Is Lobectomy by Video-Assisted Thoracic Surgery an Adequate Cancer Operation?

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Background. **Although the public perceives video-assisted thoracic surgery (VATS) as advantageous because it is less invasive than a thoracotomy, the medical community has questioned the safety of VATS lobectomy and its adequacy as a cancer operation. Reported series have not been able to address these issues because follow-up has been only short-term.**

Methods. **A multiinstitutional, retrospective review was performed in 298 consecutive patients who underwent VATS for a standard anatomic lobectomy with lymph node dissection for lung cancer. Pathologic staging was I in 233 (78%), II in 27 (9%), and IIIA in 38 (13%) patients. Kaplan Meier survival analysis was performed.**

Results. **The conversion rate from VATS lobectomy to thoracotomy was 6%, but none were for massive intraoperative bleeding. The only death (0.3%) was because of mesenteric venous thrombosis. Forty minor complications occurred in 38 patients (12.8%) undergoing VATS. The mean and median lengths of stay were 5 ± 3.39 and 4 days, respectively. Recurrence in an incision occurred in 1 patient (0.3%). The Kaplan Meier 4-year survival for stage I was 70% ± 5%.**

Conclusion. **The VATS lobectomy for bronchogenic carcinoma appears to be a safe operation, with the same survival as expected for a lobectomy done by thoracotomy.**

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Patients have the perception that video-assisted thoracic surgical (VATS) lobectomy is desirable because it involves a less invasive operation than a thoracotomy. Published reports [1–4] have shown that a VATS lobectomy can be performed with reasonable safety, but the medical community has continued to question its safety, its adequacy as a cancer operation, and whether there is in fact any advantage to VATS lobectomy [5, 6].

Although two randomized, prospective studies have shown some benefits to lobectomy by VATS, compared with lobectomy by thoracotomy [6, 7], these studies failed to prove conclusively any superiority of the VATS approach. Our clinical impression has been that, without sacrificing the completeness of the cancer operation, VATS offers the same cancer operation with a shorter length of stay, compared with a thoracotomy for a lobectomy. This review was undertaken to address these issues.

Material and Methods

Between February 1992 and December 1997, the authors in Los Angeles (R.J.M., R.J.F.) and Cincinnati (R.W., P.W.) performed either VATS lobectomy (n = 290) or pneumonectomy (n = 8) for bronchogenic carcinoma in 298 patients. This included 137 men (46%) and 161 women (54%), with a mean age of 68.1 ± 12 years (range, 39 to 85 years). The intent of the operation was to perform, through VATS, the standard lung cancer operation usually performed by thoracotomy. This was not a compromise operation for patients with poor performance status.

In addition to the standard criteria for lobectomy by thoracotomy, there are indications and contraindications unique to VATS lobectomy. The indications are tumor size less than 6 cm and a negative mediastinum by mediastinoscopy or chest computed tomographic scan.

Contraindications are as follows:

- T3 tumors
- Endobronchial tumor seen at bronchoscopy
- Positive cervical mediastinoscopy
- Neoadjuvant chemotherapy or radiation therapy
- Centrally located tumors
- Need for a sleeve resection
- Lobar or hilar nodes adherent to pulmonary vessels.

Because a centrally located tumor may require a bronchoplastic procedure, the presence of endobronchial tumor seen at bronchoscopy is a contraindication to VATS lobectomy, but not to VATS pneumonectomy. The evaluation of the relationship between the tumor and the

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pulmonary artery can be difficult by VATS, therefore a thoracotomy is indicated to decide between performance of a standard lobectomy, a sleeve resection, and a pneumonectomy. We thus approach most centrally located tumors with a thoracotomy. Neoadjuvant chemotherapy, radiation therapy, and extensive neoplastic involvement of mediastinal nodes make the mediastinal dissection more difficult, therefore these are contraindications to VATS lobectomy.

Technique

Our technique has been described previously [8], but the following are some key technical points to our approach for a VATS lobectomy. Our technique involves lymph node dissection or sampling after the individual ligation of vessels and bronchus for the lobectomy.

Under general anesthesia with one-lung ventilation, the patient is placed in a full lateral decubitus position. To allow the maximal time for the development of atelectasis, the endotracheal tube is clamped as soon as the patient is positioned and the surgeon goes to scrub. Suction through the bronchoscope in the ipsilateral main stem bronchus is often needed to promote collapsing of the lung.

The trocar and thoracoscope are placed in the eighth intercostal space in the midaxillary line on the right or posterior axillary line on the left to avoid obstruction of vision by the pericardial fat pad. The 30-degree lens allows the surgeon to see around structures in the hilum better than the 0-degree lens.

Proper placement of incisions is critical because suboptimal placement of the incisions may make the procedure very difficult. Through a 1-cm to 2 cm incision in the auscultatory triangle, a curved ring forceps manipulates the lung to allow inspection of the pleura and expose the hilum to determine the proper position for the utility thoracotomy incision. This 5-cm incision is made anteriorly from the edge of the latissimus dorsi muscle. It is directly lateral to the superior pulmonary vein for an upper lobectomy or one interspace lower for a middle or lower lobectomy. The ribs are not spread and the muscles are not mobilized or undermined, but a Weitlander retractor holds the soft tissues of the chest wall open for easier passage of instruments and to prevent the lung from expanding when suctioning in the chest.

The surgeon stands on the ventral side of the patient and the dissection begins in the hilum. This approach is similar to the approach for an anterolateral, muscle-sparing thoracotomy. This makes a VATS lobectomy much easier than trying to perform the procedure with the approach for a posterolateral thoracotomy.

Hilar dissection is performed with standard thoracotomy instruments, such as Metzenbaum scissors and DeBakey pickups. To facilitate passage of the nonarticulating endoscopic stapler (EZ 35, Ethicon or Endo-GIA, U S Surgical) across the pulmonary vessels, they are dissected more for a VATS procedure than is customary for a thoracotomy. Lifting the vessel with a zero silk tie aids placement of the stapler. For the superior pulmonary vein, the stapler is placed through the posterior incision or, for the arteries and the fissure, through an incision in the lowest intercostal space in the midclavicular line.

Table 1. Procedures by Video-Assisted Thoracic Surgery Performed for Lung Cancer in 298 Consecutive Patients

Procedure	n
Right upper lobectomy	100 (34%)
Right middle lobectomy	24 (8%)
Right lower lobectomy	52 (17%)
Bilobectomy	7 (2%)
Right pneumonectomy	2 (1%)
Left upper lobectomy	75 (25%)
Left lower lobectomy	32 (11%)
Left pneumonectomy	6 (2%)

In case bleeding should occur, a sponge stick is always available to immediately apply pressure for controlling hemorrhage. After the bleeding is temporally controlled, a decision is made as to whether VATS or a thoracotomy is needed for permanent control of the bleeding site.

After the vessels and bronchus are transected, the fissure is completed. The completeness of the fissure is therefore not a factor in determining the feasibility of performing a lobectomy by VATS.

The technique is slightly different for a lower lobectomy when the fissure is poorly developed. The artery is located by opening the fissure between the middle and lower lobes, taking down the inferior pulmonary ligament, and transecting the inferior pulmonary vein. The bronchus and the artery can then be identified from inferiorly. After dissection along the anterior and lateral surfaces of the artery, the stapler is fired across the fissure to further expose the artery. The artery and bronchus can then be transected individually.

To minimize the risk of contaminating the incision with the tumor, the lung specimen is placed in a bag for removal through the utility thoracotomy incision.

A complete lymph node dissection can be performed by VATS [8]. For example, paratracheal nodes are removed by dissecting in the planes along the superior vena cava, the trachea, and the pericardium over the ascending aorta, from the azygous vein to the subclavian artery. The dissection is easier if the azygous vein is transected.

The series included 137 men and 161 women, with a mean age of 68.1 ± 12 years, who underwent the operative procedures listed in Table 1. The procedures included right upper lobectomy (n = 100), right middle lobectomy (n = 24), right lower lobectomy (n = 52), left upper lobectomy (n = 75), left lower lobectomy (n = 32), bilobectomy (n = 7), and pneumonectomy (n = 8). The histologic types of lung cancer resected are seen in Table 2. The preoperative clinical and postoperative pathologic stagings are seen in Table 3.

Results

Mortality and Morbidity

The mean postoperative length of stay was 5.06 ± 3.39 days (range, 1 to 17 days) and the median hospital stay

Table 2. Pathologic Types of Tumors Resected by 298 Consecutive Video-Assisted Thoracic Surgical Lobectomies or Pneumonectomies

Tumor Type	n
Adenocarcinoma	194 (65%)
Squamous cell	63 (21%)
Poorly differentiated	13 (5%)
Large cell	12 (4%)
Adeno/Squam	6 (2%)
Carcinoid	3 (1%)
Small cell	2 (1%)
Adeno + sarc	1
Sarcoma	1
Lymphoma	1
Neurogenic	1
Blastoma	1

Adeno + Sarc = separate adenocarcinoma and sarcoma. Adeno/Squam = adenosquamous and squamous cell carcinoma.

was 4 days. The mean length of stay was 4.4 days in Los Angeles (228 cases: R.J.M., R.J.F.) and 6.15 days in Cincinnati (70 cases: R.W., P.W.).

There was 1 (0.3%) mortality because of mesenteric venous infarct. On the fourth postoperative day after a right lower lobectomy, the patient developed an acute abdomen. Exploratory laparotomy demonstrated complete small bowel necrosis caused by thrombosis of the superior mesenteric vein, and the patient expired.

Forty complications occurred in 38 patients (12.4%). These included prolonged air leak for more than 7 days (20 [6.7%]), bleeding requiring transfusion (5 [1.7%]), pneumonia (3 [0.7%]), prolonged serous drainage (2 [0.7%]), arrhythmias (2 [0.7%]), bronchial leak (2 [0.7%]), myocardial infarction (1 [0.3%]), transient ischemic attack (1 [0.3%]), empyema (1 [0.3%]), urinary tract infection (1 [0.3%]), and massive subcutaneous emphysema (1 [0.3%]). One patient with a bronchial dehiscence had no air leak after the operation but underwent suture closure of the dehisced bronchial staple line when she developed a large air leak on the next day. The other patient developed a small leak (not a complete dehiscence) in the left main stem bronchus after a pneumonectomy. This resolved with a chest tube and placement of fibrin glue in the stump. Two patients receiving chronic crystalline warfarin sodium therapy were readmitted for drainage of a hemothorax.

Table 3. Preoperative Clinical Stage and Postoperative Pathologic Stage of the 298 Lung Cancers Resected by Video-Assisted Thoracic Surgery

Preoperative Stage	n	Postoperative Stage	n
Stage 1	295	Stage 1	233
T1N0	231 (77%)	T1N0	180 (60%)
T2N0	64 (22%)	T2N0	53 (18%)
Stage 2	3	Stage 2	27
T1N1	(0)	T1N1	17 (6%)
T2N1	(2)	T2N1	7 (2%)
T3N0	(1)	T3N0	3 (1%)
Stage 3A	0	Stage 3A	38
T1N2	(0)	T1N2	22 (7%)
T2N2	(0)	T2N2	16 (5%)
		T3N2	1

Readmission to the Hospital

Six patients (2%) were readmitted to the hospital within 30 days after discharge. One patient had an uneventful 2-day hospital stay after a right upper lobectomy. One week later, he was admitted with pulmonary embolus. After heparinization, he developed hemothorax that required drainage. Another patient receiving chronic heparin therapy was readmitted for drainage of a hemothorax. Four days after discharge (postoperative day 7), a patient developed atrial fibrillation and a transient ischemic attack. One patient was admitted for 2 days to manage postoperative pain and fever (urinary tract infection). One patient developed a pneumothorax. Another patient developed adult respiratory distress syndrome; presumably caused by a viral pneumonia. He required intubation and a prolonged hospital course, but eventually he recovered fully.

Conversion to Thoracotomy

During the time of this study, 19 additional patients were converted to thoracotomy when the operation began with the intent to perform a lobectomy using VATS, for a 6% conversion rate (19 of 317 patients). Oncologic reasons necessitated the conversion in 14 of the 19 patients (74%). Eight patients had centrally located tumors that were best dissected through thoracotomy. Four patients were found to have unsuspected T3 tumors that were attached to the chest wall (n = 2), diaphragm (n = 1), or superior vena cava (n = 1). Two cases with abnormal (granulomatous [n = 1] or metastatic [n = 1] disease) hilar lymph nodes adherent to the superior pulmonary vein were converted to thoracotomy for safe dissection. In 2 obese patients, the visualization was poor for a left upper lobectomy because the lateral diameter of the chest decreased when they were placed in the lateral decubitus position. In 1 patient, a right middle lobectomy was performed through VATS, but a thoracotomy was made to perform a sleeve resection when frozen section showed a microscopically positive bronchial margin. Pleural symphysis necessitated a thoracotomy in 1 patient. In 1 patient, a VATS right lower lobectomy was converted to thoracotomy because minor bleeding occurred during dissection of the artery. The patient did not require a blood transfusion.

Follow-up

Mean follow-up was 28.9 months (range, 1 month to 5 years). Kaplan-Meier survival at 4 years for stage I lung cancer was 70% ± 5% (Fig 1). Among the 50 patients who have died to date, all but three deaths were related to lung cancer. Six patients are alive with recurrent disease at 6 to 42 months after resection (mean, 2.5 years).

One recurrence (0.3%) of the cancer in a VATS incision

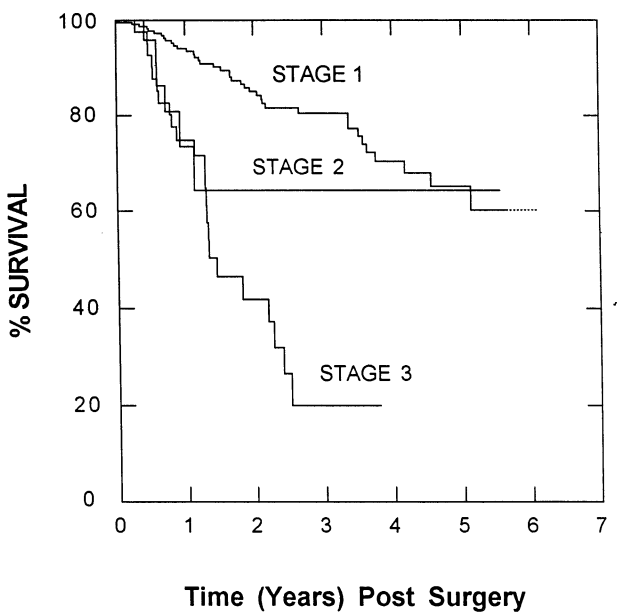

Fig 1. The Kaplan-Meier survival curves for patients with stage I, II, and IIIA lung cancer after video-assisted thoracic surgery (VATS) lobectomy.

has occurred in a patient who simultaneously developed bone metastases.

The current status of 4 patients is not known, thus clinical follow-up is complete for 294 of 298 patients (98.7%). Patients who returned to our offices underwent physical examination, biochemical profile, and chest roentgenogram at 6-month intervals. For patients who did not return to the office for follow-up, the patients and their physicians were contacted by telephone to determine their clinical status.

Comment

Lobectomy through VATS is controversial because the adequacy of the cancer operation using VATS has been questioned, because no study to date has demonstrated conclusively a benefit to the procedure, compared with lobectomy through thoracotomy, and because tumor seeding of VATS incisions has been reported [9–11]. This series was reviewed to determine whether these concerns are justified.

The Kaplan Meier survival curve seen in Figure 1 demonstrates that the survival in this series is comparable to the survival expected for lung cancer operations by thoracotomy [12–14]. This suggests that lung cancer surgery can be performed by VATS without compromising the survival achieved with a thoracotomy.

Two randomized, prospective studies of lobectomy by VATS versus thoracotomy have not proved conclusively any benefit to the VATS approach [6, 7]. Giudicelli and colleagues [6] analyzed the postoperative courses in 67 patients after lobectomy by VATS (44 patients) or by muscle-sparing thoracotomies (23 patients). The postoperative pain was significantly less ($p < 0.02$) after a VATS procedure. Although the pain-related morbidity, the mean duration of air leaks, the chest tube duration, and the hospital stay were all less after the VATS procedure than after the open procedure, these differences did not reach statistical significance for the small number of patients in that series. The overall morbidity and the pulmonary impairment were the same for both procedures.

Kirby and associates [7] reported 55 lobectomies by thoracotomy (n = 30) or VATS (n = 25). The length of stay (8.3 versus 7.1 days) and chest tube duration (6.5 versus 4.6 days) favored the VATS approach but also did not reach statistical significance. More postoperative complications occurred in the thoracotomy group than in the VATS group ($p < 0.05$). Kirby cautioned, "In the final analysis, the potential short term benefit or the surgeon's ability to perform a VATS procedure is of little value to the patients if the goal of long term cure is compromised."

In a prospective comparison of lobectomy by muscle-sparing thoracotomy (163 patients) and VATS lobectomy (49 patients), there was no difference in patient characteristics, operating time, or blood loss [15]. The length of stay (8.2 ± 9.9 days versus 5.4 ± 2.7 days), days of epidural use, and complications significantly favored the VATS approach.

In this series, two different surgical groups in separate cities performed a standard lung cancer operation (lobectomy with individual ligation of vessels and lymph node sampling or dissection) by VATS. The results of the study show that the technique of VATS lobectomy can be performed with similar outcomes at multiple institutions. The length of stay (mean, 5 days; median, 4 days) in this series was less than the 11-day mean length of stay for Medicare patients who underwent lobectomy in the United States in 1994. The present series was not a randomized, prospective comparison, but the results suggest that VATS may have a shorter length of stay than that for thoracotomy.

Concern has been raised regarding some complications unique to VATS. If significant bleeding occurs during a VATS procedure, it can be particularly dangerous because there is limited access to control the hemorrhage. In a series of 57 VATS lobectomies, two expeditious thoracotomies were required for bleeding when the endoscopic stapler cut a blood vessel without applying the staples [16]. A multiinstitutional survey of 1,560 VATS lobectomies found that the only intraoperative death was related to an intraoperative myocardial infarction, not bleeding [17]. In the present series, 1 patient (0.3%) was converted to thoracotomy urgently because of bleeding from the pulmonary artery to the right lower lobe. The incidence of serious bleeding during the performance of a VATS lobectomy appears to be very low.

If a surgeon is going to perform advanced procedures with VATS, then the surgeon must be prepared to deal with all potential complications. Because the potential for bleeding exists during a lobectomy, we keep a sponge stick available to apply pressure promptly to the bleeding site. After the bleeding has been controlled with pressure, a decision can be made regarding how to close the vessel. As a precaution, Kirby has suggested removing the knife blade before firing the endo-GIA (USSC, NJ).

Recurrence of the cancer in the VATS incisions has occurred [9–11] and has even resulted in a fatal outcome [11]. The incidence of this complication appears to be very low. One of 298 patients in the present series (0.3%) developed chest wall recurrence in the utility thoracotomy incision after the VATS lobectomy. This patient simultaneously developed bony metastases and a 1-cm mass in the utility thoracotomy incision 5 months after a right upper lobectomy for a 2-cm T1N0 adenocarcinoma. That patient's lobe had been in a plastic bag for removal through the incision. The use of a bag, therefore, does not completely eliminate this complication. We currently use a cloth bag (Lapsac) that is thicker and much stronger than the plastic bag that we formerly used. One patient who underwent a lobectomy through thoracotomy during this same time period also developed a recurrence in his incision.

Kirby and associates reported that 3 of 28 patients (11%) were converted from VATS to thoracotomy because of incomplete fissures that precluded dissection of the arteries in the fissure [7]. In the present series, no patients were converted because of incomplete fissures. Our technique is to begin the dissection in the hilum for transection of the vessels and bronchus before addressing the fissure, thus the completeness of the fissure is not an issue. This approach may decrease the incidence of air leaks, compared with dissection in the fissure.

The demographics in this series reflect the current trends in lung cancer. Although squamous cell carcinoma was the most common cell type in the past, adenocarcinoma is now the most common type of lung cancer. This series included more women than men, which is consistent with the gender ratio of patients undergoing lobectomy by thoracotomy in our practice. This reflects the increasing incidence in lung cancer in women.

A cautious approach is recommended for lobectomy by VATS. The procedure is not appropriate for all lobectomies or for all thoracic surgeons. It requires excellent video skills and knowledge of thoracic anatomy. The procedure should be performed only in appropriately selected patients by surgeons with the VATS skills that allow them to perform a complete cancer operation, not a compromise operation, with minimal morbidity and mortality. Care should be taken to minimize the risk of local recurrence by placing the specimen in a bag. Because there is a risk of bleeding, the surgeon must be prepared for this possibility.

In conclusion, this multiinstitutional series demonstrated that VATS lobectomy for lung cancer can be performed safely with minimal morbidity, survival comparable to that of lobectomy by thoracotomy, and, perhaps, a shorter length of stay. When performed by surgeons with the skills to perform a complete cancer operation by VATS, a VATS lobectomy is a reasonable treatment option for selected patients with stage I lung cancer.

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DISCUSSION

DR KEITH S. NAUNHEIM (St. Louis, MO): Thank you, Dr Anderson, Dr Pairolero. This presentation outlines the results of two of the most experienced programs with regard to the performance of thoracoscopic lobectomy and, as such, is potentially an important contribution in the field of minimally invasive thoracic surgery. I congratulate Dr Fischel and the other