Acta Med. Nagasaki 49: 75−79

Review Article

Video-Assisted Thoracic Surgery Lobectomy for Lung Cancer

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Since the early 1990s the video-assisted thoracic surgery (VATS) has been used for lobectomy, which is the standard procedure performed for early stage lung cancer. Recent developments in video systems and improvements in endoscopic instruments have allowed VATS to become established as a useful minimally invasive surgery for intra-thoracic disease. The progress seen in VATS lobectomy for lung cancer has been the subject of many recent reports that have tried to compare the current status of VATS lobectomy to conventional thoracotomy lobectomy by focusing on the indications, surgical techniques, prognosis, postoperative pain, and morbidity of the procedures. The results of the present review substantiate the impression that VATS lobectomy for stage I lung cancer patients has matured to become an established, safe and reliable surgical technique, with a long term survival at least the same as that of a conventional lobectomy. Furthermore, VATS lobectomy offers an advantage with respect to the patient's postoperative quality of life.

ACTA MEDICA NAGASAKIENSIA 49: 75−79, 2004

Keywords: Video-assisted thoracic surgery; Lobectomy; Lung cancer

Introduction

Jacobaeus[1] initially introduced the practical use of thoracoscopy for chest surgery in 1922. However, up until recently, thoracoscopy, due to its inadequate optical field, has been used primarily as a diagnostic instrument or for limited lung resection.[2-4] Since the early 1990s lobectomy, which is the standard procedure for early stage lung cancer, has been performed by video-assisted thoracic surgery (VATS). With the development of video systems and improved endoscopic instruments, VATS has become established as a minimally invasive surgical option for the treatment of intra-thoracic disease.[12-14]

Current studies have shown that VATS lobectomy for stage I lung cancer is a feasible procedure, offering satisfactory survival when compared with lobectomy done using conventional thoracotomy. Several reports have newly focused attention on the considerable impact that thoracoscopy could have in the future.[6-11] The aim of the present review was to evaluate the current status of VATS lobectomy done for lung cancer with a focus on its indications, surgical techniques, prognosis, postoperative pain, and morbidity.

Indications

Though a few reports have stated a tumor size criterion of less than 4 to 6 cm, almost all other reports have selected patients with clinical stage I disease.[15-19] Since the accuracy of mediastinal lymph node dissection by VATS is still controversial, the most critical factor which determines whether VATS is indicated is the preoperative status of the mediastinal lymph nodes. Given the need to precisely determine mediastinal lymph node involvement, some institutes use preoperative mediastinoscopy or positron emission tomography (PET) in addition to a chest computed tomogram (CT) with contrast.[15,19,20] However, PET is still not available in most Japanese institutes, and mediastinoscopy is an invasive evaluation technique routinely requiring general anesthesia. Another approach for assessing lymph node metastasis is to sample the mediastinal lymph nodes and have frozen sections examined intraoperatively.[21] Thomas et al. described the conversion of the VATS procedure to an open procedure whenever positive lymph nodes were found in order to perform a radical lymphadenectomy.[17] We use sentinel lymph node sampling, which was reported by Naruke; if the sentinel nodes show positive intraoperative pathology, a complete mediastinal lymph node dissection is performed by open thoracotomy.[221] Recent reports have demonstrated that, given the progress of VATS technology, hilar and mediastinal lymph node dissections were performed in a manner

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similar to that used in open surgery patients.[23-26]

Surgical Technique

In those cases in whom a limited resection is being done for benign disease or for the exploration of the thoracic cavity, the surgeon performs the entire procedure by observing the endoscopic image and using special instruments inserted through a few trocars.[12,13,27]

In contrast, the surgical technique of VATS lobectomy for lung cancer can vary and be quite complicated, depending on the institution. While a few reports[20,28] have demonstrated that a VATS lobectomy can be done using only three small ports, most reports have used a mini-thoracotomy to produce a larger 4th port, approximately 5 to 8 cm long in the anterolateral or midaxillary line, generally at the 4th or 5th intercostal space, as a utility port for the passage of large instruments.[15-17,19,23-26] The length of the mini-thoracotomy was influenced by either the size of the tumor or the volume of lung tissue to be removed.[19,24]

The typical operative technique performed in our institution begins with insertion of an epidural catheter, followed by the induction of general anesthesia and intubation with a double lumen endotracheal tube (Broncho-Cath, Mallinckrodt Medical, St. Louis, MO). VATS lobectomy is performed with the patients in the lateral decubitus position, and the procedure starts with a video-thoracoscopic inspection of the thoracic cavity accessed through a 10 mm port located in the midaxillary line at the 7th intercostal space (Figure 1). If the tumor extends and invades another organ or the cytology of the thoracic lavage unexpectedly reveals malignant cells, we convert to a basic open procedure. If VATS lobectomy is continued, then a 6 to 8 cm mini-thoracotomy is performed in the midaxillary line at the 4th or 5th intercostal space and a Lap-protector[29,30] (Hakko Co., Nagano, Japan), which prevents infection and tumor implantation in the wound, is attached with a small retractor. Usually, two further 12 mm ports (midclavicular line at the 6th intercostal space and at the inferior angle of the scapula) are used to allow the application of thoracoscopic instruments. The operating surgeon uses long-handled scissors and forceps through the mini-thoracotomy under direct vision, while an assistant surgeon assists through the other ports while looking at the video monitor. The incomplete fissure, pulmonary vessels, and bronchus are dissected using endostaplers through the assistant ports, and the small branches of vessels are ligated through the mini-thoracotomy.

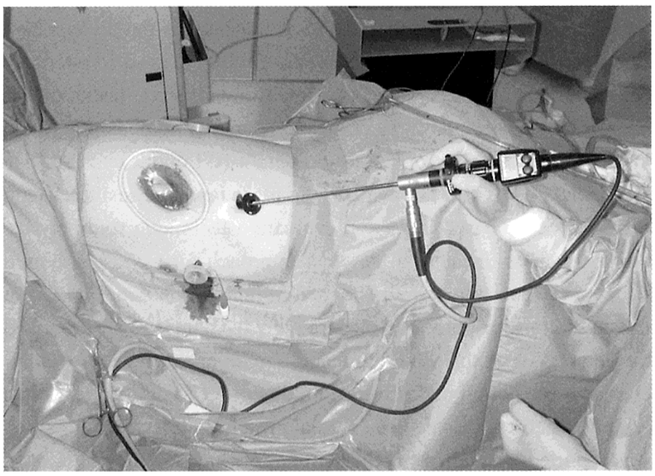

Figure 1. VATS lobectomy is performed with the patient in the lateral decubitus position. The procedure starts with a video-thoracoscopic inspection of the thoracic cavity through a 10 mm port access located in the midaxillary line at the 7th intercostal space. A 6 to 8 cm mini-thoracotomy is then performed on the midaxillary line at the 4th or 5th intercostal space, and a Lap-protector, which in this case was not attached with a small retractor. Usually two further 12 mm ports (in the midclavicular line at the 6th intercostal space and at the inferior angle of the scapula) are used for of the insertion of thoracoscopic instruments.

Prognosis

The point of greatest concern in the evaluation of VATS lobectomy done for lung cancer is whether the long-term survival after VATS is equal to that after conventional lobectomy. The published reports dealing with VATS lobectomy are summarized in Table 1. Although each report dealt with an individual case and not with randomized controlled studies, the survival of patients with pathological stage I or IA disease was excellent compared to conventional thoracotomy patients. Sugi et al. demonstrated that, in 100 consecutive patients with clinical stage IA non-small cell lung carcinoma randomized into either conventional lobectomy or VATS lobectomy, the 5-year survival rates were 85% for the open group and 90% for the VATS group.[23] A few reports proposed that the minimally invasive approach offered by VATS lobectomy, which provides a less favorable environment for malignant cell growth or dissemination, could account for the improved long-term survival compared to that of conventional lobectomy.[24,28]

Ever since Ginsberg et al. published their randomized trial of lobectomy versus limited resection for T1 N0 non-small cell lung cancer,[31] there have been no large trials that have evaluated surgical procedures for early stage lung cancer. However, to allow a VATS lobectomy to be strongly recommended to patients as an alternative standard operation for early stage lung cancer, large nationwide randomized controlled studies are needed.

Postoperative status

A consensus would appear to have been reached that the long-term survival between VATS lobectomy and conventional lobectomy is not statistically different, and that the only difference between the two is the surgical approach to the thoracic cavity (Figure 2). Nevertheless, there is some room for discussion as to whether VATS lobectomy offers a postoperative advantage.

Table 1. Large case series dealing with VATS lobectomy of stage I non-small cell lung cancer (NSCLC)

Authors	Year	Number of patients	5-year survival (%)	Mean follow up (month)	Length of mini-thoracotomy (cm)	Number of ports
McKenna et al.	1998	233	70[a]	28.9	5	2
Lewis et al.	1999	214	92[b]	34	Not applicable	4[e]
Sugi et al.	2000	48	90[c]	59.9	8	2 or 3
Kaseda et al.	2000	50	97	30[d]	5 to 8	2 or 3
Solaini et al.	2001	72	90[b]	36	Less than 5	3
Thomas et al.	2002	50	64.9[c]	Not available	5	2
Tatsumi et al.	2003	66	92.4[c]	31.8	5 to 7	2 or 3
Gharagozloo et al.	2003	179	85	37	Not applicable	3
Walker et al.	2003	117	77.9	38	5	3
Ohtsuka et al.	2004	68	89	25	5	3

[a]4-year survival.
[b]3-year survival.
[c]Patients with stage IA only.
[d]Median follow up.
[e]Patients with small incision only.

Figure 2. Postoperative photographs of a patient who underwent conventional lobectomy (left) and VATS lobectomy (right).

Postoperative pain and morbidity

Various analgesic techniques have been developed to treat postoperative pain, as well as the acute and chronic pain conditions associated with thoracotomy, since these continue to present a problem to clinicians.[32] To quantify postoperative pain and to evaluate it precisely, Hazelrigg et al. reported that the use of the visual analogue scale for pain and the careful recording of the narcotic requirements after thoracotomy are probably the most objective methods.[33] Several reports have used this evaluation system to investigate the advantage of VATS minithoracotomy over conventional thoracotomy.[34-38] However, the definition of the conventional thoracotomy used as a control for the VATS procedure was different in each report. When compared to the posterolateral approach, the VATS approach tends to be associated with significantly less shoulder dysfunction and less pain medication requirement in the early postoperative period.[39] As well, we compared the degree of surgical invasiveness in the patients who had undergone lobectomy with VATS to historical controls who had undergone the posterolateral approach. We concluded that VATS lobectomy is a less invasive and safer procedure, with less blood loss and with minimal pain, which allowed patients to be discharged from the hospital earlier (Table 2).[40]

On the other hand, instead of using the posterolateral approach as a control, "muscle-sparing thoracotomy," which preserves the latissimus dorsi muscle without division and splits the serratus anterior muscle in the direction of the muscle fibers, has also been used as a control for the VATS approach.[33,37,41,42] Nomori et al. reported that following VATS lobectomy, chest pain is reduced more during the first week after surgery than with muscle-sparing thoracotomy, but that this advantage is lost within 2 weeks.[37] Landreneau et al. also suggested that VATS may reduce the occurrence and severity of chronic pain and of shoulder dysfunction during the first postoperative year, but that this effect is not likely to affect the prevalence of long-term chronic pain.[43]

The evaluation of postoperative morbidity after pulmonary resection done using VATS and conventional lobectomy revealed that the results are as controversial as those dealing with postoperative pain. There was a trend in the VATS group to improved postoperative morbidity, as measured by the duration of air leakage, sputum retention, atelectasis and other nonfatal complications.[40,43,44] Some

Table 2. Comparison of VATS and conventional thoracotomy with respect to the parameters of operative invasiveness[a]

Parameters	VATS (n=59)	Conventional thoracotomy[b] (n=53)	p-value[c]
Operation time (min)	289±79	304±93	0.3749
Blood loss (g)	148±138	360±295	<0.001
Necessity of blood transfusion	0 (0%)	5 (9.4%)	0.0214
Chest tube duration (days)	3.0±2.3	3.9±1.9	0.0177
ICU stay (days)	1.5±1.1	3.0±1.4	<0.001
Visual analog scale on postoperative day 7	2.7±4.6	19.0±14.6	0.0258
Postoperative hospital stay (days)	13.5±4.2	16.6±5.5	0.0016
Morbidity	14 (23.7%)	27 (50.9%)	0.0034
Mortality	0 (0%)	1 (1.9%)	0.4732

[a]Cited from Muraoka et al.[40] Continuous data are summarized as mean±standard deviation.
[b]Posterolateral approach.
[c]Computed for each parameter under the null hypothesis that no difference exists between the two operations. Student's t-test was used except for the parameters of necessity of blood transfusion, morbidity and mortality, which were compared by the chi-square test.

studies have reported that these difference were not statistically significant.[37,38,41] However, it is a fact that reasons for doing a VATS lobectomy for high-risk patients include the shortening of the hospitalization period and an earlier return to daily life.[44,45]

Pulmonary function, cytokine production, others

Examining data on early postoperative pulmonary function, VATS lobectomy had advantages when compared to the posterolateral thoracotomy.[46] Kaseda et al. demonstrated that the vital capacity and the forced expiratory volume in 1 second were significantly better after VATS lobectomy than after open thoracotomy.[24] In addition to preserving better pulmonary function, the serum interleukin-6 (IL-6) level in the VATS group was significantly lower on postoperative day 0 compared to the posterolateral thoracotomy group.[47] Furthermore, VATS lobectomy was associated with lower C-reactive protein levels[48] and had a lesser effect on circulating T cells and natural killer lymphocytes, which are the key cells of cellular immunity involved in post-surgical changes.[49] Yim et al. found that VATS lobectomy, in contrast to the open thoracotomy approach, is associated with the reduced postoperative release of both proinflammatory (IL-6, IL-8) and anti-inflammatory (IL-10) cytokines.[50] However, the clinical significance of these findings and their relationship to operative invasiveness remain uncertain. Since VATS lobectomy is already being acknowledged as a standard procedure for early stage lung cancer, there may be a reluctance to conduct randomized controlled trials comparing VATS lobectomy to other surgical approaches.

Conclusion

The results of this review substantiate the impression that VATS lobectomy for stage I lung cancer patients has matured enough to become established as a safe and reliable surgical technique with a long-term survival at least equal to that of conventional lobectomy. Furthermore, VATS lobectomy, as minimally invasive surgery, offers advantages with respect to acute pain, morbidity, pulmonary function, and cytokine production during the early postoperative stage.

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