Technique

Surgical Endoscopy
Ultrasound and
Interventional Techniques

Surg Endosc (1999) 13: 293–297

Totally endoscopic Ivor Lewis esophagectomy

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Received: 17 December 1997/Accepted: 18 March 1998

Abstract. Esophagectomy is associated with significant risks of perioperative morbidity and mortality, as well as prolonged convalescence due to effects of the incisions used for conventional surgical access. Because the outcome of this procedure is palliative in the majority of patients, it is possible that laparoscopic techniques could improve initial postoperative outcomes and therefore make surgery more acceptable for patients with esophageal cancer. A new technique is described for Ivor Lewis esophagectomy, which incorporates a hand-assisted laparoscopic approach for gastric mobilization and a thoracoscopic approach for esophageal dissection and anastomosis. Initial experience in two patients has been encouraging, with postoperative hospital stay and convalescence shortened.

Key words: Oesophagectomy — Esophagus — Carcinoma — Surgery — Laparoscopy — Thoracoscopy

Esophagectomy performed by any of the traditional open approaches is associated with significant postoperative respiratory morbidity and a 30-day mortality rate between 5 and 10% [1, 3, 11, 23]. This makes the procedure unsuitable for high-risk patients and those with advanced disease, despite resection that effectively palliates dysphagia, offering the best hope of long-term survival.

With the recent interest in laparoscopic and thoracoscopic surgical techniques, attempts have been made to reduce the morbidity associated with esophagectomy by applying alternative methods for esophageal dissection that avoid an open thoracotomy incision [6, 7, 9, 10, 15, 20]. However, most of these approaches have been limited to thoracoscopic or endoscopic mobilization of the esophagus in combination with the conventional abdominal and cervical approach to the esophagus. This has not achieved a significant reduction in the respiratory morbidity associated with esophagectomy [12, 19, 21]. Early reports of laparoscopic gastric mobilization combined with transhiatal or thoracoscopic mobilization and cervical anastomosis suggest that the use of totally laparoscopic techniques may achieve a better outcome [8, 9]. However, laparoscopic gastric mobilization is time consuming due to the limitations of laparoscopic instrumentation [8, 13].

Our preferred procedure for esophageal carcinoma involving the middle or lower thirds of the esophagus has been an Ivor Lewis oesophagectomy performed through an upper midline abdominal incision and a right anterolateral thoracotomy incision by two surgical teams working synchronously. The routine use of an open cervicoabdominal approach without thoracotomy has not reduced postoperative respiratory morbidity or improved outcomes in our experience. For this reason, when commencing endoscopic esophagectomy, we sought to replicate the procedure that we normally performed at open surgery. The recent availability of several new devices for laparoscopic surgery has now enabled a totally endoscopic Ivor Lewis esophagectomy, with a hand-sewn intrathoracic anastomosis, to be performed in a time frame similar to that of the comparable open procedure.

Methods

The endoscopic Ivor Lewis esophagectomy begins with induction of general anesthesia and placement of a double-lumen endotracheal tube to enable single-lung ventilation during the thoracoscopic phase if required. The patient is then positioned in the reverse Trendelenburg position, with the table titled 20° to 30° head up and the legs extended in stirrups, with minimal hip flexion. This enables the surgeon to stand between the patient's legs for the initial abdominal phase of the operation. An assistant stands on the patient's left, and the scrub nurse on the right. A single video monitor is placed at the head end of the operating table adjacent to the patient's right shoulder.

Gastric mobilization

The procedure commences laparoscopically with gastric mobilization, creation of a gastric tube, and dissection of the lower third of the esophagus achieved transabdominally before the patent is repositioned for the thoracoscopic portion of the operation. A 12-mm trocar (port A, Fig. 1) is placed initially through a periumbilical incision, and the abdomen is insufflated to a pressure of 12 mmHg. A 45° laparoscope is used for the abdominal phase

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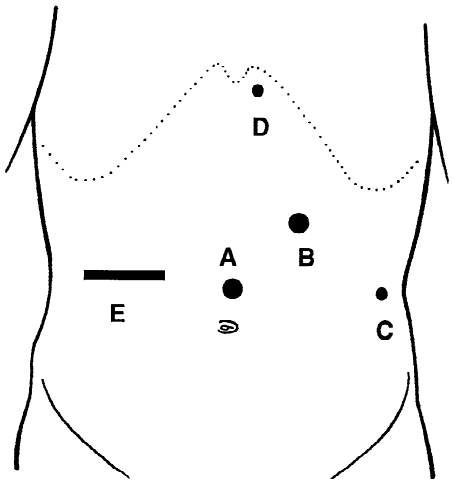

Fig. 1. Port placement for laparoscopic hand-assisted gastric mobilization. **A** 12 mm, **B** 12 mm, **C** 5 mm, and **D** liver retractor, **E** Dexterity™ Pneumo Sleeve.

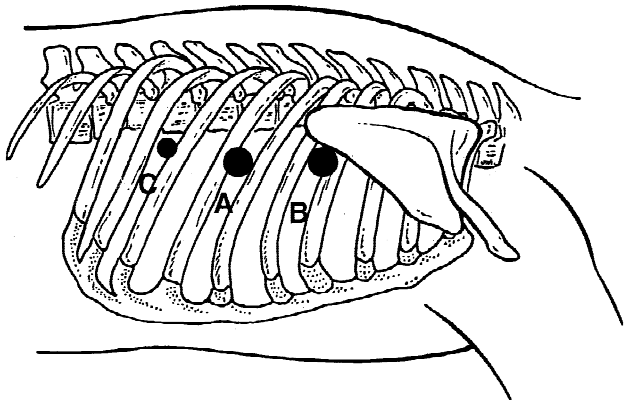

Fig. 2. Port placement for thoracoscopic stage of esophagectomy. **A** 12 mm, **B** 12 mm, and **C** 5 mm.

of the procedure. Further trocars are placed under laparoscopic vision. A 12-mm trocar (B) is placed below the left costal margin in the midclavicular line. A 5-mm trocar (C) is placed in the left flank, and a 5-mm incision (D) is made in the epigastrium for the placement of a large Nathanson liver retractor (Cook Medical Technology, Eight Mile Plains, Queensland, Australia).

A 7- to 8-cm-long transverse incision is made next approximately 3 to 5 cm above the level of the umbilicus and centered over the right midclavicular line. This is deepened through all layers of the abdominal wall to allow the placement of a Dexterity™ Pneumo Sleeve (Pilling-Weck USA, Research Triangle Park, NC). This allows the repeated introduction of the surgeon's left hand into the peritoneal cavity without the loss of pneumoperitoneum and laparoscopic exposure. The assistant manipulates the laparoscope and assists with a grasping instrument placed through the left flank port (C), while the surgeon uses his left hand for manipulation and dissection, and to manipulate laparoscopic instruments through either of the 12-mm ports (A and B). The use of the left hand greatly facilitates the initial abdominal dissection phase, simplifying the surgeon's ability to preserve the gastroepiploic arcade, create a gastric tube, and dissect the distal esophagus from below. The muscle-splitting incision is used at the completion of the procedure for specimen retrieval.

Gastric mobilization begins with dissection along the greater curvature of the stomach. The entire length of the greater curvature is dissected from distal to proximal, while preserving the right gastroepiploic artery and the gastroepiploic arcade. This is achieved using ultrasonically activated coagulating shears (LCS™, UltraCision Inc., Smithfield, Rhode Island, USA), which use rapid vibration energy to cut and coagulate vessels and tissue, eliminating the need for metal clips for small vessels. The short gastric vessels also are divided with the ultrasonic shears, and dissection is extended to the hiatus. Identification and preservation of the gastric blood supply is facilitated by manipulation of the stomach with the left hand and palpation of arterial pulsations if the omentum is fatty.

The lesser omentum is then opened and divided away from the lesser curvature of the stomach in its avascular portion. The hepatic branch of the vagus nerve is divided. The hiatus is dissected, fully mobilizing the gastroesophageal junction and the distal esophagus. At this stage the only remaining structure attached to the stomach is that of the left gastric vessels. The adventitial and nodal tissue surrounding these is dissected, and the vessels are divided close to the origin of the left gastric artery with a single application of an endoscopic linear cutting-stapling device (Ethicon or AutoSuture). This cuts and secures the vascular pedicle with a triple row of staples.

The first, second and proximal third parts of the duodenum are easily mobilized using a combination of division of the duodenum peritoneal attachments with the ultrasonic shears and digital dissection to lift the duodenum and pancreatic head forward and to the left. This mobilization is continued until the pylorus can be easily mobilized up to the esophageal hiatus. The pylorus is not routinely disrupted by a pyloroplasty or pyloromyotomy, although this could by performed if necessary.

Dissection of the lower third of the esophagus is performed next. This is facilitated by widening the esophageal hiatus (if necessary) by dividing the muscle of the right hiatal pillar between the ultrasonic shears. The distal esophagus, and usually the oesophageal tumor, can be mobilized as far as possible under vision, while exposure and dissection is facilitated and guided by the surgeon's left hand. Blind digital dissection is not performed because esophageal dissection under vision will be completed thoracoscopically.

Finally, a gastric tube is fashioned using multiple applications of an endoscopic linear cutting-stapling device (Ethicon or AutoSuture), commencing at the lesser curvature. The most proximal application of the stapler, which completes the division of the gastric tube from the pathologic specimen, is withheld for completion during the thoracoscopic phase. Without leaving a small portion intact, it would be more difficult to pull the gastric tube into the chest during this latter phase. Selection of the extent to which the stomach is tubularized or left largely intact is determined by the location of the tumor, its histologic type, and whether lesser curvature lymph nodes are macroscopically involved with tumor or not. The abdominal wounds are then covered by a sterile occlusive dressing before repositioning the patient for the next stage of the procedure.

Esophageal mobilization and anastomosis

The patient is repositioned in the prone position for the thoracoscopic portion of the procedure. This position places the esophagus uppermost in the pleural cavity and enables the right lung to fall away from it, eliminating the need for additional instruments for lung retraction. Three trocars (two 11 mm, one 5 mm) are placed through the fifth, seventh, and ninth intercostal spaces in the posterior axillary line, using a blunt dissection technique (Fig. 2). Access to the posterior mediastinum is achieved either by collapsing the right lung in association with a gasless laparoscopic exposure technique or by insufflating the right thoracic cavity at a pressure of 5 mmHg. Insufflation is preferred if unilateral lung collapse is not well tolerated by the patient.

Esophageal mobilization is completed with the aid of the ultrasonic shears. This is assisted by placing a tape around the esophagus at an early stage, facilitating manipulation and exposure of the thoracic esophagus. Dissection is continued to an appropriate level at least 10 cm above the proximal visible extent of the tumor. The azygos vein can be divided with an endoscopic stapling device, or it can be ligated and transfixed with laparoscopic sutures. The esophagus is then divided using the ultrasonic shears, which at times will weld the mucosal and muscle layers of the esophageal wall together to facilitate subsequent suturing of the anastomosis. The distal esophagus is then used to pull the gastric tube fully into the chest, while care is taken not to rotate and twist the tube. Division of the tube from the specimen is completed by a single application of the endoscopic stapling instrument, and the specimen is placed elsewhere in the right hemithorax while the esophagus is anastomosed to the gastric tube.

An end-to-side thoracoscopic handsewn anastomosis between the upper esophagus and gastric tube is fashioned, using a single layer of interrupted 2/0 Novafil sutures. The posterior layer is placed initially by suturing the gastric wall with seromuscular sutures to the full thickness of the

posterior wall of the open esophagus. The gastric wall is then opened at a point adjacent to the suture line, and the anastomosis is completed by suturing the full thickness of both stomach and esophagus anteriorly. A nasogastric tube is guided across the anastomosis before its completion. The integrity of the join is checked by instilling water through the nasogastric tube and looking for leakage intraoperatively.

The resection specimen is then pushed back through the esophageal hiatus into the abdomen for subsequent retrieval. Two drains are placed in the chest through the port wounds, a large underwater seal drain to the apex of the right hemithorax, and either a further underwater seal drain or a low-pressure suction drain to the area of the anastomosis. The remaining port is removed and the skin closed.

Specimen retrieval and jejunostomy

The patient is then repositioned in the supine position, and the specimen is retrieved through the right-sided muscle-splitting incision. Reinflation of the abdomen is not necessary for this. The alternative to this step is removal of the resection specimen through the chest wall. However, this requires a small thoracotomy incision, which can be avoided by the technique described. A feeding jejunostomy for early postoperative nutrition is also fashioned at this stage by placing a 14 Fr T-tube in the proximal jejunum approximately 20 cm distal to the duodenojejunal flexure. This tube is pulled through either the periumbilical or left upper quadrant port wound, and secured. The muscle-splitting incision is closed in two layers and the skin sutured.

Postoperative care

The patient is extubated immediately after surgery and managed initially in the high dependency unit, if feasible. Pain relief is provided by a patient-controlled analgesia machine administering morphine. The apical drain is removed on the second postoperative day. Jejunostomy feeding begins on the first or second postoperative day, and a barium swallow examination is performed on the fifth postoperative day to check anastomotic integrity. If this check demonstrates no leakage, the nasogastric tube and anastomotic drain are removed, and oral intake is begun. Discharge is allowed once the patient is ambulant and maintaining an adequate oral intake. The jejunostomy tube is removed 2 weeks later at the first postoperative visit.

Results

Two patients, ages 74 and 56 years, and weighing 63 and 92 kg, respectively, underwent a laparoscopic Ivor-Lewis esophagectomy using this technique. Both presented with dysphagia due to poorly differential adenocarcinomas involving the distal esophagus and the gastroesophageal junction. The tumor in the first patient was approximately 3 cm long and not adherent to any surrounding structures. In the second patient, a palliative procedure was performed because the tumor, 8 cm long, invaded the diaphragmatic hiatus posteriorly and extended along the left gastric artery to its origin from the celiac axis. Only patients with tumors involving the lower third of the esophagus, who were otherwise fit for a conventional esophagectomy, were initially selected for this procedure. During the same time, two other patients underwent a conventional Ivor Lewis esophagectomy due to a lack of necessary equipment or skilled assistance, and two additional patients underwent a laparoscopic gastric mobilization, thoracoscopic esophageal dissection, and cervical anastomosis for carcinomas of the upper third of the esophagus.

Total operating time was 210 and 300 min, respectively (including the time required for changing each patient's position), with the abdominal component requiring 90 and 120 min. Position changes required approximately 15 min each (i.e., 30 min per case). Blood loss was estimated to be 50 and 300 ml respectively, and transfusion was not required for bleeding in either case. Seventeen interrupted sutures were required to construct the anastomosis for each patient.

Postoperatively, both patients recovered uneventfully. Neither required assisted ventilation or management in the intensive care unit, and respiratory complications were not seen. Postoperative discomfort was minimal and easily controlled by the administration of morphine. Both patients began oral intake on the sixth postoperative day, were discharged at day 10, and returned to full physical activity within 4 weeks of surgery. At follow-up of 4 and 7 months, both patients are well.

Discussion

Despite improvements in postoperative management due largely to advances in intensive care services, conventional approaches to surgery for esophageal cancer continue to be associated with a significant risk of postoperative morbidity and mortality [1, 3, 11, 23]. Reported 30-day mortality rates after esophagectomy range from 5 to 10%, and in-hospital mortality is generally higher [1, 3, 11, 23]. Respiratory complications are common due to the effect of the wounds used for open surgical access. Postoperative thoracic epidural analgesia may assist during the first few days after surgery, although convalescence after thoracotomy is usually prolonged. The use open transhiatal dissection, which avoids thoracotomy, has not been clearly demonstrated to reduce the risk of postoperative respiratory complications or to reduce postoperative mortality.

Surgery remains the best overall treatment for esophageal cancer, offering the opportunity of long-term survival to some patients and excellent palliation of dysphagia to many others who may not be cured. However, the access-related morbidity usually results in a prolonged postoperative convalescence, which can limit physical activity for a prolonged period.

A variety of laparoscopic, thoracoscopic, and mediastinoscopic techniques for esophagectomy have been described recently [5, 6, 8, 9, 13, 15, 20]. All propose to reduce postoperative morbidity and speed convalescence. Many surgeons have adopted a technique that involves thoracoscopic esophageal mobilization [6, 10, 20] or the alternative mediastinoscopic mobilization technique described by Buess [5, 14]. These procedures are combined with an upper midline laparotomy incision for gastric mobilization and a cervical incision to enable a conventional open esophageal anastomosis in the neck. However, initial studies of these techniques have not consistently demonstrated a significant reduction in postoperative morbidity [12, 19, 21]. This may be due to the postoperative respiratory impairment associated with the use of an open upper abdominal incision, as well as the greater incidence of anastomotic leakage and recurrent laryngeal nerve palsy associated with open cervical approaches.

Jagot [13], DePaula [9], Swanstrom [22], and Dallemagne [8] all have previously described laparoscopic approaches to gastric mobilization for esophagectomy. Jagot

[13] combined laparoscopic gastric mobilization with either an open approach to the thoracic portion of an esophagectomy, using a conventional right thoracotomy incision, or a transhiatal laparoscopic esophageal dissection and anastomosis in the neck. Dallemagne [8] described a single case of laparoscopic gastric mobilization combined with thoracoscopic esophageal mobilization and conventional cervical anastomosis. This approach required 9½ hours of operating time, and the patient was discharged on the ninth postoperative day.

De Paula [9] described an experience with 12 patients who underwent laparoscopic gastric mobilization combined with laparoscopic transhiatal esophageal dissection and an open cervical approach. No thoracotomy or thoracoscopy was used for this technique. Operating time averaged 256 min, and morbidity was acceptable. All three groups used totally laparoscopic techniques to achieve gastric mobilization. Metal laparoscopic clips were used to control the gastric vessels. Swanstrom [22] described an approach similar to that of DePaula, with 9 patients undergoing a laparoscopic esophagectomy. Average operating time was 6½ hours, and postoperative stay ranged from 4 to 9 days. Overall results for this procedure were promising.

Whereas morbidity remains significant after thoracoscopic approaches combined with laparotomy, it is possible that the avoidance of both a laparotomy and thoracotomy may reduce postoperative morbidity and speed convalescence. Laparoscopic gastric mobilization combined with an intrathoracic anastomosis has been described previously only in animal studies [2, 16], with the anastomosis performed by the use of stapling techniques in both studies. A thoracoscopic stapled anastomosis for clinical surgery was described by Lloyd et al. [15], although this was used after open gastric mobilization. This article details for the first time a totally laparoscopic and thoracoscopic technique for esophagectomy with an intrathoracic handsewn anastomosis.

The application of laparoscopic techniques to abdominal malignancy is controversial. An increasing body of experimental evidence now suggests that the risk of wound metastases may be increased three- to fourfold after the use of carbon dioxide insufflation [4, 17, 18]. This may represent a significant problem for the application of laparoscopic techniques to colorectal malignancy, especially as the majority of patients undergoing open colectomy will have curable disease, and the postoperative mortality after surgery is low. Esophageal cancer, however, may be different. If it is assumed that the incidence of wound metastasis after open esophagectomy is 1%, and that the experimental studies investigating laparoscopy-associated wound metastases demonstrate a three- to fourfold increase in this rate, it is possible that 2 to 3% of patients undergoing laparoscopic esophagectomy could be disadvantaged by the development of metastases in their wounds. However, if postoperative mortality can be reduced by 2 to 3% due to reduced perioperative morbidity, then this offset would be acceptable. These possibilities are speculative and must await confirmation from further clinical experience.

The technique described in this article offers a simplification of laparoscopic techniques for oesophagectomy. It replicates our preferred approach at open surgery (i.e., an Ivor Lewis oesophagectomy). The radicality of the laparoscopic procedure described is similar to that usually performed by open techniques in our department. The use of the ultrasonic shears in combination with the Dexterity Sleeve enables gastric mobilization to be performed quickly and with relative ease. The use of hand assistance greatly facilitates abdominal dissection, and it remains necessary to make a small incision in any case for tumor retrieval. Blood loss is minimal, and operating times for the gastric mobilization component of esophagectomy are quicker than for conventional open surgery. It is also possible to extend the laparoscopic dissection into the thorax so that the lower third of the esophagus is dissected with hand assistance before the thoracoscopic component of the operation is begun.

Thoracoscopic mobilization with the patient in a prone position has been described previously [7]. In this position the lung falls away from the operative field and does not require retraction, and two-lung ventilation in combination with low-pressure insufflation can be used if necessary. A handsewn anastomosis is our preferred technique at open surgery. We have found a handsewn thoracoscopic anastomosis to be feasible, and not too time consuming. The alternative for a stapled thoracic anastomosis is difficult to achieve using a laparoscopic transhiatal technique. Overall operating time for the approach described was approximately 1 hour longer than for our usual open approach, which entails two surgical teams working synchronously.

An earlier attempt to perform a synchronous thoracoscopic and laparoscopic approach with the patient in the supine position proved difficult due to difficulties with lung retraction for the thoracoscopic surgical team, and a sequential approach as described ensures that exposure in the thorax is not compromised. The improved exposure achieved by prone positioning during the thoracoscopic stage more than compensates for the time required to reposition the patient during the procedure. The endoscopic Ivor Lewis procedure is appropriate only for the resection of tumors in the lower two-thirds of the esophagus, and may be best suited to tumors of the lower third or the gastroesophageal junction, where it is more difficult to create a long gastric tube that can reach to the neck for cervical anastomosis.

It is important to remember when considering esophagectomy that the majority of patients will not be cured by surgery, and 50% of patients will die from either their disease or their surgery within 12 months of surgery. This totally laparoscopic approach may significantly reduce the length of convalescence after surgery. For a procedure that is usually palliative, the improved quality of life during the first few months after surgery may be very important. Whether endoscopic esophagectomy will lead to an overall change in the surgical approach to esophagectomy for cancer is a prediction that awaits further clinical experience.

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