# Video-Assisted Thoracic Surgery Lobectomy: Experience With 1,100 Cases

Robert J. McKenna, Jr, MD, Ward Houck, MD, and Clark Beeman Fuller, MD

Cedars Sinai Medical Center, Los Angeles, California

*Background.* **Although many video-assisted thoracic surgery (VATS) lobectomies have been performed over the 12 years since the first VATS lobectomy, controversies about the procedure remain regarding the safety and associated morbidity and mortality of that procedure. This series is reviewed to assess these issues.**

*Methods.* **Between 1992 and 2004, we performed 1,100 VATS lobectomies in 595 women (54.1%) and 505 men (45.9%), with a mean age of 71.2 years. Diagnoses were as follows: benign disease (53), pulmonary metastases (27), lymphoma (5), and lung cancer (1,015). Of the primary lung cancers, 641 (63.1%) were adenocarcinoma. With visualization on a monitor, anatomic hilar dissection and lymph node sampling or dissection were performed, primarily through a 5-cm incision without spreading the ribs.**

*Results.* **There were 9 deaths (0.8%), and none was intraoperative or due to bleeding; 932 patients had no postoperative complications (84.7%). Blood transfusion was required in 45 of 1,100 patients (4.1%). Length of stay was median 3 days (mean, 4.78). One hundred eighty patients (20%) were discharged on postoperative day 1 or 2. Conversion to a thoracotomy occurred in 28 patients (2.5%). Recurrence developed in the incisions in 5 patients (0.57%). In 2003, 89% of 224 lobectomies were performed with VATS.**

*Conclusions.* **VATS lobectomy with anatomic dissection can be performed with low morbidity and mortality rates. The risk of intraoperative bleeding or recurrence in an incision seems minimal.**

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Although many video-assisted thoracic surgery (VATS) lobectomies have been performed over the 12 years since the first VATS lobectomy, the procedure has not gained widespread acceptance. Of the 40,000 lobectomies performed each year in the United States, approximately 5% are performed with VATS. A variety of authors from around the world have published small series that report the safety and advantages of the procedure. However, some thoracic surgeons are concerned regarding the safety and associated morbidity and mortality of that procedure. In the largest series reported to date, this series is presented to assess these issues.

## Material and Methods

### *Procedure*

Under single-lung anesthesia, the VATS procedures were anatomic dissections with individual ligation of the vessels and bronchi. A 5-mm trocar for the 5-mm, 30-degree thoracoscope was placed through the eighth intercostal space in the midaxillary line. A 2-cm incision was made in the sixth intercostal space in the midclavicular line. A ring forceps through that incision displaced the lung posteriorly to expose the superior pulmonary vein. A utility incision was made directly lateral from the vein for upper lobectomies or one intercostal space lower for middle or lower lobectomies. This incision started on the anterior border of the latissimus muscle and extended anteriorly for 4 to 6 cm. In some cases, another 1-cm incision was made in the auscultatory triangle. The vessels and bronchi were individually ligated, as previously reported [1]. Lymph nodes were either sampled or dissected.

The preoperative workup included pulmonary function tests and a chest computed tomography (CT) scan. After positron emission tomography (PET) scan was approved by Medicare for the staging of lung cancer, all patients with proven or suspected lung cancer were evaluated with a PET scan. Mediastinoscopy was performed unless the tumor was staged as 1A by the PET and the CT scans.

The type of resection was determined by the clinical setting. The most common operation for a tumor was a lobectomy. A pneumonectomy was performed if a lobectomy would not have provided a complete resection and if the patient could physiologically tolerate a pneumonectomy. A segmentectomy was performed for metachronous T1N0 tumors and for patients who could not tolerate a lobectomy.

This series includes consecutive patients for whom the preoperative intention was to resect with a VATS procedure. It does not include patients for whom the intention was to perform a thoracotomy, but the procedure was started with VATS to determine if the tumor was resectable or to optimize the location of the incision for a chest wall resection.

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Address correspondence to Dr McKenna, 8635 West Third, Suite 975W, Los Angeles, CA 90048; e-mail: mckennar@cshs.org.


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*Table 1. Anatomic Pulmonary Resections Done With Video-Assisted Thoracic Surgery*

| Type of Resection | Number |
|---|---|
| Right upper lobectomy | 403 |
| Right middle lobectomy | 92 |
| Right lower lobectomy | 158 |
| Pneumonectomy | 14 |
| Segmentectomy | 19 |
| Sleeve lobectomy | 3 |
| Bilobectomy | 18 |
| Bilateral lobectomy | 1 |
| Left upper lobectomy | 279 |
| Left lower lobectomy | 113 |

## Results

From February 1992 through December 2004, 1,100 patients underwent VATS with the intention to perform a minimally invasive anatomic pulmonary resection. They were 595 women (54.1%) and 505 men (45.9%). Mean age was 71.2 years (range, 16 to 94); 160 patients were aged 80 years or more.

The resections performed are seen in Table 1. The pathologic diagnoses for the 1,100 resections include the following: primary lung cancer (1,015 patients), benign diseases (53 patients, as seen in Table 2), metastatic disease (27 patients), and lymphoma (5 patients, including 2 cases of mucosa-associated lymphoid tissue). Table 3 shows the pathologic diagnoses for the patients with tumors. The preoperative and postoperative staging for the 1,015 primary lung cancer cases is seen in Table 4. Cases were staged as 3B and 4 postoperatively if there were satellite lesions (T4 tumors) or if a metastasis was found in another lobe (M1).

### *Hospital Course*

The mean length of stay was 4.78 days, and the median length of stay was 3 days. On the first postoperative day, 32 patients (2.9%) were discharged, and on the second postoperative day, 194 (17.6%) were discharged (Table 5).

*Table 2. Benign Diagnoses for Which 53 Patients Underwent VATS Lobectomy*

| Diagnosis | Number |
|---|---|
| Granuloma | 12 |
| Bronchiectasis | 11 |
| Abcess | 8 |
| Hamartoma | 7 |
| Usual interstitial pneumonitis | 6 |
| Bronchiolitis obliterans | 2 |
| Fungus ball | 2 |
| Paraganglioma | 1 |
| Pulmonary artery aneurysm | 1 |
| Sclerosing hemangioma | 1 |
| Sequestration | 1 |
| Amyloid | 1 |

*Table 3. Pathologic Type of Tumors Resected*

| Type | Number |
|---|---|
| Adenocarcinoma | 641 |
| Squamous cell | 135 |
| Bronchioalveolar carcinoma | 52 |
| Carcinoid | 51 |
| Adenocarcinoma–squamous cell carcinoma | 47 |
| Large cell | 43 |
| Unclassified nonsmall cell cancer | 30 |
| Small cell | 6 |
| Sarcoma | 3 |
| Mucoepidermoid | 3 |

### *Mortality and Morbidity*

There were no intraoperative deaths. There were 9 postoperative deaths (0.8%) due to the following causes: respiratory failure (3), pulmonary embolus (3), myocardial infarct (2), and venous mesenteric infarct (1).

There were no complications in 932 patients (84.7%). The remaining 168 patients had one or more of the complications seen in Table 6. Forty-five patients (4.1%) required a blood transfusion during their postoperative course. Thirteen patients were readmitted to the hospital for the following reasons: wound infection (2), chest pain (2), pneumonia (1), dyspnea (1), empyema (1), fall/neck fracture (1), myocardial infarction (1), and subcutaneous air (4).

### *Conversion to Thoracotomy*

In 28 cases (2.5%), the procedure were converted to a thoracotomy for the following reasons: evaluation of the tumor to determine the optimal resection (7), bleeding (6), adhesions (4), size of the tumor precluded removal through the utility incision (3), sleeve resection (3), chest wall invasion (3), and repair of a bronchus that had been injured by the double-lumen endotracheal tube (1).

### *Survival*

The Kaplan-Meier survival for the patients who underwent VATS anatomic resections for primary lung cancer is seen in Figure 1.

*Table 4. Preoperative and Postoperative Staging of the 1,015 Who Underwent Video-Assisted Thoracic Surgery Anatomic Resections for Primary Lung Cancer*

| Stage | Preoperative | Postoperative |
|---|---|---|
| 1A | 653 (59.4%) | 561 (51%) |
| 1B | 313 (28.5%) | 248 (22.5%) |
| 2A | 14 (1.3%) | 50 (4.5%) |
| 2B | 12 (0.9%) | 28 (2.5%) |
| 3A | 23 (2.2%) | 109 (9.9%) |
| 3B | 0 | 17 (1.5%) |
| 4 | 0 | 2 (0.2%) |

*Table 5. Complications After Video-Assisted Thoracic Surgery Anatomic Resections*[a]

| Complication | Number |
|---|---|
| None | 932 |
| Air leak (lasting ≥ 7 days) | 56 |
| Atrial fibrillation | 32 |
| Serous drainage (requiring drainage ≥ 7 days) | 14 |
| Readmit | 13 |
| Pneumonia | 13 |
| Subcutaneous air (requiring reinsertion of chest tube or subcutaneous catheter) | 12 |
| Myocardial infarction | 10 |
| Empyema | 4 |
| Bronchopleural fistula | 3 |
| Atelectasis | 2 |
| Urinary tract infection | 2 |
| Gastrointestinal (Ogilvie syndrome, bleeding) | 2 |
| Splenectomy | 1 |
| Pericarditis | 1 |
| Stroke | 1 |
| Adult respiratory distress syndrome | 1 |
| Transcent ischemic attack | 1 |

[a] Most patients (932 [84.7%]) had no complications; some patients had more than one.

## Comment

Published series of VATS lobectomy shows that the procedure is being performed around the world [2, 7–15]. However, less than 10% of lobectomies are currently performed with VATS, because most thoracic surgeons are still not comfortable with the technique. In the largest published experience with VATS lobectomy, we have shown that the procedure can be performed safely and with some apparent advantages over a thoracotomy. The length of stay is short and the rate of complications is low.

The evidence in the literature is mounting that a VATS lobectomy may have advantages over a lobectomy by thoracotomy. Opponents of the procedure believe that a VATS lobectomy is unsafe, is an incomplete cancer operation, and offers no advantage over a thoracotomy

*Table 6. Number of Patients Discharged on Postoperative day (POD) 1 Though 10*

| POD | Number of Patients | Percent |
|---|---|---|
| 1 | 32 | 2.9% |
| 2 | 194 | 17.6% |
| 3 | 294 | 26.7% |
| 4 | 198 | 18% |
| 5 | 117 | 10.6% |
| 6 | 64 | 5.8% |
| 7 | 57 | 5.2% |
| 8 | 34 | 3.1% |
| 9 | 17 | 1.5% |
| 10 | 12 | 1.1% |
| >10 | 71 | 6.5% |

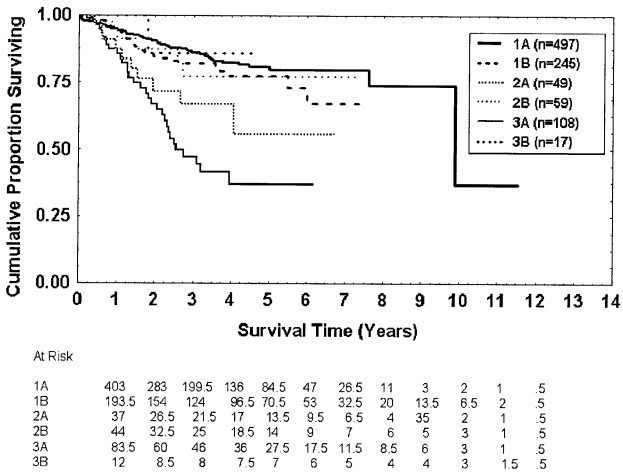


*Fig 1. Overall survival by disease stage for nonsmall-cell lung cancer video-assisted thoracic surgery lobectomy patients. (Heavy solid line = stage 1A [n = 497]; heavy dashed line = stage 1B [n = 245]; tighter dotted line = stage 2A [n = 49]; looser dotted line = stage 2B [n = 59]; lighter solid line = stage 3A [n = 108]; lighter dashed line = stage 3B [n = 17].)*

for lobectomy. Although there is no large randomized, prospective series to compare the two approaches, there are published data to suggest that the VATS approach is safe and has advantages.

One area of concern is the risk of blood loss with a VATS procedure. In a nonrandomized study, Sugiura and coworkers [16] compared patients who underwent a lobectomy by VATS (22 patients) or thoracotomy (22 patients). There was no significant difference in the average operative time. The blood loss was significantly less ($p = 0.0089$) for the VATS group (150 ± 126 versus 300 ± 192 mL). In a nonrandomized comparison, Demmy and Curtis [17] also found VATS lobectomy is associated with significant decreases blood loss compared with open thoracotomy. The VATS lobectomy performed by capable VATS surgeons does not appear to carry an increased risk of bleeding.

Another area of concern is the ability to deal with bleeding if it should occur during a VATS procedure. In a survey of 1,578 VATS lobectomies, there was only 1 intraoperative death [28]. This death was due to a myocardial infarction, not to hemorrhage, so the risk of massive hemorrhage appears to be very low. Bleeding occurred in 17 of 1,534 cases (1.1%), so the risk of bleeding appears to be low for skilled VATS surgeons [7–17]. In this series, 7 of 1,100 cases were converted to an open procedure to control bleeding. There were no deaths associated with these episodes. A VATS lobectomy is certainly an advanced video procedure. To dissect pulmonary vessels visualized on the monitor is not a skill that all surgeons possess. For the series in Table 2, the scrub nurse should keep a sponge stick available to apply pressure if bleeding occurs. Once the bleeding is controlled, the surgeon decides if definitive control can be achieved with VATS or if a thoracotomy is required.

Hospitalization appears to be the same or less after a

VATS procedure. In the series by Demmy and Curtis [17], VATS patients had shorter hospitalizations (5.3 ± 3.7 versus 12.2 ± 11.1 days, $p = 0.02$), shorter chest tube durations (4.0 ± 2.8 versus 8.3 ± 8.9 days, $p = 0.06$), and earlier returns to full preoperative activities (2.2 ± 1.0 versus 3.6 ± 1.0 months, $p < 0.01$). Pain 3 weeks later was dramatically better for the VATS group (none or mild, 63% versus 6%; severe, 6% versus 63%; $p < 0.01$). They concluded VATS lobectomy is less painful and may offer faster recovery for the frail or high-risk patient.

In a randomized trial from Germany, there were fewer complications after the VATS approach (14.2% versus 50%) [18]. Cost, as measured by anesthesia charges, laboratory charges, and hospital charges, were less with the VATS approach [19]. In a nonrandomized comparison of VATS and thoracotomy for lobectomy, Sugiura and colleagues [16] found no difference in the morbidity and mortality.

Postoperative pain does appear to be less after a VATS procedure. In a prospective, randomized trial of VATS versus muscle-sparing thoracotomy lobectomy, Giudicelli and coworkers [20] demonstrated that the postoperative pain was significantly less in the VATS group. In contrast, Kirby and associates [21] in a randomized trial showed no difference. Comparing postoperative acute pain in VATS and thoracotomy patients, Sugiura and associates [16] found many factors that favored the VATS group: duration of epidural catheter (3 ± 2 days versus 7 ± 4 days, $p = 0.0001$), and less postoperative narcotics ($p = 0.0439$) and mean frequency of analgesic use (14 ± 5 times versus 18 ± 5 times). Walker [22] reported lower visual pain scale, total dose of narcotic, need for additional narcotic, need for intercostal blocks, and sleep disturbances after VATS than a thoracotomy for lobectomy. There may be a lower incidence of postthoracotomy pain syndrome after VATS than after a thoracotomy [16].

Postoperative pulmonary function also appears to be better after VATS than after a thoracotomy. In a nonrandomized comparison of patients who had a lobectomy by a thoracotomy or VATS, postoperative $PaO_2$, $O_2$ saturation, peak flow rates, forced expiratory volume in 1 second, and forced vital capacity on both postoperative days 7 and 14 were better for the patients who had undergone the VATS procedure [23]. The VATS patients have less impairment of pulmonary function and a better 6-minute walk test than thoracotomy patients [24].

The short-term and long-term quality of life may be better after minimally invasive surgery. For 22 VATS lobectomy patients and 22 thoracotomy patients [16], the time until return to preoperative activity was 2.5 ± 1.7 months in the VATS group, which was significantly shorter ($p = 0.0267$) than the 7.8 ± 8.6 months for the thoracotomy group. Moreover, VATS lobectomy is associated with significant decreases in shoulder dysfunction, compared with thoracotomy [26, 27].

Many surgeons have expressed concerns about the adequacy of VATS lobectomy as a cancer operation. Technically, a VATS lobectomy should be, and in the hands of skilled VATS surgeons is, the same operation with the same nodal sampling or dissection as is performed through a thoracotomy. Surgeons around the world are currently doing that.

The best measure of any cancer treatment is survival. Sugi and colleagues [30] found the 5-year survival was 90% for the VATS group and 85% for the thoracotomy group ($p = 0.74$). Some surgeons have reported exceptional survival after VATS lobectomy, for example, Kaseda and Aoki [31], 94.4% at 4 years; and Lewis and Caccavale [3], 86% at a mean of 18.6 months. Others have reported the survival that is the same as reported with surgically treated lung cancer: McKenna and associates [32], 72% at 5 years; and Walker and associates [10], 77.9% at 5 years. It certainly appears that a VATS approach does not compromise the survival for lung cancer patients.

This series and the literature show that in the hands of experienced surgeons, VATS lobectomy is a safe operation that offers patients at least comparable complication rates and survival, compared with lobectomy by thoracotomy. The evidence in the literature is mounting that VATS may even offer reduced rates of complications and better survival [1, 4–6, 25, 29, 33–35].

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## DISCUSSION

**DR WILLIAM H. WARREN** (Chicago, IL): I enjoyed the talk very much. It shows a wealth of experience.

Can you please elaborate on your comments about converting VATS lobectomy to open for "oncologic reasons"? The second question is, when you have to deliver these lobes through a small incision and you're worried about implanting, tumor cells into the incision, do you bring them out through a plastic bag or do you just pull the specimen through?

**DR MCKENNA:** Centrally located tumors where I have to decide if I'm going to do a sleeve resection or a pneumonectomy, I think that evaluation is often better through thoracotomy than thoracoscopy, although in some cases, little, tiny tumors, I now have done a few sleeves. Also, tumors where the nodes are involved, I think it's often safer to dissect out and do that with a thoracotomy, although with more experience, you know, I keep pushing the limits of what I do. And the specimens are routinely put in a bag. We use the LapSac by Cook. I think it's a big, strong bag. You have to hold the patient down as you pull it out because we do use about a 6-cm incision.

**DR SCOTT J. SWANSON** (New York, NY): Outstanding report, Rob. Do you have any data about the sort of quality of life differences you see? It seems to me with your experience and some others, this should be more widely adopted. What do you see as the barrier to adopting this on a wider basis? Finally, do you see any advantage to the robot in doing this operation?

**DR MCKENNA:** Obviously, from the numbers, I'm pretty busy in Los Angeles and see a lot of cases. If you're a thoracic surgeon doing mostly hearts and you do an occasional lobectomy, then you're not going to have the volume to do it. I think some surgeons don't understand the techniques and should take the time to go to centers like yours where it's done and to know better about the procedure and know the feasibility of doing it. You don't need a lot of fancy reticulating instruments. You just need your incisions in the right place, and to understand a few simple things like that makes it a very reasonable and doable procedure. Some surgeons are just reluctant to make any changes. I think it's a simple, straightforward operation. I do it the same way as with an open procedure, and I think it does have advantages for patients.

I don't see that the robot currently has advantages. In the future the robot will, when the technology improves. Currently, you need a robot with Swiss Army knives at the end of each arm in order to do the procedure. We use a 30-degree scope, and

we're constantly looking this way and looking that way. We're pulling one instrument out and putting a stapler in and pulling that out and putting another instrument in. So with changing instruments so much, I think the robot really is more cumbersome currently. I have done robotic lobectomies in the laboratory, but I can do a straightforward lobectomy and node dissection in an hour, and there's no way you can do that and I don't see where a robot adds to that. There is new technology that will seal tissue. So once we have something like that that really works, we can complete the fissure with that, we can isolate vessels and seal up the vessels and transect them that way, and I think at that point the robot may be of benefit.

**DR FRANCIS C. NICHOLS III** (Rochester, MN): In follow-up to Scott's question about quality of life, do any of your patients have postthoracoscopy pain, and can you address narcotic usage in terms of home-going and duration of use?

**DR MCKENNA:** Of course they do. I think there's a bell-shaped curve with everything that we do. I think the bell-shaped curve has shifted over in the direction of less pain with these procedures. Twenty percent of my patients are sent home on either the first or the second postoperative day. You can't do that after a thoracotomy. Patients don't get epidurals for the VATS procedures that we do. We order subcu Dilaudid or Vicodin, and patients go home with Vicodin, and it's rare to have to refill a prescription when they go home with their 50 Vicodins. Sure, I have some patients who a year later have terrible pain, and I send them to the pain clinic and they're getting nerve blocks and a lot of help with narcotics, but in general I think it shifts the bell-shaped curve over, so people hurt less. I don't have anybody after thoracotomy who's playing golf 7 days postoperative or 10 and 6 days postoperative, where I do with VATS lobectomies.

**DR LEWIS WETSTEIN** (Freehold, NJ): These are really superb data and extremely impressive results. Can you just tell us briefly how you do a sleeve endoscopically?

**DR MCKENNA:** Well, as you're seeing here, I just use standard thoracotomy instruments. The first sleeve I did, I took out the superior segment of the lower lobe and the middle lobe and then reimplanted the intermediate bronchus into the basilar segmental bronchi, and through my utility incision, I just used a standard needle-holder and did interrupted sutures, set it up with putting one suture posteriorly and pulling that out through that posterior incision, another one anteriorly, and then sewed it up.

**DR THOMAS A. D'AMICO** (Durham, NC): Rob, I just want to commend you on your body of work. It's a tremendous contribution to the Society and to our literature.

I wanted to ask you two questions and then a brief comment. The first question is, could you share with us what you think the value of the thoracoscopic is in the pneumonectomy patients? Do they enjoy the same discharge advantages or is their hospital stay more limited by their physiology? Secondly, we have observed a lower rate of atrial fibrillation, as well. Have you thought about the etiology of that lower rate?

The brief comment is, I just want everyone to know that Scott Swanson has authored and the CALGB is sponsoring a registry trial to compare the minimally invasive technique to standard techniques for lobectomy so we can, in a multi-institutional series, replicate the work you've done. Again, I want to thank you for your great work here.

**DR MCKENNA:** I think patients hurt more as you cut more muscles and as you spread the ribs open. So offhand, I don't know the length of stay data for the pneumonectomy patients compared with the rest. But just in general, I think patients hurt less with smaller incisions than with big incisions, and, as I said, sure, my patients have hurt a lot, but in general they hurt much less and we have to refill scripts for narcotics very infrequently. So I think it's just not spreading the ribs. We don't put any instrument in to spread the ribs. I use the Weitlaner that you saw there just to hold the soft tissue open so that I can suction and not create negative pressure inside the chest and reexpand the lung. So I think not spreading the ribs makes a big difference.

**DR D'AMICO:** And why is the atrial fibrillation lower?

**DR MCKENNA:** I don't know. I have no idea why it's less. Our operations are fairly quick, and we keep patients dry and that may have something to do with it. Beyond that, I really don't know why the incidence of atrial fibrillation seems to be so low.

**DR DAVID W. JOHNSTONE** (Lebanon, NH): Your mortality rate is extremely low, about one third of what most published reports of lobectomy are. To what extent do you think that's due to the VATS technique or your team at Cedars Sinai? To what extent is that due to selection by virtue of the the fact that these patients are having VATS? They are earlier stage patients overall.

**DR MCKENNA:** I think all of those factors contribute to it. I've got a great team. On days that I'm running two rooms, we'll do 6 to 8 cases or 8 to 10 cases. So I have a very good, efficient team that understands what we're doing and what needs to be done. Patients don't go to the intensive care unit very often because the floor care is good. We take out the IVs and have the patients up and walking the morning after the operation. I think that matters. I think brief operations help. I think it's a combination of all those things. But, as you saw, I have operated on patients up to 94 years of age, so we do push the limits a bit too.