# Comparison of perioperative results of conventional versus thoracoscopic lobectomy for clinical stage I lung carcinoma

## *Klinik evre I akciğer kanserinde klasik lobektomi ile torakoskopik lobektominin perioperatif sonuçlarının karşılaştırılması*

**Erdal Okur, Volkan Baysungur, Çağatay Tezel, Gökhan Ergene, Gökçen Sevilgen, Semih Halezeroğlu**

Department of Thoracic Surgery, Süreyyapaşa Chest Diseases and Thoracic Surgery Hospital, Istanbul

***Background:*** This study aimed to compare the perioperative results of video-assisted thoracic surgery (VATS) lobectomy with those of conventional lobectomy in patients with clinical stage I non-small cell lung carcinoma (NSCLC).

***Methods:*** We began performing VATS lobectomy in our institution in December 2007. The patients with clinical stage I NSCLC who were operated after this date (VATS group, n=20) were compared with the group of patients who were in the same clinical stage and operated via conventional lobectomy (thoracotomy group, n=28) between January and November 2007.

***Results:*** The two groups had similar preoperative characteristics of age, sex, laterality, resected lobe, pulmonary functions, and histological type. The duration of operation was significantly longer in the VATS group than thoracotomy group (207.5 min versus 142.8 min, p<0.001). The total postoperative chest tube drainage was considerably less in the VATS group than thoracotomy group (240.5 ml versus 366.6 ml, p=0.01); further, the duration of hospital stay was also shorter in the VATS group than that in the thoracotomy group (4.88 days versus 6.88 days, p<0.001). The visual analog scale score that defines postoperative pain was significantly better in VATS group (2.15 versus 4.29, p<0.001). The stages of the disease, the complication rates, and the number of lymph node stations sampled during systematic mediastinal sampling were similar in both groups.

***Conclusion:*** Video-assisted thoracoscopic lobectomy is a safe and feasible method of treatment for patients with clinical stage I NSCLC. The amount of postoperative drainage is reduced, the duration of hospital stay is shorter and postoperative pain is less with VATS method.

*Key words:* Lobectomy; lung carcinoma; video assisted thoracoscopic surgery.

***Amaç:*** Bu çalışmada klinik evre I küçük hücreli dışı akciğer kanserli (KHDAK) hastalarda klasik torakotomi ile yapılan lobektomi ile video-yardımlı torakoskopik (VYT) lobektominin perioperatif sonuçları karşılaştırıldı.

***Çalışma planı:*** Kliniğimizde VYT lobektomi Aralık 2007'de yapılmaya başlandı. Bu tarihten sonra klinik evre I KHDAK tanısı ile ameliyat ettiğimiz hastaların (VYT grubu, n=20) sonuçları, aynı klinik evrede olup Ocak-Kasım 2007 tarihleri arasında klasik torakotomi (torakotomi grubu, n=28) ile lobektomi yaptığımız hastaların sonuçları ile karşılaştırıldı.

***Bulgular:*** Her iki grubun yaş, cinsiyet, ameliyat tarafı ve rezeke edilen lobu, solunum fonksiyonları ve hücre tipleri gibi ameliyat öncesi karakteristikleri benzerdi. Ameliyat süresi VYT grubunda, torakotomi grubuna kıyasla anlamlı olarak daha uzundu (207.5 dakikaya karşılık 142.8 dakika; p<0.001). Ameliyat sonrası göğüs tüplerinden yapılan toplam drenaj miktarı VYT grubundaki hastalarda, torakotomi grubundakilere kıyasla anlamlı olarak daha az bulundu (240.5 ml ye karşın 366.6 ml; p=0.01). Hastanede kalış süresi de VYT grubundaki hastalarda, torakotomi grubundakilere kıyasla daha kısaydı (4.88 güne karşın 6.88 gün, p<0.001). İlave olarak görsel analog skala skoru değerlendirmesinde ağrı, VATS grubunda anlamlı düzeyde daha az tespit edildi (2.15'e karşın 4.29, p<0.001). Her iki gruptaki hastalık evreleri, komplikasyon oranları ve sistematik mediyastinal örnekleme ile örneklenen lenf nodu istasyonu sayıları benzerdi.

***Sonuç:*** Video-yardımlı torakoskopik lobektomi, klinik evre I KHDAK'li hastaların tedavisinde güvenli ve etkili bir cerrahi yöntemdir. Video-yardımlı torakoskopik lobektomi yöntemi ile ameliyat sonrası toplam drenaj miktarları ve ağrı düzeyi daha az, hastanede kalış süresi daha kısa olmaktadır.

*Anahtar sözcükler:* Lobektomi; akciğer kanseri; video yardımlı torakoskopik cerrahi.

*Received:* March 3, 2009 *Accepted*: June 15, 2009

Correspondence: Erdal Okur, M.D. Süreyyapaşa Göğüs Hastalıkları ve Göğüs Cerrahisi Eğitim ve Araştırma Hastanesi, 1. Göğüs Cerrahisi Kliniği, 34844 Maltepe, İstanbul, Turkey. Tel: +90 216 - 421 42 00 e-mail: erdalokur@hotmail.com

After the introduction of video-endoscopic techniques to general thoracic surgery, video-assisted thoracic surgery (VATS) pulmonary resections were begun to be performed at certain centers in the 1990s.[1,2] Nowadays, in many thoracic surgery centers around the world, the VATS lobectomy is a frequently performed technique and some published series in literature report more than 1000 cases in which a VATS lobectomy was performed.[2] In addition, many studies have reported that this technique is feasible for the resection of early stage, non-small cell lung carcinoma (NSCLC).[3-6] It has been reported that with this technique, the patients experience less postoperative pain, their muscle functions are preserved better, their postoperative immune functions are less affected, the duration of the postoperative hospital stay is reduced and they achieve an earlier return to normal activities.[7-11]

Although VATS is a common practice in most thoracic surgery centers in Turkey, the VATS lobectomy is performed extremely rarely and no thoracic surgery center in our country has reported a series addressing VATS lobectomies.

The aims of our study are as follows:

1. To show that the VATS lobectomy is a safe and feasible technique,

2. To compare the perioperative results of clinical stage I NSCLC patients undergoing lobectomy through VATS or conventional thoracotomy.

## PATIENTS AND METHODS

We commenced performing VATS lobectomy operations after December 2007. In addition to the use of this technique for the treatment of certain benign cases such as bronchiectasis, the VATS lobectomy was performed on patients with tumors that fulfilled the following criteria: *(i)* a peripheral location, *(ii)* a diameter less than 5 cm, *(iii)* not demonstrating any chest wall invasions, and *(iv)* not demonstrating pathological hilar or mediastinal lymph nodes.

The preoperative evaluation was standard for all patients. A positron emission tomography-computed tomography (PET-CT) was obtained for all patients and clinical staging (clinical stage I) was ascertained. No mediastinoscopies were performed in any patient in these groups since all the tumors were peripherally located and there was no $N_1$ or $N_2$ suspicion on the PET-CT.

### Groups

Patients who fulfilled the above-mentioned criteria underwent a VATS lobectomy between December 2007 and December 2008. These patients comprised the VATS group and their characteristics were recorded prospectively. Patients who satisfied the above-mentioned criteria and were eligible for a VATS lobectomy, but underwent surgery between January and November 2007 via open lobectomy comprised the thoracotomy group; their characteristics were recorded retrospectively.

### Parameters compared

We compared patient parameters such as age, sex, laterality, the resected lobe, the forced expiratory volume in 1st second (FEV1), histological cell type, duration of surgery, the total amount of postoperative drainage, postoperative complications, tumor stages, the number of lymph node stations sampled via mediastinal lymph node dissection and the duration of hospital stay.

### Surgical technique

The surgical incisions used for thoracotomy and VATS lobectomy are shown in Figure 1a, b.

### Thoracotomy group

After intubation with a double-lumen tube, the patients were positioned in the lateral thoracotomy position. Thereafter, taking care to preserve the serratus anterior muscle, the thorax was opened through the 5th interspace and two thoracic retractors were placed to enable better exploration during the surgery. Mechanical staplers were used to divide incomplete fissures. Manual sutures were applied to close the lobar bronchus, except in three cases in which mechanical staplers were used. During and after the lobectomies, systematic lymph node sampling was performed in all patients. After checking for alveolar air leaks and sealing the detected air leaks by sutures or other sealing materials, the chest incision was closed by placing a single or double chest tube inside the patient.

### Video-assisted thoracic surgery group

After intubation with a double-lumen tube, a fiber optic bronchoscopic examination was performed wherever necessary to check the correct placement of the tube. The patients were positioned in the lateral decubitus position. Through the 8th interspace, a camera port was placed on the anterior axillary line in the right or on the midaxillary line in the left side. The second 1 to 2 cm incision was made in the posterior axillary line or sometimes a few cm more posteriorly through the 7th or 8th interspace. A 4 to 6 cm utility thoracotomy incision was made just across the vein of the lobe that is to be resected. Bundles of serratus anterior muscle were divided without cutting and the chest was entered. Rib retractors were not used in any stage of the operation; however, subcutaneous tissue and muscle bundles were retracted to enable an easy entrance of surgical instruments. A hilar dissection was performed using


**Fig. 1.** Incisions used for **(a)** thoracotomy and **(b)** video-assisted thoracoscopic lobectomy.

standard instruments used also in open thoracic surgery. The vessels were mostly divided using endostaplers, or ligated in rare cases. Incomplete fissures were also divided using mechanical staplers, and finally, the lobar bronchus was closed by mechanical bronchial staplers except in two cases in whom manual suturing was applied. In seven cases, since there was no preoperative tissue diagnosis, a wedge resection of the lesions was done first, and the lobectomy was performed only after the confirmation of the malignancy through frozen pathology. During and following the lobar dissection, systematic mediastinal lymph node sampling was also performed. After checking for air leaks, we inserted a single chest tube through the camera port and the chest incisions were closed.

The postoperative period was standard for all patients in both groups. All patients were admitted to the intensive care unit for the day of the operation. On the day following the surgery, they were transferred to the thoracic unit if there was no contraindication. For pain management, we either used patient-controlled narcotic analgesia or continuous infusion of morphine sulphate during the first day after operation in the intensive care unit. When the patients returned to the ward, they received intravenous tramadol (3 or 4 times, 50-100 mL/day) together with a non-steroidal anti-inflammatory drug (tenoxicam) and paracetamol. Chest X-rays were acquired daily, and the amount of chest tube drainage was recorded. The visual analog scale (VAS) scores of the patients in the morning of the 2$^{nd}$ postoperative day, before the administration of morning analgesics doses were also recorded. The chest tubes were removed when no air leak and no hemorrhagic drainage was evident. If there were no contraindications, the patients were discharged on the next day.

### Statistical analysis

A computer based SPSS Version 11 program (Statistical Package for Social Sciences; SPSS Inc., Chicago, Illionis, USA) was used for statistical analysis. The mean ± standard deviation (or the standard error of mean, when required) was calculated for numerical values and a Student's t-test or Mann-Whitney U-test was performed in order to compare both groups. The categorical variables between the groups were compared using the Pearson chi-square test. The differences were considered significant if p values were less than 0.05.

## RESULTS

The thoracotomy group included 28 patients (34%) while the total number of the patients who underwent lobectomy in this period was 81.

The VATS group consisted of 20 patients. In five other patients, a VATS lobectomy was initially planned but conversion to open thoracotomy later became a requisite. The reasons for this conversion were:

1. A bleeding from the first branch of the left pulmonary artery during the left upper lobectomy in the patient who was our first VATS lobectomy case,

2. A bleeding form the left inferior pulmonary vein stump,

**Table 1. Comparison between preoperative variables in the two groups**

| | Thoracotomy group (n=28) | | VATS group (n=20) | | *p* |
|---|---|---|---|---|---|
| | n | Mean±SD | n | Mean±SD | |
| Age (years) | | 64.21±8.36 | | 62.40±7.06 | 0.43* |
| Sex (male/female) | 24/4 | | 15/5 | | 0.34** |
| Laterality (right/left) | 14/14 | | 12/8 | | 0.49** |
| Resected lobe (upper/lower/middle) | 20/7/1 | | 12/7/1 | | 0.71** |
| Forced expiratory volum in 1st second (%) | | 75.42±17.33 | | 78.47±12.52 | 0.51* |
| Tumor histology | | | | | |
| Squamous cell | 16 | | 11 | | |
| Adeno carcinoma | 9 | | 9 | | 0.50** |
| Other | 3 | | – | | |

VATS: Video-assisted thoracic surgery; *: Student t-test expressed as mean±standard deviation; **: Chi-square test.

3. A right upper lobectomy case having totally incomplete major and minor fissures,

4. A patient who had a tumor invading the left pulmonary artery requiring arterioplasty and,

5. Another right upper lobectomy patient who had anatomically inaccessible trunchus anterior which was too proximally divided from the right pulmonary artery.

So the total conversion rate was 20% (5 over 25 patients). During this period, we also performed seven other VATS lobectomies due to lung diseases including bronchiectasis (n=6) and aspegilloma (n=1). The total number of lobectomies performed in this period was 86, and the rate of VATS lobectomies performed in our study was to be 32% (27 of 86 patients).

The preoperative variables of age, sex, laterality, resected lobe, percentage of the FEV1 and pathological type were similar in the two groups (Table 1).

The mean duration of the surgery was 142.8 mins. in the thoracotomy group while it was 207.5 mins. in the VATS group; the difference between the two groups was significant (p<0.001). The postoperative drainage from the chest tubes was less in the VATS group than in the thoracotomy group (240.5 ml versus 366.6 ml; p=0.01). The duration of hospital stay was also less in the VATS group than in the thoracotomy group (4.88 days versus 6.88 days; p<0.001). The VAS that defined postoperative pain was significantly better in the VATS group (2.15 versus 4.29; p=<0.001). The complication rates, the number of lymph node stations sampled and the clinical stages in the two groups were similar (Table 2).

We observed that the patients in the VATS group experienced less pain than those in the thoracotomy group. Furthermore, they were mobilized earlier and could better perform the respiratory exercises. For this reason, their chest tubes were removed and they were

**Table 2. Comparison between operative and early postoperative variables**

| | Thoracotomy group (n=28) | | VATS group (n=20) | | *p* |
|---|---|---|---|---|---|
| | n | Mean±SD | n | Mean±SD | |
| Duration of operation (min) | | 142.86±37.79 | | 207.50±49.19 | <0.001* |
| Amount of total drainage from chest tubes (ml) | | 366.67±36.49 | | 240.56±31.33 | 0.012* |
| Complications: no/yes | 19/9 | | 16/4 | | 0.35** |
| Stages | | | | | |
| 1a | 10 | | 7 | | |
| 1b | 13 | | 8 | | |
| 2a | 1 | | 1 | | |
| 2b | 4 | | 3 | | 0.79** |
| 3b ($T_4$) | – | | 1 | | |
| The number of lymph node station sampled | | 4.86±0.84 | | 4.90±0.73 | 0.93* |
| Duration of hospital stay (days) | | 6.88±1.48 | | 4.88±1.36 | <0.001*** |
| Visual analog scale score | | 4.29±1.08 | | 2.15±0.67 | <0.001*** |

VATS: Video-assisted thoracic surgery; *: Student t-test expressed as mean±standard deviation; **: Chi-square test; ***: Mann-Whitney U-test expressed as mean±standard error.

discharged earlier than the patients in the thoracotomy group.

Complications observed in the VATS group were pneumonia in two patients, prolonged intubation in a patient with limited pulmonary reserve, and a chylous leak in another patient. Conservative treatment performed for 10 days failed to treat the chylous leak and a thoracotomy was warranted. During the exploration, we observed that the leak originated from the right lower paratracheal region. The leak was successfully sutured.

Complications in the thoracotomy group included atelectasis in three, prolonged air leaks in two, and pneumonia in two patients. Severe cardiac arrhythmia and a wound infection were also observed. No mortality was observed in either group.

## DISCUSSION

Owing to the use of endoscopic techniques in thoracic surgery, surgical therapies began to be performed through smaller incisions, causing less of a trauma to the patients and thereby less pain, and ensuring a faster recovery and an earlier return to daily activities. In the initial years when the endoscopic techniques began to be employed in thoracic surgery, only pleural or lung biopsies could be performed using this method. Thereafter, wedge resections started to be performed via VATS technique too. This was followed by anatomical lung resections. Currently, it is reported that more complicated surgical procedures, such as sleeve lobectomies, can be performed with this technique.[12]

Although there are still some apprehensions regarding the use of VATS lobectomy in early stage NSCLC, there is a considerable literature confirming the feasibility of this technique.[3-6,13] In our study, we did not observe any differences in the complication rates between the VATS and the thoracotomy groups. In older patients, the VATS method was reported to entail a lesser rate of morbidity and mortality than in the other age groups.[14,15] Another apprehension regarding the use of the VATS method for the resection of NSCLC relates to the effectiveness of the mediastinal lymph node dissection performed by this method. The individual studies of Sagawa et al.[16] and Watanabe et al.[17] compared the number and the amount of the lymph nodes obtained through the VATS method with those obtained using the open thoracotomy method and both the studies found that the number and the amount of the lymph nodes obtained with both methods are similar. Additionally, Shirashi et al[18] reported that a VATS lobectomy was not inferior with regard to its ability to achieve locoregional control in comparison with a conventional open lobectomy. In our study, the mean numbers of the lymph node stations sampled during the systematic mediastinal lymph node sampling were statistically similar in the VATS and thoracotomy groups; if anything, this number was slightly greater in the VATS group than the latter (4.86 versus 4.90). In our experience and with the help of a larger image obtained using a telescope in the VATS method, better visualization and better dissection could be achieved.

In our study, the mean chest tube drainage in the VATS group (240 ml) was considerably less than that observed in the thoracotomy group (366 ml). Such a result has not been mentioned in the literature before; however, in our opinion, there may be two possible explanations for this: Firstly, the shorter incision through the intercostal muscle and the pleura causes less oozing of blood from these sites. Secondly, with the help of larger images acquired with a telescope, all regions of the pleura could be better visualized than was previously possible in thoracotomy.

We observed that the patients in the VATS group experienced significantly less pain than those in the thoracotomy group. This was probably due to the smaller incision size, the comparatively smaller amount of muscle cut and, most importantly, the fact that we never used a rib retractor that causes a trauma to the ribs at the point where the retractor is placed. Sugiura et al.[11] found less narcotic need, decreased analgesic demand and a lower incidence of post-thoracotomy pain in their study. Theoretically, thanks to the diminished pain and better preserved muscle function, the patients in the VATS group are expected to be mobilized earlier and to perform respiratory exercises more efficiently, leading to an early removal of the chest tube and early discharge from the hospital. We applied a single chest tube to all patients in the VATS group while some patients in the thoracotomy group had two chest tubes. The visual analog scale score in the VATS group (2.15) was found to be much less than that of the thoracotomy group (4.29). In a former study that we had performed to compare the VAS scores of patients after single or double chest tube application following conventional lobectomy,[19] the VAS score in the single tube group was found as 4.12, which is still much higher score than that of VATS group in this study.

In our study, the duration of the hospital stay was considerably shorter in the VATS group than in the thoracotomy group (4.88 days versus 6.88 days). Similar results relating to shorter hospital stay durations were reported by Cattaneo et al.[15] in their study.

As in the case of all new surgical methods, there is a learning curve for VATS lobectomy. In this learning period, the conversion from VATS to open thoracotomy may be warranted. In the case of our first patient, who underwent a left upper lobectomy, conversion from

VATS to open thoracotomy was required due to bleeding from the first branch of the left pulmonary artery that occurred while this artery was being stapled. In another patient, again an uncontrolled bleeding from a stapled vein occurred. Two of the conversions were due to reasons of anatomical inaccessibility, one because of a fissure and the other because of a too posteriorly located trunchus anterior branch. The last case needed a pulmonary angioplasty in order to avoid a pneumonectomy and to save the lower lobe of the left lung. Following these experiences, we were able to control bleeding by clamping the vessel and suturing it manually without converting the lobectomy from VATS to open thoracotomy.

The surgical duration in our study was approximately four to five hours in the initial patients; however, the duration gradually decreased to approximately two hours in the last patients.

In our study, the number of patients on which a lobectomy was performed using the VATS method is quite small. We think that a larger series is required to support our initial results. Furthermore, we also need to observe the later oncological outcome of the patients who underwent lobectomies via the VATS method.

Our suggestion to our colleagues intending to perform a VATS lobectomy for the first time will be to shift to an anterior thoracotomy and to approach the patient from the anterior side in order to get familiarized with the anterior approach to the hilum. Observing this method while it is performed in an experienced center in order to grasp the basic principles and the appropriate selection of the entrance sites can also prove valuable. The dissection should be performed slowly and patiently and all the vessels and bronchi should be encircled with tape prior to stapling. Cost may be an important deciding factor because the instruments used in VATS, especially the staplers, are expensive. After our first few cases, we chose to begin with ligating the vessels instead of stapling most of the time in order to decrease the costs. In two of the cases in the present series, the bronchi were closed manually, and so, all the procedure including the vessel ligations was performed without staplers.

In conclusion, the VATS lobectomy is as safe and feasible surgical method similar to the conventional lobectomy performed via thoracotomy. Considering its advantages such as reduced pain and chest tube drainage during the postoperative period and the shorter duration of hospital stay, the VATS lobectomy should be the preferred method of surgical treatment in clinical stage I NSCLC.

## REFERENCES


1. Yim AP, Ko KM, Ma CC, Chau WS, Kyaw K. Thoracoscopic lobectomy for benign diseases. Chest 1996;109:554-6.
2. McKenna RJ Jr, Houck W, Fuller CB. Video-assisted thoracic surgery lobectomy: experience with 1,100 cases. Ann Thorac Surg 2006;81:421-5.
3. McKenna RJ Jr, Wolf RK, Brenner M, Fischel RJ, Wurnig P. Is lobectomy by video-assisted thoracic surgery an adequate cancer operation? Ann Thorac Surg 1998;66:1903-8.
4. Walker WS, Codispoti M, Soon SY, Stamenkovic S, Carnochan F, Pugh G. Long-term outcomes following VATS lobectomy for non-small cell bronchogenic carcinoma. Eur J Cardiothorac Surg 2003;23:397-402.
5. 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.
6. Shigemura N, Akashi A, Funaki S, Nakagiri T, Inoue M, Sawabata N, et al. Long-term outcomes after a variety of video-assisted thoracoscopic lobectomy approaches for clinical stage IA lung cancer: a multi-institutional study. J Thorac Cardiovasc Surg 2006;132:507-12.
7. Kirby TJ, Mack MJ, Landreneau RJ, Rice TW. Lobectomy-video-assisted thoracic surgery versus muscle-sparing thoracotomy. A randomized trial. J Thorac Cardiovasc Surg 1995;109:997-1001.
8. Landreneau RJ, Mack MJ, Hazelrigg SR, Naunheim K, Dowling RD, Ritter P, et al. Prevalence of chronic pain after pulmonary resection by thoracotomy or video-assisted thoracic surgery. J Thorac Cardiovasc Surg 1994;107:1079-85.
9. Yim AP, Wan S, Lee TW, Arifi AA. VATS lobectomy reduces cytokine responses compared with conventional surgery. Ann Thorac Surg 2000;70:243-7.
10. Nakajima J, Takamoto S, Kohno T, Ohtsuka T. Costs of videothoracoscopic surgery versus open resection for patients with of lung carcinoma. Cancer 2000;89(11 Suppl):2497-501.
11. Sugiura H, Morikawa T, Kaji M, Sasamura Y, Kondo S, Katoh H. Long-term benefits for the quality of life after video-assisted thoracoscopic lobectomy in patients with lung cancer. Surg Laparosc Endosc Percutan Tech 1999;9:403-8.
12. Mahtabifard A, Fuller CB, McKenna RJ Jr. Video-assisted thoracic surgery sleeve lobectomy: a case series. Ann Thorac Surg 2008;85:S729-32.
13. Swanson SJ, Herndon JE 2nd, D'Amico TA, Demmy TL, McKenna RJ Jr, Green MR, et al. Video-assisted thoracic surgery lobectomy: report of CALGB 39802--a prospective, multi-institution feasibility study. J Clin Oncol 2007; 25:4993-7.
14. Shaw JP, Dembitzer FR, Wisnivesky JP, Litle VR, Weiser TS, Yun J, et al. Video-assisted thoracoscopic lobectomy: state of the art and future directions. Ann Thorac Surg 2008; 85:S705-9.
15. Cattaneo SM, Park BJ, Wilton AS, Seshan VE, Bains MS, Downey RJ, et al. Use of video-assisted thoracic surgery for lobectomy in the elderly results in fewer complications. Ann Thorac Surg 2008;85:231-5.
16. Sagawa M, Sato M, Sakurada A, Matsumura Y, Endo C, Handa M, et al. A prospective trial of systematic nodal dissection for lung cancer by video-assisted thoracic surgery: can it be perfect? Ann Thorac Surg 2002;73:900-4.
17. Watanabe A, Koyanagi T, Ohsawa H, Mawatari T, Nakashima S, Takahashi N, et al. Systematic node dissection by VATS is

not inferior to that through an open thoracotomy: a comparative clinicopathologic retrospective study. Surgery 2005;138:510-7.
18. Shiraishi T, Shirakusa T, Hiratsuka M, Yamamoto S, Iwasaki A. Video-assisted thoracoscopic surgery lobectomy for c-T1N0M0 primary lung cancer: its impact on locoregional control. Ann Thorac Surg 2006;82:1021-6.
19. Okur E, Baysungur V, Tezel C, Sevilgen G, Ergene G, Gokce M, et al. Comparison of the single or double chest tube applications after pulmonary lobectomies. Eur J Cardiothorac Surg 2009;35:32-5.