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## **Results of video-assisted thoracoscopic surgery for esophageal cancer during the induction period**

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### **Abstract**

*Objective.* The attainment of proficiency in thoracoscopic radical esophagectomy for thoracic esophageal cancer requires much experience. We aimed to master this procedure safely with our regular surgical team members under the direction of an experienced surgeon. We evaluated the efficacy of instruction during the induction period and the significance of our results.

*Methods.* We compared the results of 12 thoracic esophageal cancer patients who underwent thoracoscopic radical esophagectomy in our institution (group A) to those of the initial 17 patients who underwent the same operation at the director's institution (group B).

*Results.* We were able to perform complete thoracoscopic radical esophagectomies without any direction after experiencing 10 cases that were performed under adequate direction. The number of dissected lymph nodes and the duration of the procedure were similar in the two groups: 34 (22.53) vs. 26 (9.55) nodes,  $P = 0.23$ ; and 327.5 (230.455) vs. 315 (190.515) min,  $P = 0.947$ , respectively. The amount of thoracic blood loss was significantly less in group A than in group B: 185 (110.380) g vs. 440 (110.2360) g,  $P = 0.0035$ . Postoperative pneumonia and atelectasis were observed in 25.0% of group A patients and in 17.6% of group B patients. The incidence of recurrent nerve palsy was 30.7% in group A and 11.7% in group B, but there was no statistically significant difference ( $P = 0.19$ ). The morbidity rates in group A and group B were 41.6% and 29.4%, respectively ( $P = 0.694$ ).

*Conclusion.* Thoracoscopic radical esophagectomy can be mastered relatively quickly and safely under the direction of an experienced surgeon and a regular surgical team.

**Key words** Esophageal cancer · Thoracoscopic surgery · Learning curve · Supervisor · Direction

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This article is based on a study first reported in *Nihon Naishikyougeka Gakkaizasshi* (J Jpn Soc Endosc Surg) 2006;11:155–161 (in Japanese with English abstract).

## **Introduction**

Esophageal cancer is one of the most lethal internal malignancies in the world. Although the efficacy of esophagectomy with extended lymphadenectomy remains to be proven by a prospective randomized study, some reports have shown that better survival can be obtained after extended rather than conventional lymphadenectomy.<sup>1,2</sup> However, extended lymphadenectomy increases operative morbidity, especially pulmonary complications.<sup>2</sup> Video-assisted thoracoscopic esophagectomy (VATS) has been developed to reduce the surgical insult.<sup>3</sup> VATS minimizes the reduction in vital capacity secondary to chest wall injury, and it provides survival results comparable to those obtained with open radical esophagectomy.<sup>4</sup>

Esophagectomy with extended lymphadenectomy is complex surgery; therefore, a surgeon should pass through a learning curve before performing this procedure.<sup>5</sup> Matthews et al.<sup>6</sup> have shown, from a retrospective survey of esophageal cancer resections, that considerable improvement in outcome can be demonstrated when surgeons perform six or more esophagectomies annually. Furthermore, scopic surgery requires the mastery of several basic technical skills using indirect two-dimensional optical systems. The performance of scopic surgery continues to improve as the number of cases becomes considerable.<sup>7</sup> Similarly, the overall benefits of VATS tend to correlate with the number of cases experienced. For example, many reports involving limited experience concluded that the VATS was not beneficial.<sup>8-14</sup> Other reports describe the beneficial effects of VATS when the author and operator was someone who had experienced a substantial number of cases.<sup>15-18</sup> Osugi, who performed more than 200 open esophagectomies, reported that he acquired the basic skills for VATS during his first 17 cases, but that a plateau in his technique had not been reached until 34 cases had been performed.<sup>19</sup> In addition, lethal complications had been found from reports involving surgeons with limited experience.<sup>9,10</sup> These previous reports demonstrated the

difficulty and danger during VATS induction, especially for centers performing small numbers of esophageal surgery cases. Although VATS has been noted to reduce the surgical insult of esophageal cancer therapy, the difficulty of attaining proficiency in performing VATS has inhibited this procedure's widespread adoption. The induction of complex surgery such as VATS without sufficient knowledge and instrumentation may result in unsatisfactory outcomes and reduced procedure prevalence of VATS. Furthermore, the educational system to train VATS has yet to be established in Japan. However, sharing the knowledge of instrumentation and instructing surgeons as to the techniques may help spread and induce new surgical methods such as VATS. Continuing supervision of the fully trained surgeon would allow shorter training periods.<sup>5</sup> In addition, optimal coordination among the surgeon, assistant, and scopist is

also important in scopic surgery.

From January 2003 until the present time, we have been performing VATS with extensive mediastinal lymphadenectomy for thoracic esophageal cancer to reduce surgical insult. We have strived to master VATS safely with the fixed members, with as little experience as we could, under the direction of an experienced surgeon. In this report, we evaluated the efficacy of instruction in the VATS induction period and the significance of our results by comparing the results of our cases with those obtained at the director's institution.

## **Subjects and methods**

### Patients

At Kanazawa University, we initially limited the VATS procedure to T1 and T2 tumors without lymph node metastasis. After attaining surgical skill from our experience with the initial six cases, we enlarged the criteria to include T3 tumors with regional lymph node metastasis. We also included criteria based on the patient's condition as follows: no previous upper gastrointestinal tract operation, no previous chemotherapy or radiation

therapy, no extensive pleural adhesions, pulmonary function capable of sustaining single-lung ventilation, no concomitant serious medical condition such as liver cirrhosis, and patient preference for VATS.

From January 2003 to December 2004, a total of 26 patients with squamous cell carcinomas of the thoracic esophagus were candidates for radical esophagectomy at our institution. Among them, 16 patients met our criteria for VATS. The first patient underwent operation by a specialist surgeon (Osugi) from Osaka City University as a demonstration. Dr. Osugi directed the VATS performed at our institution (Kanazawa University) beginning with the second patient. The procedure was converted to conventional thoracotomy in two patients because pleural adhesions were encountered in one patient and contiguous tumor spread was present in another patient. One patient underwent palliative thoracoscopic esophagectomy because the tumor had invaded the right main bronchus. Thus, curative thoracoscopic esophagectomy and extensive lymphadenectomy were completed in 12 patients by a single operator (Ninomiya) at Kanazawa University (group A).

Before beginning the VATS at Kanazawa University, the operator had performed 32 conventional esophagectomies and extended lymphadenectomies as an assistant and performed one procedure as the primary operator. Ninomiya had once visited Osaka City University to learn VATS from a specialist surgeon (Osugi) and was given didactic

videos. He had attempted VATS twice on pigs at the training center. During the induction period of VATS, all members, including the operator, assistant, and scopist, remained the same to ensure consistency and obtain early and maximal cooperation. Osugi attended the initial 10 VATS at Kanazawa University and directed the operator (Ninomiya), assistant, and scopist about how to complete the procedure safely and to maintain curative dissection quality. The first patient underwent VATS by Osugi and the second case was converted to thoracotomy owing to the pleural adhesions discussed above. Therefore, Osugi directed eight cases in group A.

The controls consisted of the initial 17 patients who underwent the same operation with the same criteria at the director's institution (Osaka City University) (group B). From August 1995 to November 1996, a total of 33 patients with squamous cell carcinoma of the thoracic esophagus were candidates for radical esophagectomy in Osaka City University. Among them, 21 patients were scheduled for VATS. The procedure was converted to thoracotomy in four patients. The reasons for operative conversions were as follows: pleural adhesion in one, undissectable lymph node spread in one, and contiguous tumor spread in two patients. All operations were performed by one surgeon (Osugi) who had performed more than 200 conventional thoracotomies before beginning the VATS procedure.

## Procedure

All patients underwent three-stage esophagectomy and reconstruction. During the thoracic procedure, patients were placed in the left lateral position. A 5-cm minithoracotomy was created in the fifth intercostal space (ICS) in the mid-axillary line (AL). Four 11.5-mm trocars were inserted around the mini-thoracotomy (third ICS on the mid-AL, fifth ICS on the posterior AL, seventh ICS on the posterior AL, and the seventh ICS on the mid-AL). The position of the surgeons and video monitors, as well as the site of the minithoracotomy and trocar insertion were the same as described by Osugi et al.<sup>19</sup> The right lung was deflated and anteriorly displaced by gentle compression with the retractor. Lung retraction and a 30° telescope made it possible to observe the entire mediastinum. Esophageal mobilization and mediastinal lymph node dissection were performed under the director's instruction in the initial eight cases in group A, as described previously.<sup>19</sup> The mediastinal lymph nodes were dissected carefully by utilizing the magnifying effect of the video while keeping the camera in close proximity and at an adequate angle to the dissection area. In particular, the lymph nodes around the bilateral recurrent laryngeal nerves were completely removed, with identification and preservation of those nerves. Trachea rotation by a smoothed

tip retractor and 30° telescope presented a good view around the left recurrent nerve on the left side of the trachea where direct visualization is difficult even during open surgery. Esophageal mobilization and en bloc mediastinal lymph node dissection were performed to expose the aortic wall, left mediastinal pleura, pericardium, membranous portion of the tracheobronchus, and the diaphragm just as they are performed in open surgery. Subsequently, the tracheobronchial nodes and infraaortic arch nodes were dissected, separately.

For the second stage, the patients were placed in the supine position. Following dissection of pericardiac and celiac axis nodes, the mobilized esophagus was pulled down through the enlarged hiatus. The stomach was prepared for reconstruction by division at the cardia with a stapler. The second stage was done by laparotomy in the first five patients and by hand-assisted laparoscopic surgery in the latter seven patients in group A. All patients in group B underwent laparotomy.

In the third stage, the cervical nodes were dissected through a collar incision, and the stomach was pulled up through the posterior mediastinum. The procedure was completed with a cervical esophagogastric anastomosis.

#### Data analysis

The tumor was staged according to the TNM classification of the American Joint Committee on Cancer and the Union Internationale Control le Cancer. The clinicopathological factors and surgical outcomes, including the duration of procedure, amount of blood loss, number of dissected nodes, and incidence of complications during the VATS procedure were compared between the two groups. Values are expressed as medians (range). The chi-squared test was used to compare the clinicopathological factors in the two groups. The Mann-Whitney U-test was used to compare surgical outcomes.  $P < 0.05$  was considered to be statistically significant.

#### Results

At Kanazawa University, the operator had been able to perform a complete thoracoscopic radical esophagectomy without any direction after undergoing instruction

for 10 cases under adequate direction with the regular surgical team members. The representative photograph after mediastinal lymph node dissection is presented in Fig. 1. The clinicopathological factors and surgical outcome in group A were compared to those in group B. There were no differences in the background or clinicopathological

factors between the two groups (Table 1). The number of dissected lymph nodes and the duration of procedure were similar in the two groups (Table 2, Fig. 2). The amount of thoracic blood loss was significantly less in group A than in group B ( $P = 0.0035$ ) (Table 2, Fig. 3). No patients received blood transfusions in group A. There were no surgery-related deaths in either group. Postoperative pneumonia and atelectasis were observed in 25.0% of group A patients and in 17.6% of group B patients. The incidence of recurrent nerve palsy was 30.7% in group A and 11.7% in group B, but there was no statistically significant difference ( $P = 0.19$ ). The morbidity rates in group A and group B were 41.6% and 29.4%, respectively ( $P = 0.694$ ) (Table 3).

## **Discussion**

We could master the basic skills of VATS safely in a relatively short period of time after only 10 cases of esophageal cancer under the direction of an experienced surgeon and a regular surgical team. Although the operator had little experience with esophageal surgery at the beginning of this study, supervision and instruction from the fully trained surgeon allowed the operator to perform VATS safely during the induction period.

Generally, VATS is complex surgery, and attaining proficiency in this procedure requires much experience. Satisfactory outcomes can be obtained only after the development of a training course in a center that performs a sufficient number of esophageal surgeries to provide the operator with the opportunity to refine necessary skills. We thought that primary education about the VATS procedure to a fixed member in each institution is essential to make a short, steep learning curve. Therefore, we tried to master the VATS procedure by following the same method that the experienced surgeon performed with the regular surgical team members under the supervision of the fully trained surgeon. We also used special instruments, including retractor, scissors, and forceps, optimized for VATS by the supervisor.<sup>19</sup> The initial problem when performing VATS involved ensuring an adequate operative view by the assistant and scopist, and manipulation of instruments. Sometimes we had difficulty obtaining good eye-hand coordination and in appreciating the mediastinal anatomy under the magnifying effect of the thoracoscope. The director's advice during the operation as well

as preoperative imaging by the director's video was useful when performing the operation under the video monitor. Although the monitor image is indirect and two-dimensional, it is quite educational to learn the detailed anatomy in the mediastinum and the methods for dissecting the mediastinal lymph nodes while pre-

servicing the important organs. As a result of the instruction, we obtained the basic skills of VATS after only 10 cases under direction.

In this present study, we evaluated the efficacy of instruction in the VATS induction period and the success of our results by comparing our cases to those performed at the director's institution. Although the length of the procedures were not different for the two groups, the amount of thoracic blood loss was significantly less in our institution compared to that in the director's institution. No patients in our institution required blood transfusions. The adequate direction by the supervisor might have decreased the unexpected blood loss during manipulation. As shown in Fig. 2, the reduction in procedure time with experience was difficult to assess because the indications for VATS were enlarged to include advanced tumors with lymph node metastasis after the experience of the initial six cases. Case 12 had a bulky tumor, and it took 455 min to complete the curative operation safely by VATS. On the other hand, case 11 (T1 N0 M0) took only about half of the time required for the first case (T2 N0 M0) (230 vs. 448 min).

The morbidity rate of 41.6% in group A was comparable to that noted with open esophagectomy.<sup>2,20</sup> The relatively high morbidity ratio in group A might be due to the limited surgical experience of the surgeon in esophageal surgery. The multicenter questionnaire study of scopic surgery in Japan showed that intraoperative complications of VATS occurred in 41 (13.9%) of 294 cases, including 33 nerve injuries (11.2%) and 4 tracheo-bronchus injuries (1.36%) (Report of the Cancer Research Ministry of Health, Labor, and Welfare, Japan November 2002, unpublished data). We did not encounter lethal complications, such as tracheobroncheal perforation. The most frequent complication was recurrent laryngeal nerve palsy, experienced by five patients, three of whom required temporary tracheotomy. However, all of these recurrent nerve palsy occurrences were transient and disappeared during the following 6 months. Recurrent nerve palsy might have been due to the manipulation related to dissecting the lymph nodes around the recurrent laryngeal nerves, which is also a difficult procedure to perform in open surgery. The rate of pulmonary infection in our cases was 25%, which is comparable to that for open esophagectomy combined with extended lymph-adenectomy.<sup>2</sup> Overall, complications were found in the initial seven cases, but the latter five patients experienced no postoperative complications. Further attainment of surgical skill may reduce postoperative complications.

## **Conclusion**

It is possible to attain the requisite basic skill to perform thoracoscopic radical



esophagectomy for thoracic esophageal cancer in a relatively short period of time under the direction of an experienced surgeon. The primary education of the regular surgical team by post-accreditation supervision is essential for the safe, rapid induction of complex scopic surgery. This education system can produce intercenter dissemination of knowledge and skill. As the result, minimally invasive radical esophagectomy will become widely and effectively used.

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**Fig. 1** Final appearance after mediastinal lymph node dissection.

**A** Lymph node clearance along the bilateral recurrent nerves. **B** Lymph node clearance of the infra-aortic arch region. **C** Lymph node clearance of the subcarinal area. **D** Lymph node clearance of

the middle mediastinal region. T, trachea; RMB, right main bron-

chus; LMB, left main bronchus; RSA, right subclavian artery;

LSA, left subclavian artery; LPA, Left pulmonary artery; LPV,

left pulmonary vein; A, aortic arch; P, pericardium; RRN, right

recurrent nerve; LRN, left recurrent nerve; LPP, left parietal

pleura

**Fig. 2** Operative duration for the two groups. White columns indicate the patients who underwent operation under the direction of an experienced surgeon; black columns indicate the patients who underwent operation without direction.

**Fig. 3** Thoracic blood loss for the two groups. White columns indicate the patients who underwent operation under the direction of an experienced surgeon; black columns indicate the patients who underwent operation without direction.

**Table 1 Comparison of clinicopathological characteristics of both groups**

		Group A	Group B	<i>p</i> -value
Number of cases		12	17	
Gender	Male	10	15	>0.999
	Female	2	2	
Median age (range)		66 (52-72)	62 (47-71)	0.6569
Location of tumor	Upper thoracic esophagus	4	3	0.323
	Middle thoracic esophagus	6	13	
	Lower thoracic esophagus	2	1	
Histopathological X Grading (G)	1	2	0	0.2774
	2	1	4	
Depth of invasion (pT)	3	5	8	0.6223
	is	4	5	
	1	0	1	
	2	6	5	
	3	2	4	
lymph node metastasis (pN)	0	4	7	0.4598
	1	8	9	
Pathologic stage (pStage)	O	4	8	0.6984
	I	0	1	
	II a	5	5	
	II b	3	3	
	III	2	2	
	III	2	6	

**Table 2 Comparison of number of dissected mediastinal nodes, length of thoracic procedure and thoracic blood loss of both groups**

	<b>Group A</b>	<b>Group B</b>	<b><i>p</i>-value</b>
	<b>(n=12)</b>	<b>(n=17)</b>	
<b>Number of dissected nodes</b>	<b>34 (22-53)</b>	<b>26 (9-55)</b>	<b>0.230</b>
<b>Length of procedure (min)</b>	<b>327.5 (230-455)</b>	<b>315 (190-515)</b>	<b>0.947</b>
<b>Amount of blood loss (g)</b>	<b>185 (110-380)</b>	<b>440 (110-2360)</b>	<b>0.0035</b>

**Values are median (range)**

**Table 3 Comparison of postoperative complications of both groups**

<b>Postoperative complications</b>	<b>Group A (n=12)</b>	<b>Group B (n=17)</b>	<b><i>p</i>-value</b>
<b>Pneumonia and atelectasis</b>	<b>3 (25.0%)</b>	<b>3 (17.6%)</b>	<b>0.974</b>
<b>Recurrent nerve palsy</b>	<b>4 (30.7%)</b>	<b>2 (11.7%)</b>	<b>0.19</b>
<b>Chylothorax</b>	<b>1 ( 8.3%)</b>	<b>1 ( 5.8%)</b>	<b>&gt;0.99</b>
<b>Total</b>	<b>5 (41.6%)</b>	<b>5 (29.4%)</b>	<b>0.694</b>

Figure 1

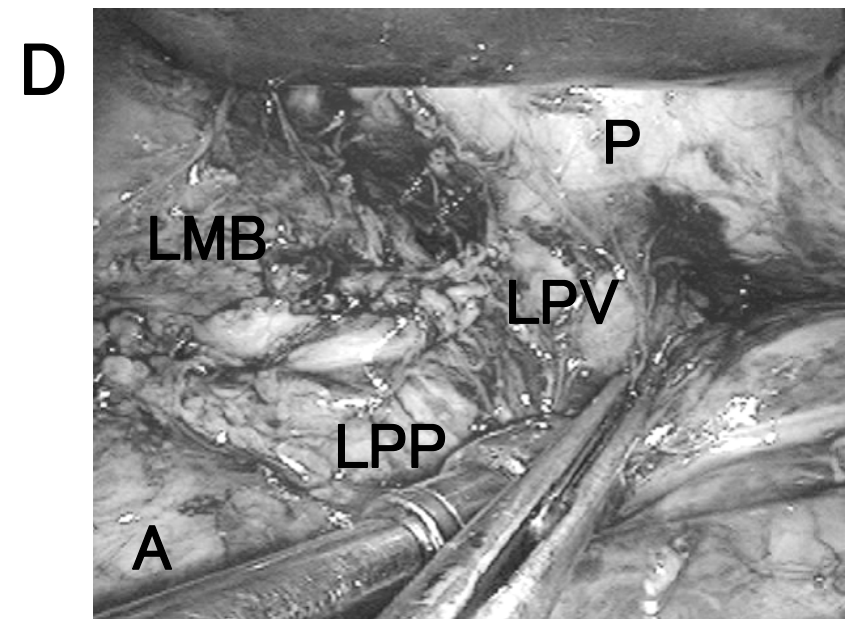
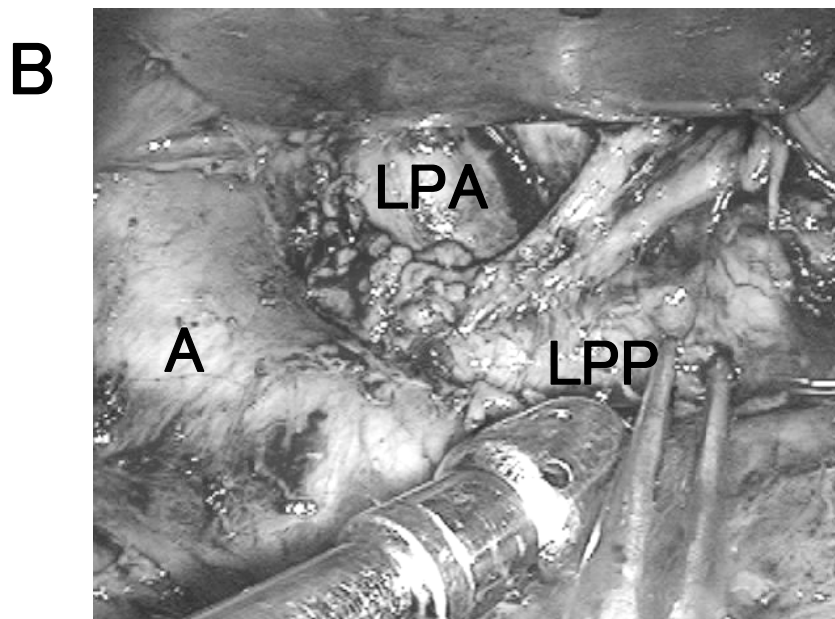
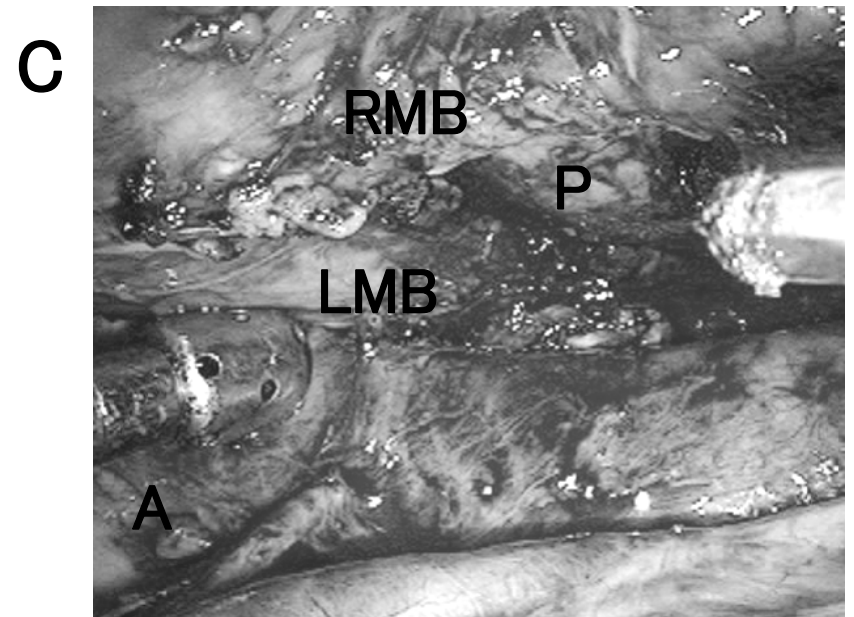
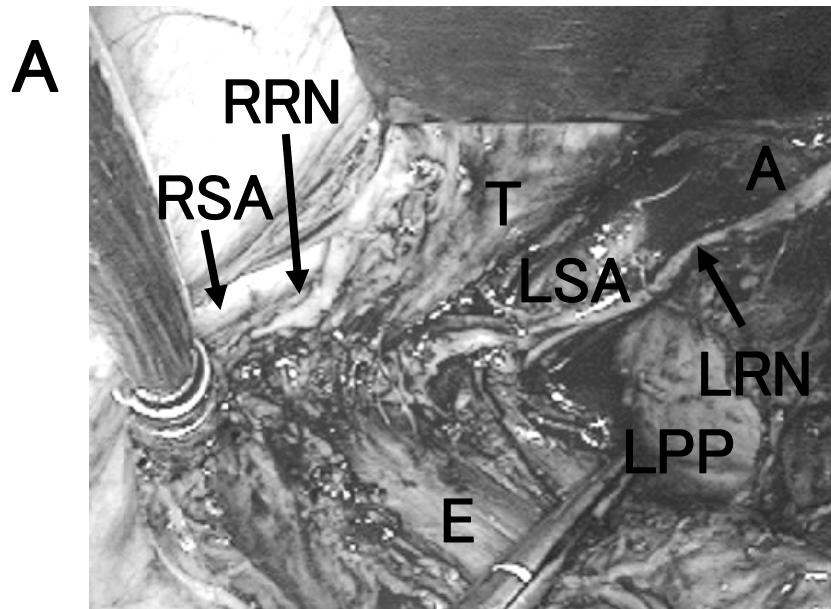


Figure 2

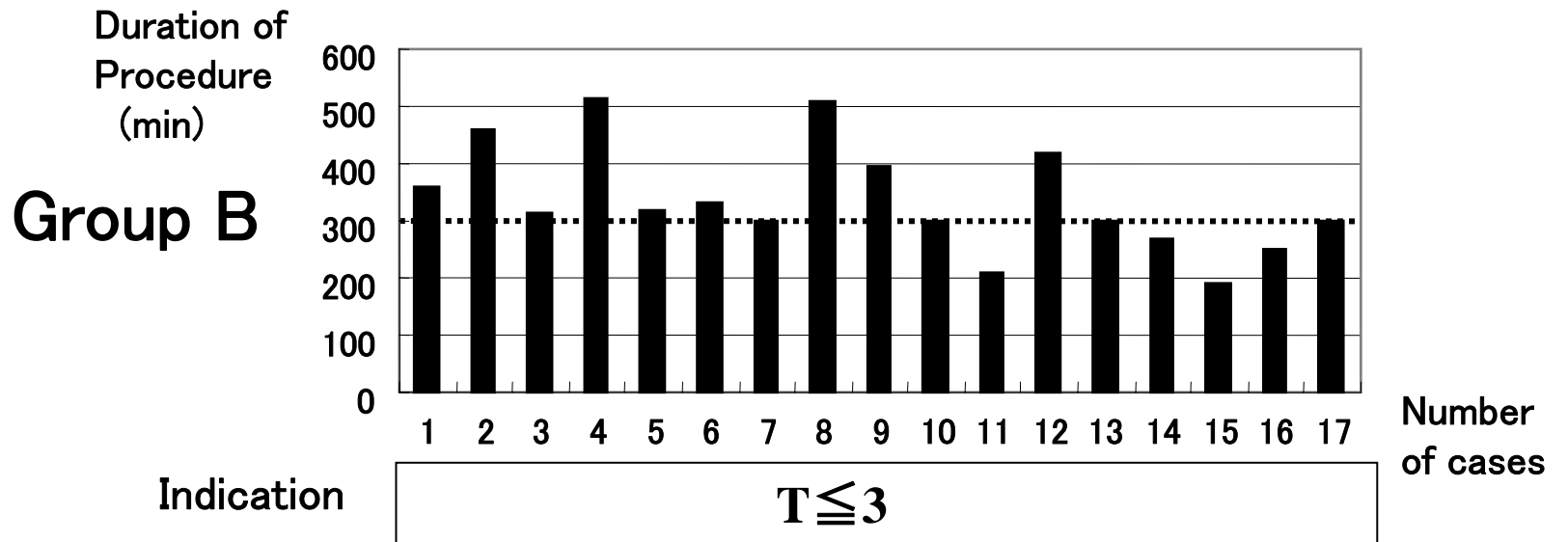
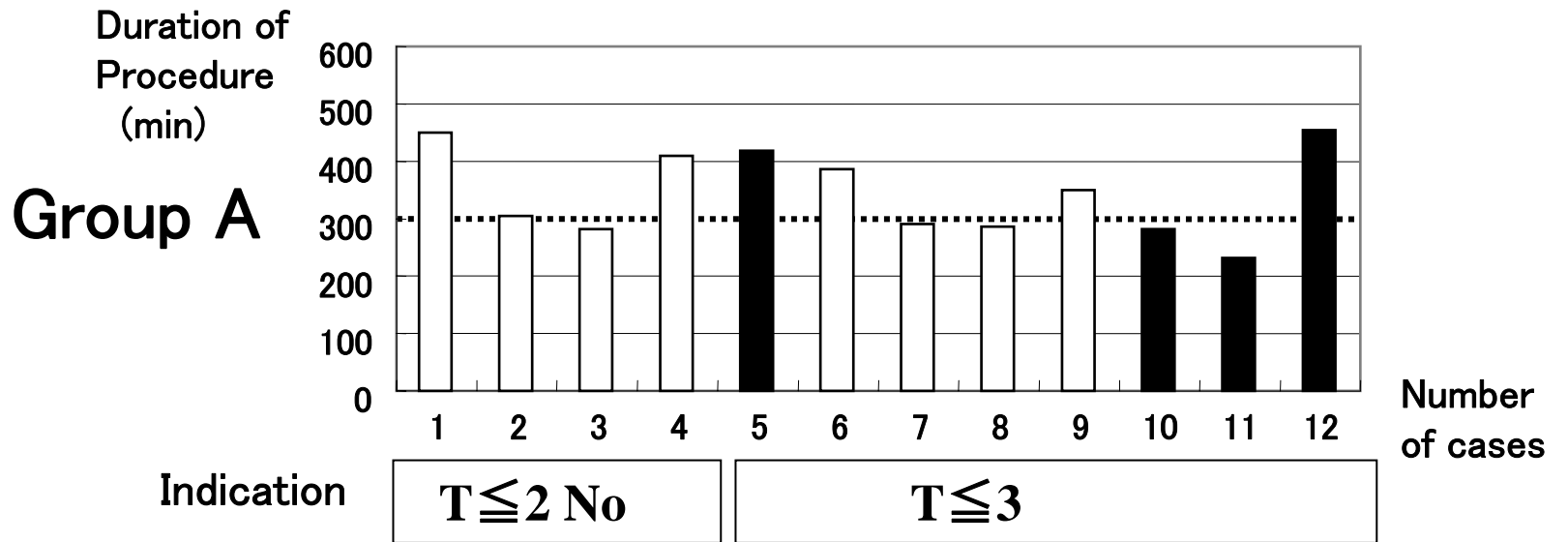




Figure 3

