Review Article

VIDEO ASSISTED ESOPHAGECTOMY FOR ESOPHAGEAL CANCER

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Abstract

Video assisted surgery for esophageal cancer is an advanced surgical technique. It is being adopted with a concept of minimally invasive surgery. Since there are several options of the operative procedure for thoracic esophageal cancer, there are several laparoscopic approaches.

The first VATS esophagectomy through a right thoracoscopic approach and the first transhiatal esophagectomy were reported in early 1990's.

Mediastinoscope-assisted esophagectomy is also reported as a substitute of the blunt dissection of the esophagus. Moreover, video assisted Ivor-Lewis esophagectomy by right thoracotomy with intrathoracic anastomosis has also been tried. Furthermore, laparoscopic gastric mobilization and gastroplasty is also widely accepted as a substitution for open laparotomy. This article serves to review the literature on laparoscopic approaches for esophageal cancer.

Introduction

Video assisted surgery for esophageal cancer is an advanced surgical technique and being adopted as part of a concept of minimally invasive surgery. Since there are several options in the operative procedure for thoracic esophageal cancer depending on the tumor location and the clinical stage, laparoscopic approaches for the cancer are also proposed in several procedures (Table 1). The first video assisted thoracoscopic surgery (VATS) of right trans-thoracic esophagectomy (TTE) was reported by Cuschieri et al. in 1992 [1], and the first laparoscopic transhiatal esophagectomy (LTHE) were reported by Sadanaga et al. in 1994 [2]. Mediastinoscope-assisted esophagectomy is also reported as a substitute for the blunt dissection of the esophagus [3]. Moreover, video assisted Ivor-Lewis esophagectomy with right thoracotomy with intrathoracic anastomosis has also been tried[4]. Furthermore, laparoscopic gastric mobilization is widely accepted even in combination with an open thoracotomy.

Operative procedures

VATS right trans-thoracic esophagectomy

VATS is a less invasive operative procedure which was initially applied for pulmonary disorders, such as the partial resection of the lung for pneumothorax and lung cancer. In 1992, the first report of the application of VATS to the right trans thoracic esophagectomy (VTTE) was done by Cuschieri et al [1]. Recently, some of the high-volume centers world-wide are reporting the clinical results of their trials (Table 2). One of the reasons for the expansion of the procedure is that energetic dissectors such as Laparoscopic Coagulated Sears (LCS) are commonly used for laparoscopic surgery which is used for the dissection of the esophagus and the lymph nodes. The other reason is that laparoscopic approach to malignant gastrointestinal disorders such as gastric cancer and colonic cancer are well accepted.

Indication: Indication for VTTE is not limited to the early esophageal cancer. All of the reported studies listed in the table 2 included locally advanced cancer.

Limitation of the procedure described in the literature are as follows, expect for severe adhesion for example having a history of right thoracotomy, failure of one lung ventilation, and bulky tumor and organ invasion.

Positioning of the patients: The right posterolateral position is widely used for VTTE. The reason for using this position is that it is the same positioning as for open surgery, so it is more familiar than other positions. The advantage of the prone position is advocated by Cuschieri and Mitchell [5, 6]. By this positioning, as the right lung falls away from the operative field by gravity, good visual exposure of the esophagus without single lung ventilation is obtained, resulting in the reduction of the postoperative respiratory complications. Many articles prefer the right thoracoscopic approach before the supine position for cervical incision and abdominal incision, but some author prefers to start the operation with cervical and abdominal incisions [7].

LN dissection: Even though the controversy regarding the various procedures for esophageal cancer exist, the importance of the en bloc resection of mediastinal lymph node for the operative procedure of thoracic esophageal

cancer is well accepted.

Although, it is difficult to discuss the quality and extensiveness of lymph node dissection between these literatures in Table 2, paraesophageal and paratracheal lymph node dissection was performed in almost all reports, only two reports described that the operation was performed without lymph node dissection [8], or without extensive lymph node dissection [9]. Akaish [10] and Kawahara [7] presented the details of extensive lymph node dissection according to the Guidelines for the Clinical and Pathologic Studies on Carcinoma of the Esophagus. The comparison between this literature, or between open thoracotomy and VTTE for the accuracy of the mediastinal lymphadenectomy is measured by the number of harvested lymph nodes. Table 2 shows the harvected number of lymph nodes according to the literature (Table 2).

Reconstruction: Reconstruction is usually done by the gastric tube. Since additional incision is not required posterior mediastinum route and cervical anastomosis is preferred. Luketch et. al. reported largest series of VTTE, 213 cases were posterior mediastinum route and 9 cases were substernal route.

Since intra thoracic 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 the application of the Video-assisted technique. One report from Braghetto et al. showed that according to their non-randomized results the short term result of the minimally invasive esophagectomy (VTTE+LTHE) showed fewer major complications and a lower mortality rate than the conventional approach [11]. Nguyen et al. retrospectively compared their 18 series of thoracoscopic and laparoscopic esophagectomy with open TTE and THE [12]. This revealed that their minimally invasive esophagectomy had shorter operative time, less blood loss, and better hospital courses. Table 2 summarizes the operative results and complications with VTTE. Conversion rate of VATS esophagectomy to other approach was 0 to 23%. The main reasons of conversion were adhesion, bulky and invasive tumor. Major complications were also reported; 8 cases of active bleeding, including 5 cases of aortic injury and

one case of tracheal injury which required open thoracotomy, and one case of right main bronchial injury which was sutured with a VATS procedure. With comparison with the meta-analysis data of open surgery of esophageal cancer [13], the results from VTTE reports vs. open TTE meta-analysis data of each points of the operation were as follows: the average blood loss of open TTE is 1001mL, whereas only one VTTE study marked over 1000mL blood loss[6]. The average operative time of the open TTE is 5.0 hrs, whereas 8 VTTE reports out of 11 reports which assessed the operation time show it took more than five hours. It is likely that like other laparoscopic surgery procedures, VTTE may require a longer operation time but incurs a smaller amount of the blood loss. The calculated percentage of in-hospital mortality was 9.2% in open TTE and 2.1% (21/999) in VTTE cases, and hospital stay was 21.0 days in open TTE and within 7-26 days in VTTE cases. These results suggest that the lesser invasiveness of VTTE is beneficial in the short term.

Since there is no randomized control trial which directly compares the long term survival and the operation procedures, long term benefits to the patient are not

directly proven. Although some articles address the long-term benefit of VTTE, only a few describe the detail of the tumor stages and their survival. Luketich et al. reported that survival 40 months after surgery was about 70% for stage I patients, but it was 20% to 30% for stage II and III patients [14]. Nguyen et al. reported 2-year survival of their series as follows: stage I, 100%; stage II, 58%; stage III, 48% and stage IV, 0% [15]. Osugi et al. compared their results to that of open surgery. Their historical comparison revealed that there was no difference in survival between the approaches, even when patients were stratified by the status of the lymphnode metastasis and the T factors [16].

HATS: Hand assisted thoracoscopic surgery (HATS) is an alternative procedure for thoracoscopic surgery [17]. Okushiba and Suzuki combined HATS with hand assisted laparoscopic surgery (HALS) for gastric mobilization and abdominal lymphadenectomy [18, 19]. For the HATS procedure, the assisting surgeon inserts his/her left hand into the thoracic cavity from the abdominal incision through the anterior phreno-mediastial route. Retraction of the lung and trachea are done manually with the hand of the assistant. The advantage of HATS is the gentle

retraction of the lung from the caudal side of the thorax, obviating the need for lung retractors. Furthermore, this procedure allows the surgeon's hand to use its sense of touch within the thoracic cavity, which can confirm if the the tumor has invaded the surrounding organs such as the trachea.

Minimally invasive esophagectomy: Combination of "complete" thoracoscopic and laparoscopic esophagectomy with cervical anastomosis is reported as minimally invasive esophagectomy (MIE) [20, 21]. Nguyen et al. reported their series of MIE[15]. This study favored the role of MIE with shorter operation time, blood loss, and in hospital course. Luketich et al. reported over two hundred cases of MIE [14]. Based on the favorable results of lower mortality rate and shorter hospital stay, they are developing a phase II intergroup study.

Laparoscopic gastric mobilization and gastroplasty: Laparoscopic gastric mobilization was reported by several institutions [22-24]. Bresadola et al. reported that laparoscopic gastroplasty leads to a shorter hospital stay than open gastroplasty in their comparative study [23].

HALS: Hand assisted laparoscopic surgery (HALS) has been shown to be an

effective tool when performing advanced laparoscopic procedures. HALS is a valuable resource when performing complex gastroesophageal operations, including gastrectomy, esophagectomy, and bariatric surgery [25]. Advantages of HALS procedure for the abdominal stage of the operative procedure of thoracic esophageal cancer were reported [18, 19].

Non-thoracotomy esophagectomy

Laparoscopic transhiatal esophagectomy: laparoscopic transhiatal esophagectomy (LTHE) with the cervical incision for esophago-gastro anastomosis is reported by several institutions (Table 3).The concept of LTHE is to avoid blunt dissection by blind maneuver of open transhiatal esophagectomy (THE). The merit of hand-assisted transhiatal esophagectomy is discussed [26, 27]. Bernabe et al. reported their case-control study whose results were that hand-assisted transhiatal esophagectomy leads to shorter operative time, less blood loss, and shorter hospital stay than open transhiatal esophagectomy [26]. By the comparison to the meta-analysis data of open surgery of THE[13], LTHE

reports marked less mortality (2.4%(4/165) vs 5.7%), and shorter hospital stay (6.4 to 17days vs 17.8±10.3days) (Table 3). These results suggest that the purpose of less invasiveness by LTHE is beneficial in the short term.

Mediastinoscope-assisted esophagectomy: Mediastinoscope-assisted esophagectomy (MATHE) is not only a substitute for the blunt dissection of the esophagus. Under the direct vision of mediastinoscopes, structures such as the trachea, both main bronchi, the vagal trunks, the parietal pleura and mediastinal lymph nodes can be clearly identified [3, 28-30]. Through a left cervicotomy, endoscopic dissection of the upper thoracic esophagus is accomplished with a mediastinoscope. For MATHE procedure, special metallic mediastinoscopes equipped with a working channel and a blunt dissecting cap [3, 28, 31, 32] or a commercially available retractor (Subcu-dissector) with transparent flat tip was used as a mediastinoscope [30]. The merit of insufflation of the mediastinal space was proposed by Ikeda et al[33]. They reported that infusion of carbonic dioxide from the cervical trocars up to the pressure of 4 mmHg will obtain the good mediastinal view. The safety and less-invasiveness of MATHE was reported by

several institutions [28, 30, 31]. Tangoku et al. reported their 42 case of thoracic esophageal cancer[30]. The application of their MATHE operation was as follows, superficial esophageal cancer and medical risk factors, mainly pulmonary dysfunction. The operation was performed safely under direct vision, with little morbidity and no mortality. Overall survival rate was 30%, and the cause specific survival was 70.5%. Bumm et al. reported their long-term results of 124 patient of distal esophageal adenocarcinoma who underwent MATHE [34]. Their matched-pairs analysis revealed that overall survival after MATHE is better than after conventional THE in patients with involved lymph nodes.

Laparoscopic Ivor-Lewis esophagectomy: Ivor-Lewis esophagectomy (ILE) is usually applied for lower thoracic esophageal cancer, which is done with right thoracotomy and laparotomy. For the gastrointestinal reconstruction, intrathoracic anastomosis of the remnant esophagus and the gastric tube is performed. Laparoscopic approach for ILE was reported by several institutions [4, 35, 36]. Major difficulty of this procedure is intra thoracic anastomosis, even by mechanical anastomosis or by laparoscopic hand-sawn anastomosis. Robertson

et al. reported that 5 out of 17 cases of laparoscopic ILE required conversion to thoracotomy because of technical difficulties with the anastomosis [36].

Robot-assisted thoracoscopic esophagectomy

Robot-assisted thoracoscopic esophagectomy by using the Da Vinci system were performed by Bodner [37] and van Hillegersberg [38]. They conclude that robot-assisted operations are feasible for effective lymphadenoctomy with low blood loss. Kunisaki et al. used voice-controlled robot, the AESOP system (3000 HR) for the VATS esophagectomy to hold the videoscope[39]. By using this system, stable, close-up, and long-lasting operative view was obtained.

Discussion

There are two approaches to esophageal cancer, Transthoracic esophagectomy (TTE) and Transhiatal esophagectomy (THE). TTE with extensive lymph node dissection is applied as an extensive operation for the esophageal cancer which

is mainly located within higher to middle thoracic esophagus. THE is mainly applied for the lower and abdominal esophagus [40]. Although the literature which compares TTE and THE with randomized study did not prove the statistically significant difference in long term survival of these two operations for thoracic esophageal cancer [41-44], meta-analysis of these two procedures concluded that although TTE has a higher early morbidity in pulmonary dysfunction and mortality rate [13], there was a trend regarding the improvement of the long term survival. If the video assisted approach reduces the morbidity of the TTE, especially the risk of post operative pulmonary dysfunction, it will be beneficial TTE will both reduce the early morbidity and in improve the long-term survival. In conclusion, although the reports from experienced centers indicate that video-assisted esophagectomy is comparable to conventional surgery in terms of intra- and post operative outcomes, in this period, there is no direct proof of the advantage of video-assisted esophagectomy, and this operation requires a high level of technical proficiency the indication of this operation should be well considered. Therefore, there is a need to consider these facts before using this

procedure.

It would be useful to have the advantages of the procedures both in immediate post operative outcomes and follow-up morbido-mortality confirmed by prospective randomized trials.

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Table 1. Laparoscopic surgery for esophageal cancer described

Technique
VATS trans-thoracic esophagectomy (with cervical anastomosis)
Minimally invasive esophagectomy (Combination of “complete” thoracoscopic and laparoscopic esophagectomy)
Hand assisted thoracoscopic surgery
With Laparoscopic gastric mobilization (and gastroplasty)
Robot-assisted thoracoscopic esophagectomy
Laparoscopic transhiatal esophagectomy
Mediastinoscope-assisted transhiatal esophagectomy
Video assisted Ivor-Lewis esophagectomy

Table 2. VATS trans-thoracic esophagectomy

Author	No.	Conversion	Vocal cord paralysis	Anastomotic leakage	Major respiratory complications (reintubation, medication or intervention)	Other major complications (intervention and prolonged hospital stay)	Operating time (thoracic/total)	Blood Loss (thoracic/total)	In hospital mortality	Hospital stay	Lymph node dissection (thoracic/total)
Collard[45]	13	3	NA	NA	2	-	233/NA	NA	1	NA	(21-51)/NA
Azagra[46]	8	0	NA	1	1	-	180/NA	600/NA	0	NA	NA
Cuschieri[5]	26 (6 Prone position)	1	2	1	3	-	NA/330	NA	0	12	NA
Mitchell[6]	8(Prone position)	0	0	0	2	-	150/460	NA/1500	0	15	8.5/NA
McAnena[8]	9	1	3	1	1	Bleeding 1	128/280	NA/>600	0	18	NA/9-26
Gossot[47]	29	5	3	5	5	NA	135/NA	200 / NA	1	15	NA
Akaishi[10]	39	0	7	2	3	chylothorax 1	200/448	270/767	0	NA	19.7/(paragastric 12.5)
Dexter[48]	24(5 Prone position)	2	8	2	13	Cardiovascular 4, PE 1, chylothorax 2, Tracheal necrosis 1.	183/NA	NA	3	18	13//NA
Perachia[49]	18	0	1	2	1	Hemorrhage 2,	114/336	NA/213	1	NA	12/NA
Law[50]	22	4	4	0	4	-	110/240	NA/450	1	NA	7/NA
Kawahara[7]	23	0	5	1	2	Tracheal injury 1, chylothorax 1,	111/NA	163/NA	0	26	29/NA
Smithers[51]	153 (Prone position)	11	NA	6	39	chylothorax 4, hemorrhage 2, PE 1, MI 1, Tracheal necrosis 1	104/299	165/NA	8	14	11/NA
Nguyen[15]	46(VTTE 41, others 5)	1	1	2	3	Tracheal fistula 1, diaphragmatic herniation 1, MI 1, PE 1, hemorrhage 1	116/350	NA /279	2	8	NA/10.3
Osugi[52]	80	0	12	1	13	chylothorax 3,	223/NA	274/NA	0	NA	33.9 /NA
Okushiba[18]	18(HATS)	0	3	NA	3	-	NA /550	NA/550	0	NA	20.1/48.1
Luketich[14]	222(MIE 214, LTHE 8)	16	8	26	21	Gastric tip necrosis 7, chylothorax 7, tracheal tear 2, PE 3, MI 4, pericardial tamponade 1.	NA/NA	NA	3	7	NA
Suzuki[19]	19(HATS)	0	4	1	0	-	NA/476	NA/343	0	10	NA
van Hillegersberg[38]	21(robot-assisted)	3	3	3	10	Thoracheoneoesophageal fistula 1	180/450	400/950	1	18	NA/20

VTTE; VATS right trans-thoracic esophagectomy, HATS; Hand assisted thoracoscopic surgery, MIE; minimally invasive esophagectomy, LTHE; laparoscopic transhiatal esophagectomy, PE; pulmonary embolism.

Table 3. Laparoscopic thanshiatal esophagectomy

Author	No.	Conversion	Vocal cord paralysis	Anastomotic leakage	Major respiratory complications (reintubation, medication or intervention)	Other major complications (intervention and prolonged hospital stay)	Operating time	Blood loss	In hospital mortality	Hospital stay	Lymph node dissection
DePauma[53]	12	1	3	1	3	-	256	(minimal)	0	7.6	NA
Yahata[54]	6	0	0	2	0	-	NA	600	0	NA	NA
Swanstrom[55]	9	0	6	0	0	Subclavian vein thorombosis 1, Ileus 1.	390	290	0	6.4	NA
Van denBroek[56]	25	9	2	2	2	Chylothorax 2 Evisceration 1, Bleeding of jejnum feeding tube 1	300	600	0	16	7
Bonavina[24]	16	3	1	1	0	-	270	NA	0	10	13
Bann[57]	20	2	4	2	5	Hemorrage 1,Cerebrovascular evevt 1	415	300	1	17	5
Avital[58]	22	1	1	1	2	Intra-abdominal abscess 1, Ileus 2	380	220	1	8	14.3
Bernabe[26]	17	0	NA	NA	NA	NA	336	331	0	9.1	8.7
Jobe[59]	20	1	2	4	3	Chylothorax 1	448	175	0	9	NA
Delgado Gomis[60]	24	0	0	2	4	Hemothorax 1.	293.8	566.7	2	11.5	9.85