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Original Article / Özgün Makale

Videothoracoscopic lobectomy training in non-small cell lung cancer

Küçük hücreli dışı akciğer kanserinde videotorakoskopik lobektomi eğitimi

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ABSTRACT

Background: This study aims to evaluate the outcomes of video-assisted thoracoscopic surgery lobectomies performed by a training consultant or an experienced consultant.

Methods: The study included 103 patients (81 males, 22 females; mean age 59.6±9.5 years; range, 32 to 84 years) who underwent video-assisted thoracoscopic surgery lobectomy due to non-small cell lung cancer. The training consultant assisted on the same side with the experienced consultant during the operations of the experienced consultant. The experienced consultant observed in the operating room and provided advice from a distance during the first five operations of the training consultant. Comorbidities, postoperative complications, and mortality were evaluated.

Results: Patients' demographic characteristics, comorbidities, and postoperative complications were similar between the two surgeons (p>0.05). Operative time, incidence of prolonged air leak, and length of hospital stay were higher in procedures performed by the training consultant (p<0.05). There were no significant differences in rates of life-threatening complications or mortality.

Conclusion: Video-assisted thoracoscopic surgery lobectomy can be performed safely by surgeons in training. Effective training programs may produce outcomes comparable to those of experienced surgeons.

Keywords: Learning curve, lung cancer, thoracoscopic lobectomy, video-assisted thoracoscopic surgery.

ÖZ

Amaç: Bu çalışmada eğitilen bir uzman veya deneyimli bir uzman tarafından uygulanan video yardımlı torakoskopik cerrahi lobektomilerin sonuçları değerlendirildi.

Çalışma planı: Çalışmaya küçük hücreli dışı akciğer kanseri nedeniyle video yardımlı torakoskopik cerrahi lobektomi geçiren 103 hasta (81 erkek, 22 kadın; ort. yaş 59.6±9.5 yıl; dağılım, 32-84 yıl) dahil edildi. Eğitilen uzman, deneyimli uzmanın ameliyatları sırasında deneyimli uzman ile aynı tarafta yardımcı oldu. Deneyimli uzman, eğitilen uzmanın ilk beş ameliyatı sırasında ameliyathanede gözlem yaptı ve bir mesafeden tavsiyede bulundu. Komorbiditeler, ameliyat sonrası komplikasyonlar ve mortalite değerlendirildi.

Bulgular: Hastaların demografik özellikleri, komorbiteleri ve ameliyat sonrası komplikasyonları iki cerrah arasında benzer idi (p>0.05). Ameliyat süresi, uzamış hava kaçağı insidansı ve hastanede yatış süresi eğitilen uzmanın uyguladığı işlemlerde daha yüksek idi (p<0.05). Hayatı tehdit edici komplikasyon ve mortalite oranlarında anlamlı farklılık yoktu.

Sonuç: Video yardımlı torakoskopik cerrahi lobektomi eğitim almakta olan cerrahlar tarafından güvenle uygulanabilir. Etkili eğitim programları deneyimli cerrahlarınki ile karşılaştırılabilecek sonuçlar verebilir.

Anahtar sözcükler: Öğrenme eğrisi, akciğer kanseri, torakoskopik lobektomi, video yardımlı torakoskopik cerrahi.

Video-assisted thoracoscopic surgery (VATS) has been performed since 1991.[1] Although there is insufficient data regarding open surgery in the early days, with advances in technology, VATS has become a commonly practiced procedure in many centers today. Many publications have stated that VATS lobectomy is a safe and oncologically appropriate procedure. Advantages of this approach are shorter hospital stays, preserved muscle function, less pain, earlier postoperative discharge, less intraoperative bleeding,

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fewer morbidities, and longer survival.[2-8] Recent systematic reviews report that VATS increases survival in early-stage lung cancer.[9]

However, despite the many advantages of VATS, there continue to be reports of major and fatal complications in the literature. The main risk in this technique is the occurrence of uncontrollable hemorrhages.[10] Inexperienced surgeons are intimidated by the possibility of hemorrhage, and experienced surgeons are less willing to ask surgeons in training to perform these procedures due to the same concern. On the other hand, technology-assisted surgical procedures are becoming increasingly important in daily practice. There are different training programs for VATS and robotic surgery training.[2,4,11-13] The learning curve for VATS lobectomy is considered to be 50 cases.[14] Survey studies report that only 58% of residency training programs include VATS lobectomy.[15] In this study, we aimed to evaluate the outcomes of VATS lobectomies performed by a training consultant (TC) or an experienced consultant (EC).

PATIENTS AND METHODS

A total of 173 patients who underwent intended VATS lobectomy due to non-small cell lung cancer between January 2013 and December 2017 at the First Surgery Clinic of the Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital were evaluated. Data obtained from a prospective database included patients' age, gender, body mass index, operative time, pathology, removed lobe, duration to chest tube removal, length of hospital stay, amount of transfusion, and 30- and 90-day mortality and morbidity. The study protocol was approved by the Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Between 2013 and 2016, all VATS lobectomies in our clinic were performed by a single EC. Starting in 2016, a VATS training program was established, and a TC began training. The TC had three-year experience in lung cancer as a specialist in open surgery and had performed multiple pleural biopsies, bullous lung, and diagnostic operations with VATS. He had also gained virtual resection experience using a VATS simulator (Medtronic Inc., Minneapolis, Minnesota, USA). The TC assisted the EC in 62 cases between January 2016 and December 2016. Between January 2017 and December 2017, the TC performed 22 VATS lobectomies.

Of the 173 patients who underwent surgery in our clinic, we excluded 15 patients whose procedures were converted from VATS to thoracotomy and five patients for whom the EC assisted the TC during surgery. We also excluded the EC's first 50 cases as they were considered the learning curve. Therefore, the retrospective analysis included 103 patients (81 males, 22 females; mean age 59.6±9.5 years; range, 32 to 84 years) (Figure 1).

All patients underwent a pulmonary function test and computed tomography of the chest and upper abdomen. Patients with a predicted postoperative forced

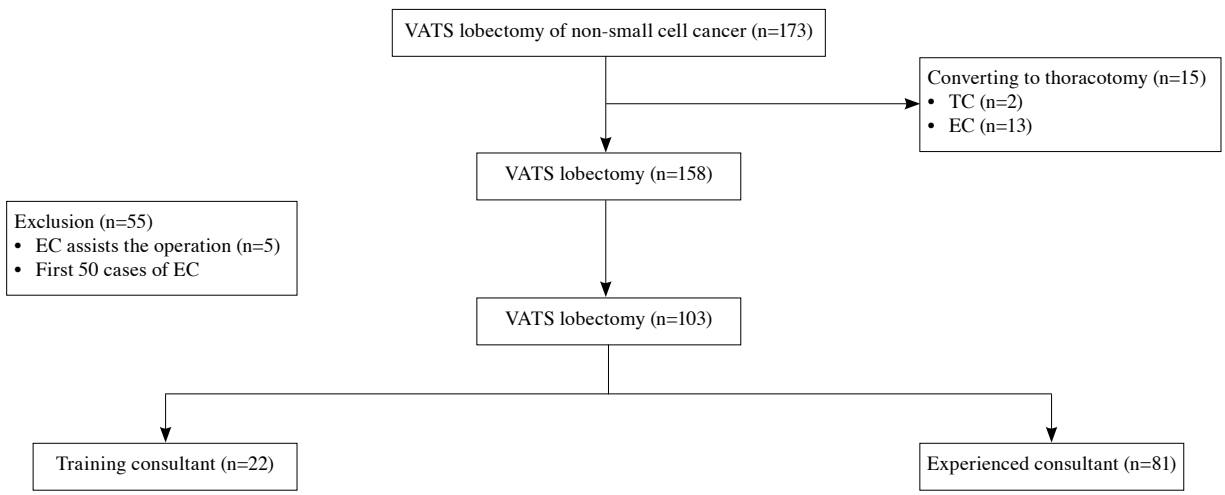

Figure 1. Patient selection flow chart.

VATS: Video-assisted thoracoscopic surgery; EC: Experienced consultant; TC: Training consultant.

expiratory volume in the first second (FEV_1) below 40% (low FEV_1) underwent secondary tests. Patients were evaluated for adequate blood glucose and blood pressure control. Patients who had a history of cardiac problems or were over 60 years of age were evaluated by the cardiology department using echocardiogram. All patients underwent preoperative diagnostic bronchoscopy. Positron emission tomography, endobronchial ultrasound, and mediastinoscopy were performed for mediastinal evaluation. Patients with positive mediastinal lymph nodes were referred for neoadjuvant therapy.

Exclusion criteria for VATS lobectomy were: patients with a tumor diameter >7 cm, patients with diaphragm or chest wall invasion, and patients whose bronchoscopy and/or tomography indicated the need for pneumonectomy or sleeve resection.

Comorbidities were divided into three groups: cardiac problems (arrhythmia, heart failure, myocardial infarction); respiratory problems (chronic obstructive pulmonary disease, asthma); and endocrine disorders (diabetes mellitus, goiter).

Postoperative complications developing in the first 30 days included prolonged air leak, chylothorax, hemorrhage requiring reoperation, surgical site infection, arrhythmia, recurrent laryngeal nerve damage, and phrenic nerve damage. Mortality was evaluated as deaths that occurred in the first 30 and 90 days postoperatively. Lung cancer staging was performed according to The International Association for the Study of Lung Cancer eighth edition staging.[16] The duration of the operation was considered as the period between incision and skin closure.

Operations were performed with an anterior approach, usually using two ports and a 5-cm utility incision. Following double-lumen selective intubation, patients were placed in the lateral decubitus position for surgery. The cameras were placed to be in front of the surgeon and assistant. The TC assisted on the same side with the EC in the EC's operations. At the TC's operations, assistant trainers of the EC helped during operations. The scrub nurse was positioned directly across from the assistant.

Table 1. Comparison of demographic characteristics of patients who underwent video-assisted thoracoscopic surgery lobectomy

	Experienced consultant			Training consultant			Total			
Variables	n	%	Mean±SD	n	%	Mean±SD				*p*
Age (year)			59.7±9.8			60.1±8.8			59.8±9.7	0.880
<70	71	87.7		19	86.4		90	87.4		0.872
>70	10	12.3		3	13.6		13	12.6		
Gender										0.682
Male	63	77.8		18	81.6		81	78.6		
Female	18	22.2		4	18.2		22	21.4		
FEV_1 (%)			80.2±18.8			78.1±12.9			79.4±19.1	0.760
Low FEV_1	14	17.3		1	4.5		15	14.6		0.182
ASA Classification										0.011
Class 1	15	18.5		11	50		26	25.2		
Class 2	49	60.5		8	36.4		57	55.3		
Class 3	17	21.0		3	13.6		20	19.4		
Comorbidity	39	48.1		6	27.3		45	43.7		0.080
Cardiac problems	11	13.6		5	22.7		16	15.5		0.325
Respiratory problems	24	29.6		2	9.1		26	24.3		0.049
Endocrinologic problems	12	14.8		2	9.1		14	13.6		0.487
Body mass index			25.2±4.1			24.3±3.1			23.3±3.9	0.532
Hospitalization (days)			5.4±3.8			7.1±4.0			5.7±3.9	0.004
Drainage time (days)			4.7±3.7			5.1±3.8			4.8±3.7	0.721

SD: Standard deviation; FEV_1: Forced expiratory volume in first second; ASA: American Society of Anesthesiologists Classification.

A 10-mm camera port was created at the level of the eighth intercostal space in the anterior axillary line. Thoracic pathologies, adhesions, and diaphragm level were evaluated using a 30° 10-mm thoracoscope (Logic HD, Richard Wolf GmbH, Knittlingen, Germany). A 5-cm utility incision was then made at the fourth or fifth intercostal space in the anterior line of the latissimus dorsi muscle. A wound protector (SurgiSleeve, Covidien, Massachusetts, USA) was placed after entering the thorax. Lobectomy was performed following the same principles as open surgery. A 2-cm auxiliary third port incision was placed in the mid-scapular area when needed. Pulmonary arteries, veins and bronchus were ligated with endoscopic closure devices (endoGIA, Covidien plc, Norwalk, Connecticut, USA). Specimens were removed using endoscopic specimen bags. Systematic lymph node sampling was performed from stations 2, 4, 7, 8, 9, 10, and 11 on the right side and 5, 6, 7, 8, 9, 10, and 11 on the left side. A single 28-F chest tube was placed in all patients. All patients were extubated in the operation room and transferred to the surgical intensive care unit. They were monitored in the intensive care unit until their general condition stabilized. During the first five operations of the TC, the EC observed in the operating room and provided advice from a distance.

Statistical analysis

Continuous variables were expressed as median and range. Categorical values were analyzed by Fischer's exact test. Mann-Whitney U test was used for comparison of continuous variables. P values <0.05 were considered statistically significant.

RESULTS

In 15 patients (12.7%), the intended VATS was converted to an open procedure. Eight of those patients (6.8%) were converted to thoracotomy due to hemorrhage and seven patients (5.1%) due to failure to reduce pleural adhesions. The conversion was necessary for two (8.3%) of the surgeries performed by the TC and 13 (13.8%) of those performed by the EC (p=0.471). Six of the hemorrhages occurred during pulmonary artery dissection, and two were the result of injuries that occurred while stapling the pulmonary vein. All hemorrhages were controlled by conversion to thoracotomy.

Of the 103 cases that were completed as VATS lobectomy, 81 patients (78.6%) were males, 22 (21.4%) were females, and the mean age was 59.7±9.5 years (range, 32-84 years). The EC performed 81 (78.1%) of the surgeries, and the TC performed 22 (21.4%). The mean FEV_1 value of the patients was 79.4±17.6%. The demographic characteristics of the patients according to the groups are given in Table 1.

Sixty-four patients (62.1%) were operated on the right side and 39 patients (37.9%) on the left side. Right upper lobectomy was performed most commonly (n=37, 35.9%) (Table 2). Mean incision size was 4.7±0.8 cm. Operative time was significantly shorter in operations performed by the EC compared to those performed by the TC (p=0.002). There were no significant differences between the TC and EC in terms of histopathological types, tumor size, number of lymph nodes sampled, or tumor stage. Operative and histopathological comparisons are presented in Table 3.

Eleven patients (10.7%) received transfusions intraoperatively. Transfusions were given to eight patients (9.9%) operated by the EC and three patients (13.6%) operated by the TC (p=0.613). Intraoperative blood loss was 248.8±196.0 mL for the EC and 355.6±224.0 mL for the TC, but the difference did not reach statistical significance (p=0.06).

Complications were observed in 22 (21.4%) of the 103 patients. Prolonged air leak occurred in 11 patients (10.7%), arrhythmia in six patients (5.8%), pneumonia in four patients (3.9%), hemorrhage requiring revision in four patients (3.9%), surgical site infection in two patients (1.9%), chylothorax in two patients (1.9%),

Table 2. Comparison of resection types

	Experienced consultant		Training consultant		Total		
Resection type	n	%	n	%	n	%	*p*
Right upper lobectomy	11	26.8	9	40.9	37	35.9	
Right middle lobectomy	5	6.2	1	4.5	6	5.9	
Right lower lobectomy	18	22.2	4	18.2	22	21.4	0.501
Left upper lobectomy	15	18.5	4	18.2	19	18.4	
Left lower lobectomy	15	18.5	4	18.2	19	18.4	

Table 3. Comparison of histopathological and operative features

	Experienced consultant			Training consultant			Total			
Variables	n	%	Mean±SD	n	%	Mean±SD				*p*
Operation side										0.870
Right	50	61.7		14	63.6		64	62.1		
Left	31	38.3		8	36.4		39	37.9		
Number of ports										0.869
2	65	80.2		18	81.8		83	80.6		
3	16	19.8		4	18.2		20	19.4		
Utility size (cm)			4.7±0.8			4.7±0.9			4.7±0.8	0.845
Operation time (min)			155.2±48.8			191.2±54.6			162.9±51.9	<0.001
Pathology										0.811
Adenocarcinoma	52	64.2		12	54.5		64	58.7		
Squamous cell carcinoma	14	17.3		9	40.9		23	27		
Others	15	18.5		1	4.5		16	15.5		
Tumor diameter (cm)			3.3±1.1			3.0±1.3			3.1±1.3	0.220
Stage										0.941
1	52	64.2		15	68.2		67	65.0		
2	25	30.9		6	27.3		31	30.1		
3	4	4.9		1	4.5		5	4.9		
Mediastinal lymph nodes			19.4±7.2			17.0±5.4			18.9±6.9	0.137

SD: Standard deviation;

and phrenic nerve injury in one patient (1%). Blood pleurodesis was performed in six of the 11 patients with a prolonged air leak. A Pleuracan catheter (Pleuracan, B. Braun, Melsungen, Germany) was placed in two patients, and air leak resolved spontaneously for the other three patients after postoperative day 10. The comparison of complications between the groups is shown in Table 4.

Six patients (6.9%) of the EC and two patients (8.3%) of the TC were converted to open surgery due to bleeding. There was no statistically significant difference between the two groups (p=0.810). One of the TC's operations that was converted to open surgery due to bleeding was an upper right lobectomy, and the other was an upper left lobectomy. Six of the EC operations have been returned to open surgery

Table 4. Comparison of complications between groups

	Experienced consultant		Training consultant		Total		
Variables	n	%	n	%	n	%	*p*
Complications	16	19.8	6	27.3	22	21.4	0.445
Air leak	5	6.2	6	27.3	11	10.7	0.004
Pneumonia	3	3.7	1	4.5	4	3.9	
Arrhythmia	5	6.2	1	4.5	6	5.8	
Chylothorax	1	1.2	1	4.5	2	1.9	
Wound infection	1	1.2	1	4.5	3	2.0	>0.05
Hemorrhage	3	3.7	1	4.5	4	3.9	
Recurrent nerve damage	1	2.4	0	0	1	1.6	
Phrenic nerve damage	0	0	1	4.5	1	0	

due to bleeding. There was no statistically significant difference in terms of types of the operations (p=0.587).

There was no intraoperative or 30-day mortality, and the 90-day mortality rate was 2.9% (n=2). Both of these patients died of toxicity due to chemotherapy administered postoperatively.

DISCUSSION

Many young surgeons today are turning to minimally invasive surgical techniques. Rocco et al.[17] predicted that where available, there would be a trend toward minimally invasive surgery for major resections. However, the number of centers performing videothoracoscopic resections is still limited in many countries, including Turkey. This may be due to the lack of training programs for VATS lobectomy.

In a study regarding VATS lobectomy training conducted in 2006 with assistants and specialists, Ferguson and Walker[18] noted that VATS was also a safe method with low morbidity and mortality when performed by assistants. Similarly, Wan et al.[19] showed that trainees could safely perform VATS lobectomy under the supervision of experienced surgeons. Peterson and Hansen[10] later reported comparable mortality rates with TCs and ECs. However, they noted that prolonged air leak occurred more often and operative time was longer with TCs. Similarly, in our study, the TC and EC had similar morbidity rates, but prolonged air leak was more common after procedures performed by the TC (p=0.004). We believe that the occurrence of air leak was more often in the TC's operations than those of the EC because the lung parenchyma was more severely damaged.

Reed et al.[20] recommend the stepwise VATS lobectomy program for VATS training. Petersen and Hansen[10] and Carrot and Jones.[15] also implemented this program. Furthermore, Larsen et al.[21] reported that simulator training reduces the morbidity rate and shortens operative time. The TC in our study practiced with a simulator during the VATS training program and assisted the EC in 62 cases over the course of one year.

We believe that such training programs can reduce the complication rates of surgeons who are starting to perform resections by VATS. Ferguson and Walker[18] also reported a lower rate of conversion to open procedures in operations performed under the supervision of experienced surgeons.

In a Turkish study on VATS lobectomy training including 68 patients, Cosgun et al.[21] noted that 50 cases of experience are necessary for tumor palpation and accurate localization with endoscopic devices. The authors claimed that pleural adhesions are common due to previous infections and the poor socioeconomic conditions of the country and therefore, the posterior approach will be more successful. However, we believe that the anterior approach is more suitable for VATS and (with patience and experience) pleural adhesions do not pose a problem in many cases.

Favoring lower lobe resections when first starting to perform VATS is believed to increase training success, as lower lobe resections are generally easier anatomically than upper lobe resections.[21] In our study, of the two procedures performed by the TC that were converted to open surgery due to hemorrhage, one was a right upper lobectomy, and the other was a left upper lobectomy. Of the six procedures performed by the EC that were converted to open surgery, four were right upper lobectomies, one was a left lower lobectomy, and one was a left upper lobectomy. Although the difference was not statistically significant, there was a trend for converted procedures to be mostly upper lobectomies. Therefore, we concur that lower lobe resections may be preferable when beginning VATS lobectomy.

The retrospective nature of the study and the comparison of a single experienced surgeon to a single trainee surgeon are the limitations of this research.

In conclusion, the results of this study suggest that video-assisted thoracoscopic surgery lobectomy training can be conducted successfully by first providing simulator practice and assistance training, then having training consultants assist experienced consultants, followed by the experienced consultant observing the training consultant. With appropriate training, video-assisted thoracoscopic surgery lobectomy performed by surgeons in training is safe with acceptable outcomes. We believe that there should be more video-assisted thoracoscopic surgery training programs and that young surgeons should be encouraged to become proficient in and practice minimally invasive surgery.

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