS group was found to be higher, whereas the other four studies did not show a significant difference. In our recent study, we analyzed a much more homogeneous subgroup making sure that the patient groups had similar characteristics regarding comparison criteria and in accordance with the 8th Edition of Tumor, Node, Metastasis (TNM) staging system. The largest data comparing the effectiveness of the two procedures in NSCLC is a study in which 39 articles were analyzed and it includes 3,256 open thoracotomy and 3,114 VATS procedures.[13] The results indicate shorter tube drainage time, shorter hospital stay, less morbidity and better survival in the group undergoing resection via VATS.

Postoperative mortality is the most frequently reported surgical quality measurement.[14] Therefore, in our study, 30- and 90-day mortalities were investigated and compared between VATS and open thoracotomy, and no significant difference was found between the two procedures. Another noteworthy finding in our study is that nine patients who underwent VATS bilobectomy had no postoperative 30- and 90-day mortality and five-year survival was 100%. There is no specific report on VATS bilobectomy in the literature.[15]

However, bilobectomy is mentioned in large series. In our series, the rate of VATS bilobectomy is 4.5%. This rate is 1.6% in McKenna et al.'s[16] series consisting of 1,100 patients and 3.8% in the series of Hansen and Petersen.[17] In general, it can be speculated that the advantages of minimally invasive procedures obtained with VATS lobectomy are similar after VATS bilobectomy. Brunelli et al.[18] found the 30- and 90-day mortality rates in patients who underwent VATS lobectomy due to lung cancer as 1.9% and 2.5%, respectively. Some other studies have demonstrated that 90-day mortality is twice as high as 30-day mortality; however, these reports have also shown no significant difference for VATS and open thoracotomy.[19-24] Multicenter studies are undoubtedly needed to reach a definitive conclusion.

Our study has some limitations. First, short-term medical data such as postoperative complications and length of hospital stay were not analyzed. Second, since one of the main objectives of the study was to compare postoperative mortality and long-term survival rates, patient selection criteria are not homogeneous, particularly in terms of tumor size, extent (need for bilobectomy) and lymph node involvement. Third, the study is single-center, retrospective and as such is affected by inherent selection bias. The model has been derived from the patients who have been selected for operation in our unit. The selection of 30- and 90-days as time cutoff was made to be consistent with previous investigations. Fourth, in several cases that started with VATS, it was converted to open thoracotomy during the operation; however, these were not excluded from the study and were analyzed as thoracotomy cases. Conversion cases may have prolonged surgery time and increased complication rate, thus leading to bias against open surgery and reducing the validity of the results.

In conclusion, throughout the study period, video-assisted thoracic surgery was more preferred in patients with advanced age, in those who did not receive neoadjuvant therapy, did not have lymph node metastasis, had a smaller tumor, and did not require any procedure other than lobectomy. Although large-scale and multicenter studies are needed to reach a definitive conclusion, the mortality and survival data obtained in our study are similar for both groups, and we can conclude that resection via video-assisted thoracic surgery is a fairly good alternative to open thoracotomy. Analysis of statistically similar groups has also supported these outcomes.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Samancılar Ö. Current minimally invasive surgical approaches for lung cancer treatment. Nucl Med Semin 2018;4:39-42.
2. Flores RM, Ihekweazu UN, Rizk N, Dycoco J, Bains MS, Downey RJ, et al. Patterns of recurrence and incidence of second primary tumors after lobectomy by means of video-assisted thoracoscopic surgery (VATS) versus thoracotomy for lung cancer. J Thorac Cardiovasc Surg 2011;141:59-64.
3. Flores RM, Park BJ, Dycoco J, Aronova A, Hirth Y, Rizk NP, et al. Lobectomy by video-assisted thoracic surgery (VATS) versus thoracotomy for lung cancer. J Thorac Cardiovasc Surg 2009;138:11-8.
4. Yang X, Wang S, Qu J. Video-assisted thoracic surgery (VATS) compares favorably with thoracotomy for the treatment of lung cancer: A five-year outcome comparison. World J Surg 2009;33:1857-61.
5. Taioli E, Lee DS, Lesser M, Flores R. Long-term survival in video-assisted thoracoscopic lobectomy vs open lobectomy in lung-cancer patients: A meta-analysis. Eur J Cardiothorac Surg 2013;44:591-7.
6. Detterbeck FC, Boffa DJ, Kim AW, Tanoue LT. The Eighth edition lung cancer stage classification. Chest 2017;151:193-203.
7. Toker A, Özyurtkan MO, Demirhan Ö, Ayalp K, Kaba E, Uyumaz E. Lymph node dissection in surgery for lung cancer: Comparison of open vs. video-assisted vs. robotic-assisted approaches. Ann Thorac Cardiovasc Surg 2016;22:284-90.
8. Cheng D, Downey RJ, Kernstine K, Stanbridge R, Shennib H, Wolf R, et al. Video-assisted thoracic surgery in lung cancer resection: A meta-analysis and systematic review of controlled trials. Innovations (Phila) 2007;2:261-92.
9. Yang HX, Woo KM, Sima CS, Bains MS, Adusumilli PS, Huang J, et al. Long-term survival based on the surgical approach to lobectomy for clinical stage I nonsmall cell lung cancer: Comparison of robotic, video-assisted thoracic surgery, and thoracotomy lobectomy. Ann Surg 2017;265:431-7.
10. Higuchi M, Yaginuma H, Yonechi A, Kanno R, Ohishi A, Suzuki H, et al. Long-term outcomes after video-assisted thoracic surgery (VATS) lobectomy versus lobectomy via open thoracotomy for clinical stage IA non-small cell lung cancer. J Cardiothorac Surg 2014;9:88.
11. Whitson BA, Andrade RS, Boettcher A, Bardales R, Kratzke RA, Dahlberg PS, et al. Video-assisted thoracoscopic surgery is more favorable than thoracotomy for resection of clinical stage I non-small cell lung cancer. Ann Thorac Surg 2007;83:1965-70.
12. Chen FF, Zhang D, Wang YL, Xiong B. Video-assisted thoracoscopic surgery lobectomy versus open lobectomy in

patients with clinical stage I non-small cell lung cancer: A meta-analysis. Eur J Surg Oncol 2013;39:957-63.
13. Whitson BA, Groth SS, Duval SJ, Swanson SJ, Maddaus MA. Surgery for early-stage non-small cell lung cancer: A systematic review of the video-assisted thoracoscopic surgery versus thoracotomy approaches to lobectomy. Ann Thorac Surg 2008;86:2008-16.
14. Rizzardi G, Bortolotti L. Risk factors and 90-day mortality after video-assisted thoracoscopic lobectomy for lung cancer: The discussion is still open. Video-assist Thorac Surg 2018;3:2.
15. Augustin F, Maier H, Lucciarini P, Bodner J, Klotzner S, Schmid T. Extended minimally invasive lung resections: VATS bilobectomy, bronchoplasty, and pneumonectomy. Langenbecks Arch Surg 2016;401:341-8.
16. McKenna RJ Jr, Houck W, Fuller CB. Video-assisted thoracic surgery lobectomy: Experience with 1,100 cases. Ann Thorac Surg 2006;81:421-5.
17. Hansen HJ, Petersen RH, Christensen M. Video-assisted thoracoscopic surgery (VATS) lobectomy using a standardized anterior approach. Surg Endosc 2011;25:1263-9.
18. Brunelli A, Dinesh P, Woodcock-Shaw J, Littlechild D, Pompili C. Ninety-day mortality after video-assisted thoracoscopic lobectomy: Incidence and risk factors. Ann Thorac Surg 2017;104:1020-6.
19. Damhuis RA, Wijnhoven BP, Plaisier PW, Kirkels WJ, Kranse R, van Lanschot JJ. Comparison of 30-day, 90-day and in-hospital postoperative mortality for eight different cancer types. Br J Surg 2012;99:1149-54.
20. D'Amico TA. Defining and improving postoperative care. J Thorac Cardiovasc Surg 2014;148:1792-3.
21. Pezzi CM, Mallin K, Mendez AS, Greer Gay E, Putnam JB Jr. Ninety-day mortality after resection for lung cancer is nearly double 30-day mortality. J Thorac Cardiovasc Surg 2014;148:2269-77.
22. Powell HA, Tata LJ, Baldwin DR, Stanley RA, Khakwani A, Hubbard RB. Early mortality after surgical resection for lung cancer: An analysis of the English National Lung cancer audit. Thorax 2013;68:826-34.
23. McMillan RR, Berger A, Sima CS, Lou F, Dycoco J, Rusch V, et al. Thirty-day mortality underestimates the risk of early death after major resections for thoracic malignancies. Ann Thorac Surg 2014;98:1769-74.
24. Hu Y, McMurry TL, Wells KM, Isbell JM, Stukenborg GJ, Kozower BD. Postoperative mortality is an inadequate quality indicator for lung cancer resection. Ann Thorac Surg 2014;97:973-9.