8 Minimally Invasive Total Gastrectomy

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Introduction

Gastric cancer is highly fatal with an overall 5-year survival of approximately 30–50% [1–3]. In North America, gastric cancer tends to be detected at a later stage than in Asia; with stage at presentation, variations in adherence to surgical guidelines and tumor biology likely lead to poor overall survival. In Japan and Korea, survival is much higher reflecting earlier detection through population-based screening and a more aggressive surgical approach. Stage-matched series show that through appropriate surgical technique, Western surgeons are able to achieve surgical outcomes equivalent to Asian series [4–7].

Surgical resection, either alone or in combination with chemotherapy and/or radiation, offers the only possibility of cure for gastric cancer. The extent of resection for gastric adenocarcinoma is determined by the location of the tumor in the stomach, the stage at presentation, and the need to obtain microscopically negative margins. The majority of tumors in the antrum and pylorus can be adequately resected with a distal or subtotal gastrectomy, whereas lesions proximal to this, diffuse histology, or patients with familial gastric cancer often require total gastrectomy [8, 9].

Minimally invasive approaches for gastrectomy offer several advantages over the open approach including less blood loss, decreased analgesia requirements, fewer wound complications, and shorter hospital stay, yet at the cost of longer operative time [10, 11]. In early gastric cancers (EGC), which are cancers limited to the mucosa or submucosa regardless of lymph node status, it is well established that laparoscopic distal gastrectomy offers several short-term advantages over the open technique with equivalent lymph node harvest, morbidity, and perioperative mortality [12, 13–15]. EGC has a predicted lymph node involvement of 5% for mucosal cancers and 20% for submucosal cancers, with series from Japan and Korea having a 5-year overall survival of EGC of over 95% [16–19]. Although the final 5-year results from the KLASS-01 trial, a randomized controlled trial (RCT) comparing laparoscopic to open distal gastrectomy for clinical stage 1 gastric cancer, are not yet published, the interim results are encouraging. In Asia,

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laparoscopic distal gastrectomy for EGC, which represents up to 57% of all gastric cancers, is routinely performed [9, 14, 20].

The role of laparoscopic gastrectomy for more advanced tumors has not yet been established. The KLASS-2 trial, an ongoing Korean multi-institutional RCT, seeks to provide large-scale prospective data to help answer this question for distal tumors [21]. Tumors included in the KLASS-2 trial include cT2-T4a lesions, with at most limited perigastric nodal metastases [21]. Data from retrospective studies investigating patients with more advanced gastric cancer, however, are encouraging. A recent case-matched study investigating total gastrectomy for gastric cancer in over 3000 patients demonstrated no difference in long-term survival rates between laparoscopic and open conventional gastrectomy [22]. In addition, several nonrandomized studies support both the oncologic and clinical safety of laparoscopic D2 lymphadenectomy for advanced gastric cancer [10, 12, 23–28].

As surgeon experience grows both in Asia and North America, there is interest in applying minimally invasive techniques to total gastrectomy for both early and advanced gastric cancer. Creating the anastomosis and performing D2 lymph node dissection are significantly more technically demanding for total gastrectomy than for distal gastrectomy [10]. With experience, however, the results seem promising. Several meta-analyses comparing laparoscopic to open gastrectomy for advanced gastric cancer showed no statistical difference in overall survival and disease-free survival between the laparoscopic and open groups [29, 30]. In addition, a single-institution retrospective study assessing 336 patients who received either open or laparoscopic gastrectomy with D2 lymph node dissection for advanced gastric cancer showed no difference in morbidity, survival, or pattern of recurrence [31]. In Asia, other published studies have shown comparable 5-year survival rates for laparoscopic gastrectomy to open gastrectomy [32, 33]. The results from the KLASS-03 trial, a large-scale RCT comparing open to laparoscopic total gastrectomy for early gastric cancer, will provide additional critical information to help with patient selection for this technically demanding operation [34].

As evidence and experience in minimally invasive techniques develop, minimally invasive gastrectomy appears to be an attractive option for appropriately selected cases. This chapter will discuss appropriate patient selection and learning curve of the procedure, the technique of laparoscopic gastrectomy with D2 lymphadenectomy, and considerations for postoperative management.

Learning Curve

Several earlier studies have assessed the learning curve of laparoscopic distal gastrectomy. Using a composite score looking at postoperative complications, operating room time, as well as adequacy of lymph node dissection, Jin et al. showed a learning curve of approximately 40 cases [35]. Moreover, Kunisaki et al. demonstrated that outcomes for laparoscopic distal gastrectomy approached that of open distal gastrectomy after 60 cases [36]. There is little data in the literature regarding the learning curve for laparoscopic total gastrectomy. In a study assessing 256 sequential laparoscopic total gastrectomies at a single institution, Jung et al. describe a learning curve of 100 cases, after which point operative time and blood loss stabilize [37]. Interestingly, in this study, when assessing lymph node harvest as the outcome, learning curves seem somewhat shorter, with a significant improvement in lymph node retrieval rate between the first 33 cases compared to the next 21 cases [37]. A second study assessing 203 sequential laparoscopic total gastrectomies for early gastric cancer among two surgeons showed a slightly shorter learning curve of approximately 45 cases [38].

These aforementioned studies are limited by the fact that they do not describe the surgeons' experience with open gastrectomy, nor their experience with other advanced minimally invasive operations. Additionally, they do not report oncologic outcomes. Since an examination of the learning curve for open gastrectomy suggests that oncologic outcomes are improved after 100 cases, short- and long-term outcomes should be examined for programs incorporating a new technique, such as laparoscopic gastrectomy for cancer [39]. Finally, to date, all learning curve data are from Asia where both open and laparoscopic surgeries for gastric cancer are performed more frequently than in North America. Some of these centers perform 700–1000 gastrectomies annually, by a team of surgeons with fellowship training in gastric cancer, while the median annual number of gastrectomies reported in the National Cancer Database (NCDB) is 9 [40]. In the Western context where tumors are more advanced, patients tend to have a higher body mass index and less favorable anatomy, and surgeons have less laparoscopic experience with gastrectomy for cancer, the learning curve is likely to be more significant.

There is data suggesting that robotic gastrectomy may have a shorter learning curve compared to laparoscopic gastrectomy. In a single-institution study, the learning curve for robotic surgery was between 12 and 14 cases for two experienced surgeons, each of whom had performed more than 250 laparoscopic gastrectomies [41]. This learning curve is shorter than that described by others with learning curves between 20 and 25 cases [42–44]. In all situations, however, these reported learning curves apply to surgeons who have significant experience with both open and laparoscopic gastrectomy.

Exposure to this procedure, not just as a surgeon but also as an assistant, has been shown to shorten the learning curve for the procedure. A Japanese study demonstrated that surgical trainees who had assisted in over 60 cases, either as the camera operator or as the first assistant, had learning curves shortened to 6 cases (while under the assistance of an experienced surgeon) [45]. In addition, in an educational system where trainees had significant exposure to laparoscopic gastrectomy, there was no difference in morbidity, blood loss, or lymph node harvest when comparing cases at the early and late phases of the learning curve [46]. Training opportunities either through assisting in the operating room or in simulated environments, therefore, have potential to shorten the learning curve for this technically demanding procedure.

Patient Selection

Appropriate patient selection is essential when deciding whether to perform laparoscopic or open gastrectomy for adenocarcinoma. Although the only patient-related contraindication for the procedure is inability to tolerate pneumoperitoneum, other patient factors should be considered including experience of the surgeon, location of the tumor, and degree of lymph node dissection. Indeed, especially when surgeons are in the early phase of their experience, selecting patients with few medical comorbidities, low body mass index, and small early tumors is critical.

Preoperative Planning and Diagnostic Laparoscopy

Prior to surgical intervention for gastric cancer, patients should have a complete work-up. At minimum, this includes upper endoscopy and biopsy of the tumor and CT scan of the chest and abdomen and pelvis to assess for T stage, the potential for nodal involvement, and for metastatic disease. Endoscopic ultrasound may be of benefit to differentiate between early and more advanced lesions. A meta-analysis, which included 5601 patients, demonstrated that endoscopic ultrasound had good sensitivity and specificity (0.86 and 0.91, respectively) to differentiate between T1 and T2 lesions with T3 and T4 tumors [47]. The accuracy of the endoscopic ultrasound, however, is highly operator dependent and likely related to the volume performed, which is very institution dependent, especially in the West where gastric cancer is infrequently assessed using endoscopic techniques.

Frequently, preoperative imaging is inaccurate in advanced gastric cancer and can miss radiologically occult metastatic disease [48]. Therefore, if a patient has no evidence of metastatic disease on imaging, has T3 or T4, or nodal involvement, then we recommend performing staging laparoscopy with peritoneal washings for cytology. This approach is supported by various national and society guidelines including Cancer Care Ontario (CCO), Society of American

Gastrointestinal and Endoscopic Surgeons (SAGES), and the Scottish Intercollegiate Guidelines Network (SIGN) [49, 50]. Positive cytology at diagnostic laparoscopy is a significant predictor of mortality and is defined as pM1 disease [51]. If peritoneal deposits or positive cytology are identified at diagnostic laparoscopy and the patient has no symptom, the REGATTA RCT demonstrated that chemotherapy provides equivalent survival with fewer complications compared to resection [52].

Technique of Diagnostic Laparoscopy

For diagnostic laparoscopy, the patient is positioned in the supine position with arms extended and padded appropriately. A minimum number of ports are placed (one camera port and either one or two working ports). The camera port (12 mm) is created using an open Hassan technique at the umbilicus. The working ports (5 mm) are in the right upper and left upper quadrant, respectively. Once pneumoperitoneum is established, then the abdominal cavity is systematically inspected for any signs of metastatic disease. The pelvis, liver, right and left paracolic gutters, greater and lesser omentum, as well as transverse mesocolon are all systematically assessed. If the tumor is located on the posterior wall of the stomach, then the gastrocolic omentum is opened and the retrogastric space assessed. If any lesions are identified that are concerning metastatic disease, they are biopsied and sent for pathological analysis. If ascites is identified, then it is sampled and sent for cytology.

Washings for cytology are then performed. Warmed normal saline (250 ml) is infused sequentially into the left upper quadrant, right upper quadrant, and pelvis. The patient is gently agitated after each infusion of warmed saline to allow contact over all organs and tissues. Saline (30 ml) is then sequentially collected from each area and sent separately for cytology. Once pathological analysis has confirmed no metastatic disease, then we plan for definitive surgery.

Patient Positioning and Operating Room Setup for Laparoscopic Gastrectomy

The patient is positioned supine on a split-leg table. The arms are extended from the body and secured on arm boards or tucked at the sides of the patient. All pressure points are padded. Safety straps ensure that the patient is secured to the table, and footboards are used to avoid the patient sliding when in reverse Trendelenburg position. Monitors for the laparoscopic camera are positioned near the patient's head.

Various positions for the surgeon and assistants have been described. These include (1) the surgeon operating from between the legs, the first assistant on the patient's right side, and the second assistant holding the camera on the patient's left side or (2) the camera operator standing between the patient's legs, the surgeon initially standing on the patient's left side with the first assistant on the right side, and then the surgeon switching to the patient's right side as the case progresses [53–55] (Fig. 8.1). We prefer the latter approach as it gives the greatest amount of flexibility.

Port Placement

Access to the abdomen is gained either via Veress needle technique under the left costal margin or via open Hassan technique at the superior aspect of the umbilicus [55]. Pneumoperitoneum is then established. Various port placement strategies have been described; however, general principles include having the camera port just superior to the umbilicus and working ports approximately 5 cm or a hands-breadth apart. Our practice is to place the camera just superior to the umbilicus through a Hassan port, place a 5/12-mm right upper quadrant port and a 5/12-mm left upper quadrant port, and then place two more 5-mm ports. One in the left upper quadrant and one in the right upper quadrant (Fig. 8.2). We place a liver retractor (Nathanson) through a small

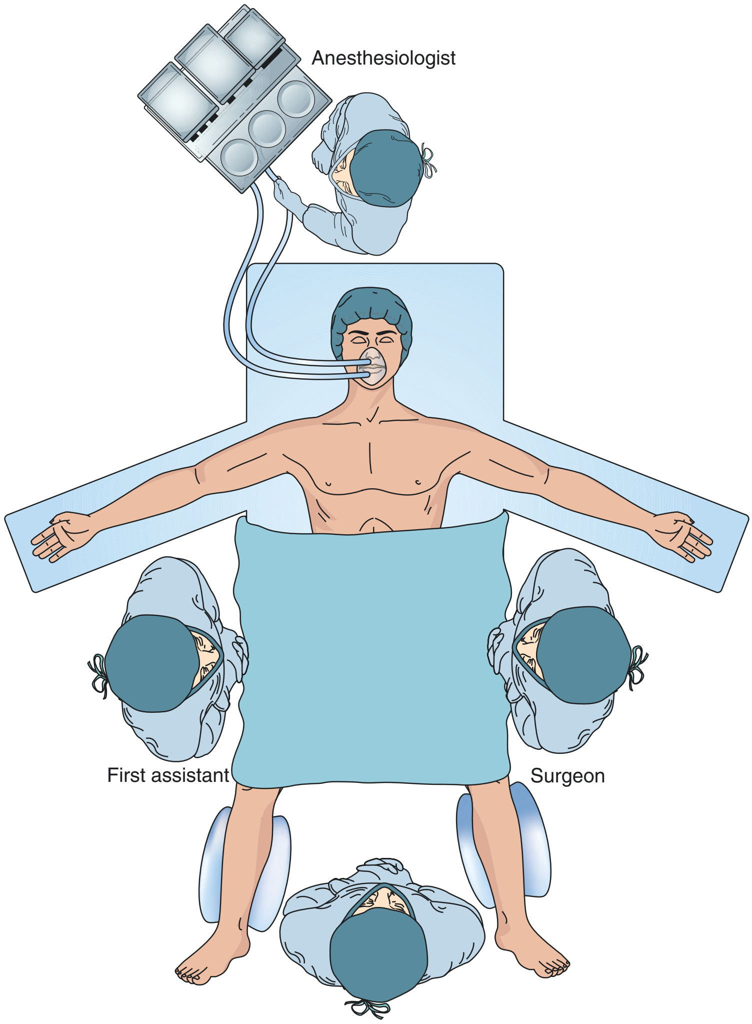

Fig. 8.1 Patient positioning and operating room setup

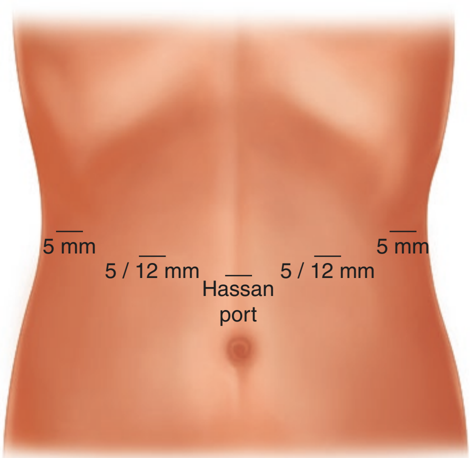

Fig. 8.2 Trocar/port placement for laparoscopic total gastrectomy

incision just under the xyphoid process and use this to retract the liver during the operation. Alternatively, the liver can be suspended with a sponge over a suture, bringing it up to the anterior abdominal wall [56].

Gastrocolic Omentum and Station 4sb and 4sa Lymph Nodes

After diagnostic laparoscopy to ensure no metastatic disease, definitive resection commences (Video 8.1). The patient is placed in reverse Trendelenburg position. The assistant retracts the transverse colon inferiorly, and the surgeon retracts the greater omentum cephalad using atraumatic bowel graspers. Using hook electrocautery, the surgeon incises the avascular plane between the colon and greater omentum, thus entering the lesser sac. Entry into the lesser sac is usually around the midpoint of the transverse mesocolon. The surgeon then retracts the stomach and greater omentum cephalad and proceeds toward the spleen taking down the attachments of the omentum to the transverse mesocolon using an energy device. As the surgeon approaches the spleen, it is important to identify the splenic flexure of the colon in order to avoid inadvertent injury. Once the tail of the pancreas is identified, the origin of the left gastroepiploic vessels can be seen between the tail of the pancreas and the lower border of the spleen. These are identified and divided separately with clips. As the surgeon moves cephalad, they will encounter the short gastric vessels. These are isolated and divided either using clips or an energy device under direct visualization. Nodal tissue around the short gastric vessels (station 4sa) is included with the specimen. Of note, if there is clinical suspicion for involved 4sb nodes, then the 2014 Japanese Gastric Cancer Association guidelines advocate for total gastrectomy even if the lesion itself can be removed with distal gastrectomy [9].

Dissection continues as far as possible to the left crus of the diaphragm. Without performing a splenectomy, it can be very technically challenging for station 10 nodes (splenic hilar nodes) to be included with the specimen due to the complex and variable anatomy of the splenic vessels. Should a complete station 10 lymphadenectomy be required for tumor factors, then local technical expertise should be taken into consideration when deciding whether or not to perform a spleen-preserving procedure. Our practice is to perform a splenectomy if we plan to include a complete station 10 lymphadenectomy in our dissection.

Greater Curve, Right Gastroepiploic Vessels, and Station 4d and 6 Lymph Nodes

The surgeon then reverses direction and continues the omentectomy toward the patient's right side. The stomach continues to be retracted cephalad and the transverse colon retracted caudally. The surgeon continues to take the omentum off the transverse colon mesentery working toward the gallbladder, thus including nodal tissue along the greater curvature of the stomach (station 4d).

Posterior attachments of the stomach to the anterior surface of the pancreas are divided as the surgeon moves toward the pylorus. This maneuver facilitates anterior retraction of the stomach and exposes the second part of the duodenum and head of the pancreas. This step is facilitated by gentle traction on the pancreas with a small sponge.

In order to retrieve infra-pyloric nodal tissue, the right gastroepiploic vein is cleared at its root and clipped. Then the same is done with the right gastroepiploic artery. If possible, the anterosuperior pancreaticoduodenal vein is identified to confirm the limit of dissection for station 6 nodal tissue. Nodal tissue is then meticulously removed from the head of pancreas working up toward the duodenum and infra-pyloric area. Dissection is performed keeping in mind the borders of the station 6 nodal area (the first branch of the right gastroepiploic artery, the lower border of the pancreas, and the anterosuperior pancreaticoduodenal vein).

Division of Duodenum

The gastroduodenal artery (GDA) is identified as it travels posterior to the duodenum. Staying anterior to the GDA, a window/tunnel is made under the duodenum going inferior to superior. From this inferior window, a sponge is then placed posterior to the duodenum. The stomach and duodenum are reflected caudally. At this point, the surgeon will be able to visualize the sponge on the cranial aspect of the first part of the duodenum. The peritoneum over the sponge is incised. This will create a window to allow for the division of the duodenum approximately 1–2 cm distal to the pylorus. The duodenum is then divided with one firing of an endovascular linear stapler (staple height 3–4 mm). Prior to duodenal transection, ensure that both the nasogastric tube and temperature probe (if inserted by anesthesia) have been removed. Our practice is to oversew the duodenal stump.

Right Gastric Vessels and Station 5 Lymph Nodes

After the duodenum is divided, the stomach is retracted caudally. The hepatoduodenal ligament is dissected, and the pars flaccida is opened. Carefully follow the GDA from where it was identified posterior to the first part of the duodenum and trace it to the hepatic artery proper. The left lateral aspect of the hepatic artery proper is exposed, and the root of the right gastric artery is identified as it comes off the hepatic artery proper. Clip and divide the right gastric artery at its origin.

Left Gastric Vessels and Station 7, 9, and 11 Nodes

Retract the stomach superiorly and cranially to patient's right side. Incise the peritoneum over the superior border of the pancreas with the assistant retracting the pancreas caudally with a sponge. Using a closed instrument, the assistant gently retracts the pedicle containing the left gastric vessels. The left gastric vein will be visualized at the intersection of the common hepatic artery and the splenic artery. We clear the left gastric vein and divide it at the point of drainage into the portal or splenic vein. Then we continue the dissection toward the patients' left side and carefully dissect nodal tissue from the proximal portion of the splenic artery and vein (11p) using an energy device. We clear soft tissue from around the left gastric artery (station 7) and isolate and clip it at its origin. Proceed toward the hiatus posteriorly on the stomach clearing station 9 nodes.

We clear the splenic vessels going toward the splenic hilum (including nodal station 11d). In over 50% of patients, there is a posterior gastric artery originating from the splenic artery. Be cognizant of this anatomy and identify and divide it formally if present or the surgeon risks running into troublesome bleeding.

Computed tomography (CT) scans should be reviewed preoperatively to determine if there is an accessory or replaced left hepatic artery. If possible, the surgeon should attempt to preserve these during the D2 dissection. This necessitates avoiding dividing the left gastric artery at its origin; however, studies have shown that nodal harvest is equivalent if the accessory or replaced vessel is skeletonized and preserved [57].

Lesser Curve and Station 12 and 8a Nodes

Staying on the GDA and the divided right gastric artery, clear off the anterior surface of the hepatic artery proper, reflecting nodal tissue to the specimen and to the patient's left-hand side. Be mindful of the portal vein posteriorly. This step will enable inclusion of station 12a lymph nodes with the specimen. Continue reflecting nodal tissue toward the patient's left side and clear station 8a nodes (from the anterior aspect of the common hepatic artery) with the specimen.

Hiatal Dissection and Station 1 and 2 Lymph Nodes

At this point, the only remaining attachments of the stomach are at the hiatus. The pericardial lymph nodes (stations 1 and 2) are resected en bloc with the specimen. Station 2 lymph nodes should be preserved if performing subtotal gastrectomy. The anterior fat pad of the distal esophagus is cleared and the esophagus circumferentially dissected. The esophagus is then divided with one firing of an endovascular linear stapler. The specimen is either placed into an appropriately sized endocatch bag (usually 15 cm) or it can be removed from the abdomen after extending the supra-umbilical port site or by creating a Pfannenstiel incision. Margins are sent for frozen section analysis dependent upon tumor type and location.

Reconstruction

Laparoscopic reconstruction from total gastrectomy is made with a Roux-en-Y esophagojejunostomy. This is a technically challenging anastomosis and can be classified as intra- or extracorporeal and further classified as a side-to-side anastomosis with linear staplers or end-to-side anastomosis with circular staplers.

Intracorporeal End-to-Side Anastomosis

Our preference is the intracorporeal end-to-side anastomosis with the transorally inserted Anvil (OrVil, Medtronic). Following esophageal transection, the OrVil tube (consisting of a nasogastric tube attached to an anvil) is inserted transorally. Once the tube reaches the esophageal stump, an esophagotomy is made on the stump using electrocautery. The nasogastric tube is delivered through the esophagotomy and the anvil thus deployed in the distal esophagus. The nasogastric tube is cut from the anvil and removed from the abdominal cavity. The temperature probe and nasogastric tube should be removed from the esophagus prior to placement of the OrVil device.

A loop of jejunum from the ligament of Treitz that comes up easily to the esophageal stump is chosen. The jejunum is then divided with a linear stapler. The staple line is then removed with electrocautery and four stay sutures placed around the open roux limb. The 5/12-mm port in the left upper quadrant is upsized and the EEA stapler inserted through the abdominal wall. Using the stay sutures, the open end of the small bowel is manipulated over the stapler. After the end-to-side anastomosis is created intracorporeally with the jejunum in an antecolic position (Fig. 8.3), the circular stapler is withdrawn and the jejunal stump is closed laparoscopically with an endolinear stapler.

The jejuno-jejunostomy is then performed in the usual fashion, choosing a point approximately 40–60 cm distal from the esophagojejunostomy to prevent bile reflux. The anastomosis is made with one firing of a linear stapler, and then the common enterotomy is sewn closed. The resulting mesenteric defects are conventionally sutured closed to prevent internal hernias.

Postoperative Care

In general, we do not recommend nasogastric tube or intraperitoneal drainage tubes [58]. Patients may begin clear fluids on postoperative day one. As the patient progresses, their diet is advanced to a post-gastrectomy diet. Dietician referral and counseling regarding post-gastrectomy diet is helpful prior to discharge. We do not routinely perform gastrograffin swallow to evaluate for a leak if a patient is clinically well. Should there be clinical concern for a leak, however, prompt resuscitation and CT scan with oral contrast or an oral contrast study is required. After discharge, close follow-up to ensure adequate nutrition and supplementation for vitamin B12, iron, and calcium are indicated as required [59].

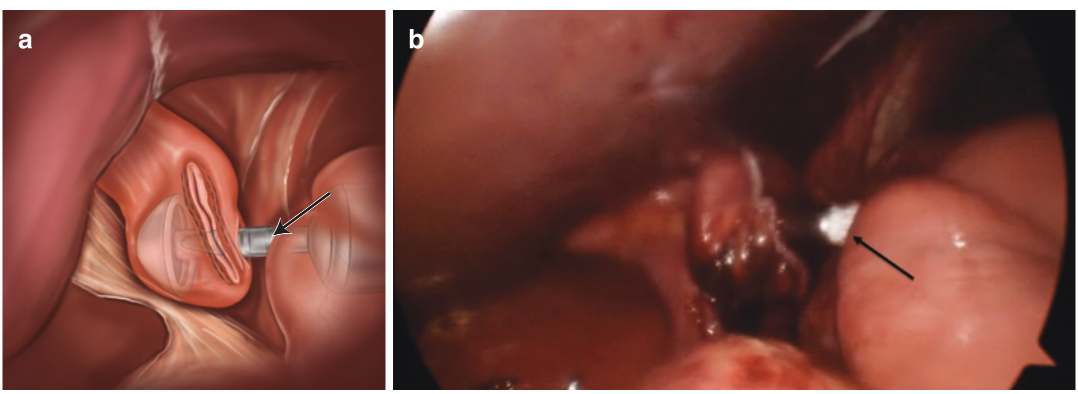

Fig. 8.3 (**a**) Illustration of the EEA stapler within the Roux limb. The trocar/pin of the EEA stapler is attached to the anvil within the distal esophagus. (**b**) Paired intraoperative image showing the white base of the anvil (black arrow) attached to the trocar/pin of the EEA stapler

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