Minimally Invasive McKeown Esophagectomy

Yehonatan Nevo and Lorenzo Ferri

Abstract

Minimally invasive McKeown esophagectomy (MIE) has several potential benefits over the open approach, including: reduced post-operative pain, lower rates of pulmonary complications, and faster recovery with shorter length of stay. MIE also results in less blood loss, reducing the need for blood transfusions. MIE is a demanding procedure but with the right training and proctoring can be safely adopted into practice without compromising the surgical or oncological quality.

Keywords

Esophagectomy · Minimally-invasive · Three-hole · Thoracoscopic · Laparoscopic · Lymphadenectomy

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Introduction

Minimally invasive McKeown esophagectomy (MIE) has several potential benefits over the open approach, including: reduced post-operative pain, lower rates of pulmonary complications, and faster recovery with shorter length of stay. MIE also results in less blood loss, reducing the need for blood transfusions. MIE is a demanding procedure but with the right training and proctoring can be safely adopted into practice without compromising the surgical or oncological quality [1–11].

Preoperative Considerations

- *Pain Management*: We routinely use thoracic epidural catheter, although paravertebral analgesia has recently emerged as a safe alternative while avoiding the thoracic epidural associated-side effects including hypotension. Intercostal (IC) nerve blocks using long-acting liposomal local anesthetics is another alternative to epidurals in minimally invasive thoracic surgery patients, though it's efficacy in MIE is yet to be proven.
- *Single-lung ventilation*: Excellent single-lung ventilation is vital to maintain good exposure during thoracoscopy. Although positive pressure capnothorax especially in the prone position, can obviate the need for

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a double lumen tube, our preference is for single-lung ventilation. Because of the short right mainstem bronchus, we prefer a double-lumen tube rather than a right sided bronchial blocker for lung isolation.

- *EGD with endoscopic pyloromyotomy*: An on-table esophagogastroduodenoscopy (EGD) is routinely performed to verify the lesion and confirm its location prior to beginning the procedure. Particular attention is devoted to the extent of involvement in the lesser and greater curvatures, which may alter the conduit. Endoscopic pyloromyotomy is done using an ITknife2™ (model KD-611L, Olympus) with cutting the pyloric mucosa and muscularis propria in three different areas, ensuring that the lip of tissue between the duodenal bulb and pre-pyloric antrum is completely eliminated and the pyloric channel is completely open (Fig. 1). We have previously demonstrated the utility and effectiveness of this novel technique of pyloric drainage.
- *Enhanced Recovery Pathway*: Establishing and following an enhanced recovery pathway (ERP) provides standardized and evidence-based perioperative management for the esophagectomy patient. We have shown that ERPs are cost-effective, with decreased complications and shortened postoperative length of stay. Key elements of the pathway include extubation immediately after the operation, avoidance of routine ICU care, early removal, or complete avoidance of the nasogastric (NG) tube, early oral feeding, and diligent chest physiotherapy with frequent ambulation. Prehabilitaiton is an important element of ERP's. Preoperative conditioning intervention including exercise, nutrition, and physcological prehabilitation help prevent functional impairment before and after surgery, as well as improve quality of life. Patients receive teaching from a nurse-educator at the pre-operative clinic, and are provided with a comprehensive information booklet that reviews all procedures in an easy-to-understand language with illustrations.

Operative Technique

Thoracoscopy

After completion of intraoperative EGD including endoscopic pyloromyotomy, the patient is positioned in the hybrid left lateral-prone position (Fig. 2). Patients are placed in the left semi-prone position, and the operating table is then rotated to create the left lateral decubitus position. The left leg (lower leg) is flexed gently at the knee and the upper leg remains in extension, with adequate padding between the legs. The arms are well padded and supported on arm boards. A vacuumed beanbag is used to secure the patient, in addition to the use of tape or Velcro.

We employ a four-port thoracoscopy using 12 mm trocars (Fig. 3). Our trocar placements are the following:

1. Third intercostal space, anterior axillary line
2. Fifth intercostal space, posterior axillary line

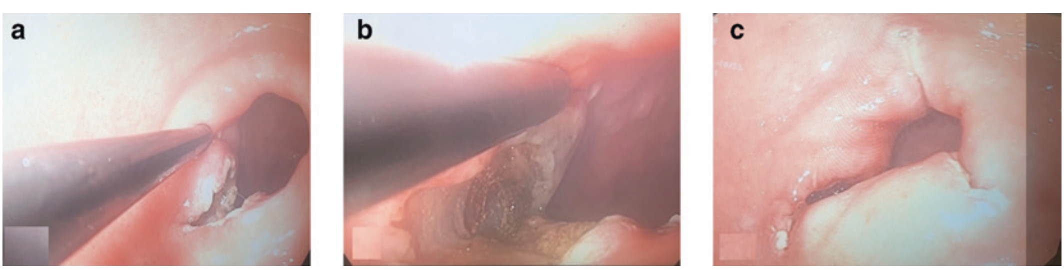

Fig. 1 **a** The endoscopic Myotomy is performed by using ITknife **b** The muscularis propria is adequately cut and the pyloric channel is completely open **c** Pyloromyotomy in three different areas

Fig. 2 Hybrid left lateral-prone positioning for thoracoscopy

Fig. 3 Thoracoscopy trocar placement

3. Seventh intercostal spaces mid axillary line
4. Ninth intercostal spaces posterior axillary line.

The first port is inserted using an optical trocar and artificial pneumothorax is achieved using carbon dioxide at a pressure of 8–10 mmHg to collapse the right lung and expand the mediastinum. The subcarinal dissection is performed by initially rotating the table to almost prone position. The azygous vein is circumferentially dissected and divided with a linear stapler device and the pleura is divided anteriorly and posteriorly along the length of the esophagus with hook cautery. The mobilization of the thoracic esophagus is performed from the thoracic inlet to the diaphragm, and subcarinal mediastinal lymph node dissection is completed (Fig. 4). Further dissection is completed with a harmonic scalpel, and a Penrose drain is used to encircle the esophagus to provide countertraction. The thoracic duct is clipped behind the lower esophagus and resected together with the esophagus.

Dissection with energy devices near the trachea is performed with great care, as inadvertent injury may result in airway fistulization. The supracarinal dissection is performed by placing the patient in the left lateral decubitus position. The pleura is incised along the posterior edge of the esophagus up to the right subclavian vein. The dorsal and left sides of the upper esophagus are dissected along with the thoracic duct. Dissection along the left and right recurrent laryngeal nerve (RLN) is then performed. The anterior part of the upper esophagus is dissected from the trachea, and the upper esophagus is circumferentially dissected along with the surrounding nodes. The thoracic duct is clipped at the level of the arch of the aorta.

Once the esophagus is fully mobilized from the thoracic inlet to the diaphragm, with all nodal tissue swept into the specimen, it is divided at a level proximal to the tumor, usually cephalad to the azygous vein, consequently also dividing the vagus below the bifurcation of the recurrent laryngeal nerves with electrocautry. The proximal and distal margins are secured to a common umbilical tape to facilitate retrieval via the neck and laparoscopy. The chest is copiously irrigated and a large-capacity 19-French closed suction Jackson-Pratt (JP) drain is inserted in lieu of a chest tube (Fig. 5) The trocar sites are closed in layers, and the double-lumen endotracheal tube is exchanged for a single-lumen tube to enhance mobility of the airway during the cervical portion of the operation.

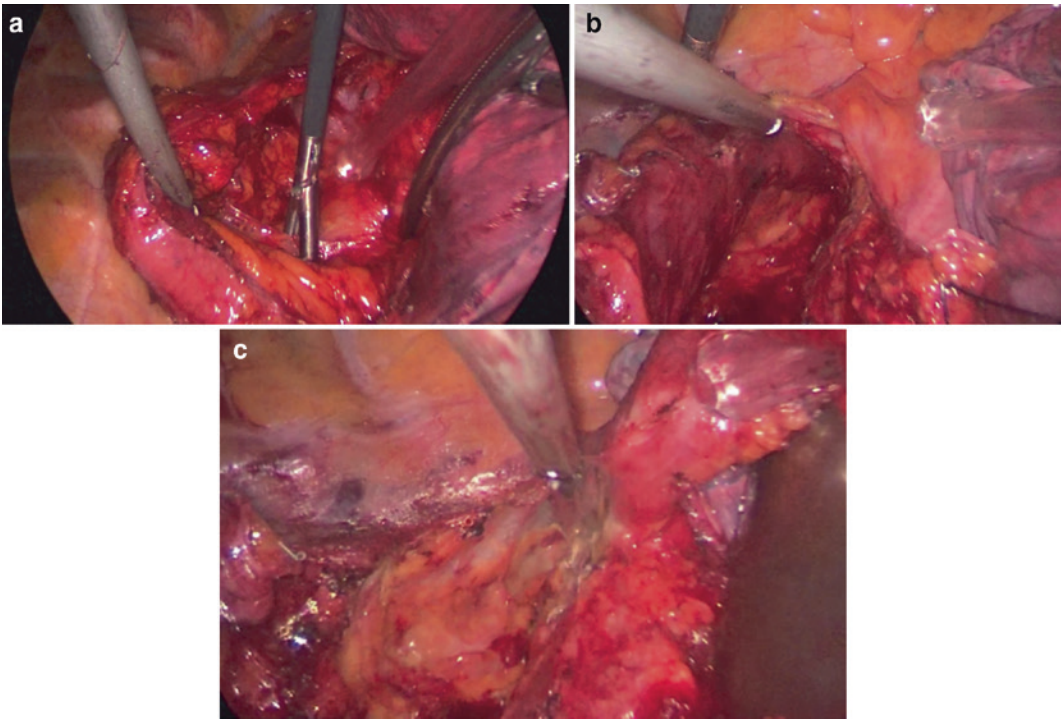

Fig. 4 **a** Esophageal mobilization **b**, **c** Subcarinal dissection

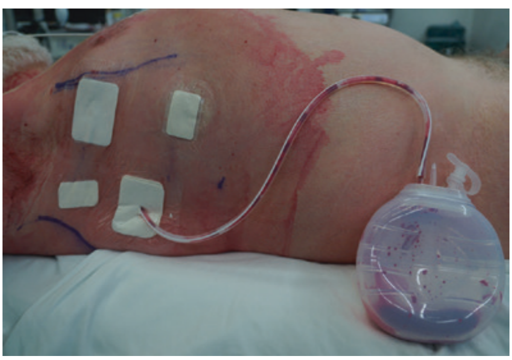

Fig. 5 Use of large-capacity Jackson-Pratt drains in lieu of chest tubes

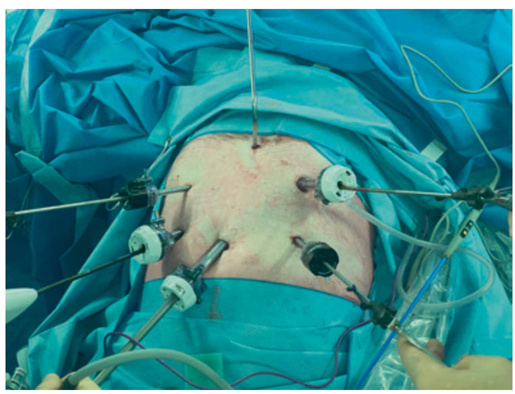

Fig. 6 Laparoscopy trocar placement

Laparoscopy

The patient is repositioned in the supine, split-leg position for laparoscopy. The neck is extended, with a roll placed between the scapula. A five-port laparoscopy is employed (Fig. 6). A 12-mm optiview port is placed in the left upper quadrant mid-clavicular line, a 12-mm port is placed supraumbilically for the camera, a 5-mm port on the left, mid-point between the umbilical and left upper quadrant ports, for operating instruments, a 5-mm incision in the epigastrium for the Nathanson liver retractor, and a 5-mm operating port in the right upper quadrant at the midclavicular line and a 12-mm port on the right, mid-point between the umbilical and the right upper quadrant ports for operating instruments. A 10-mm, 30° camera is employed.

The gastrohepatic omentum is opened and the right and left crura are circumferentially dissected without complete division of the phrenoesophageal membrane, in order to preserve pneumoperitoneum.

We perform a complete D2 celiac lymph node dissection by skeletonizing the splenic artery, the hepatic artery, and the splenic vein (Fig. 7). The left gastric pedicle is dissected, skeletonized, clipped, and divided. We do not staple the left gastric pedicle, as it may provide an inadequate lymph node dissection. All lymph node–bearing tissue is included with the specimen (Fig. 8). We proceed along the entire celiac axis down to the aorta to include the periceliac lymph nodes en bloc with the specimen.

The greater curve is dissected after creation of a window in the gastrocolic omentum, and the lesser sac is entered. Dissection proceeds 5 cm from the greater curvature, with extreme caution taken to preserve the gastroepiploic arcade, the dependent blood supply to the future conduit (Fig. 9). The retrogastric attachments are freed and dissection is carried up to the left esophageal hiatus. A Kocher maneuver is completed, with adequate mobilization of the pylorus ensured by testing its extension to the caudate lobe or right crus. After ensuring satisfactory hemostasis, the esophageal hiatus is completely mobilized and the phrenoesophageal membrane is divided.

An accessory incision 5 cm in length is constructed in the upper midline, with insertion of a wound protector (Fig. 10). A 4-cm gastric conduit is fashioned with sequential firings of the GIA™ stapler (generally three firings) and oversewing of the staple line (Fig. 11). Extracorporeal construction is a useful adjunct in the creation of an excellent conduit and greatly facilitates assessment and revision of the distal margin, should this be necessary.

Cervical Phase

A 4- to 5-cm cervical collar incision is made, the platysma is incised, and subplatysmal planes are generated. The omohyoid muscle and middle thyroid vein are divided for optimal exposure.

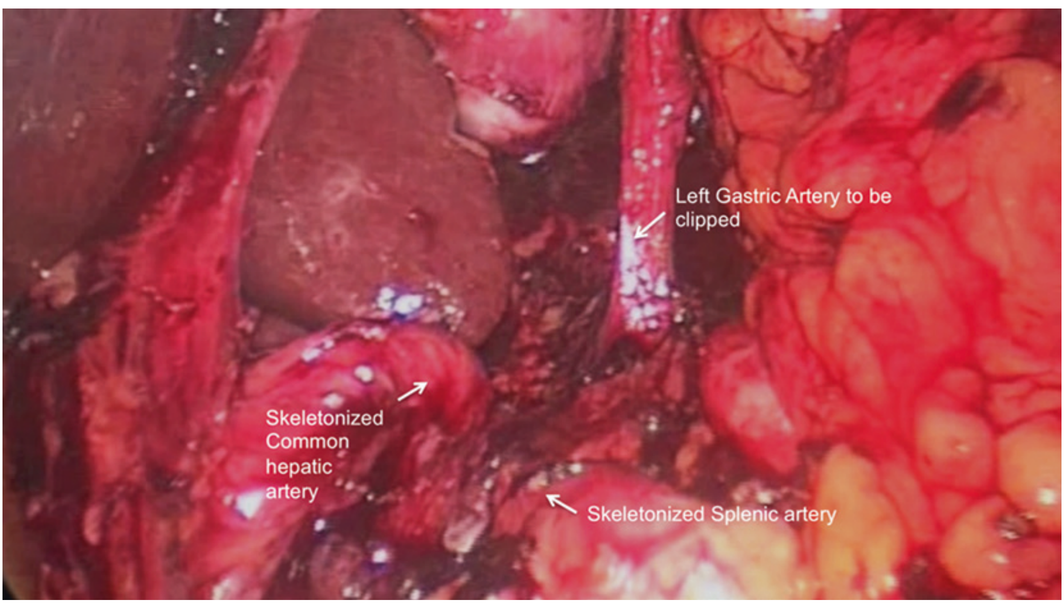

Fig. 7 D2 dissection and dissection of the left gastric pedicle to be divided

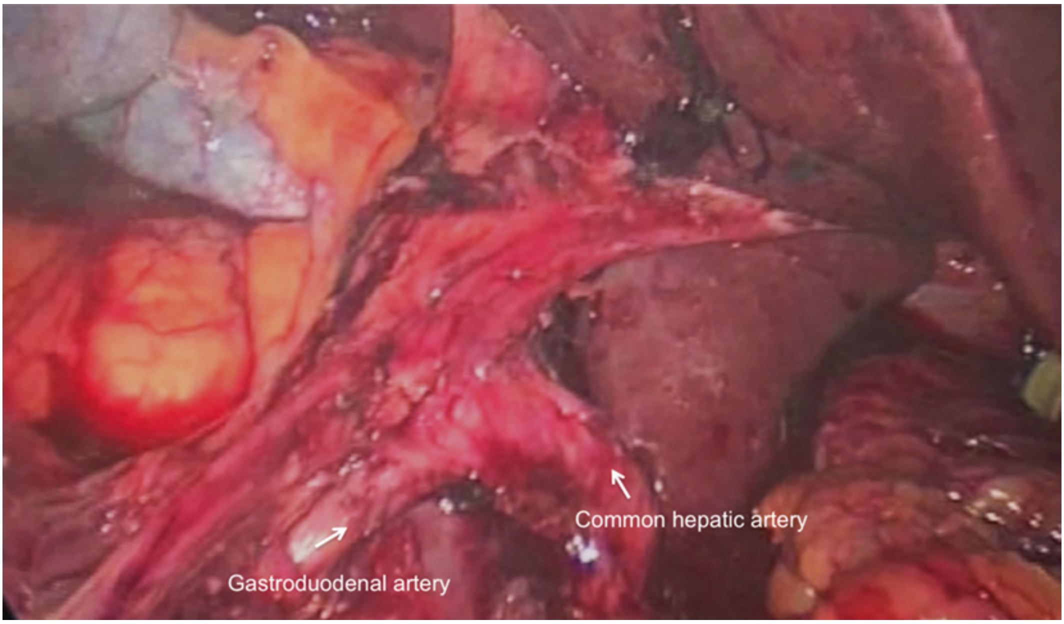

Fig. 8 Completed D2 dissection demonstrating skeletonized hepatic and gastroduodenal arteries

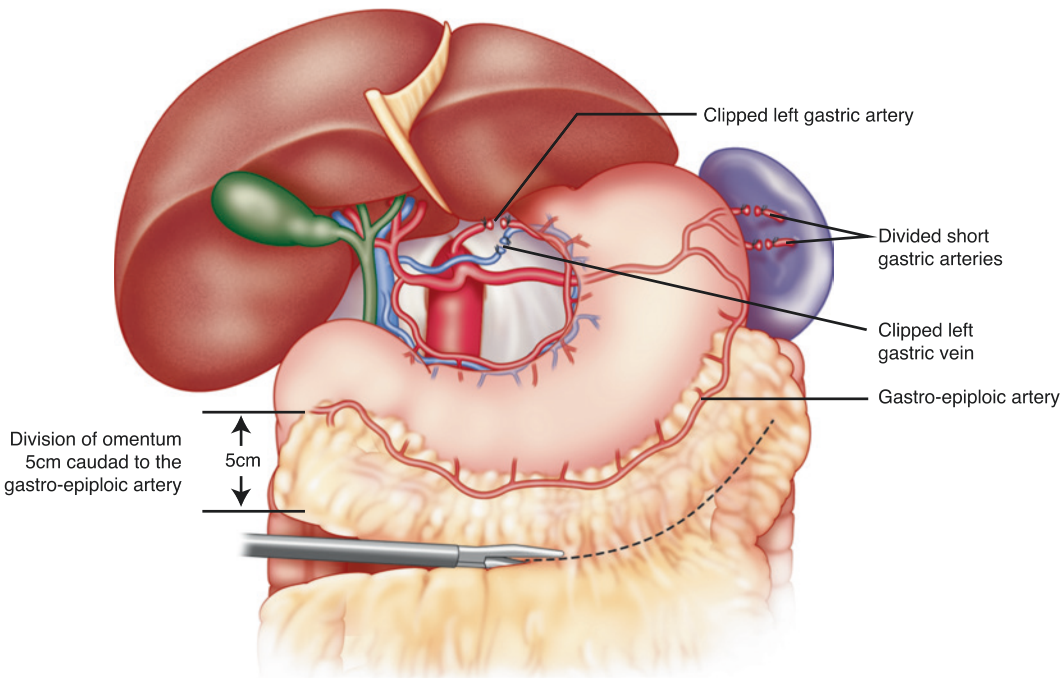

Fig. 9 Dissection along the greater curve of the stomach

Fig. 10 Accessory incision

Blunt dissection and lateral mobilization are completed in order to deliver the esophagus into the wound. Identification of the left recurrent laryngeal nerve is paramount to its preservation, and lymph nodes along this structure are resected (Fig. 12). The proximal margin is revised in the neck, and stay sutures of 4-0 silk are placed at four corners to facilitate the eventual anastomosis (Fig. 13).

The conduit is introduced into an endoscopic camera bag in preparation for guidance to the neck (Fig. 14). The proximal end is secured with a Foley catheter, which is also attached to the umbilical tape at the cervical esophagus. The surgeon then gently guides the conduit in the posterior mediastinal orthotopic position, using the accessory incision and delivering the conduit into the neck while always maintaining orientation to prevent conduit torsion.

The cervical anastomosis can be completed with a stapling device (side to side or end to side) or, as we prefer, through a hand-sewn anastomosis (Fig. 15). Our preference is to use single-layer running suture with incorporation of the muscular layer and small bites of mucosa. A JP drain is inserted in the neck near the anastomosis. Fascia for the abdominal incisions is closed with 1 polydioxanone suture (PDS). The platysma at the collar incision is approximated with 2-0 Vicryl sutures. Skin closure is completed with 4-0 Monocryl sutures.

We do not routinely employ a jejunostomy under most circumstances because the associated complication rate surpasses our rate of anastomotic leak.

Perioperative Care

In the postoperative part of our ERP the following daily objectives are included: removal of the NG tube (we recently omitted the use of routine NG tube placement entirely) and foley catheter on day 1. Sips of water are allowed on day

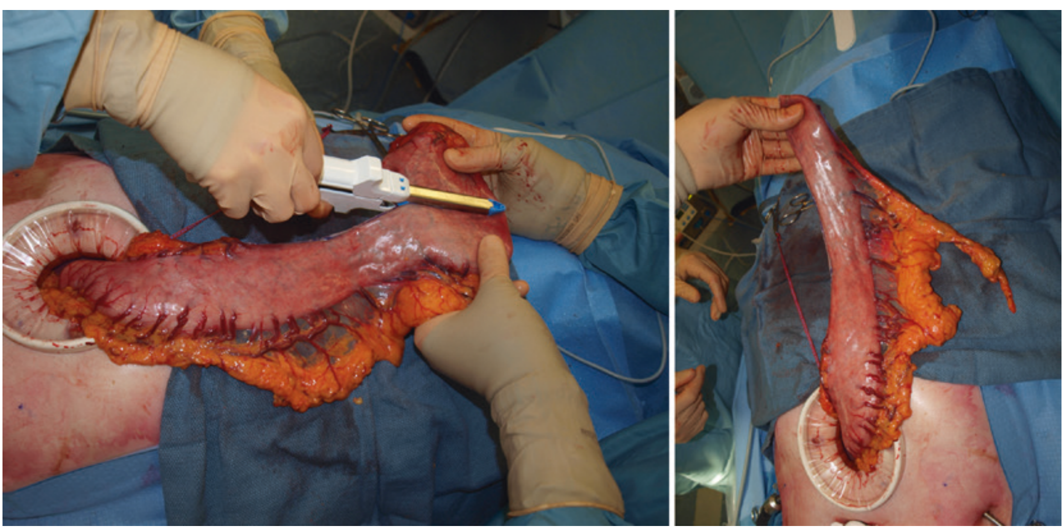

Fig. 11 Construction of gastric conduit

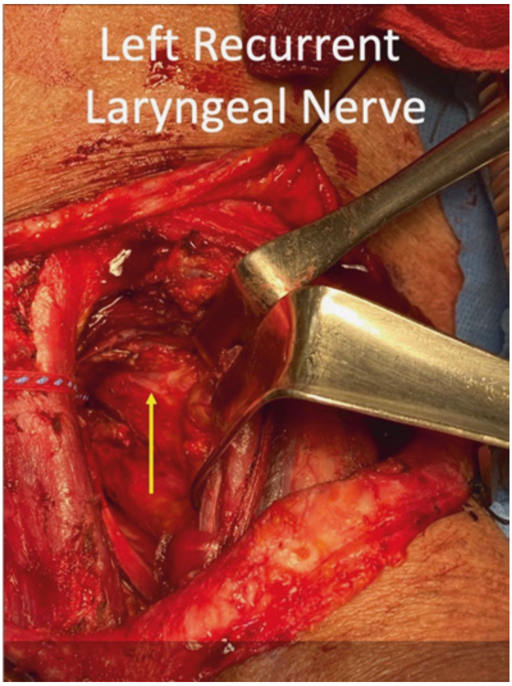

Fig. 12 Dissection of cervical esophagus with visualization and preservation of recurrent laryngeal nerves

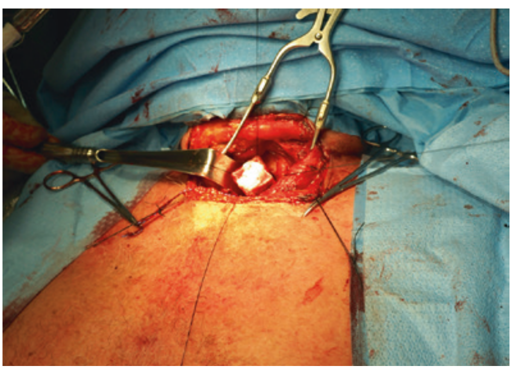

Fig. 13 Prepared cervical esophagus with stay sutures

2 with gradual progression to a liquid diet. We do not perform a routine barium esophagogram based on review of our experience showing minimal impact on the clinical course, and remove the 19-French JP drain on day 5. The epidural catheter is also removed on day 5.

The planned discharge date is day 6, although patients can leave earlier if appropriate. Each patient is assessed daily and is deemed fit for discharge if he meets the following criteria: sufficient liquid oral intake, adequate oral analgesia using both opioid and non-opioid analgesics, vital signs within normal limits and inflammatory parameters not trending up. A dedicated nurse-coordinator follows the patients routinely after surgery and contacts them after discharge; patients can also contact the nurse directly if ad-hoc issues arise at home.

Technical Pitfalls and Complications

Bleeding

Serious hemorrhage during esophageal surgery is reported to occur in up to 4% of surgeries. The extent of bleeding and repair largely depends on the vessel injured. Excellent anatomical knowledge and awareness of the trajectory of all major vessels is critical during esophageal dissection. The esophagus is in proximity to several major vessels, including the aorta, pulmonary veins, and pulmonary arteries; their inadvertent injury will result in catastrophic hemorrhage. Furthermore, if the feeding vessels to the esophagus originating from the aorta are not adequately controlled during mobilization, significant bleeding can result.

Splenic Injury

Splenectomy rates during esophagectomy are reported to be between 4 and 9%. Injury is primarily due to excessive tension on the short gastric vessels during gastric mobilization, which results in a splenic capsular tear. If possible, splenic salvage techniques for arresting the hemorrhage are attempted prior to splenectomy. The increasing use of laparoscopy has decreased splenic injury rates, owing to decreased tension on the short gastric vessels.

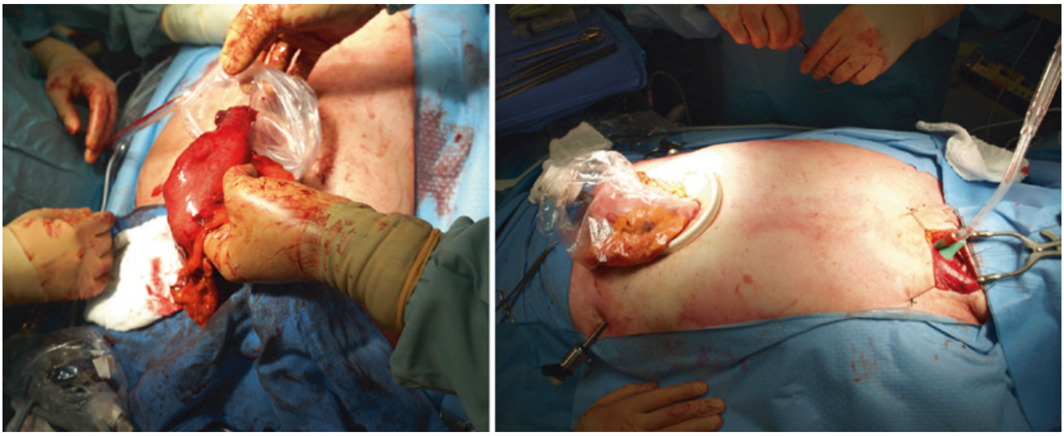

Fig. 14 Insertion of conduit in camera bag in preparation for guidance to neck

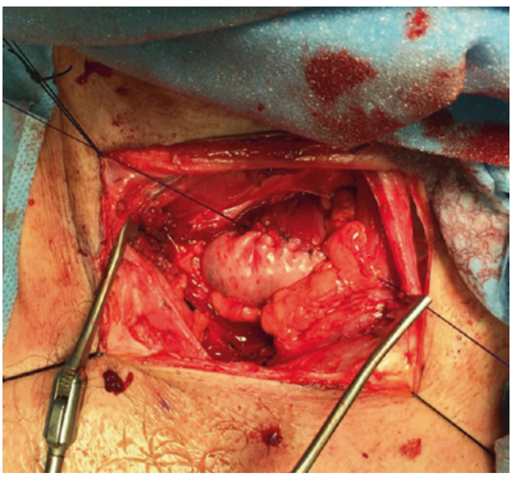

Fig. 15 Construction of cervical anastomosis

Airway Injury

The trachea, the carina, and the right and left bronchi are all susceptible to injury during esophageal mobilization. The thin-walled membranous portion of the airway that abuts the esophagus is particularly vulnerable to cautery or blunt injury. Injuries proximal to the endotracheal tube usually will not result in an unstable physiological status, as air does not escape into the thoracic cavity. These injuries are primarily repaired with absorbable sutures in an interrupted fashion, with further buttressing with muscle or a fat pad. Injuries that are distal to the endotracheal tube may result in significant hemodynamic instability (although this is limited for double-lumen tubes). Repair options include advancing the tube past the injury, if possible, and swift repair of the opening.

Nerve Injury

The recurrent laryngeal nerve is vulnerable to injury during dissection at the thoracic inlet and during the cervical portion of the three-hole esophagectomy. Careful dissection and clear visualization of the nerve avoids its inadvertent injury.

Conduit Necrosis

One of the most dreaded complications is the loss of the gastric conduit due to inadvertent injury to the right gastroepiploic arcade. The rate of gastric conduit ischemia is approximately 3%, with higher rates reported for colonic and jejunal conduits. Conduit ischemia can be addressed by gentle handling of the conduit, careful dissection (especially at the pyloro-antral region), and verification of the artery trajectory during dissection of the greater curve.

Other Postoperative Complications

A complete discussion of postoperative complications is beyond the scope of this chapter. Early postoperative complications include chylothorax, delayed conduit necrosis, and anastomotic leak. Respiratory complications (atelectasis, pneumonia) are among the most common and morbid for the post-esophagectomy patient and are best avoided with early ambulation, incentive spirometry, and excellent chest physiotherapy. Cardiac complications such as atrial fibrillation and supraventricular tachycardia may occur in isolation in the postoperative period, but they often herald another complication such as an anastomotic leak or pneumonia, so their occurrence should prompt a thorough work-up.

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