Minimally Invasive Esophagectomy Step by Step: How I Do It

12

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12.1 3 Stage McKeown MIE Procedure (see the Video 12.1)

There are three different thoracoscopic approaches: the prone position, the lateral position and the semiprone position.

The advantages of the prone position are: (a) the attainable range of thoracic cage and diaphragmatic excursion is greater than in the side position; (b) the amplitude of mediastinal swing or displacement is less; (c) exposure of the esophageal area is facilitated; (d) the weight of the lung itself allows it to fall forward; and (e) in the event of bleeding the blood flows away from its source, thus permitting its control with greater ease.

This approach was not commonly used until its introduction for Minimally Invasive Esophagectomy.

12.1.1 Thoracoscopy in Prone Position

1. After induction of general anaesthesia, standard intratracheal intubation follows.

   Patient is then positioned in prone decubitus position on a standard device in order to support on the head, upper thorax and pelvis. Abdomen is maintained free for breathing excursions. Position of the arms is very important in order to get abduction of the scapula. The arms are positioned on a support device in flexion of the shoulders and ellebows (Fig. 12.1a).

   In this way the area between the spine and the inner edge of the scapula is broadened.
2. Surgeon stands on the right side of patient with the first assistant on his/her right side looking to the monitor in front of them. Scrub nurse stand on the left side of the surgeon (Fig. 12.1b).
3. Four trocars are placed along the inner edge of the right scapula (Fig. 12.1c). The first at the level of the lowest point of the scapula, a 10 mm for the 30° thoracoscope. The second, at the level of fourth intercostal space, 5 mm; the third, at the level of eighth intercostal space, 12 mm and the last, at the level of third as work trocar for assistant (suction, lung retraction etc.). The first trocar is introduced open in the thoracic cavity, after

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Fig. 12.1 (**a–c**) Placement of patient in the prone position. Operating room setting during operation. Position of trocars along the medial aspect of the scapula

control by finger palpation that the thoracic space is free of adhesions. After introduction of the first trocar a positive insufflation of 7–8 mmHg is initiated in order to retract enough the right lung for an adequate visualization of the posterior mediastinum.

4. Inspection is performed of the pleural cavity and the esophageal area in order to assess if resection is possible (Fig. 12.2a, b).

   Dissection starts anteriorly by cutting the pulmonary ligament, following the cutting line along the lung, along of the right pulmonary vein, the right bronchus up to the azygos vein.
5. Dissection is performed as much as possible from this right side. The esophagus is dissected as far to the left from the hiatus and pericard sac. Dissection and lymphadenectomy of the right bronchus and carina is performed. Lymphadenectomy is not picking of lymph nodes but 'en bloc', the lymph nodes remain attached to the specimen. The right vagal nerve is dissected and divided at the lower edge of the right bronchus. The left bronchus and the distal trachea are now dissected. Dissection takes place by means of the hook and sealing device taking care do not touch the trachea or bronchi.
6. Furthermore the azygos vein is dissected free and divided by means of vascular endo-stapler.
7. On the posterior side, the mediastinal pleura is cut longitudinally along the azygos vein

from the aorta arch to the costo-phrenic angle. In this way a broad piece of pleura is resected with the esophagus.

8. Along the plane of the descending aorta, the thoracic duct (between the aorta and azygos vein) is dissected free and clipped at distal and proximal level. Other surgeons prefer to preserve the thoracic duct. With retraction of the esophagus to the right, the tissue (fascia) from the aorta to the esophagus (mesoesophagus) is divided by means of sealing device (Fig. 12.3a–d). In this way the posterior plane of the pericard, left pulmonary vein and contralateral pleura is reached. Gentle traction of esophagus is needed by the first assistant.
9. Dissection continues in proximal direction between esophagus and trachea (pars membranacea) to stop at the apex of the thoracic cavity (Fig. 12.4a–e).
10. If a total mediastinal lymphadenectomy is indicated the paratracheal lymphadenectomy starts at the right side. After stripping the pleura to reach the superior vena cava, from there the lymphadenectomy is performed up

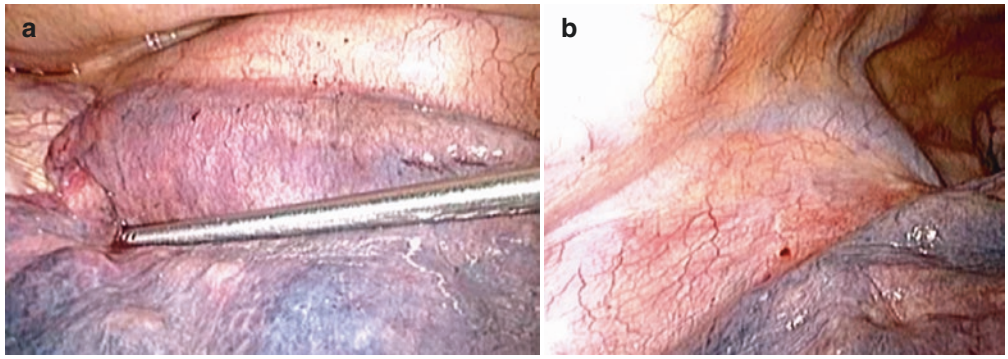


Fig. 12.2 (**a**, **b**) Inspection of the thorax

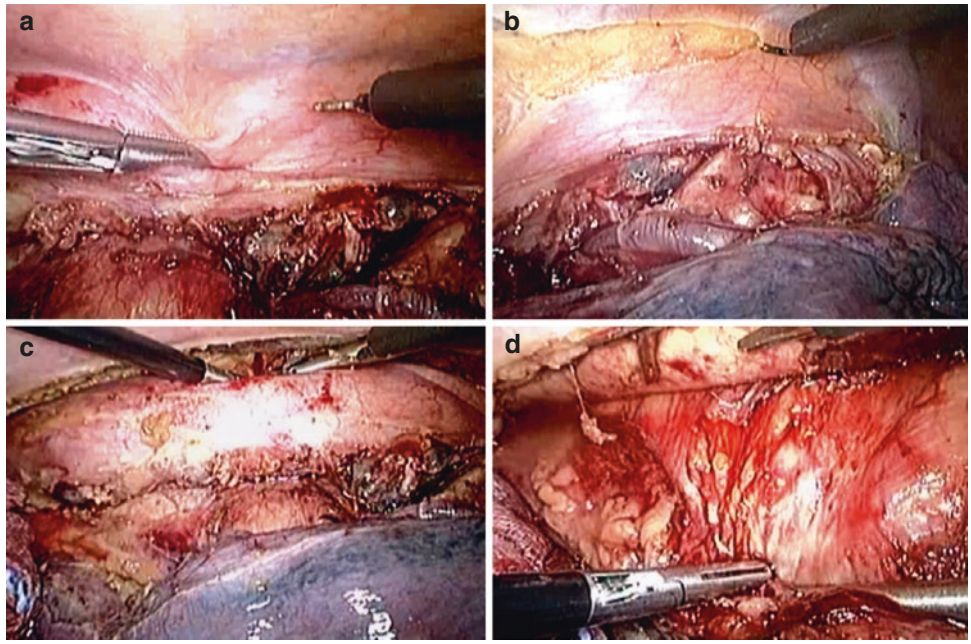


Fig. 12.3 (**a**–**c**) Opening the pleura on both sides of the esophagus. (**d**) View of the mesoesophagus

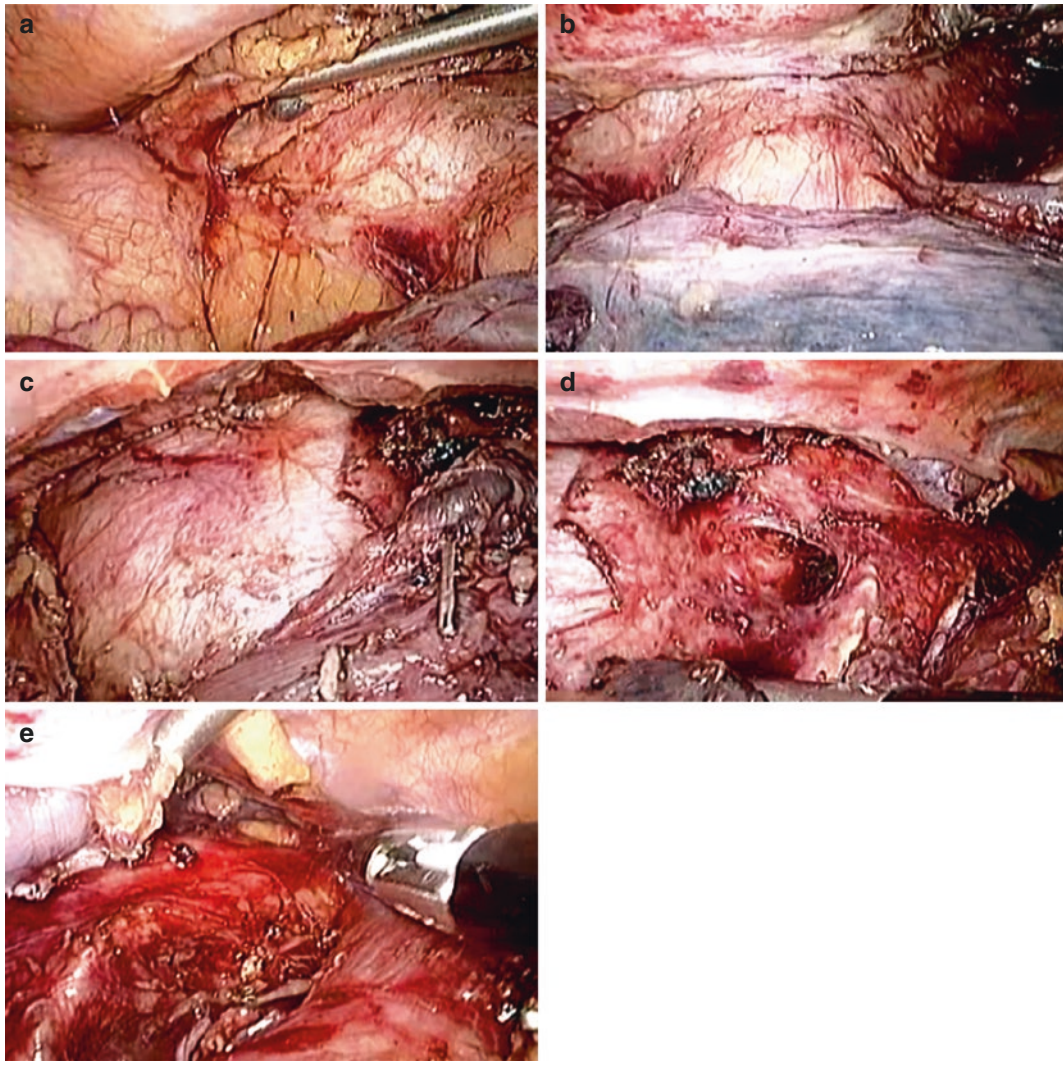


Fig. 12.4 (**a**–**e**) Inspection of mediastinum after esophageal resection: hiatus, pericard sac, carina and trachea

to the trachea, taking care not damage the right vagal nerve. The lymphadenectomy of the right recurrent laryngeal nerve is done after visualization of the nerve at the right subclavian artery (groups 2 and 4R). At the left side lymphadenectomy starts with careful dissection of the left recurrent nerve. Dissection should be done gently without tractions and not use of diathermia, only scissors.

11. After haemostasis and general inspection the thoracic cavity is drained and the ports closed.

12.1.2 Laparoscopy

1. Patient is placed for the laparoscopy and cervical phase of the operation. Five trocars are introduced in the upper abdomen (Fig. 12.5a).
2. Extensive lymphadenectomy of the celiac trunk and branches (D1+) is performed through the gastro-hepatic ligament after dividing the pars flaccida. After dissection and division of the left gastric artery and vein, dissection continues up to the hiatus.

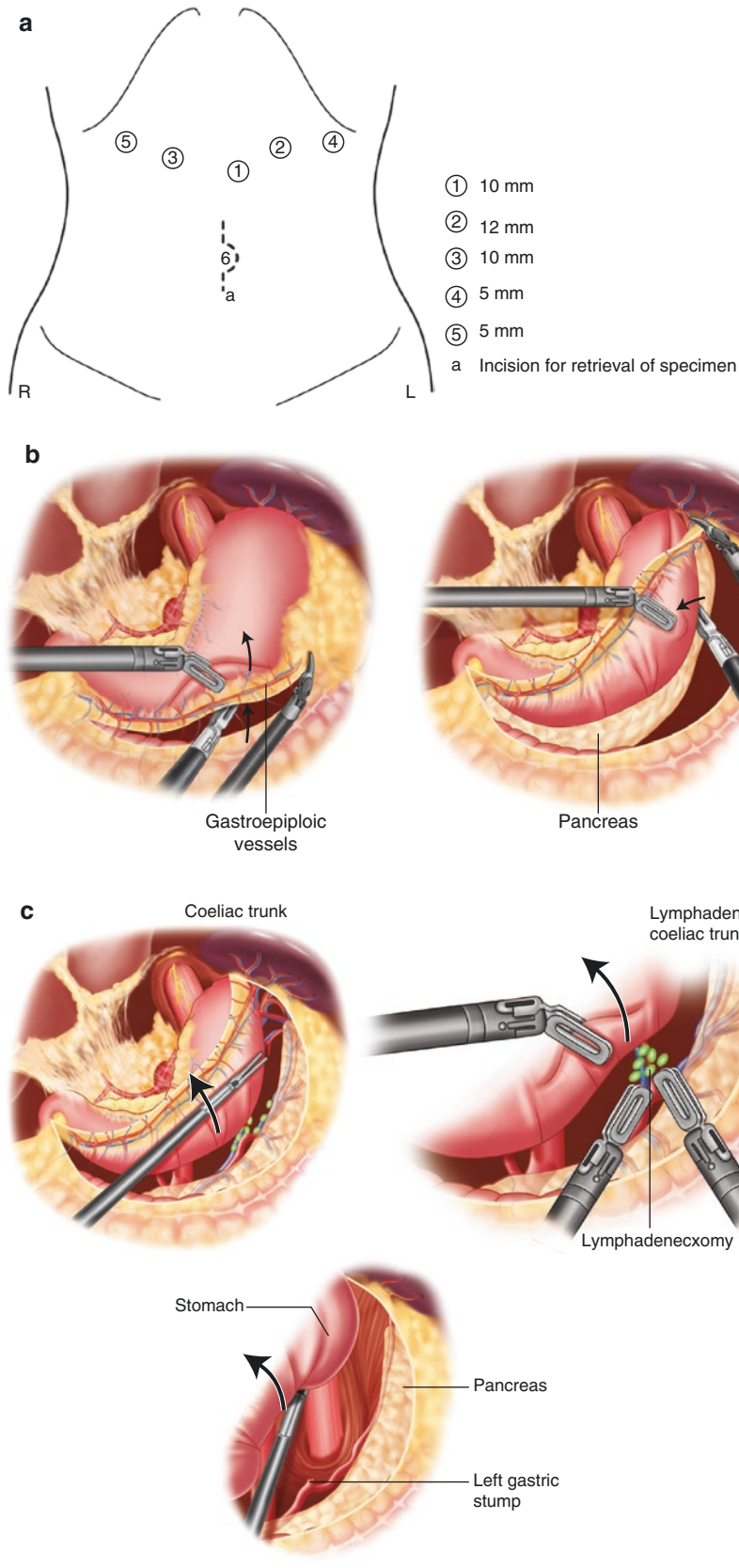


Fig. 12.5 (**a**–**e**) Laparoscopy and positions of trocars. Lymphadenectomy of the celiac trunk and dissection of the stomach with preservation of gastroepiploic vessels

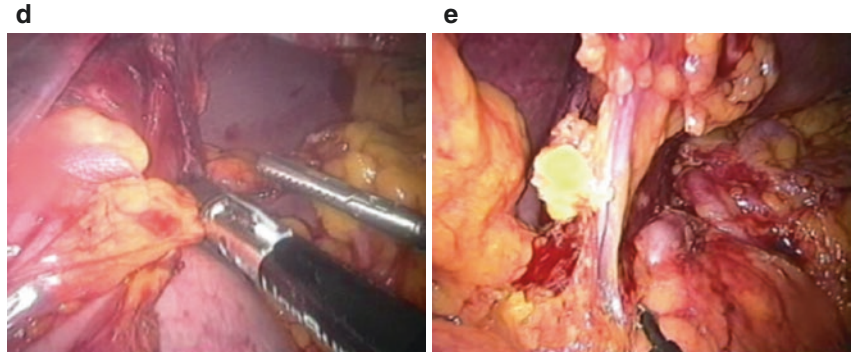


Fig. 12.5 (continued)

3. Gastrocolic ligament is opened and working first in direction to the hiatus and afterwards to the pylorus, the stomach is mobilized completely with preservation of the gastro-epiploic vessels (Fig. 12.6b–e). In this part of the intervention you can perform first the lymphadenectomy followed by the gastrolysis or first the gastrolysis followed by lymphadenectomy.
4. Last part of the laparoscopic approach is the dissection of the hiatal area in which the hiatus is enlarged anteriorly and carefully a communication is made with the thoracic dissection area (insufflation is lowered up to 8 mm Hg in order to avoid ventilation problems). Take care that all the specimen, esophagus and stomach are completely free!

12.1.3 Cervical Phase

1. At the same time a second team (if possible) approach the esophagus at the cervical area and after division the esophagus, the distal part is attached to a nasogastric tube in order to permit that the specimen can be retrieved by the abdominal surgeon through a well-protected supraumbilical incision of 7 cm. A 3–4 cm gastric tube is created by means of a linear stapler device. The gastric tube is fixed to the nasogastric tube, placed into the cervical area and anastomosed (Fig. 12.6a–d).

   Other option will be to create the gastric tube totally intracorporeally (intraabdominal). Once the gastric mobilization has been accomplished, the gastric tube of 3–4 cm is created by means of endostaplers leaving a bridge between the specimen and the gastric tube (other option is to divide the stomach completely and to attach the gastric tube to the specimen by means of two stitches) (Fig. 12.7). Through a well protected neck incision the specimen and the gastric tube can now be exteriorized. After resection, an esophago-gastric tube anastomosis will be performed.

12.2 Minimally Invasive Ivor-Lewis Esophagectomy (See the Video 12.2)

A two stage minimally invasive Ivor-Lewis approach with an intra-thoracic esophagus-gastric tube anastomosis is an increasingly performed intervention for many infracarinal located esophageal tumors (distal esophageal adenocarcinomas and Siewert 1 and 2).

1. The operation starts with the laparoscopic procedure with lymphadenectomy of the celiac trunk branches (D1+).
2. The stomach is mobilized with preservation of the gastro-epiploic vessels and a broad piece of proximal omentum.
3. The gastric tube (3–4 cm wide) is created by endostaplers.
4. The hiatus is dissected and distal esophagus dissected free along the oncological planes (aorta and pericard sac).
5. A jejunostomy is created
6. Patient is then placed in a prone decubitus position for right thoracoscopy.

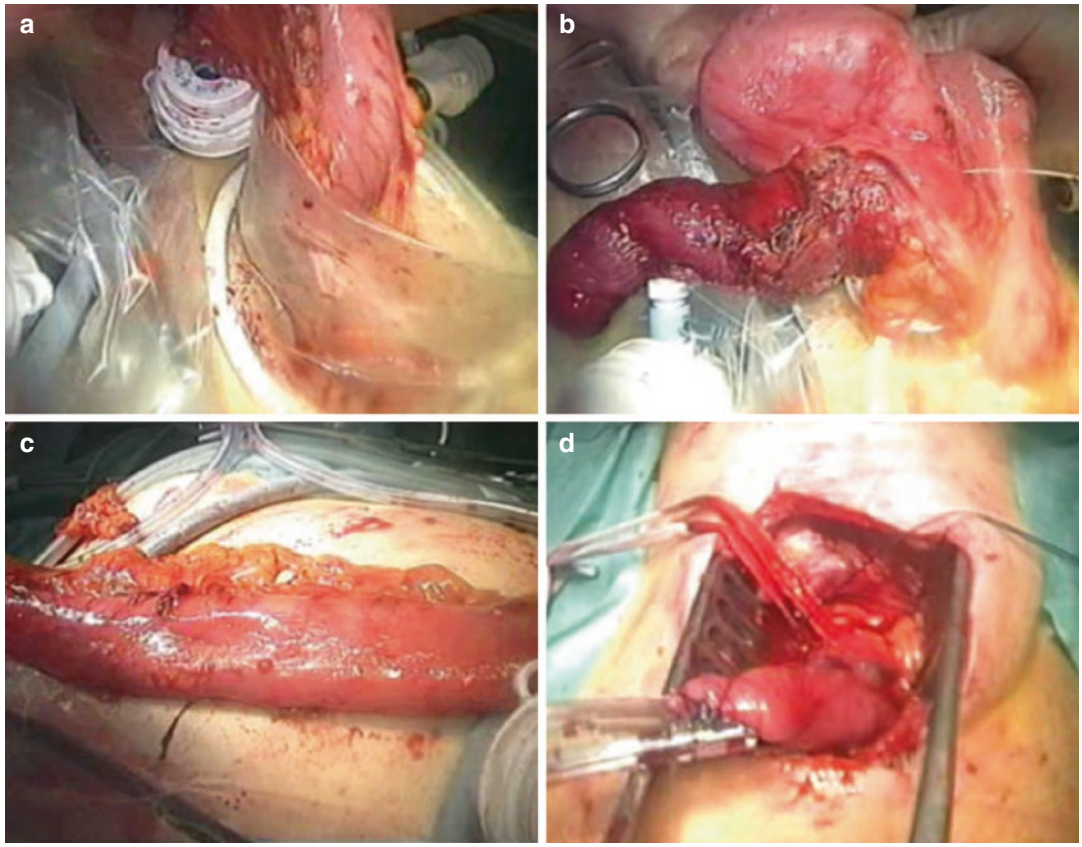


Fig. 12.6 (**a**–**d**) Exteriorization of the specimen, creation of gastric tube and neck anastomosis

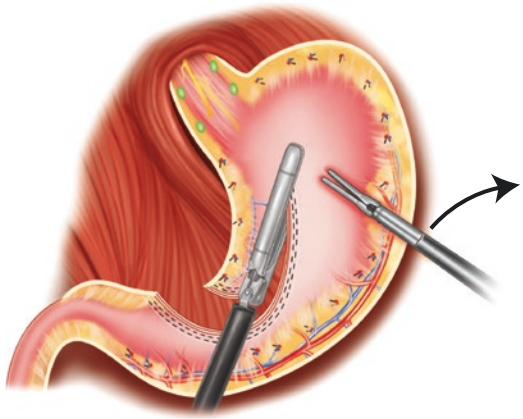


Fig. 12.7 Creation of gastric tube intracorporeally

7. After mobilization of the esophagus and lymphadenectomy up to the carina (if indicated a total lymphadenectomy should be performed), the esophagus is divided by staplers at the level of the azygos vein.
8. The gastric tube and the specimen are pulled into the thorax through a wide hiatus. There are different possibilities to perform the anastomosis.

Summary of intrathoracic anastomosis (Figs. 12.8, 12.9, 12.10, 12.11, and 12.12)

(a) Manual anastomosis (Fig. 12.8)
(b) Linear stapler anastomosis followed by closure of the opening (Fig. 12.9)
(c) Circular stapler anastomosis
    - Orvil device® anastomosis (21 or 25 mm) (Fig. 12.10a, b)

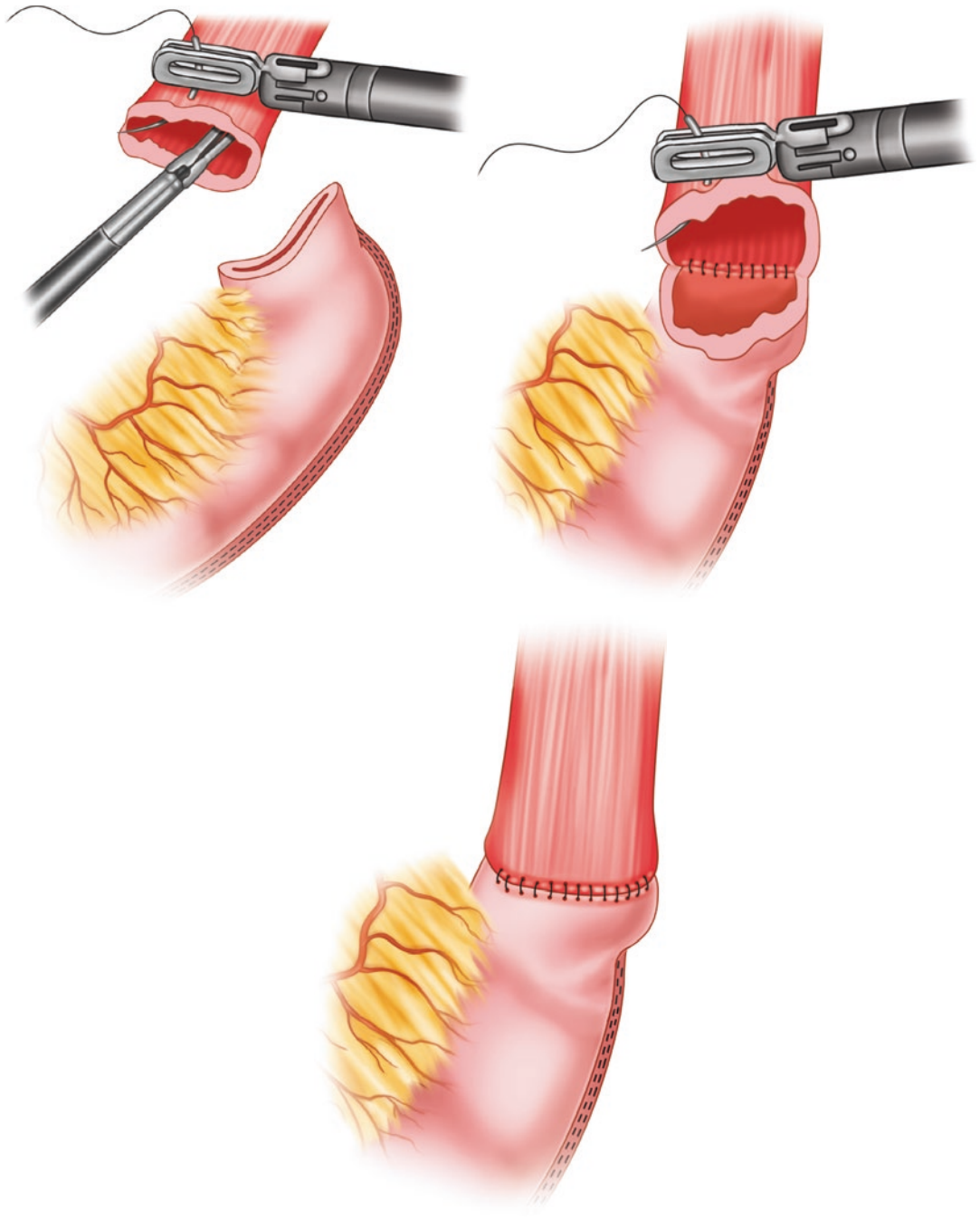


Fig. 12.8 Manual anastomosis

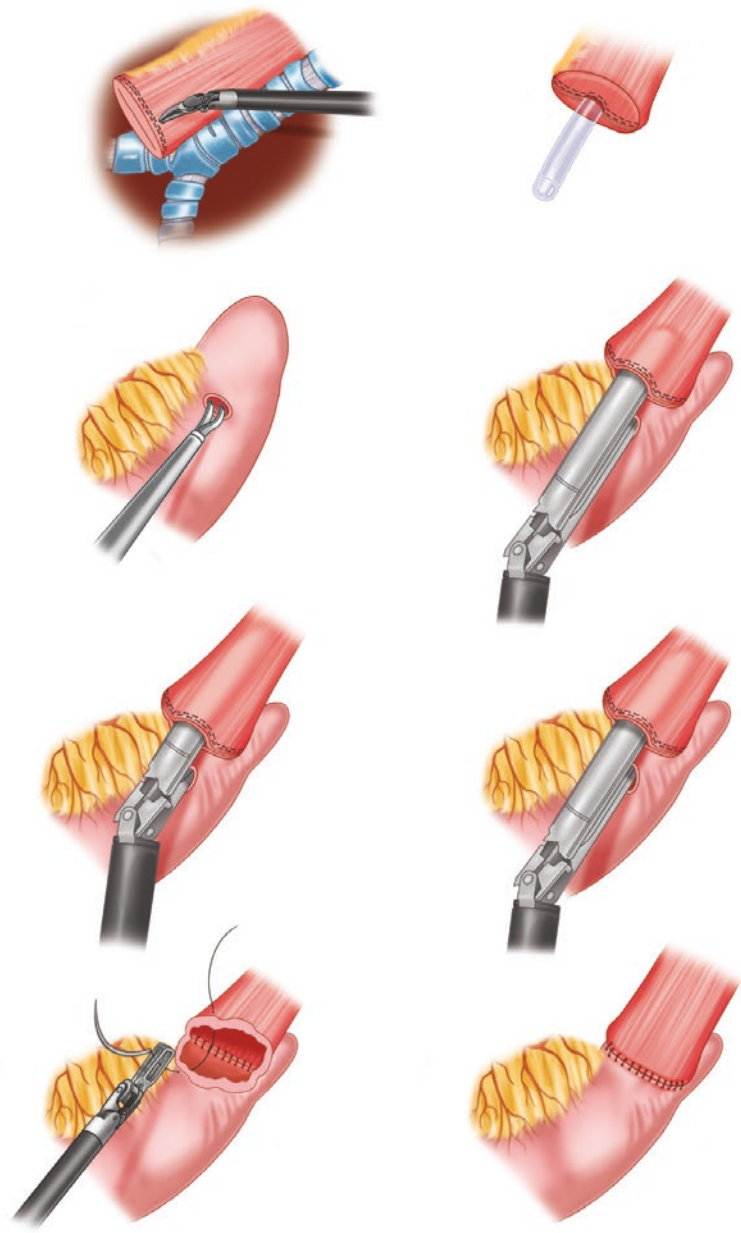


Fig. 12.9 Linear side to side anastomosis

- Conventional circular stapler around purse string (21, 25 or 28 mm) (Omental wrap anastomosis, Fig. 12.11)
- Robot assisted anastomosis (RAMIE) (Fig. 12.12).

9. A small protected thoracotomy is necessary for initiating the type of anastomosis in which a circular stapler will be positioned in the gastric tube and the anvil in the esophageal stump. For performing the manual, robot assisted and linear anastomosis, doing an initial small-assistance thoracotomy is not required. Only at the end of the procedure will the specimen need to be retrieved through the abdomen (patient must be repo-

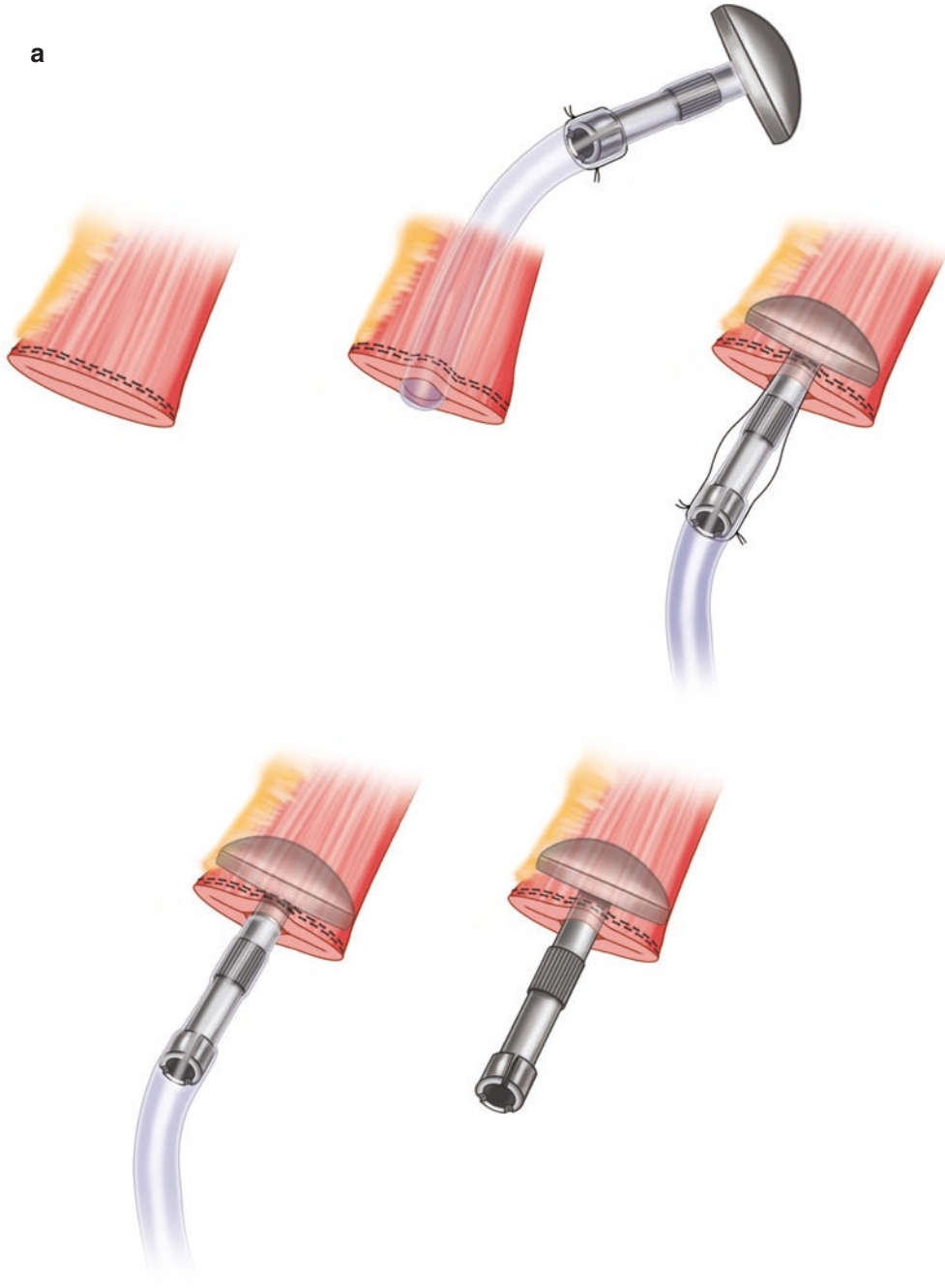


Fig. 12.10 (**a**) Circular anastomosis ORVIL. (**b**) Circular anastomosis ORVIL plus omental wrap, placement orvil in the esophagus stump

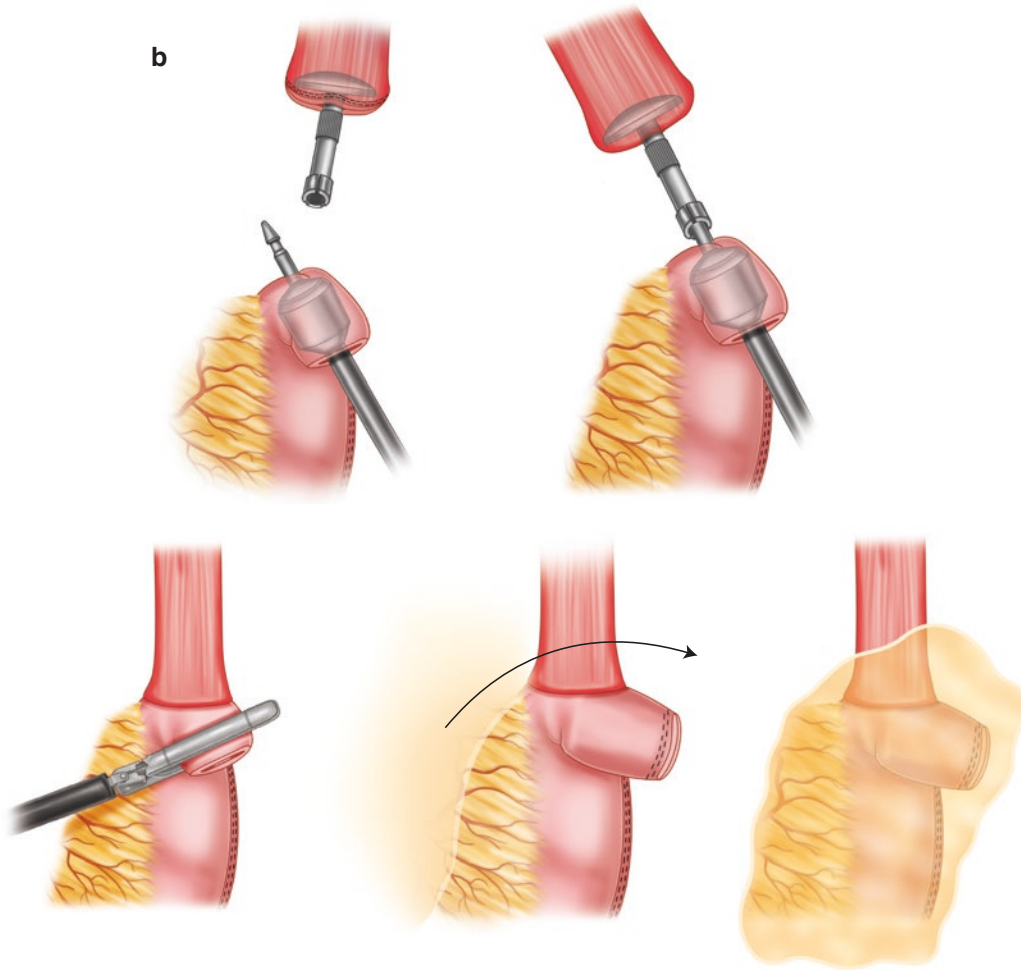


Fig. 12.10 (continued)

sitioned again) or retrieved at the end of the thoracoscopy by way of a small thoracotomy incision.

10. Concerning the type of intubation needed during the anastomosis phase, what is required for the manual, robot assisted, and the linear anastomosis is only a single intubation with two-lung ventilation (some anesthesiologists will use a selective intubation during the whole procedure). Whereas

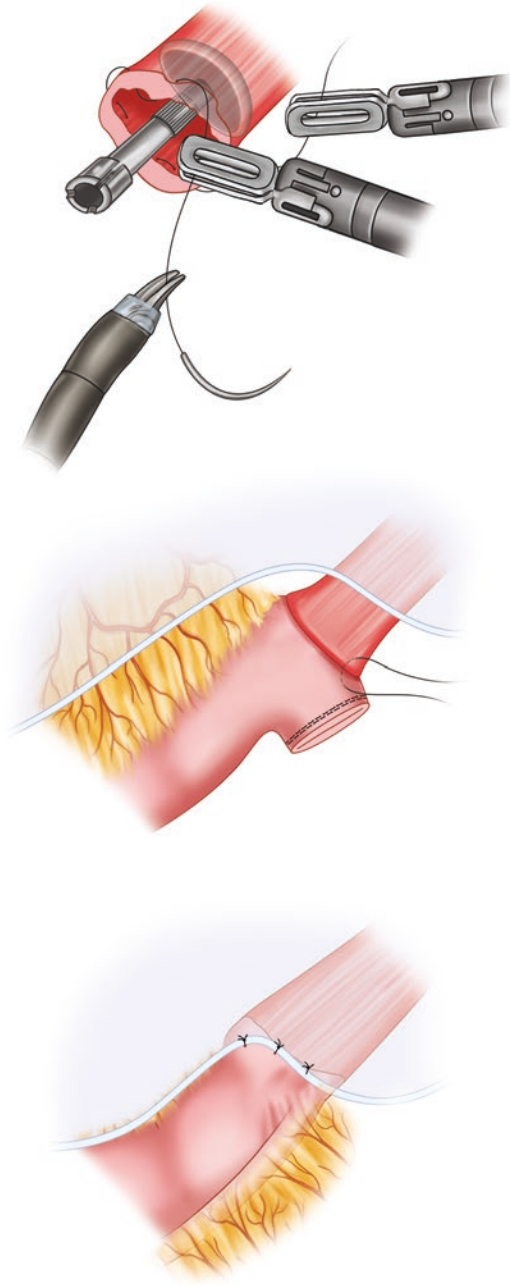


Fig. 12.11 Conventional circular stapler anastomosis and pleural flap

holding for the circular stapler anastomosis, a total collapse of the right lung during anastomosis is essential either by (a) selective intubation, or (b) placing a Fogarty catheter in the right bronchus to be inflated during the anastomosis phase or (3) applying to the wound a glove or some gel cap system along with maintaining a thoracic insufflation at 7–8 mmHg (Fig. 12.13).

12.3 Minimally Invasive Transhiatal Esophagectomy Operative Technique (see the Video 12.3)

The conventional operation technique described by Orringer and Sloan [1] is performed laparoscopically.

1. The patient is positioned in the supine position with the legs in the French position and the neck extended with exposure of the left side. The operating surgeon stands between the legs of the patient looking at two monitors placed at shoulder level of the patient. Two assistants stand on both sides of the patient, with the nurse on the right side of the surgeon.
2. A pneumoperitoneum is created by a 10-mm incision halfway between the xiphoid and the umbilicus on the left side of the middle line. The 30 degree camera is introduced through this trocar, and four other trocars are placed in the upper abdomen (Fig. 12.14).
3. Abdominal and local inspection at the hiatus takes place (Fig. 12.15). After displacement of the lateral segments of the left hepatic lobe and caudal traction of the stomach, a transhiatal dissection of the esophagus is laparoscopically performed in the plane between the pericardium, aorta, and both pleurae. For this part of the operation, a sealing device is used. After division of the hepatogastric ligament (pars flacida) and the most proximal short vessels, the space between the right crus and the esophagus is gentle opened in order to dissect the esophagus free and place a sling around it. In the case of junction tumors, a ring of the hiatus muscle is resected. The sling, placed around the esophagus, will permit traction of the esophagus in the caudal direction (Fig. 12.16).

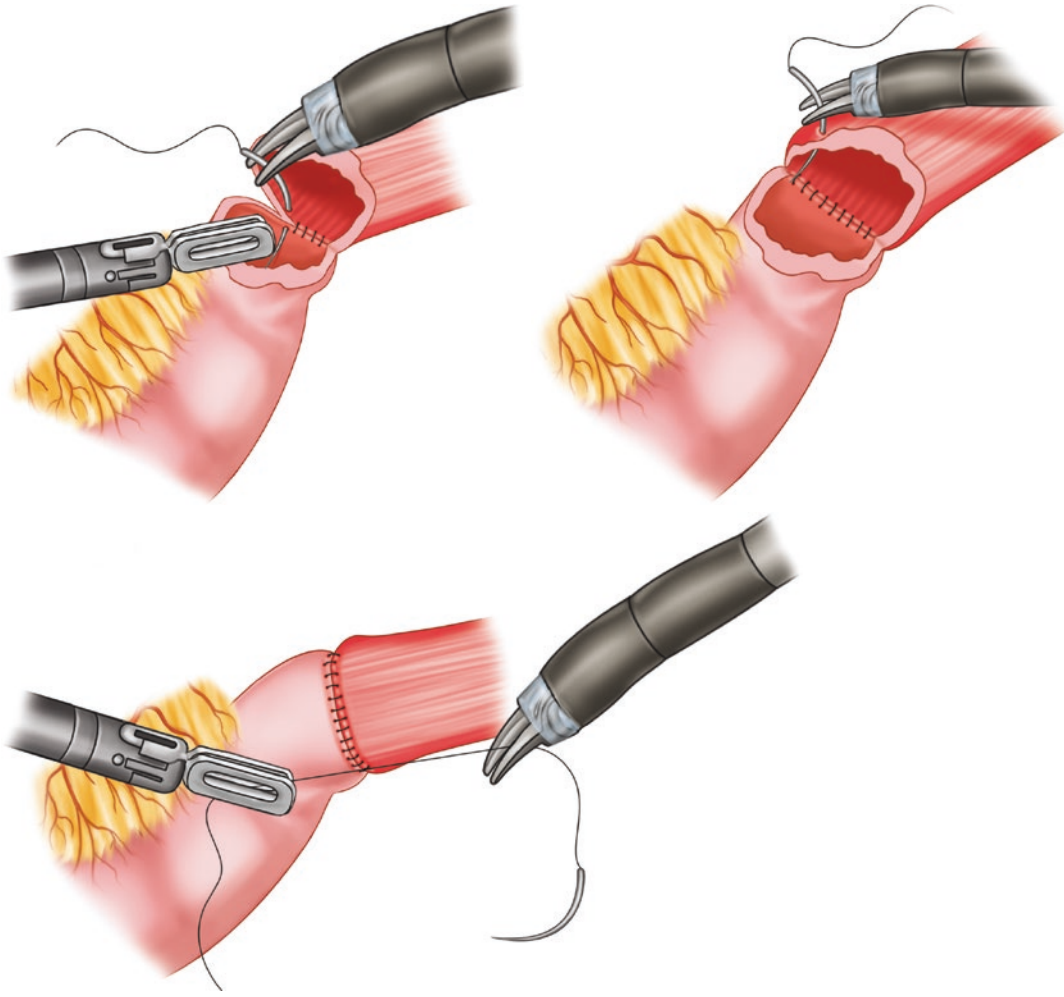


Fig. 12.12 Robot assisted anastomosis (RAMIE)

4. The hiatus is enlarged by dividing the anterior part with the division of the phrenic vein by means of the Ligasure device according to Pinotti [2] (Fig. 12.17). Anteriorly dissection is performed in an avascular plane in the anterior mediastinum with visualization of the pericardium and pulmonary vein (Fig. 12.18). Dissection continues anteriorly up to the level of the carina, in which the lymph nodes can be visualized but not resected.
5. On the right side of the esophagus, the aorta is approached at the level of the hiatus and in an avascular plane dissected free as high as possible in the posterior mediastinum.
6. Lateral dissection is performed on both sides at the level of the pleurae. The pleurae are always opened, on both sides in most cases, with resection of some part of it if necessary. The anaesthesiologist is warned of this situation because the mechanical ventilation must be adapted. Mechanical ventilation is corrected by means of increase of minute volume, use of positive end-expiratory pressure (PEEP) and decrease of the insufflation pressure to about 10 mmHg [3]. The esophagus is resected laparoscopically in this way, together with para-esophageal tissue and

Fig. 12.13 Gel cap system used in the small thoracotomy wound in order to maintain the insufflation and permit introduction of staplers and work trocars

periesophageal lymph nodes, to the level of the carina (Fig. 12.19a–d).

7. By retracting the stomach to the left, a D1+ lymphadenectomy of the celiac trunk and their branches is performed, to be followed by division of the left gastric artery and vein by means of a sealing device or clips. From there, the dissection is completed up to the hiatus (Fig. 12.20a–c).
8. The sealing device is used to mobilize the greater curvature of the stomach by dividing the gastro-colic ligament from the antrum-body junction, with preservation of the gastroepiploic vessels. Afterwards, the short gastric vessels are approached and divided up to the left crus of the hiatus.

   (These two steps, 7 and 8, can be performed in different order, first lymphadenectomy followed by gastric dissection or first gastric dissection followed by lymphadenectomy).
9. The next step is dissection of the cervical esophagus by means of a left-side cervical incision.
10. At the same time (if possible), another surgeon performs a small assistance periumbilical incision (7 cm) with protection. Through the lateral left trocar, a venous stripper is introduced into the gastric lumen by a small incision in the lesser gastric curvature and then pushed up to the cervical dissected esophagus. If the stripper cannot be pushed because of the obstruction caused by the

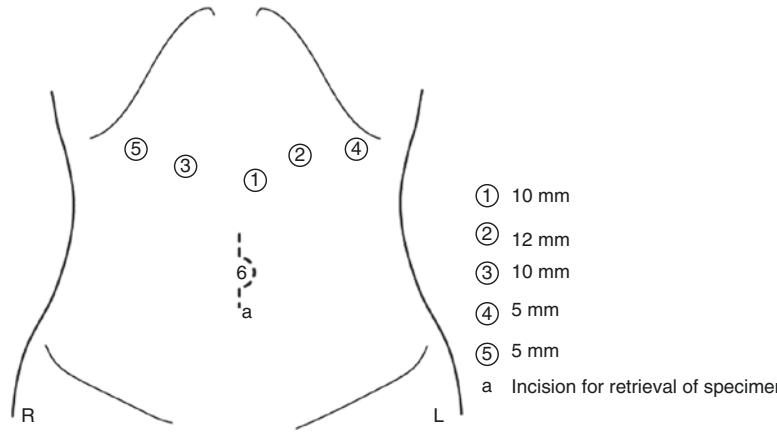


Fig. 12.14 Patient is placed for laparoscopic and cervical part of the procedure. Surgeon stands between the legs of the patient looking to the monitor at the level of the patient's shoulders (**a**). Position of the trocars along both subcostal margins (**b**)

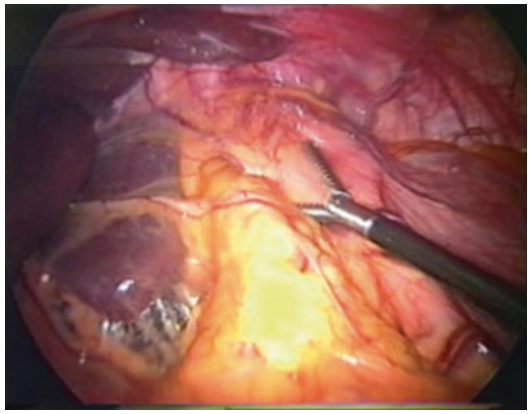


Fig. 12.15 Complete abdominal inspection is followed by local inspection of the hiatal area. Especially attention is paid, if tumor is located in the G-E junction, to its relation with the hiatal structures and lymph nodes

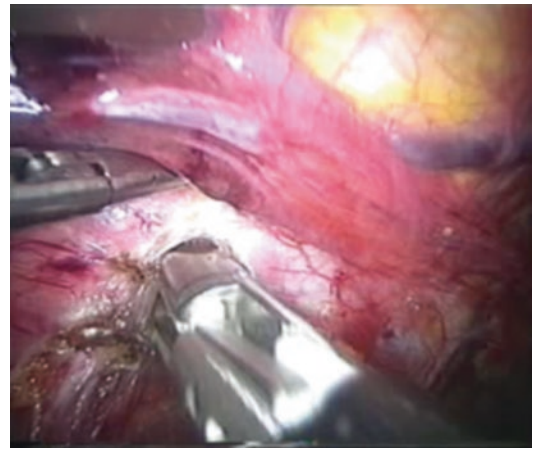


Fig. 12.17 Hiatus is open anteriorly according to Pinotti; the phrenic vein being divided by means of clips or sealing device

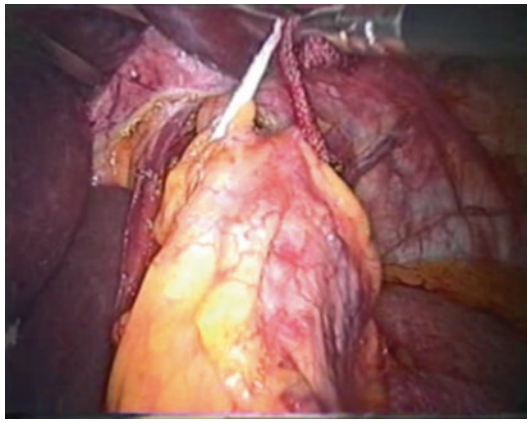


Fig. 12.16 In the case of a G-E junction tumor, a ring of the hiatus is excised in continuity with the tumor. Very gentle dissection permits to dissect the esophagus free and to put a sling around it for traction

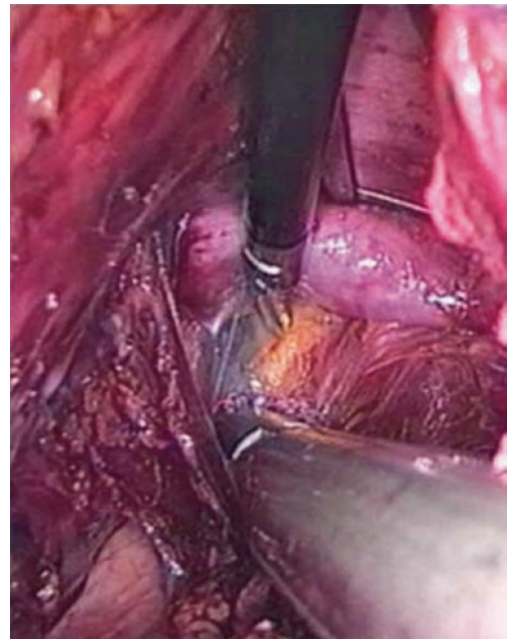


Fig. 12.18 Gentle blunt dissection is anteriorly performed along the plane of the pericard sac and inferior pulmonary vein

tumour, the feeding tube can be withdrawn via the small opening in the stomach and then exteriorised. The cervical esophagus is divided, after which the most distal part is closed around the stripper. A nasogastric tube is attached to it. Through the abdominal incision and manual assisted stripping of the esophagus will take place. This nasogastric tube can be used afterwards to lead the gastric tube upside to the cervical incision.

11. In this way, with the hand of the surgeon in the abdomen, the controlled stripping can be safely performed. In most patients, branches of the vagal nerves must be divided at this stage to retrieve the specimen through a fully protected periumbilical incision (Fig. 12.21a–c).
12. Once the specimen retrieved outside the abdomen, the mobilization of the stomach is completed, and the gastric tube is created,

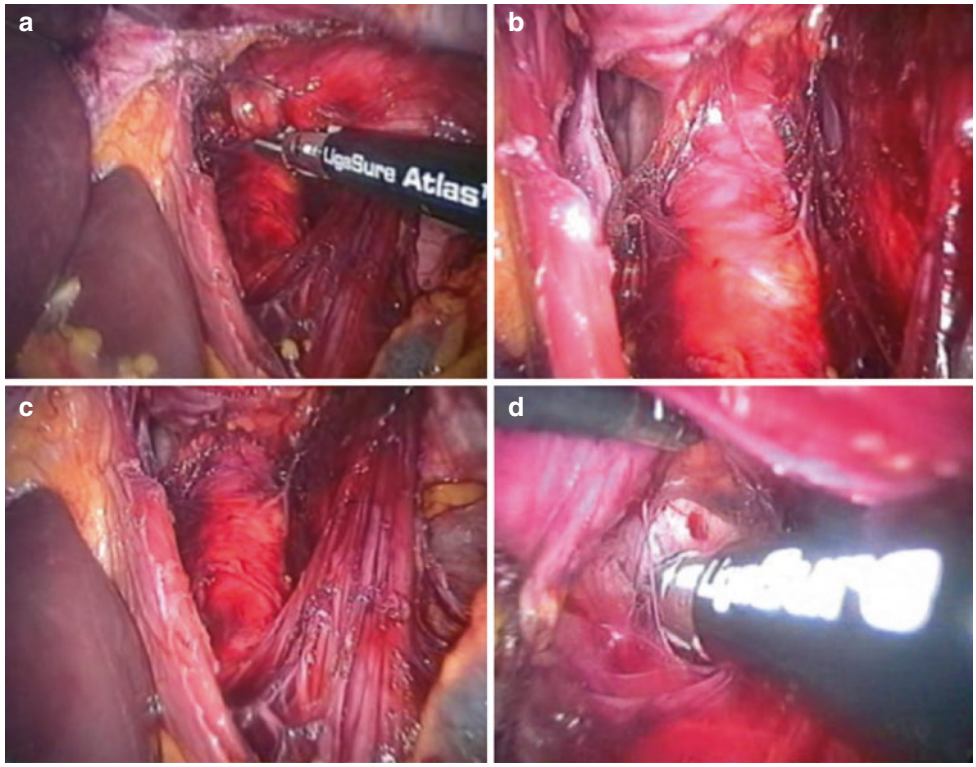


Fig. 12.19 (**a**–**d**) Posteriorly the aorta is dissected free at the level of the hiatus and dissected bluntly in proximal direction (**a**–**c**). Dissection proceeds at both lateral parts, taking down the lateral tissue (most of cases with a wedge of the pleura) by means of sealing device. (**d**): the carina is visualized

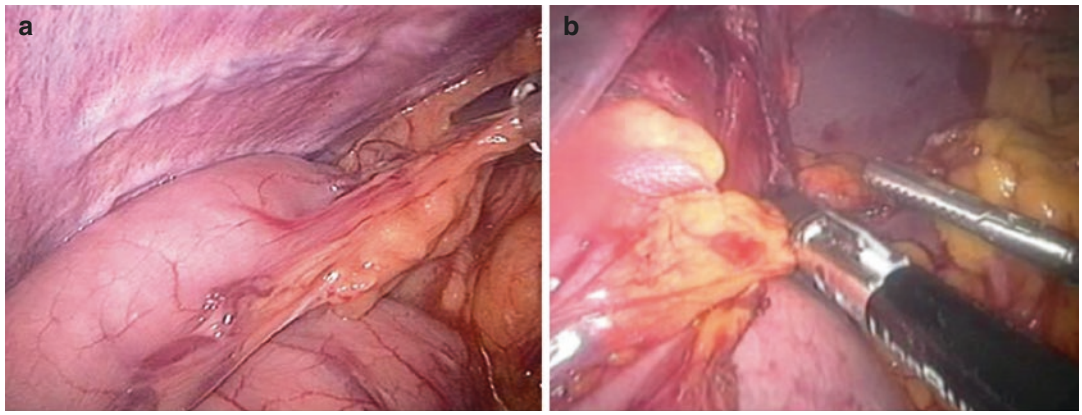
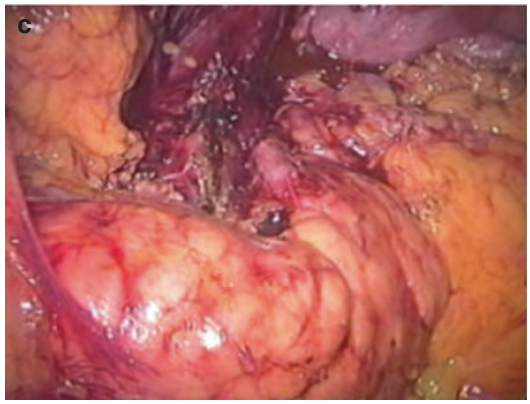


Fig. 12.20 (**a–c**) Procedure proceeds with gastrolysis along the greater curvature with preservation of the gastro-epiploic vessels (**a**–**b**). Lymphadenectomy of the celiac trunk should be now performed (**c**)



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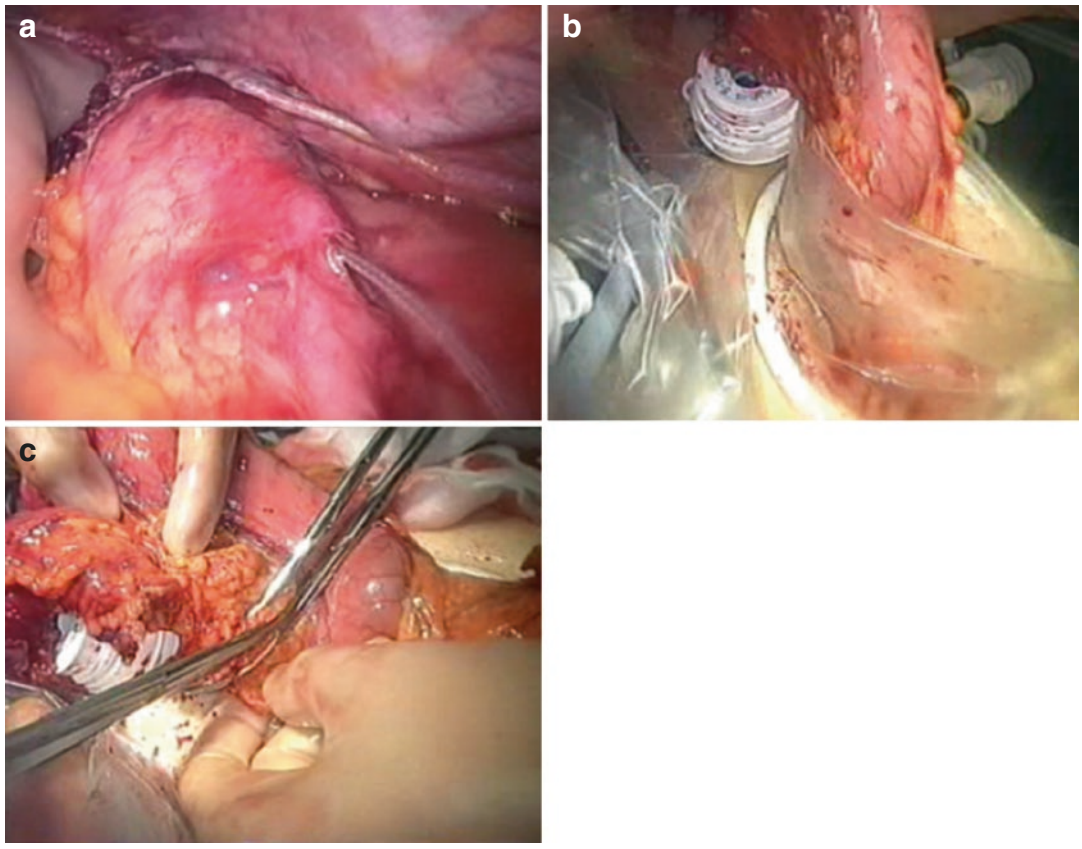

Fig. 12.21 (**a–c**) The cervical incision is done and after division of the esophagus, and by means of a stripper the specimen can be retrieved and exteriorized through the small and well protected abdominal wound

3–4 cm width, by using stapling device. The gastric tube then is oversewn and attached to the nasogastric tube and replaced in the abdomen. Next, the gastric tube is placed under vision into the cervical esophagus by traction of the nasogastric tube. A cervical anastomosis is created (Fig. 12.22a–c).

13. Through the transumbilical incision a jejunostomy feeding tube was placed for feeding and the two thoracic cavities were drained by two thoracic drains placed through the trocar openings. In none of the patients in this series was a Kocher manoeuvre, a pyloromyotomy, or a pyloroplasty performed.

Postoperatively patients were extubated after the operation when haemodinamically and respiratory stable.

Patients were fed through the jejunostomy feeding tube from the first day after their operation, until the oral feeding could be completely resumed.

Active mobilization and physiotherapy follows. On postoperative day 3 the nasogastric tube was removed and oral feeding was started.

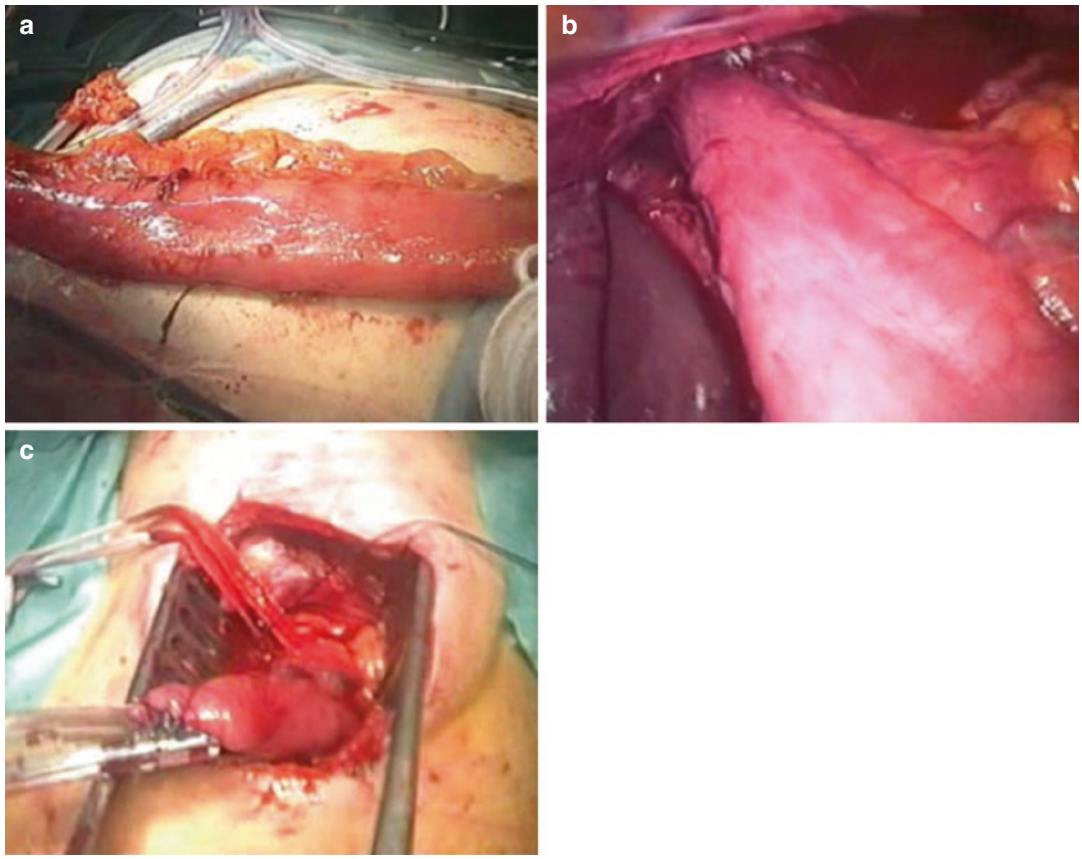

Fig. 12.22 (**a–c**) Once the specimen is exteriorized, gastric tube (3–4 cm) is created by means of staplers along the greater curvature. The good vascularized gastric tube is oversewn, attached to a nasogastric tube and pulled up into the cervical wound and anastomosed (**a–c**). Through the small laparotomy a jejunostomy catheter is introduced and both thoracic cavities are drained by means of drains introduced through the abdominal trocars ports

12.4 Comments

Current use of pyloroplasty remains controversial as well [4]. Even though many authors still include the drainage of the pylorus in the operative procedure. In our experience the avoidance of this pyloroplasty have not lead to any emptying problems of the gastric tube during the postoperative period but control of the pylorus passage at the third postoperative day is important. Therefore we do not recommend a routine pyloroplasty as part of the gastric tube formation.

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