Review Article

Video-Assisted Esophagectomy for Esophageal Cancer

TOSHIKI SHICHINOHE, SATOSHI HIRANO, and SATOSHI KONDO
Surgical Oncology, Hokkaido University Graduate School of Medicine, Kita-15, Nishi-7, Kita-ku, Sapporo 060-8638, Japan

Abstract
Video-assisted surgery for esophageal cancer is an advanced surgical technique. It has been developed on the basis of the concept of minimally invasive surgery. Given that there are several options regarding the operative procedures for thoracic esophageal cancer, several laparoscopic approaches have been proposed. The first video-assisted thoracoscopic esophagectomy through a right thoracoscopic approach and the first transhiatal esophagectomy were reported in the early 1990s. A mediastinoscope-assisted esophagectomy has also been reported as a substitute for a blunt dissection of the esophagus. Moreover, a video-assisted Ivor-Lewis esophagectomy by right thoracotomy with intrathoracic anastomosis has also been performed. Furthermore, laparoscopic gastric mobilization and gastroplasty are also widely accepted substitutions for open laparotomy. This article reviews the literature on the laparoscopic approaches for esophageal cancer.

Key words Video-assisted esophagectomy · VATS esophagectomy · Thoracoscopic esophagectomy · Laparoscopic esophagectomy

Introduction
Video-assisted surgery for esophageal cancer is an advanced surgical technique which has been developed on the basis of the concept of minimally invasive surgery. Given that there are several options regarding the operative procedures for thoracic esophageal cancer, depending on the tumor location and the clinical stage, several laparoscopic approaches for the cancer have also been proposed (Table 1). The first video-assisted thoracoscopic surgery (VATS) of right transthoracic esophagectomy (TTE) was reported by Cuschieri et al. in 1992, and the first laparoscopic transhiatal esophagectomy (LTHE) was reported by Sadanaga et al. in 1994. A mediastinoscope-assisted esophagectomy has also been reported as a substitute for a blunt dissection of the esophagus. Moreover, a video-assisted Ivor-Lewis esophagectomy (ILE) with right thoracotomy with intrathoracic anastomosis has also been tried. Furthermore, laparoscopic gastric mobilization is widely accepted even in combination with an open thoracotomy.

Operative Procedures

VATS Right Transthoracic Esophagectomy
Video-assisted thoracoscopic surgery is a less invasive operative procedure which was initially applied for pulmonary disorders such as a partial resection of the lung for pneumothorax and lung cancer. In 1992, the first report of the application of VATS to a right transthoracic esophagectomy (VTTE) was done by Cuschieri et al. Recently, some of the high-volume centers worldwide have reported the clinical results of their trials (Table 2). One of the reasons for the expansion of this procedure is owing to the fact that newly developed dissectors such as laparoscopic-coagulating shears are commonly used for laparoscopic surgery which is used for the dissection of the esophagus and the lymph nodes. The other reason is that the laparoscopic approach to malignant gastrointestinal disorders, such as gastric cancer and colonic cancer has become widely accepted.

Indications
The indications for VTTE are not limited to early esophageal cancer. All of the reported studies listed in Table 2 included locally advanced cancer.
Table 1. Laparoscopic surgery for esophageal cancer described

<table>
<thead>
<tr>
<th>Technique</th>
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<tr>
<td>VATS transthoracic esophagectomy (with cervical anastomosis)</td>
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<tr>
<td>Minimally invasive esophagectomy (combination of “complete” thoracoscopic and laparoscopic esophagectomy)</td>
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<tr>
<td>Hand-assisted thoracoscopic surgery</td>
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<td>With laparoscopic gastric mobilization (and gastroplasty)</td>
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<tr>
<td>Robot-assisted thoracoscopic esophagectomy</td>
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<td>Laparoscopic transhiatal esophagectomy</td>
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<td>Mediastinoscope-assisted transhiatal esophagectomy</td>
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<td>Video-assisted Ivor-Lewis esophagectomy</td>
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The limitations of the procedure described in the literature are as follows: it is appropriate for most patients except for those with severe adhesion, for example, those having a history of a right thoracotomy, a failure of one lung ventilation, or a bulky tumor and organ invasion.

Positioning of the Patients
The left lateral decubitus position is widely used for VTTE. The reason for using this position is that it is the same position as that used for open surgery, so it is more familiar than the other positions. The advantages of the prone position have been advocated by Cuschieri and Mitchell et al. By this positioning, as the right lung falls away from the operative field by gravity and insufflation of the thoracic cavity, a good visual exposure of the esophagus without single lung ventilation is obtained, thus resulting in a reduction of postoperative respiratory complications. Many authors prefer the right thoracoscopic approach before setting the supine position for cervical incision and abdominal incision, whereas some prefer to start the operation with cervical and abdominal incisions.

Lymph Node Dissection
Even though controversy regarding the various procedures for esophageal cancer remains, the importance of an en bloc resection of the mediastinal lymph node as an operative procedure for thoracic esophageal cancer is well accepted.

Although it is difficult to discuss the quality and extent of a lymph node dissection when comparing these studies in Table 2, all reports but two described a paraesophageal as well as a paratracheal lymph node dissection. Akaishi et al. and Kawahara et al. presented the details of extensive lymph node dissection. Comparisons between an open thoracotomy and VTTE regarding the accuracy of a mediastinal lymphadenectomy are made on the basis of the number of harvested lymph nodes. Table 2 shows the harvested number of lymph nodes according to the different studies.

Reconstruction
Reconstruction is usually done by a gastric tube. As an additional incision is not required, the posterior mediastinal route is preferred for the reconstruction next to VTTE. Luketch et al. reported the largest series of VTTE, and 213 cases used the posterior mediastinal route, whereas 9 cases used the substernal route. Given that intrathoracic anastomosis is technically difficult when using the VATS procedure, cervical anastomosis is preferred.

Short-Term and Long-Term Benefits of VTTE
Even though there are no randomized trials, which compare VTTE and conventional open TTE, some articles show the benefits of using video-assisted techniques. Braghetto et al. reported that according to their non-randomized results the short-term results of a minimally invasive esophagectomy (VTTE + LTHE) showed fewer major complications and a lower mortality rate than the conventional approach. Nguyen et al. retrospectively compared their series of 18 thoracoscopic and laparoscopic esophagectomies with open TTE and THE. This revealed that their minimally invasive esophagectomy had a shorter operative time, less blood loss, and better hospital courses. Table 2 summarizes the operative results and complications with VTTE. The conversion rate of a VATS esophagectomy to the other approach was 0%–23%. The main reasons for conversion were adhesion, and a bulky and invasive tumor. Major complications were also reported, namely, eight cases of active bleeding, including five cases of aortic injury, and one case of tracheal injury which required an open thoracotomy, and one case of right main bronchial injury which was sutured with a VATS procedure. When comparing the meta-analysis data of open surgery of esophageal cancer, the results of the VTTE reports (Table 2) versus the open TTE meta-analysis data from each point of the operation were as follows: the average blood loss of open TTE is 1001 ml, whereas only one VTTE study marked a blood loss in excess of 1000 ml. The average operative time of the open TTE is 5 h, whereas 8 of 11 VTTE reports which