Review

Thoracoscopic Esophagectomy for Intrathoracic Esophageal Cancer

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Thoracoscopic approaches for esophageal cancer are still disparate. Complete scopic technique is feasible for esophagectomy. Mini-thoracotomy is effective for excellent exposure of the mediastinum for lymph node dissection. The magnifying effect of a video, by keeping the camera in close proximity to the dissection is essential to perform the same quality of dissection as open surgery. The benefit, for respiratory morbidity, remains to be studied in a large number of patients. Minimizing the chest wall injury contributed, to the reduction of constrictive pulmonary damage. Survival after the thoracoscopic approach was favorably compared with open surgery, when extensive lymphadenectomy was performed. Because the efficacy improves with the surgeon's experience, satisfactory outcome will only be obtained in a center performing a sufficient volume of esophageal surgery to provide the surgeon with opportunities to refine his necessary skills. Improvements in technique and instrumentation should make the procedure more accessible and steepen the learning curve. (Ann Thorac Cardiovasc Surg 2005; 11: 221–7)

Key words: thoracoscopic esophagectomy, lymph node dissection, respiratory morbidity, oncological outcome, learning of the procedure

Introduction

The extended lymphadenectomy for esophageal cancer is necessary for retrieving the node likely to be metastasized and to obtain good prognosis in patients with the lesion invading the submucosal layer, or deeper. The other alternative to reduce surgical invasiveness is to perform esophagectomy via thoracoscopy, rather than an open procedure. Since the first report by Cuschieri et al.,[1] the thoracoscopic approach has attracted surgeons' attention as a way to reduce surgical insult, and has been reported by a number of centers. Many reported the feasibility of the technique, and a few have reported the advantage over open surgery, so far. In this paper, the present status of thoracoscopic esophagectomy for cancer is being reviewed.

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Indication

Indication is the same as open surgery, as far as the stage of the disease is concerned, although diseased patients at the small T stage were candidates for thoracoscopic approach in some institutes, when they started employing the procedure.[2] The indication is listed in Table 1.[3] Once the camera and ports are inserted safely, considerable pleural adhesion can be mobilized through thoracoscopy. During the thoracoscopic procedure, the right lung should be deflated to provide an operative field, with the result that the procedure can be indicated for patients with pulmonary function, tolerating single lung ventilation for a sufficient period.[4] Patients with other comorbidities, such as liver cirrhosis, etc. are contraindicated. Law et al.[5] reported that the advantages of thoracoscopic surgery, over open surgery were not obtained in patients with increased operative risk. We do not recommend this procedure for

Table 1. Indication of thoracoscopic esophagectomy for esophageal cancer

Absence of extensive pleural adhesions
Absence of contiguous tumor spread to adjacent structures
Pulmonary function capable of sustaining single lung ventilation
Absence of a concomitant serious medical condition, such as liver cirrhosis
Patients preference for the procedure
Patients without anticancer treatment?

patients who received preoperative anticancer treatment, especially radiation, because this therapy may obscure the microanatomy, which can only be confirmed under the magnification of scopic surgery. We are concerned that anticancer treatment reduces the most important benefit of scopic surgery. However, Higashino et al.[6] and Miyazaki et al.[7] indicate the procedure for such a medically invaded patient to reduce surgical invasiveness.

Preparation and Approach

Approaches for thoracoscopic esophagectomy are still disparate. In all reports, except two,[8,9] using a prone position, split ventilation is used to facilitate exposure of the posterior mediastinum, and the patient is in the left lateral position. For patients in the prone position, the posterior mediastinum can be seen without spilt ventilation, because the lung lowers with gravity. However, this appealing position has a major shortcoming. The rapid conversion to open surgery from thoracoscopic surgery is impossible in the event of misadventure. In almost all reports of left lateral position, the right arm is raised (in our case, 140-degree) to leave the axilla free for port insertion.

There are possibly two methods in application of monitors, although only a few have referred to this issue. Most surgeons place a monitor at the cranial side of the patient and watch the same monitor together with assistants, who stand at the other side of the patient. This method is commonly used by surgeons who have developed the skill of laparoscopy. However, good eye-hand coordination cannot be established for middle and lower mediastinum. Figure 1 shows the position of operators, monitors, and port site in our method.[3,10] The surgeon is positioned on the dorsal side of the patient, the same as for open surgery. The image, on the monitor for assistants, is reversed horizontally and vertically from that of the surgeon so

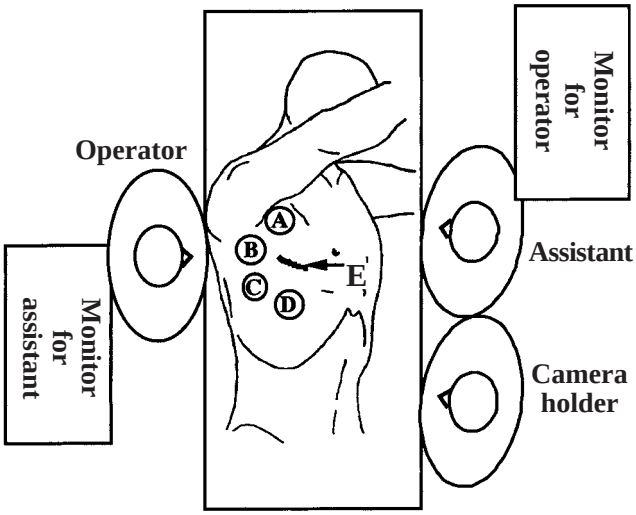

Fig. 1. Position of the patient, operator, assistants, and monitors, and site of mini-thoracotomy and ports in our method.
A: 3rd intercostal space on mid-axilla line.
B: 5th intercostal space on posterior-axilla line.
C: 7th intercostal space on posterior-axilla line.
D: 7th intercostal space on mid-axilla line.
E: 5-cm mini-thoracotomy on the 5th inter-costal space on the anterior-axilla line.

that, when the camera is positioned the left-hand side is the cranial side on the operator's monitor, and the cranial side is the right-hand side on the assistant's monitor. As a result, good eye-hand coordination can be obtained for the whole mediastinum, for the operator and assistants, who are facing each other, simultaneously.

Most of the authors reported that the thoracoscopic procedure was completed through 5 or 6 ports. We apply 5-cm mini-thoracotomy at 5th inter-costal space on the anterior axilla line.[3,6] The reasons for using mini-thoracotomy are that it enhances the mediastinal exposure and makes the procedure safer. Peeping through a mini-thoracotomy is inadequate for safe dissection because the view is insufficient, and two-dimensional, and the mediastinum is barely visible. For the same quality of lymph node dissection, as in open surgery, good exposure of mediastinum and an en-face view of the left side of the tracheobronchus, is essential. For this purpose, the forceful retraction of the tracheobronchus is necessary. The retractors, introduced through a port are not sufficiently rigid to be effective and their sharp edge may tear the membranous part of the tracheobronchus, when it slips. Mini-thoracotomy allows the introduction of our own retractor,[3] which is sufficiently rigid, with a smooth tip, to manipulate the tracheobronchus safely. Theoretically,

Table 2. Thoracoscopic esophagectomy; literary review of lymph node dissection

Author	Collard 1993[13]	McAnena 1994[24]	Mitchell 1994[25]	Robertson 1996[26]	Dexter 1996[14]	Akaishi 1996[10]	Peracchia 1997[18]	Law 1997[5]	Kawahara 1999[16]	Okushiba 2003[12]	Osugi 2003[29] All cases	Osugi 2003[29] After learning
N. patients	12	9	8	17	24	39	18	18	23	18	80	46
N. nodes retrieved	(12-51)	(9-26)	11	7	13	19.7	12	7	29	20.1	34	36
median (range)				(2-8)				(2-13)				
Blood loss (g)	?	>600	1,500	?	?	270	210	450	136	?	274	160
Mean time (min)	150-360	128	150	135	184	200	114	110	111	?	223	182

in the event of misadventure, hemostasis can be obtained during conversion to an open procedure, although we have not encountered such a complication. On the other hand, the limitations of mini-thoracotomy are minor.

Kawano et al.[11] and Okushiba et al.[12] reported the hand-assisted method. An assistant inserts his left hand into the thoracic cavity, through an incision in the upper abdomen, and via the diaphragm. Hand manipulation is helpful for exposure of the mediastinum.

Dissection

In many reports, some authors have referred to their procedure of esophageal mobilization and mediastinal dissection in detail.[2,3,8,10,13-16] However, it was not always clear whether lymph node dissection, or just lymph node sampling, was performed. Although Collard et al.[13] have described an en-bloc resection with lymph node dissection, they found that performing the procedure endoscopically was time consuming and hazardous, and they finally went back to open surgery.[17] Peracchia et al.[18] reported that a total mediastinal lymphadenectomy does not seem to be possible through thoracoscopy, due to the difficulty of access to left parathracheal and infra-aortic nodes. But, we conclude that the same quality of lymph node dissection can be performed thoracoscopically in reasonable duration.[19] The most remarkable shortcoming of scopic surgery is the impossibility of direct hand manipulation. When a complicated operation such as radical esophagectomy, is performed thoracoscopically, the procedure tends to become unreliable and time consuming because of poor mediastinal exposure and a lack of tactile orientation. However, the most distinctive advantage of scopic surgery, namely the magnifying effect of a video, which can be obtained by keeping the camera in close proximity to the dissection, possibly overcomes any disadvantage. Under the magnified view, the meticulous anatomy, such as the esophageal and tracheal branches of recurrent nerves, ventral branches of thoracic sympathetic nerves, lymphatics, and even small vessels in the epineurium of the recurrent nerves can be easily recognized, just as the same as an operation under a loupe. If this advantage is utilized well, the dissection can be carried out, following a more precise anatomy than open surgery.

Reports from Japan tend to refer clearly to lymph node dissection,[3,10,12,16] possibly based on their emphasis on dissection in open surgery.[20] The quality of lymph node dissection is difficult to be evaluated from literature. According to Japanese studies,[19,21] the average number of retrieved mediastinal nodes is slightly more than 30. The reported results of dissection are listed in Table 2.

From our experience, excellent exposure of the mediastinum is essential for safe and high quality lymph node dissection. For this purpose, we apply mini-thoracotomy.

Postoperative Complication

Respiratory morbidity following open radical esophagectomy is high, ranging from 15 to 20%.[19,22,23] The thoracoscopic approach had been promoted, in anticipation of reducing morbidity, but the results are disappointing. Many studies failed to demonstrate the obvious advantage in reducing respiratory morbidity.[4,5,14,17,18,24-27] The conventional open esophagectomy is associated with surgical invasiveness, consisting of mediastinal and chest wall injury. Mediastinal dissection increases mediastinal injury, which is the major outcome of surgical invasiveness in esophageal cancer surgery, and the effect of reducing chest wall injury has become unclear, even if it is performed thoracoscopically. Luketich et al.[28] reported that the incidence of pneumonia was 7.7% in their studies of 222 patients. We also found that the incidence of pulmonary complication after learning about the procedure, was only 5%.[29] In our research of patients, the risk was calculated as; Risk = $0.311 - 0.004 \times$ number of experienced cases. Therefore, the efficacy of performing

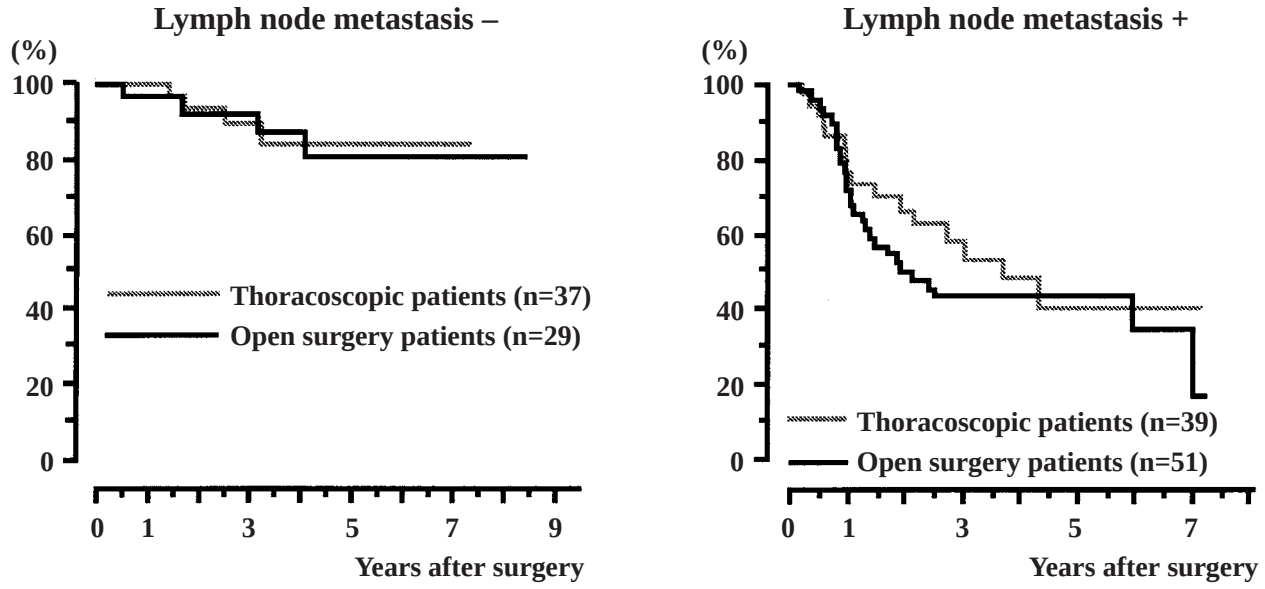

Fig. 2. Comparison of our survival after thoracoscopic and open surgery in the patients with or without lymph node metastasis.

radical esophagectomy, through thoracoscopy on the respiratory morbidity remains to be studied on the basis of reports consisting of a large number of patients. Fukunaga et al.[30] revealed that thoracoscopic esophagectomy resulted in less production of inflammation-related cytokines, such as interleukin-6 and interleukin-8, than open esophagectomy. This subclinical data indicates that the thoracoscopic approach is potentially less invasive than open surgery.

It is well known that conventional lateral thoracotomy itself, reduces total chest compliance and increases the work done on the lung, every minute.[31] Moreover, esophagectomy through right thoracotomy reduces vital capacity and total lung capacity.[32] It had been expected that performing esophagectomy, through thoracoscopy could reduce pulmonary damage caused by chest wall injury. We reported that restrictive pulmonary damage was less, following thoracoscopic surgery than open surgery,[19] and Akaishi et al.[10] also reported that the pulmonary function was better following thoracoscopic surgery than open surgery. Taguchi et al.[33] compared the results of spirometry and exercise tolerance between patients esophagectomized thoracoscopically and conventionally. Reduction of vital capacity was less and the quality-of-life measured by Zubrod score was well maintained, in patients who had thoracoscopic esophagectomy than others.

Oncological Results

There are some reports about survival following thoracoscopic esophagectomy.[5,14-16,18,26] However, the number of patients, and follow-up period is insufficient. Only three authors[8,19,28] reported the survival of a sufficient number of patients for a reasonable follow-up period. Smithers et al.[8] reported that 1-, 2-, and 5-year survival was 70%, 57%, and 40%, respectively. Luketich et al.[28] reported that survival, 40 months after surgery, was about 70% for stage I patients, but it was as low as 20% and 30% for stage III and II, respectively. They did not compare the results of thoracoscopic surgery to that of open surgery. Only we compared the results of these two approaches, although open surgery was the historical control.[19] There was no difference in survival with the difference in approach, even when patients were stratified by stages. Hematogenous was the most common pattern of initial recurrence. There was no difference in the pattern of recurrence between both groups of patients. Figures 2 and 3 show survival of our 76 thoracoscopic patients followed up for at least three years, because recurrence death is rare more than three years after esophagectomy,[34] and 80 open surgery patients met the same condition as thoracoscopic patients. Seeding is a latent oncological risk of scopic surgery for malignant diseases,[35] and tumor implantation in the surgical wound (port-site recurrence) has been documented after thoracoscopic surgery.[5,27,36,37]

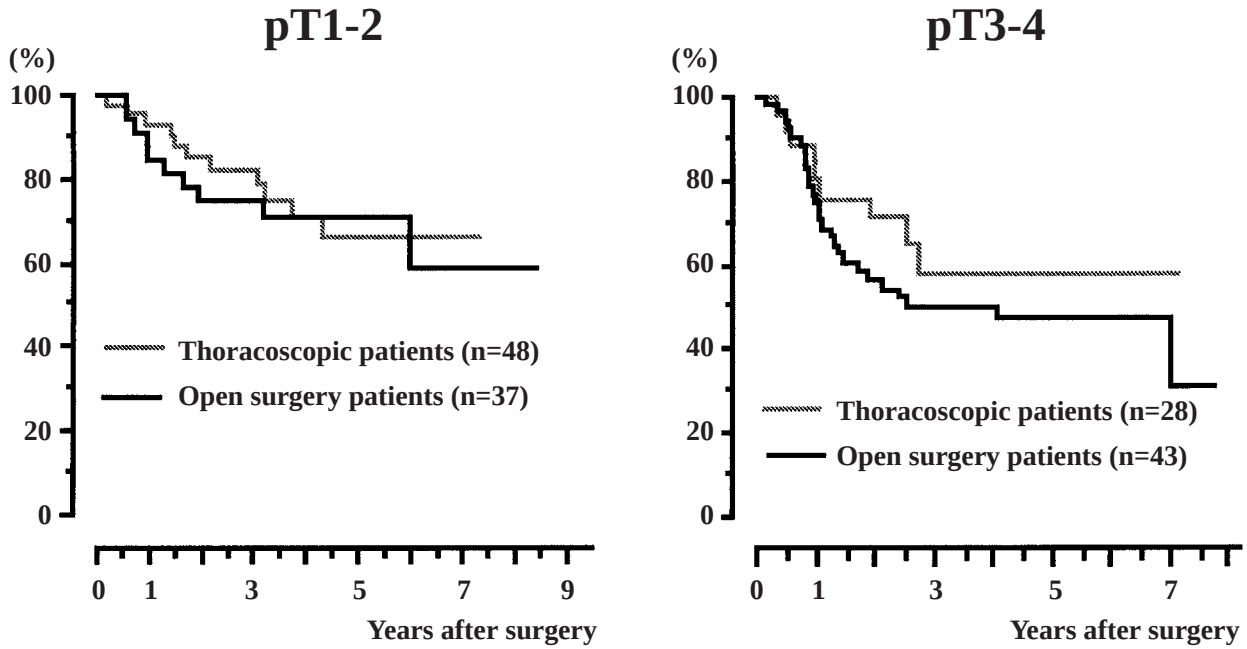

Fig. 3. Comparison of our survival after thoracoscopic and open surgery in the patients with T1 and 2 or T3 and 4.

However, no patients in our studies (140 patients till now) developed this problem. Seeding may have been avoided because contiguous spread was contraindicated for thoracoscopic surgery, and lymphatic tissue, likely to contain tumors, was handled gently under good exposure of the mediastinum. Our results (not a randomized study) substantiate the contention that the thoracoscopic approach is favorable to open surgery oncologically.

Correlation between Experience and Outcome

Esophagectomy, itself, necessitates a substantial amount of learning,[38] and extensive mediastinal dissection may require additional experience. Although the beneficial effects of training in scopic surgery have not been demonstrated formally, performance continues to improve with a considerable number of cases.[39] Overall benefits of thoracoscopic esophagectomy tended to relate to the number of cases experienced. The reports of a small amount of experience concluded that the thoracoscopic approach is not beneficial, however the author experienced a substantial number of cases concluded to be beneficial. Luketich's reports are representative. He concluded that it was not beneficial, in considering 8 patient's experience,[40] unclear for 77 patients, and beneficial for 222 patients (Table 3). Looking at the data from our learning curve (Fig. 4), the basic skills seem to be acquired during the first 17 cases, and the most remarkable difference was found between the first 36 cases and the others.[29] Therefore, because efficacy improves with the surgeon's experience, satisfactory outcome will only be obtained in a center performing a sufficient amount of esophageal surgery to provide the surgeons with an opportunity to refine his necessary skills.

Sharing the knowledge of instrumentation and instruction of the know-how of techniques is important in promoting thoracoscopic esophagectomy. A surgical group at Kanazawa University (Ninomiya I) obtained reasonable learning experience in 10 cases, under our instruc-

Table 3. Correlation between overall efficacy of thoracoscopic approach and number of experienced cases

Beneficial	222: Luketich,[28] 2003	162: Smithers,[8] 2001
	80: Osugi,[29] 2003	39: Akaishi,[10] 1996
Unclear	77: Luketich,[2] 2000	23: Kawahara,[16] 1999
	18: Okushiba,[12] 2003	13: Collard,[13] 1993
No benefit	29: Gossot,[4] 2000	24: Dexter,[14] 1996
	22: Law,[5] 1997	18: Peracchia,[18] 1997
	17: Robertson,[26] 1996	15: Gossot,[27] 1995
	9: McAnena,[24] 1994	8: Luketich,[40] 1998

Number of cases: author, year reported

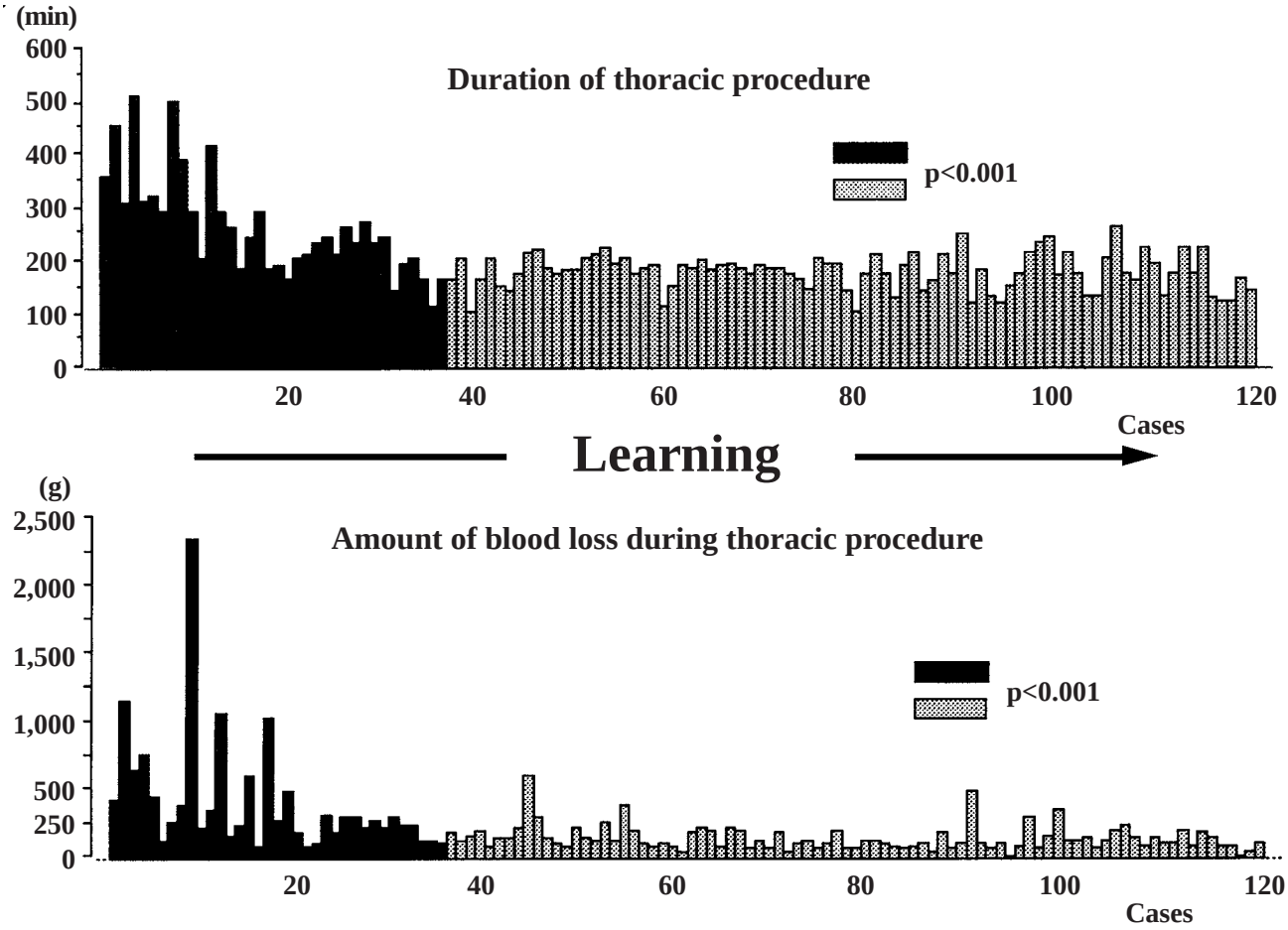

Fig. 4. Our learning curve (Operative blood loss during thoracoscopic procedure and duration of thoracoscopic procedure in the order of experience) of 120 patients.

tion, with less blood loss than our cases before initial learning (personal communication). Efficacy of scopic surgery depends more on the instruments, than in open surgery. It is reasonable to expect that improvements in technique and instrumentation, including optical, will occur as world-wide experience grows, and this should make the procedure more accessible and steepen the learning curve.

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