Chapter 8
Minimally Invasive Treatment of GERD

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Abstract A laparoscopic total fundoplication is considered today the gold standard for the surgical treatment of gastroesophageal reflux disease (GERD). Short-term outcome is excellent, with low perioperative morbidity and fast recovery. Long-term follow-up has shown that symptom control is achieved in about 80–90 % of patients 10 years after a fundoplication.

This chapter describes the technical steps of a laparoscopic fundoplication.

Keywords Gastroesophageal reflux disease • Laparoscopic Nissen fundoplication • Total fundoplication • Partial fundoplication • Toupet fundoplication • Guarner fundoplication • Dor fundoplication

Introduction

The indications for surgical treatment of gastroesophageal reflux disease (GERD) have changed during the last two decades. While in the past antireflux surgery was often considered for patients who did not have a good response to acid-reducing medications, today the best indication for surgery is instead a good control of symptoms with proton pump inhibitors (PPIs) [1].

An antireflux operation is indicated when pathologic gastroesophageal reflux is documented by 24-h ambulatory pH monitoring and/or combined multichannel intraluminal impedance and pH testing (MII-pH) [2]. Indications include

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(a) heartburn and regurgitation not completely controlled by medications; (b) when it is suspected that respiratory symptoms are induced by gastroesophageal reflux; (c) desire of the patient to stop chronic use of PPI; (d) poor patient's compliance with medical treatment; (e) cost of medical therapy; (f) development of osteoporosis; (g) *C. difficile* infections, pneumonia, or hypomagnesemia; and (h) young patients in whom lifelong medical treatment is not advisable.

A laparoscopic total fundoplication is considered today the procedure of choice because it increases the resting pressure and length of the LES, decreases the number of transient LES relaxations, and improves quality of esophageal peristalsis [3, 4]. This procedure is associated with low morbidity, short hospital stay, and excellent outcome [5, 6]. Follow-up has shown that control of symptoms is achieved in about 80–90 % of patients 10 years after a fundoplication [7–9]. Control of reflux is not influenced by the pattern of reflux (i.e., upright versus supine) [6]. Furthermore, the procedure is equally safe and effective in young and elderly patients [5].

Postoperative dysphagia is one of the main risks of antireflux surgery. Several studies, mostly from Europe and Australia, have found that a partial fundoplication is as effective as a total fundoplication, and it is associated with a lower rate of postoperative dysphagia [10]. In the United States, however, many studies have shown that while a partial fundoplication and a total fundoplication have a similar rate of postoperative dysphagia, a partial fundoplication is less effective in controlling reflux than a total fundoplication. These data suggest that a total fundoplication should be the procedure of choice for patients with GERD regardless of the preoperative esophageal motility [3, 11, 12]. In most centers in the United States, a partial fundoplication is therefore performed only in selected patients with very impaired or absent esophageal peristalsis, such as those with scleroderma or achalasia.

Several eponyms are used in the literature to denote different antireflux operations: Nissen, Nissen-Rossetti, Toupet, Lind, Guarner, Hill, and Dor. However, we feel that it is more important to focus on the technical elements which make a fundoplication effective and long lasting.

This chapter discusses the technical aspects of total and partial laparoscopic fundoplication for the treatment of GERD.

Laparoscopic Total Fundoplication

Positioning of the Patient on the Operating Table

The patient lies supine on the operating table over a beanbag that is inflated to prevent sliding during the operation when a steep reverse Trendelenburg position is used. After induction of general anesthesia, an orogastric tube is inserted to keep the stomach decompressed, and it is removed at the end of the procedure. The legs are extended on stirrups, and the knees are flexed at a 20° to 30° angle. The surgeon

Table 8.1 Instrumentation for laparoscopic fundoplication

Five 10-mm ports
0° and 30° scope
Graspers and needle holder
Babcock clamp
L-shaped hook cautery with suction-irrigation capacity
Scissors
Laparoscopic clip applier
Electrothermal bipolar vessel sealing system
Liver retractor
Suturing device
2-0 silk sutures
Penrose drain
56-French esophageal bougie

performs the entire procedure standing between the patient's legs, with an assistant on the right side and another one on the left side of the operating table.

Instrumentation for Laparoscopic Fundoplication

The equipment required for the procedure includes five 10-mm trocars, a 30° camera, a hook cautery, and various other instruments (Table 8.1).

Step 1: Placement of Trocars

A five-trocar technique is used for the operation (Fig. 8.1). Trocar 1 is placed 14 cm inferior to the xiphoid process, in the midline, or 1–2 cm to the left of the midline to be in line with the esophagus. Extreme care must be taken when positioning this trocar, since the insertion site in the supraumbilical area is just above the aorta and its bifurcation. In order to increase the distance between the abdominal wall and the aorta and therefore reduce the risk of vessel injuries, the abdomen is initially inflated by using a Veress needle to a pressure of 15 mmHg. Subsequently, under direct vision, an optical port with a 0° scope is placed. Once this port is placed, the 0° scope is replaced with a 30° scope, and the other trocars are inserted under laparoscopic vision.

Trocar 2 is placed in the left midclavicular line at the same level with trocar 1, and it is used for insertion of a Babcock clamp, a grasper to hold the Penrose drain placed around the esophagus, or for devices used to divide the short gastric vessels. Trocar 3 is placed in the right midclavicular line at the same level of the other two trocars, and it is used for the insertion of a retractor to lift the left lateral segment of the liver. Trocars 4 and 5 are placed under the right and left costal margins, so that their axes form an angle of about 120° with the camera. They are used for the dissecting and suturing instruments.

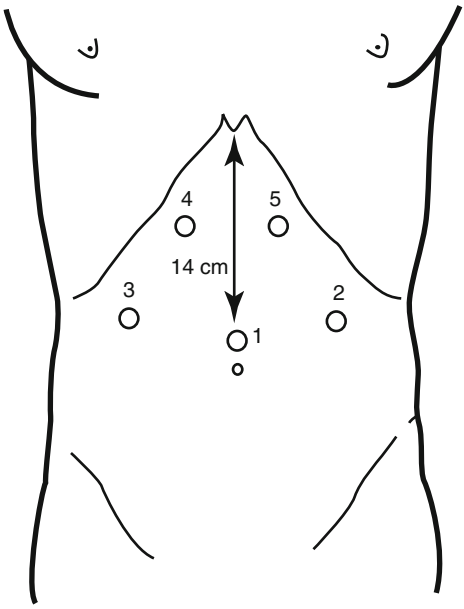

Fig. 8.1 Trocars' placement. Trocar *1* 30° camera, *trocar 2* Babcock clamp, *trocar 3* liver retractor, *trocars 4 and 5* dissection and suturing instruments

Step 2: Division of Gastrohepatic Ligament; Identification of Right Crus of the Diaphragm and Posterior Vagus Nerve

The gastrohepatic ligament is divided, beginning above the caudate lobe of the liver, where the ligament is usually very thin, and continuing toward the diaphragm until the right crus is identified. The crus is then separated from the right side of the esophagus by blunt dissection, identifying the posterior vagus nerve. The right crus is dissected inferiorly toward the junction with the left crus.

During the dissection of the right crus from the esophagus, the electrocautery should be used with extreme caution. Because of the lateral spread of the monopolar current, the posterior vagus nerve may be damaged, even without direct contact. A bipolar instrument represents a safer alternative.

An accessory left hepatic artery originating from the left gastric artery is frequently present in the gastrohepatic ligament. Preservation of this artery should be attempted if possible; however, if this vessel limits the exposure, it may be divided.

Step 3: Division of Peritoneum and Phrenoesophageal Membrane Above the Esophagus and Identification of the Left Crus of Diaphragm and Anterior Vagus Nerve

The peritoneum and the phrenoesophageal membrane above the esophagus are transected with the electrocautery, and the anterior vagus nerve is identified. The left

crus of the diaphragm is dissected bluntly downward toward the junction with the right crus.

This dissection must be performed with extreme caution to avoid an injury to the anterior vagus nerve or the esophageal wall. Accordingly, the nerve should be left attached to the esophageal wall, and the peritoneum and the phrenoesophageal membrane should be lifted from the wall by blunt dissection before they are divided.

Step 4: Division of Short Gastric Vessels

The 5-mm laparoscopic bipolar instrument is introduced through trocar 2. A grasper is introduced through trocar 5 and held by the surgeon, while traction on the greater curvature of the stomach is applied by an assistant through trocar 4. The dissection begins at the level of the middle portion of the gastric body and continues upward until the most proximal short gastric vessel is divided [13].

Bleeding, either from the short gastric vessels or from the spleen, and damage to the gastric wall are possible complications during this step of the procedure.

Excessive traction and division of a not completely coagulated vessel are the most common causes of bleeding from the short gastric vessels, while a burn from the electrocautery during dissection between vessels and traction applied with the graspers or the Babcock clamp are the most common mechanisms of damage to the gastric wall.

Step 5: Creation of a Window Between Gastric Fundus, Esophagus, and Diaphragmatic Crura and Placement of Penrose Drain Around the Esophagus

A Babcock clamp is applied at the level of the esophagogastric junction to retract upward the esophagus. A window is opened by a blunt and sharp dissection under the esophagus, between the gastric fundus, the esophagus, and the left pillar of the crus. The window is then enlarged, and a Penrose drain is passed around the esophagus, incorporating both the anterior and the posterior vagus nerves.

The two main complications that can occur during this part of the procedure are (1) creation of a left pneumothorax and (2) perforation of the gastric fundus. A left pneumothorax is usually created when the dissection is performed above the left pillar of the crus in the mediastinum, rather than between the crus and the gastric fundus.

Perforation of the gastric fundus is usually caused by pushing a blunt instrument under the esophagus. Sometimes, monopolar electrocautery used for dissection can cause a perforation. An electrocautery burn may be not recognized intraoperatively, and it usually manifests itself clinically during the first postoperative day.

Step 6: Closure of Crura

The diaphragmatic crura are closed with interrupted 2-0 silk sutures that are tied intracorporeally. Retraction of the esophagus upward and toward the patient's left with the Penrose drain provides proper exposure. The first stitch should be placed just above the junction of the two pillars. Additional stitches are placed 1 cm apart, and a space of about 1 cm is left between the uppermost stitch and the esophagus.

Step 7: Insertion of the Bougie into the Esophagus and Across the Esophageal Junction

After removal of the orogastric tube, a 56-French bougie is inserted down the esophagus through the esophagogastric junction [14]. The crura must be snug around the esophagus but not too tight: a closed grasper should slide easily between the esophagus and the crura.

The most serious complication during this step is an esophageal perforation. Lubrication of the bougie and slow advancement of the bougie by the anesthesiologist help prevent this complication. In addition, all instruments must be removed from the esophagogastric junction, and the Penrose drain must be opened. These measures prevent the creation of an angle between the stomach and the esophagus, which increases the risk of perforation.

Step 8: Wrapping of Gastric Fundus Around the Lower Esophagus

The surgeon gently pulls the gastric fundus under the esophagus with two graspers. The left and right sides of the fundus are wrapped above the esophagogastric junction. A Babcock clamp introduced through trocar 2 is used to hold the two flaps together during placement of the first stitch. The two edges of the wrap are secured to each other by three 2-0 silk placed at 1 cm of distance from each other. Two coronal stitches are then placed between the top of the wrap, the esophagus, and the right or left pillar of the crus. Finally, one additional suture is placed between the right side of the wrap and the closed crura (Fig. 8.2).

One way to evaluate whether the wrap is going to be floppy consists of delivering the fundus under the esophagus, checking for the origins of the transected short gastric vessels. Essentially, the wrap is being done using both the anterior and the posterior wall of the fundus. If the wrap remains to the right side of the esophagus and does not retract back to the left, then it is floppy and suturing can be performed. If not, the surgeon must make sure that the upper short gastric vessels have been

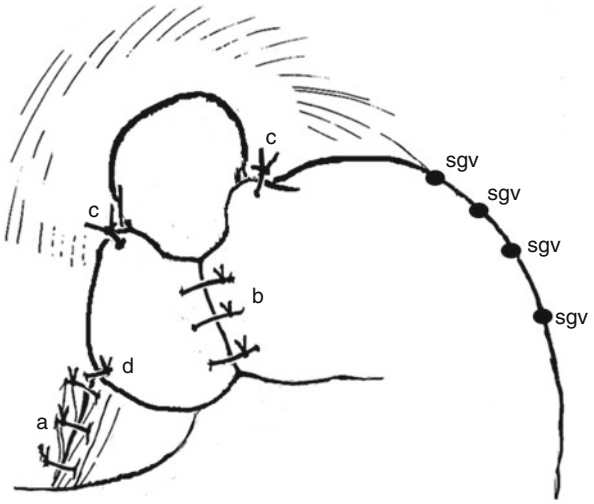

Fig. 8.2 Total fundoplication. *a* indicates closure of crura, *b* wrap, *c* coronal sutures, *d* posterior suture, and *sgv* divided short gastric vessels

transected and the posterior dissection completed. To avoid redundancy of the wrap, a "shoeshine" maneuver should be performed. If tension is still present after these maneuvers, a partial wrap is preferable.

Damage to the gastric wall may occur during the delivery of the fundus. The surgeon should use atraumatic graspers pulling gently and passing the tissue from one grasper to the other. The wrap should be no more than 2–2.5 cm in length.

Step 9: Final Inspection, Removal of Instruments and Trocars from the Abdomen, and Closure of the Port Sites

The instruments and the trocars are removed from the abdomen under direct vision, and the trocars sites are closed.

Laparoscopic Partial Fundoplication

The first six steps are identical to those of a total fundoplication.

Partial Posterior Fundoplication

Once the gastric fundus is delivered, it is gently pulled under the esophagus with two graspers. The right and left sides of the wrap are separately sutured to the esophagus, leaving 80°–120° of the anterior esophageal wall uncovered. Three 2-0

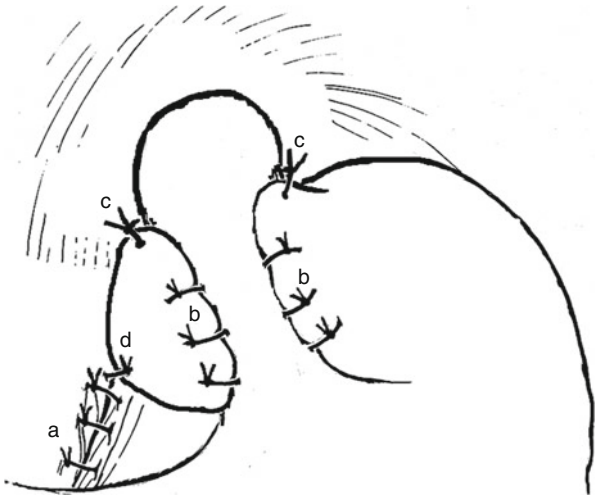

Fig. 8.3 Partial fundoplication. *a* crura closure, *b* posterior partial fundoplication, *c* two coronal stitches placed between the *top* of the wrap, the esophagus, and the *right* or *left* pillar of the crus, *d* one additional stitch placed between the *right* side of the wrap and the closed crura

silk sutures are placed on each side between the muscular layers of the esophageal wall and the gastric fundus. Two coronal stitches are then placed between the top of the wrap, the esophagus, and the right or left pillar of the crus. One additional stitch is placed between the right side of the wrap and the closed crura. The resulting wrap measures about 240°–280° (Fig. 8.3).

Partial Anterior Fundoplication

It is a 180° anterior fundoplication. Two rows of sutures (2-0 silk) are used. The first row is on the left side of the esophagus and has three stitches. The top stitch incorporates the fundus of the stomach, the left side of the esophageal wall, and the left pillar of the crus. The second and third stitches incorporate the gastric fundus and the muscular layer of the left side of the esophagus. The fundus is then folded over the esophagus so that the greater curvature of the stomach is next to the right pillar of the crus. The second row of sutures on the right side of the esophagus consists of three stitches between the fundus and the right pillar of the crus. Finally, two additional stitches are placed between the fundus and the rim of the esophageal hiatus to eliminate any tension from the fundoplication.

Postoperative Course

Patients are fed with clear liquids and then a soft diet the morning of the first postoperative day and are instructed to avoid meat, bread, and carbonated beverages for the following 2 weeks. About 85 % of patients are discharged within 23 h, and 95 % of patients are discharged within 48 h. Most patients resume their regular activity within 2 weeks.

Postoperative Complications

Esophageal or gastric perforation is a feared complication of laparoscopic fundoplication, which may be caused either by traction or by an inadvertent electrocautery burns during any step of the dissection. A leak usually manifests itself during the first 48 h. The patient will show peritoneal signs if the spillage is limited to the abdomen; shortness of breath and a pleural effusion will be noted if spillage also occurs in the chest. The site of the leak must always be confirmed by a contrast study with a water-soluble contrast agent. Optimal management consists of a reoperation and direct repair.

Short-Term Outcomes

Almost every patient after total fundoplication experiences some degree of dysphagia postoperatively. Dysphagia usually resolves after 6–10 weeks [3]. If dysphagia persists beyond this period, one or more of the following could be the cause:

1. A too tight or too long (i.e., >2.5 cm) wrap [14]. In case of a too tight wrap, endoscopic dilatation represents the initial therapy in most cases [15], while redo surgery is an alternative option in case of failure of endoscopic treatment.
2. Lateral torsion of the wrap to the right with corkscrew effect secondary to tension from intact short gastric vessels or to a small gastric fundus [13].
3. A wrap made with the body of the stomach rather than the fundus. LES and the gastric fundus relax simultaneously with swallowing after a properly done fundoplication. In this case, the fundus will not relax as the LES does on arrival of the food bolus [16].
4. Choice of the wrong procedure. A partial wrap is preferable in case of severely impaired or absent esophageal peristalsis [17], because a 360° wrap may be the cause of postoperative dysphagia and gas bloat syndrome.

Long-Term Outcomes

Ten-year or greater follow-up studies have shown that symptom relief and reflux control is achieved in about 80–90 % of patients undergoing total fundoplication for GERD [7–9].

On the other hand, long-term studies have reported a less effective control of gastroesophageal reflux with a partial fundoplication rather than a total fundoplication [3, 11, 12]. At 5-year follow-up, recurrence of gastroesophageal reflux confirmed by pH monitoring was reported in more than 50 % of patients after partial fundoplication [3, 11, 12].

Late complications of fundoplication include wrap disruption and herniation of an intact wrap. If the gastroesophageal junction and the wrap slip into the chest, the patient may experience dysphagia and regurgitation. The diagnosis is confirmed by

a barium swallow. The incidence of paraesophageal hernia may be increased if the coronal suture is not used and the closure of the crura is not performed or if it is too loose [13, 16]. This step not only is essential for reducing the risk of paraesophageal hernia [16, 18, 19], but also it is important from a physiologic point of view, as it helps to strengthen the LES preventing reflux.

Conflict of Interest The authors have no conflicts of interest to declare.

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