Surg Endosc (1999) 13: 218–223

Surgical Endoscopy
Ultrasound and
Interventional Techniques

Video-assisted thoracoscopic esophagectomy for esophageal cancer

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Received: 25 November 1997/Accepted: 11 March 1998

Abstract

Background: The Ivor-Lewis procedure is a radical, invasive, and effective procedure for the resection of most esophageal cancers. To minimize invasiveness, we performed thoracoscopic and video-assisted esophagectomy and mediastinal dissection for esophageal cancer.

Methods: From November 1995 to June 1997, 23 patients with intrathoracic esophageal cancer, excluding T4 cancers, underwent thoracoscopic and video-assisted esophagectomy. Bilateral cervical dissections were performed as well as preparation of the gastric tube and transhiatal dissection of the lower esophagus. The cervical esophagus was cut using a stapler knife, and esophageal reconstruction was performed through the retrosternal route or anterior chest wall. Next, thoracoscopic mediastinal dissection and esophagectomy were performed.

Results: The mean volume of blood loss was 163 ± 122 ml; mean thoracoscopic surgery duration, 111 ± 24 min; mean postoperative day for patients to start eating, 8 ± 3 days; and mean hospital stay, 26 ± 8 days. No patient developed systemic inflammatory response syndrome postoperatively. Tracheal injury occurred and was repaired during the thoracoscopic approach in one patient. No patients died within 30 days after surgery. Postoperative complications included transient recurrent nerve palsy in five patients, pulmonary secretion retention requiring tracheotomy in two, and chylothorax in one. Five patients died of cancer recurrence within 1 year of surgery.

Conclusions: Our surgical experience with thoracoscopic and video-assisted esophagectomy indicate that it is a feasible and useful procedure.

Key words: Thoracoscopic esophagectomy — Esophageal cancer

The Ivor-Lewis procedure is a radical operation for the resection of most esophageal cancers. It consists of a thoracotomy for esophageal mobilization and mediastinal dissection, a laparotomy for the formation of a gastric tube, and perigastric dissection as well as cervicotomy for neck dissection and esophagogastric anastomosis. In 1992, Cuschieri [3] described thoracoscopic dissection of the esophagus and mediastinal nodes in malignant disease and demonstrated that the approach was both safe and minimally invasive. However, some patients who received the thoracoscopic approach were later converted to conventional thoracotomy because of a large tumor or intraoperative complications such as vascular or tracheobronchial injury [6, 8, 10]. To decrease intraoperative complications and minimize surgical invasiveness, we performed thoracoscopic and video-assisted esophagectomy (TVAE).

Patients and methods

From November 1995 to June 1997, 23 patients (3 women and 20 men) with esophageal cancer (patients with T4 cancer were excluded) underwent TVAE. Their ages ranged from 40 to 74 years (mean age, 62). Tumor location was in the upper intrathoracic esophagus in five patients, the middle intrathoracic esophagus in nine, and the lower intrathoracic or abdominal esophagus in nine (Table 1). Tumor staging was performed according to the pathologic TNM classification of the esophagus published by the American Joint Committee on Cancer and the Union Internationale Contre le Cancer in 1987: stage 0 in two patients, stage I in three, stage IIA in five, stage IIB in three, stage III in five, and stage IV in one. Five patients had pathologic T3 tumors that were preoperatively diagnosed by chest CT as involving invasion into adjacent tissues. These patients underwent preoperative chemoradiotherapy consisting of radiation (1.5 Gy/day for 20 days), intravenous administration of cis platinum (80 mg/m^2 from day 1 to day 14), and 5-FU (10 mg/kg from day 1 to day 5 and from day 14 to day 18).

Surgical procedure

Initially, the patient was placed in a supine position. General anesthesia was accomplished through double-lumen intubation. After establishing the cervical and abdominal approaches, neck dissection and mobilization of the cervical esophagus were performed. Both recurrent laryngeal nerves were isolated carefully, and the superior paraesophageal and paratracheal nodes were dissected bilaterally through a cervical approach. The cervical esophagus was isolated and cut using a stapler (GIA, U.S. Surgical Corp. Norwalk, CT, USA).

During the cervical approach, upper median laparotomy and paragastric

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Table 1. Patients with thoracoscopic and video-assisted esophagectomy for esophageal cancer

No.	Age gender	Location	pTNM stage	Preoperative status	Outcome (metastases)
1	65 M	Upper	T3N0M0 IIA	Well	24 M alive (bone)
2	44 M	Middle	T3N1M1 IV	Resection and radiation for brain metastasis	2 M dead (pleura)
3	72 M	Upper	T3N1M0 III	Well	20 M alive (lung)
4	58 M	Upper	T3N0M0 IIA	Cerebral infarction Ischemic heart dysfunction	10 M dead (trachea)
5	49 M	Lower	T3N1M0 III	Well	7 M dead (liver, lung)
6	72 M	Lower	T3N1M0 II	Diabetes, hepatitis	15 M alive
7	67 M	Middle	T2N0M0 IIA	Well	15 M alive
8	67 M	Lower	TisN0M0 0	Well	11 M alive
9	59 M	Upper	TisN0M0 0	Gastrectomy for gastric cancer	11 M alive
10	66 M	Middle	T1N1M0 IIB	Well	10 M alive
11	50 M	Middle	T1N0M0 I	Well	9 M alive
12	59 M	Lower	T2N0M0 IIA	Well	9 M alive
13	73 F	Lower	T3N0M0 IIA	Well	7 M alive
14	66 M	Lower	T3N1M0 III	Well	8 M alive
15	69 M	Lower	T3N0M0 IIA	Well	9 M alive
16	62 M	Upper	T3N1M0 IIA	Total gastrectomy for gastric cancer	6 M dead (neck)
17	72 M	Middle	T1N0M0 I	Total gastrectomy for gastric cancer	8 M alive
18	72 M	Upper	T2N1M0 IIB	Total gastrectomy for gastric cancer	8 M alive
19	57 M	Middle	T3N1M0 III	Alcoholic liver dysfunction	6 M died (mediastinum)
20	74 F	Middle	T2N1M0 IIB	Well	6 M alive
21	40 F	Middle	T3N1M0 III	Hysterectomy for uterine cancer	5 M alive
22	64 M	Middle	T1N0M0 I	Well	5 M alive
23	57 M	Lower	T3N1M0 III	Well	4 M alive

node dissection were performed, and the gastric tube was prepared for esophageal reconstruction. Mobilization of the stomach and abdominal esophagus was carried out with preservation of the right gastroepiploic arcade and ligature of the left gastric artery at its origin from the celiac artery. This was accomplished with removal of the related lymph nodes. Branches to the omentum from the right gastroepiploic vessels, short gastric vessels, and left gastroepiploic vessels were divided with a harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, OH, USA). The esophagus was transected at the esophagogastric junction or cardia of the stomach with a Roticulator (U.S. Surgical Corp.). A slim gastric tube based on the greater curvature of the stomach was created with a stapler (GIA-90, U.S. Surgical Corp.). The diaphragmatic hiatus was widened, the lower esophagus mobilized, and the lower posterior mediastinal nodes, including the diaphragmatic and paraesophageal nodes, dissected through the diaphragmatic hiatus. The small vessels and lymphatics were coagulated and cut with a harmonic scalpel. The right lower mediastinal pleura was opened, and the distal stump of the esophagus was inserted into the right pleural cavity.

Reconstruction of the esophagus with the gastric tube was made by the retrosternal approach in 19 patients. In four patients with total gastrectomy for concomitant gastric cancer, an isoperistaltic subcutaneous left colon replacement of the esophagus was performed. The preparation of the arterial supply was based on the left colic artery. In three patients who underwent total gastrectomy, end-to-end esophagocolostomy and end-to-side colojejunostomy was performed. In one patient, total gastrectomy was performed before replacement of the left colon. The cervical esophagogastric or esophagocolic anastomosis was made before the thoracoscopic approach. A jejunostomy tube for alimentary nutrition was placed in the jejunum 30 cm distally to the ligament of Treitz. The cervical and abdominal wounds were then closed.

Next, the patient was placed in a left decubitus position, a flat pillow was placed under the chest, the right lung was deflated, and one-lung ventilation was started. Then the trocars were placed in the sixth intercostal space at the posterior aspect of the scapular angle and in the eighth intercostal spaces. Additional trocars were placed in the fourth and sixth intercostal spaces on the anterior axillary line, and in the fifth and seventh intercostal spaces on the middle axillary line. A 30-degree telescope was inserted through the middle lower port (Fig. 1). The lung was displaced inferiorly by a forked retractor (Endoretract, U.S. Surgical Corp.) through the lower anterior port, and the azygous vein was divided through the lower posterior port with endovascular staplers. Then the pleura was opened at the azygos vein from the top of the thorax to the diaphragm. The proximal site of the esophagus was identified and grasped with an endoscopic tissue grasper through the port at the posterior aspect of the scapular angle and

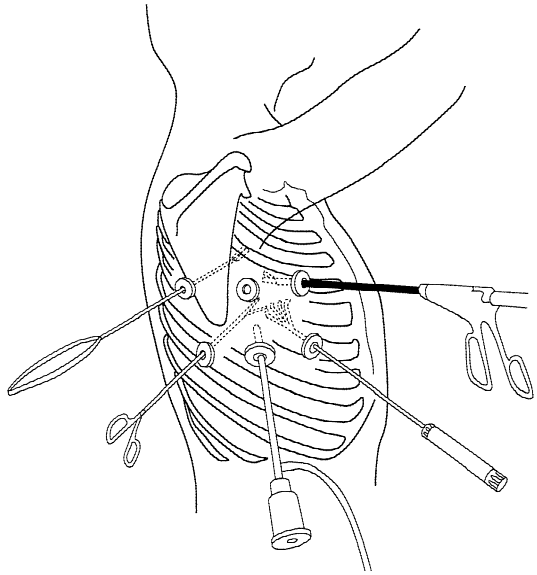

Fig. 1. Trocars were inserted from the fourth to the eighth intercostal space.

Table 2. Operative duration, blood loss, complications, postoperative NPO days and hospital stay in patients with TVAE

Case	Operative duration (min)	Blood loss (ml)	Intraoperative and postoperative complication	Postoperative NPO (days)
1	95	425	Recurrent nerve palsy	8
2	120	324	Recurrent nerve palsy Sputum retention (tracheostomy)	8
3	105	145	Recurrent nerve palsy	8
4	101	247	None	8
5	135	175	Recurrent nerve palsy	8
6	120	425	Sputum retention (tracheostomy)	8
7	120	150	None	8
8	130	249	None	8
9	120	132	None	8
10	140	296	None	8
11	80	30	None	7
12	150	172	None	7
13	90	100	None	7
14	120	235	Recurrent palsy	14
15	105	100	None	7
16	110	60	None	7
17	120	125	None	7
18	170	240	None	7
19	75	20	None	7
20	85	20	None	8
21	85	20	Chylothorax	21
22	130	30	Tracheal injury	7
23	65	30	None	7

NPO, nothing per os (by mouth); TVAE, thoracoscopic video-assisted esophagectomy.

pulled downward. Subsequently, esophageal mobilization and paraesophageal dissection were carried out with thoracoscopic dissecting scissors and thoracoscopic forceps (SCANLAN Thoracoscopic Ultra Sharp Dissecting Scissors and SCANLAN Thoracoscopic Jacobson Debaky Forceps, SCANLAN, St. Paul, Minnesota) through the posterior ports and with a harmonic scalpel through the upper anterior port. The paratracheal nodes and the right tracheobronchial nodes were dissected along the right vagus nerve. Next, the trachea was displaced anteriorly with a curved retractor (Endomaxiretract, U.S. Surgical Corp.) through the upper anterior port, and the left recurrent laryngeal nerve was identified. Then the left tracheobronchial nodes were dissected. The lung was retracted anteriorly, the middle esophagus mobilized, and the subcarina and hailar nodes dissected. Thoracoscopic dissecting scissors was inserted through the lower posterior port, and a harmonic scalpel was inserted through the middle inferior port. The techniques of thoracoscopic lymph node dissection are shown in Fig. 2.

The dissection performed for mobilization of the tumor was located in a loose plane outside the limits of the lesion. The bronchial arteries were left intact if possible, and the vagus nerves were cut peripherally to the pulmonary branches. The esophageal and paraesophageal nodes were dissected to the distal stump of the esophagus. The esophagus was put in a vinyl bag and pulled out through the posterior hole. When it was difficult to pull the bag out, the incision of the posterior hole was widened to 3 cm. A chest tube was placed in the pleural cavity, the lung inflated, and the wounds closed.

Initial postoperative pain control was accomplished with epidural analgesia. Enteral hyperalimentation was started on postoperative day 1. A routine postoperative esophagogram was obtained 7 or 8 days after reconstruction, and oral feeding was started when no esophageal leakage was confirmed.

Results

In 23 patients, esophageal resection was performed with TVAE (Table 2). The mean number of lymph nodes dissected through thoracoscopy was 29 ± 12, the mean volume of blood loss during thoracoscopic approach, 163 ± 122 ml; the mean duration of one-lung ventilation, 111 ± 24 min; the mean postoperative day po, 8 ± 3 days; and the mean hospital stay, 26 ± 8 days.

Intraoperative complications occurred in one patient. The membranous portion of the trachea adjacent to the tracheal cuff of the double-lumen intubation tube was injured and perforated during the thoracoscopic approach. Video-assisted direct suture closure was performed using 4-0 PDS with a pleural pledget, and the membranous portion of the trachea and left main stem bronchus were wrapped with thymic tissue introduced behind the superior vena cava. The postoperative course was uneventful. It was difficult to divide the esophagus from the trachea or the left main stem bronchus when a T3 tumor was located in the upper intrathoracic esophagus adjacent to the tracheobroncheal tree. The esophagus should be isolated without injury to the esophageal wall or the tracheobronchal membranous wall.

No patients required postoperative ventilatory support. The mean white blood cell count elevated to $10.9 \pm 4.1 \times 10^3$ after surgery and recovered to $7.6 \pm 3.5 \times 10^3$ by day 3. The mean C reactive protein (CRP) level recovered to normal range 3 weeks after surgery (from 14.7 ± 6.1 on day 2 to 1.6 ± 1.4 on day 21). No patients developed systemic inflammatory response syndrome [9] after surgery (Fig. 3). Postoperative chest pain decreased rapidly during the recovery period, and analgesics were not necessary in any of the patients after removal of the epidural catheter on postsurgery day 4.

No patients died within 30 days after surgery, and there were no serious postoperative complications. Morbidity in-

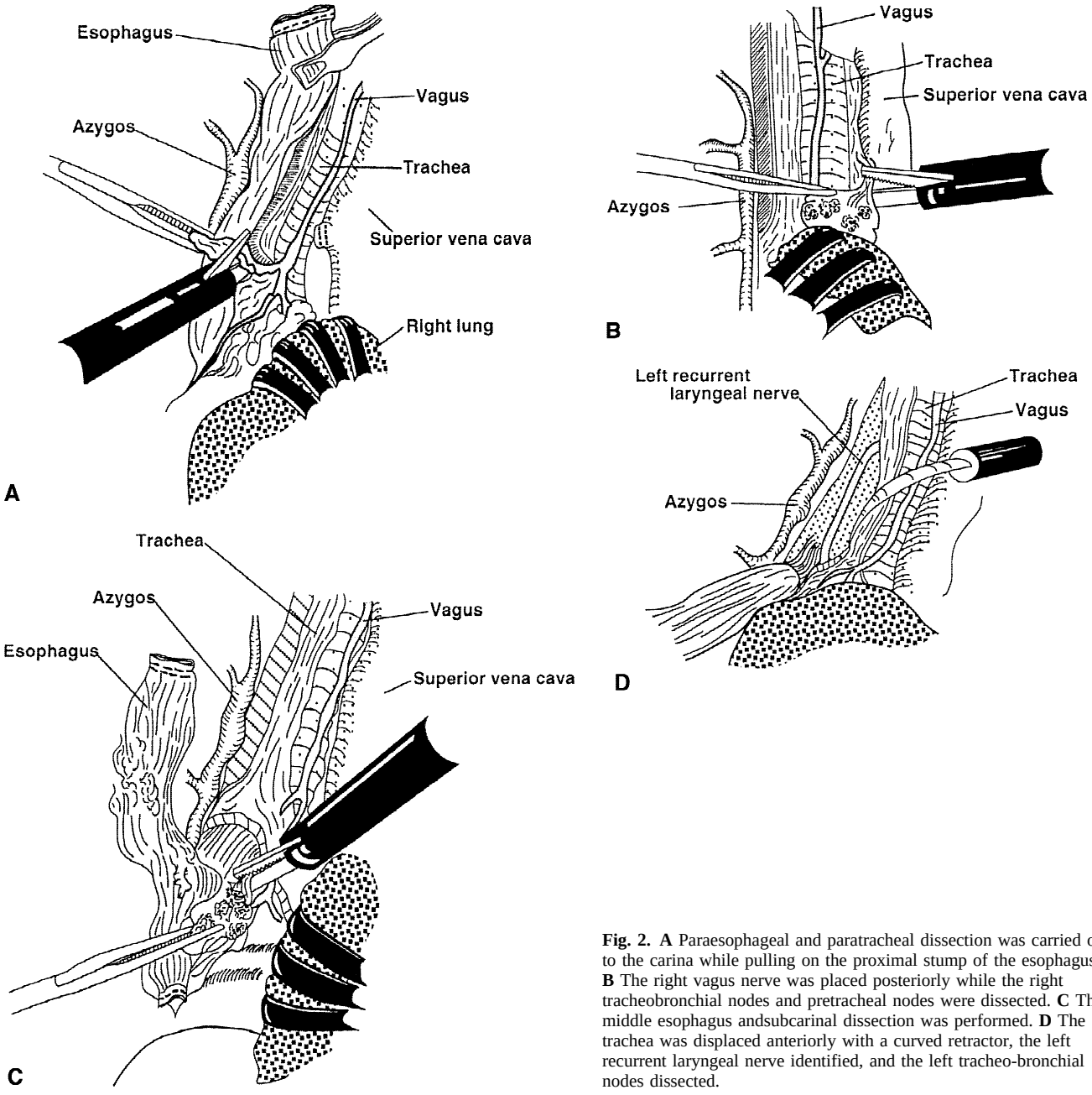

Fig. 2. **A** Paraesophageal and paratracheal dissection was carried out to the carina while pulling on the proximal stump of the esophagus. **B** The right vagus nerve was placed posteriorly while the right tracheobronchial nodes and pretracheal nodes were dissected. **C** The middle esophagus andsubcarinal dissection was performed. **D** The trachea was displaced anteriorly with a curved retractor, the left recurrent laryngeal nerve identified, and the left tracheo-bronchial nodes dissected.

cluded transient recurrent nerve palsy in five patients and minor leakage at the esophagogastric anastomosis in one patient, for whom patient oral feeding was started on postsurgery day 14. Pulmonary secretion retention required tracheostomy in two patients. One had severe diabetes, and the other patient had previously undergone surgical resection of a brain metastasis as well as cranial irradiation 1 month before esophagectomy. In one patient, chylothorax occurred in the right pleural cavity, so intravenous nutrition instead of enteral hyperalimentation was administered for 3 weeks after surgery, at which time feeding was started.

Five patients died of cancer recurrence. The patient who underwent cranial resection and radiation therapy for brain metastasis died of pleural metastasis 2 months after esophagectomy. In the one patient with T3 disease located in the middle esophagus adjacent to the left main stem bronchus, local recurrence in the left main stem bronchus appeared 7 months after surgery. Radiotherapy was performed for a total dose of 60 Gy, but the patient died of pneumonia 10 months after surgery. Two patients are living with lung and bone metastasis 24 and 20 months postsurgery. Sixteen patients are alive and disease free 4 to 15 months after surgery.

Discussion

This surgical procedure has been performed by several surgeons using either two or three stages. In the three-stage operation, the first stage consists of thoracoscopic esophageal mobilization. The second stage is gastroplasty through laparotomy, and in the third stage cervical anastomosis is

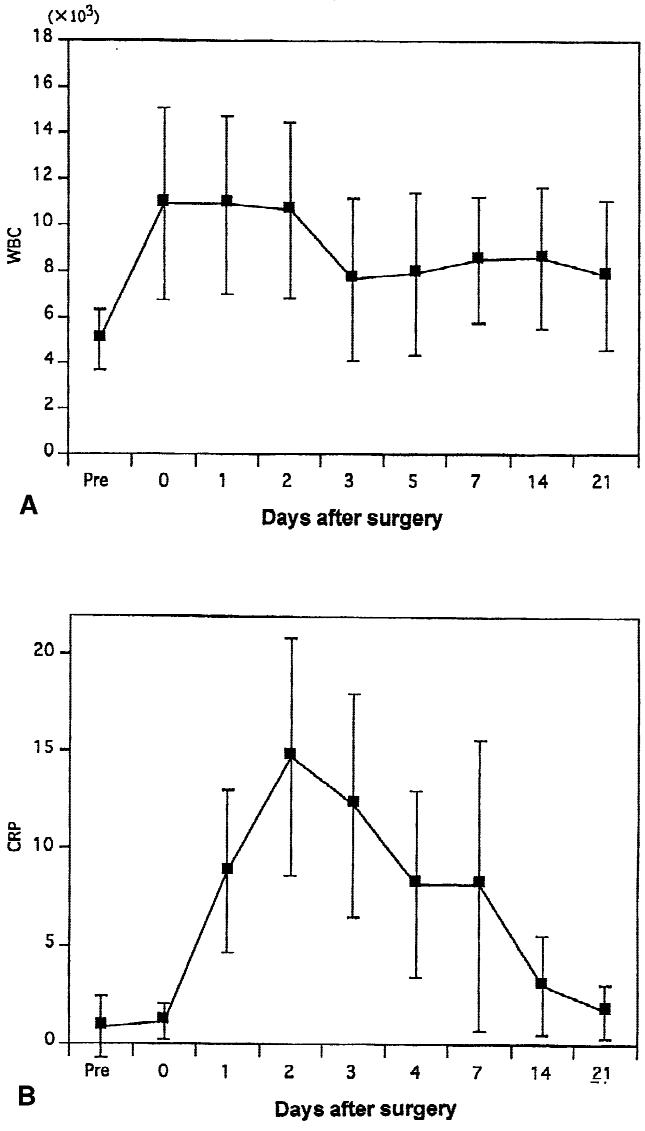

Fig. 3. Mean WBC **(A)** and CRP **(B)** before and after surgery.

carried out between the esophagus and the gastric tube pull-through [2–4, 6, 8]. Alternatively, in the two-stage version, the first stage is the gastroplasty, and the second stage is the thoracoscopic esophageal resection and intrathoracic esophagogastrotomy using an intraluminal stapler [7, 10]. In our series, the first stage was the gastroplasty and esophagogastric or esophagocolostomy through the retrosternal or anterior chest wall, and the second stage was the thoracoscopic esophageal resection.

In previous reports, the average time of the thoracoscopic stage was 128 to 280 min [6–8], and the average blood loss was 200 to 250 ml [6, 7]. Intraoperative complications included intercostal injury, azygos arch injury, aorta injury, and perforation of the right main stem bronchus [2, 5, 8]. These complications were caused by technical and instrumental problems or because the tumor was too large to mobilize by the thoracoscopic approach. In one of our patients, the membranous portion adjacent to the cuff of the intubation tube was injured by the dissecting scissors. Care should be taken to dissect the esophagus at the membranous portion of the trachea and at the left main stem bronchus adjacent to the cuff of a double-lumen intubation tube.

The transhiatal mobilization and dissection of the lower third of the esophagus using a harmonic scalpel contributed to the thoracoscopic mobilization of the esophagus and dissection of the lower posterior mediastinal nodes, especially when the tumor was located in the lower third of the esophagus. The harmonic scalpel is useful for coagulating and sealing small vessels and lymphatics adjacent to nerves, great vessels, or tracheobronchial trees because this instrument is less damaging to surrounding tissues than electrocautery. A harmonic scalpel coagulates via ultrasonic energy and reduces the risk of lateral tissue injury because tissue temperatures do not exceed 80°C.

Gossot [5] and Robertson [10] reported that pulmonary complications including atelectasis, pneumonia, respiratory failure, and anastomotic leakage occurred at the same rate with the thoracoscopic approach as with conventional thoracotomy, and their mortality rates were 3.8 and 12% [5, 10]. Therefore, the use of a thoracoscopic approach does not appear to reduce the postoperative incidence of either pulmonary or anastomotic complications [5, 10].

Liu et al. [7] suggested that esophagectomy through the right thoracoscopic approach is a safe and feasible procedure. In their initial experiences with 20 patients who underwent video-assisted endoscopic esophagectomy, the postoperative course was uneventful in all patients, and there were no anastomotic leaks, pulmonary complications, or postoperative hospital deaths. Akaishi [1] reported that thoracoscopic mediastinal lymphadenectomy is technically feasible, and its completeness is comparable to that of the open technique. The decline in pulmonary function is significantly less when using this technique than that seen in their previous experiences with the open technique.

No patients developed systemic inflammatory response syndrome after surgery. However, there was some inflammatory response, and it took 3 weeks for their recovery of normal serum-CRP level after surgery.

The results our surgical experiences with this technique lead us to the conclusion that video-assisted thoracoscopic esophagectomy is feasible and useful because we observed few complications during surgery; only mild systemic inflammatory responses appeared after surgery; and mediastinal dissection could be performed as completely as in open surgery. Although postoperative pulmonary complications occurred, such as atelectasis, sputum retention requiring tracheostomy, and minor anastomotic leakage, none of our patients died during the operation or postsurgery hospital recovery period. Even though tracheal injury occurred during one thoracoscopic approach, the patient underwent video-assisted esophagectomy without the need for conversion to open surgery.

It is too soon to assert that the thoracoscopic approach to the esophagus will reduce the complication rate of esophagectomy because the indications of TVAE are still unclear. This operation is probably not indicated for T4 disease, but is effective in T1 and T2 disease. In T3 disease, even with large mediastinal adenopathy, TVAE is probably useful. Further evaluation of this technique, patient selection criteria, and long-term outcome are needed.

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