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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 gastropasty 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 tried⁴. 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 Sear (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 harvested 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 cancer¹³, 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 loss⁶. 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 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 gastropasty: Laparoscopic gastric mobilization was reported by several institutions ²²⁻²⁴. Bresadola et al. reported that laparoscopic gastropasty leads to a shorter hospital stay than open gastropasty 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 surgery²⁵. 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 esophagectomy²⁶. By the comparison to the meta-analysis data of open surgery of THE¹³, LTHE

reports marked less mortality (2.4%(4/165) vs 5.7%), and shorter hospital stay (6.4 to 17days vs 17.8 ± 10.3 days) (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 al³³. 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 cancer³⁰. 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 MATHE³⁴. 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 lymphadenectomy with low blood loss. Kunisaki et al. used voice-controlled robot, the AESOP system (3000 HR) for the VATS esophagectomy to hold the videoscope³⁹. 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 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.

References

1. Cuschieri A, Shimi S, Banting S. Endoscopic oesophagectomy through a right thoracoscopic approach. *J R Coll Surg Edinb* 1992; 37:7-11.
2. Sadanaga N, Kuwano H, Watanabe M, Ikebe M, Mori M, Maekawa S, et al. Laparoscopy-assisted surgery: a new technique for transhiatal esophageal dissection. *Am J Surg* 1994; 168:355-7.
3. Bumm R, Holscher AH, Feussner H, Tachibana M, Bartels H, Siewert JR. Endodissection of the thoracic esophagus. Technique and clinical results in transhiatal esophagectomy. *Ann Surg* 1993; 218:97-104.
4. Liu HP, Chang CH, Lin PJ, Chang JP. Video-assisted endoscopic esophagectomy with stapled intrathoracic esophagogastric anastomosis. *World J Surg* 1995; 19:745-7.
5. Cuschieri A. Thoracoscopic subtotal oesophagectomy. *Endosc Surg Allied Technol* 1994; 2:21-5.
6. Mitchell I, Corless D, Deligiannis E, Wastell C. Thoracoscopic esophagectomy. *Minimally Invasive Surgery* 1994; 3:307-310.
7. Kawahara K, Maekawa T, Okabayashi K, Hideshima T, Shiraishi T, Yoshinaga Y, et al. Video-assisted thoracoscopic esophagectomy for esophageal cancer. *Surg Endosc* 1999; 13:218-23.
8. McAnena OJ, Rogers J, Williams NS. Right thoracoscopically assisted oesophagectomy for cancer. *Br J Surg* 1994; 81:236-8.
9. Gossot D, Fourquier P, Celerier M. Thoracoscopic esophagectomy: technique and initial results. *Ann Thorac Surg* 1993; 56:667-70.
10. Akaishi T, Kaneda I, Higuchi N, Kuriya Y, Kuramoto J, Toyoda T, et al. Thoracoscopic en bloc total esophagectomy with radical mediastinal lymphadenectomy. *J Thorac Cardiovasc Surg* 1996; 112:1533-40; discussion 1540-1.
11. Braghetto I, Csendes A, Cardemil G, Burdiles P, Korn O, Valladares H. Open transthoracic or transhiatal esophagectomy versus minimally invasive esophagectomy in terms of morbidity, mortality and survival. *Surg Endosc* 2006; 20:1681-6.

12. Nguyen NT, Follette DM, Wolfe BM, Schneider PD, Roberts P, Goodnight JE, Jr. Comparison of minimally invasive esophagectomy with transthoracic and transhiatal esophagectomy. *Arch Surg* 2000; 135:920-5.
13. Hulscher JB, Tijssen JG, Obertop H, van Lanschot JJ. Transthoracic versus transhiatal resection for carcinoma of the esophagus: a meta-analysis. *Ann Thorac Surg* 2001; 72:306-13.
14. Luketich JD, Alvelo-Rivera M, Buenaventura PO, Christie NA, McCaughan JS, Litle VR, et al. Minimally invasive esophagectomy: outcomes in 222 patients. *Ann Surg* 2003; 238:486-94; discussion 494-5.
15. Nguyen NT, Roberts P, Follette DM, Rivers R, Wolfe BM. Thoracoscopic and laparoscopic esophagectomy for benign and malignant disease: lessons learned from 46 consecutive procedures. *J Am Coll Surg* 2003; 197:902-13.
16. Osugi H, Takemura M, Lee S, Nishikawa T, Fukuhara K, Iwasaki H, et al. Thoracoscopic esophagectomy for intrathoracic esophageal cancer. *Ann Thorac Cardiovasc Surg* 2005; 11:221-7.
17. Kawano T, Iwai T. Hand-assisted thoracoscopic esophagectomy using a new supportive approach. *Surg Endosc* 2001; 15:330.
18. Okushiba S, Ohno K, Itoh K, Ohkashiwa H, Omi M, Satou K, et al. Hand-assisted endoscopic esophagectomy for esophageal cancer. *Surg Today* 2003; 33:158-61.
19. Suzuki Y, Urashima M, Ishibashi Y, Abo M, Omura N, Nakada K, et al. Hand-assisted laparoscopic and thoracoscopic surgery (HALTS) in radical esophagectomy with three-field lymphadenectomy for thoracic esophageal cancer. *Eur J Surg Oncol* 2005; 31:1166-74.
20. Fernando HC, Christie NA, Luketich JD. Thoracoscopic and laparoscopic esophagectomy. *Semin Thorac Cardiovasc Surg* 2000; 12:195-200.
21. Luketich JD, Schauer PR, Christie NA, Weigel TL, Raja S, Fernando HC, et al. Minimally invasive esophagectomy. *Ann Thorac Surg* 2000; 70:906-11; discussion 911-2.
22. Jagot P, Sauvanet A, Berthouix L, Belghiti J. Laparoscopic mobilization of the stomach for oesophageal replacement. *Br J Surg* 1996; 83:540-2.
23. Bresadola V, Terrosu G, Cojutti A, Benzoni E, Baracchini E, Bresadola F. Laparoscopic versus open gastropasty in esophagectomy for esophageal cancer: a

- comparative study. *Surg Laparosc Endosc Percutan Tech* 2006; 16:63-7.
24. Bonavina L, Bona D, Binyom PR, Peracchia A. A laparoscopy-assisted surgical approach to esophageal carcinoma. *J Surg Res* 2004; 117:52-7.
 25. Glasgow RE, Swanstrom LL. Hand-assisted gastroesophageal surgery. *Semin Laparosc Surg* 2001; 8:135-44.
 26. Bernabe KQ, Bolton JS, Richardson WS. Laparoscopic hand-assisted versus open transhiatal esophagectomy: a case-control study. *Surg Endosc* 2005; 19:334-7.
 27. Gerhart CD. Hand-assisted laparoscopic transhiatal esophagectomy using the dexterity pneumo sleeve. *Jsls* 1998; 2:295-8.
 28. Bonavina L, Incarbone R, Bona D, Peracchia A. Esophagectomy via laparoscopy and transmediastinal endodissection. *J Laparoendosc Adv Surg Tech A* 2004; 14:13-6.
 29. Bumm R, Siewert JR. Results of transmediastinal endoscopic oesophageal dissection. *Endosc Surg Allied Technol* 1994; 2:16-20.
 30. Tangoku A, Yoshino S, Abe T, Hayashi H, Satou T, Ueno T, et al. Mediastinoscope-assisted transhiatal esophagectomy for esophageal cancer. *Surg Endosc* 2004; 18:383-9.
 31. Buess G, Kaiser J, Manncke K, Walter DH, Bessell JR, Becker HD. Endoscopic microsurgical dissection of the esophagus (EMDE). *Int Surg* 1997; 82:109-12.
 32. Manncke K, Raestrup H, Walter D, Buess G, Becker HD. Technique of endoscopic mediastinal dissection of the oesophagus. *Endosc Surg Allied Technol* 1994; 2:10-5.
 33. Ikeda Y, Niimi M, Kan S, Sasaki Y, Shatari T, Takami H, et al. Mediastinoscopic esophagectomy using carbon dioxide insufflation via the neck approach. *Surgery* 2001; 129:504-6.
 34. Bumm R, Feussner H, Bartels H, Stein H, Dittler HJ, Hofler H, et al. Radical transhiatal esophagectomy with two-field lymphadenectomy and endodissection for distal esophageal adenocarcinoma. *World J Surg* 1997; 21:822-31.
 35. Watson DI, Davies N, Jamieson GG. Totally endoscopic Ivor Lewis esophagectomy. *Surg Endosc* 1999; 13:293-7.
 36. Robertson GS, Lloyd DM, Wicks AC, Veitch PS. No obvious advantages for thoracoscopic two-stage oesophagectomy. *Br J Surg* 1996; 83:675-8.
 37. Bodner JC, Zitt M, Ott H, Wetscher GJ, Wykypiel H, Lucciarini P, et al. Robotic-assisted thoracoscopic surgery (RATS) for benign and malignant esophageal

- tumors. *Ann Thorac Surg* 2005; 80:1202-6.
38. van Hillegersberg R, Boone J, Draaisma WA, Broeders IA, Giezenan MJ, Borel Rinkes IH. First experience with robot-assisted thoracoscopic esophagolymphadenectomy for esophageal cancer. *Surg Endosc* 2006; 20:1435-9.
 39. Kunisaki C, Hatori S, Imada T, Akiyama H, Ono H, Otsuka Y, et al. Video-assisted thoracoscopic esophagectomy with a voice-controlled robot: the AESOP system. *Surg Laparosc Endosc Percutan Tech* 2004; 14:323-7.
 40. Orringer MB, Marshall B, Stirling MC. Transhiatal esophagectomy for benign and malignant disease. *J Thorac Cardiovasc Surg* 1993; 105:265-76; discussion 276-7.
 41. Jacobi CA, Zieren HU, Muller JM, Pichlmaier H. Surgical therapy of esophageal carcinoma: the influence of surgical approach and esophageal resection on cardiopulmonary function. *Eur J Cardiothorac Surg* 1997; 11:32-7.
 42. Goldmanc M, Maddern G, Le Prise E, Meunier B, Campion JP, Launois B. Oesophagectomy by a transhiatal approach or thoracotomy: a prospective randomized trial. *Br J Surg* 1993; 80:367-70.
 43. Chu KM, Law SY, Fok M, Wong J. A prospective randomized comparison of transhiatal and transthoracic resection for lower-third esophageal carcinoma. *Am J Surg* 1997; 174:320-4.
 44. Hulscher JB, van Sandick JW, de Boer AG, Wijnhoven BP, Tijssen JG, Fockens P, et al. Extended transthoracic resection compared with limited transhiatal resection for adenocarcinoma of the esophagus. *N Engl J Med* 2002; 347:1662-9.
 45. Collard JM, Lengele B, Otte JB, Kestens PJ. En bloc and standard esophagectomies by thoracoscopy. *Ann Thorac Surg* 1993; 56:675-9.
 46. Azagra JS, Ceuterick M, Goergen M, Jacobs D, Gilbert E, Zaouk G, et al. Thoracoscopy in oesophagectomy for oesophageal cancer. *Br J Surg* 1993; 80:320-1.
 47. Gossot D, Cattani P, Fritsch S, Halimi B, Sarfati E, Celerier M. Can the morbidity of esophagectomy be reduced by the thoracoscopic approach? *Surg Endosc* 1995; 9:1113-5.
 48. Dexter SP, Martin IG, McMahon MJ. Radical thoracoscopic esophagectomy for cancer. *Surg Endosc* 1996; 10:147-51.
 49. Peracchia A, Rosati R, Fumagalli U, Bona S, Chella B. Thoracoscopic esophagectomy: are there benefits? *Semin Surg Oncol* 1997; 13:259-62.

50. Law S, Fok M, Chu KM, Wong J. Thoracoscopic esophagectomy for esophageal cancer. *Surgery* 1997; 122:8-14.
51. Smithers BM, Gotley DC, McEwan D, Martin I, Bessell J, Doyle L. Thoracoscopic mobilization of the esophagus. A 6 year experience. *Surg Endosc* 2001; 15:176-82.
52. Osugi H, Takemura M, Higashino M, Takada N, Lee S, Ueno M, et al. Learning curve of video-assisted thoracoscopic esophagectomy and extensive lymphadenectomy for squamous cell cancer of the thoracic esophagus and results. *Surg Endosc* 2003; 17:515-9.
53. DePaula AL, Hashiba K, Ferreira EA, de Paula RA, Grecco E. Laparoscopic transhiatal esophagectomy with esophagogastroplasty. *Surg Laparosc Endosc* 1995; 5:1-5.
54. Yahata H, Sugino K, Takiguchi T, Yoshioka S, Tanji H, Shinozaki K, et al. Laparoscopic transhiatal esophagectomy for advanced thoracic esophageal cancer. *Surg Laparosc Endosc* 1997; 7:13-6.
55. Swanstrom LL, Hansen P. Laparoscopic total esophagectomy. *Arch Surg* 1997; 132:943-7; discussion 947-9.
56. Van den Broek WT, Makay O, Berends FJ, Yuan JZ, Houdijk AP, Meijer S, et al. Laparoscopically assisted transhiatal resection for malignancies of the distal esophagus. *Surg Endosc* 2004; 18:812-7.
57. Bann S, Moorthy K, Shaul T, Foley R. Laparoscopic transhiatal surgery of the esophagus. *Jsls* 2005; 9:376-81.
58. Avital S, Zundel N, Szomstein S, Rosenthal R. Laparoscopic transhiatal esophagectomy for esophageal cancer. *Am J Surg* 2005; 190:69-74.
59. Jobe BA, Kim CY, Minjarez RC, O'Rourke R, Chang EY, Hunter JG. Simplifying minimally invasive transhiatal esophagectomy with the inversion approach: Lessons learned from the first 20 cases. *Arch Surg* 2006; 141:857-65; discussion 865-6.
60. Delgado Gomis F, Gomez Abril SA, Martinez Abad M, Guallar Rovira JM. Assisted laparoscopic transhiatal esophagectomy for the treatment of esophageal cancer. *Clin Transl Oncol* 2006; 8:185-92.

Table 1. Laparoscopic surgery for esophageal cancer described

<i>Technique</i>
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 gastropasty)
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
Akaiishi ¹⁰	39	0	7	2	3	chylothorax 1	200/448	270/767	0	NA	19.7/(para gastric 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
Peracchia 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 (VT TE 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/43	0	10	NA
van Hillegersberg ³⁸	21 (robot-assisted)	3	3	3	10	Thoracheoneo esophageal 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 transhiatal 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
DePau 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 thrombosis 1, Ileus 1.	390	290	0	6.4	NA
Van denBroek ⁵⁶	25	9	2	2	2	Chylothorax 2 Evisceration 1, Bleeding of jejunum 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	Hemorrhage 1, Cerebrovascular event 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

