J Gastrointest Surg (2013) 17:822–828
DOI 10.1007/s11605-012-2068-2

HOW I DO IT

Laparoscopic Total Fundoplication for Gastroesophageal Reflux Disease. How I Do It

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Received: 15 August 2012 / Accepted: 15 October 2012 / Published online: 6 November 2012

Abstract
Introduction A laparoscopic fundoplication is considered today the procedure of choice for the treatment of gastroesophageal reflux disease (GERD).
Discussion Several eponyms are used in the literature to denote different antireflux operations: Nissen, Nissen-Rossetti, Toupet, Lind, Guarner, Hill, and Dor. We feel that it is more important to focus on the technical elements which make a fundoplication effective and long lasting. The type of fundoplication (total vs. partial) is tailored to the quality of esophageal peristalsis as documented by the preoperative manometry. In the USA, a partial fundoplication is chosen only for patients with very impaired or absent esophageal peristalsis.
Conclusion This article describes the technique of laparoscopic total fundoplication for GERD. Partial fundoplication is performed following the same technical elements as the total fundoplication. A 240° to 270° wrap rather than a 360° wrap is performed.

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

Introduction

The indications for surgery for gastroesophageal reflux disease (GERD) have changed in the last 20 years. Surgery was often considered for patients who did not respond well to acid-reducing medications. Today, the best candidate for surgery is instead a patient who has good control of symptoms with proton pump inhibitors.[1] An operation is indicated when abnormal GER is demonstrated by ambulatory pH monitoring and/or combined multichannel intraluminal impedance and pH testing (MII-pH).[2] Indications include: unwillingness of the patient to take medications; heartburn and regurgitation not completely controlled by medications; when it is suspected that respiratory symptoms are induced by GER; poor patient's compliance with medical treatment; cost of medical therapy; postmenopausal women with osteoporosis; complications of the medical therapy such osteoporosis, *Clostridium difficile* infections, pneumonia or hypomagnesemia; and young patients in whom life-long 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 lower esophageal sphincter (LES), decreases the number of transient LES relaxations and improves quality of esophageal peristalsis.[3,4] This procedure is associated with a low morbidity, a 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] 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]

One of the main risks of antireflux surgery is postoperative dysphagia. Several studies, mostly from Europe and Australia, have found that a partial fundoplication is as effective as a total fundoplication, but it is associated with a lower rate of postoperative dysphagia.[8] In the USA, however, many studies have shown that while a partial

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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, suggesting that a total fundoplication should be the procedure of choice for patients with GERD regardless of the preoperative esophageal motility.[3,9,10] In most centers in the USA, a partial fundoplication is therefore performed only in selected patients with very impaired or absent esophageal peristalsis, such as those with scleroderma and those who undergo Heller myotomy for achalasia.

The following describes a step-by-step approach of a laparoscopic total fundoplication for the treatment of GERD.

Positioning of the Patient on the Operating Table

The patient lies supine on the operating table over a bean bag 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 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 Total Fundoplication

The equipment required for the procedure includes five 10-mm trocars, a 30° camera, a hook cautery, and various other instruments (Table 1).

Table 1 Instrumentation for laparoscopic total fundoplication

Five 10-mm trocars
30° camera
Graspers and needle holder
Babcock clamp
L-shaped hook cautery with suction–irrigation capacity
Scissors
Laparoscopic clip applier
LigaSure™ Vessel Sealing System (Valleylab, Boulder, CO, USA)
Liver retractor
Endo Stitch device (Covidien, Norwalk, CT, USA)
Penrose drain
2-0 silk sutures
56 French esophageal bougie

Step 1: Placement of Trocars

Five trocars are used for the operation (Fig. 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 hiatus, and it is used for a 30° camera. Trocar 2 is placed in the left mid clavicular 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 while surrounding the esophagus; or for devices used to divide the short gastric vessels. Trocar 3 is placed in the right mid-clavicular 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.

Comments

Extreme care must be taken when positioning trocar 1 in the supraumbilical area, since this site is just above the aorta and its bifurcartion. We initially inflate the abdomen by using a Veress needle to a pressure of 18 mmHg for placement of this trocar, so that the increased distance between the abdominal wall and the aorta reduces the risk of vessel injuries. Alternatively, a Hassan cannula can be used. We

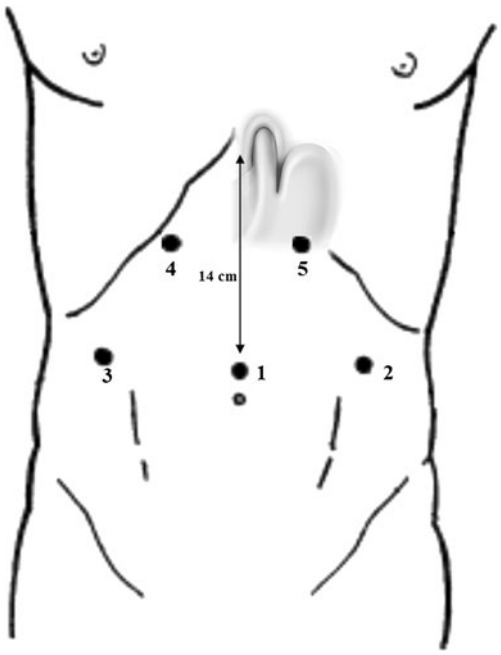

Fig. 1 Trocars' placement; Trocar1=30° camera, Trocar2=Babcock clamp, Trocar3=liver retractor, Trocars4 and 5=dissection and suturing instruments

recommend using an optical trocar with a 0° scope to obtain access. Once trocar 1 is placed, the pneumoperitoneum pressure is reduced to 15 mmHg, and the other trocars can be placed under direct vision.

A too-low placement of the trocars makes the entire procedure more difficult. If trocar 3 is too low, the left lateral segment of the liver will not be properly retracted and the esophagogastric junction will not be adequately exposed. If port 2 is too low, the esophagogastric junction will not be easily reached by the Babcock clamp, and the device used to divide the short gastric vessels will not be able to take down the upper short gastric vessels. If trocars 4 and 5 are too low, the dissection at the beginning of the procedure and the suturing at the end will be challenging.

Other mistakes of trocar positioning include a too-medial placement of trocar 3 that makes the liver retractor interfere with the instrument used through trocar 4. The gallbladder fossa is a good landmark for placing this trocar.

Maintaining the proper angle (80° to 120°) between the instruments inserted through trocars 4 and 5 and the camera is crucial: if the angle is too small or too large, the dissection and the suturing may be difficult.

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 (Fig. 2).

Comments

An accessory left hepatic artery originating from the left gastric artery is frequently present in the gastrohepatic ligament. If this vessel limits the exposure, it may be safely divided. However, if this is a fully replaced left hepatic artery, it is preserved.

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.

Step 3: Division of Peritoneum and Phreno-Esophageal Membrane above Esophagus; Identification of the Left Crus of Diaphragm and Anterior Vagus Nerve

The peritoneum and the phreno-esophageal 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 (Fig. 3).

Comments

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 phreno-esophageal membrane should be lifted

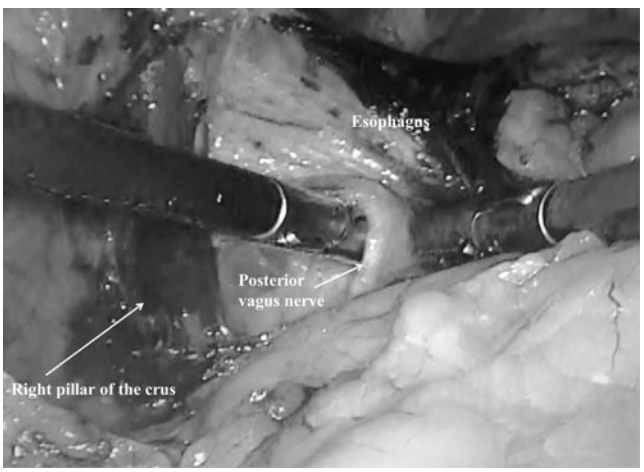

Fig. 2 Dissection of the right pillar of the crus

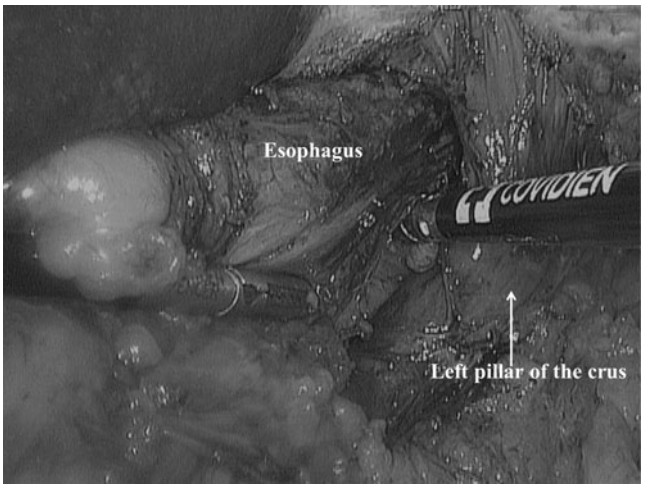

Fig. 3 Dissection of the left pillar of the crus

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 an assistant applies traction on the greater curvature of the stomach through trocar 4. The surgeon begins the dissection at the level of the middle portion of the gastric body and continues upward until the most proximal short gastric vessel is divided.[11]

Comments

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 or division of a vessel that is not completely coagulated are usually the main causes of bleeding from the short gastric vessels, while a burn from the electrocautery during dissection between vessels or 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; 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.

Comments

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. It can be avoided by a proper dissection and identification of the left pillar of the crus.

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

An Endo Stitch device (Covidien, Norwalk, CT, USA) with interrupted 2-0 silk sutures that are tied intracorporeally is used to close the diaphragmatic crura. 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 (Fig. 4).

Comments

Because it would interfere with exposure and suturing, the bougie is not placed inside the esophagus during this part of the procedure.

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

After the orogastric tube is removed, the anesthesiologist inserts a 56 French bougie down the esophagus through the esophagogastric junction.[12] The crura must be snug around the esophagus but not too tight: a closed grasper should slide easily between the esophagus and the crura.

Comments

The most serious complication during this step is an esophageal perforation. Lubrification of the bougie and instruction to

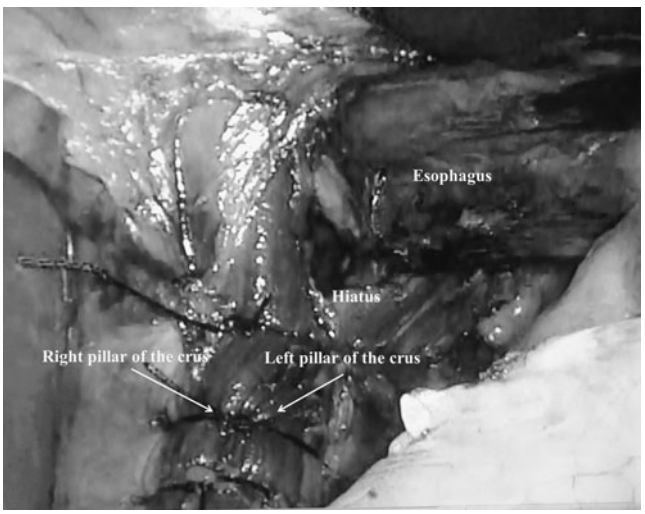

Fig. 4 Closure of the crura

the anesthesiologist to advance the bougie slowly and to stop if any resistance is encountered help preventing 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 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 (Fig. 5). 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. 6).

Comments

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 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 transected and the posterior dissection completed. If tension is still present after these maneuvers, a partial wrap is preferable.

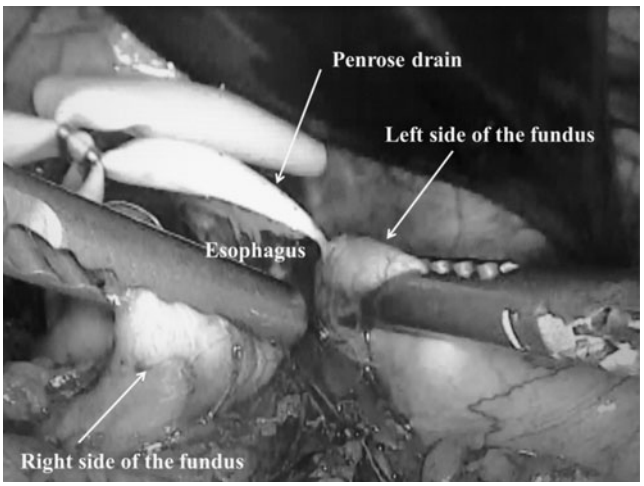

Fig. 5 Wrapping of the gastric fundus around the lower esophagus

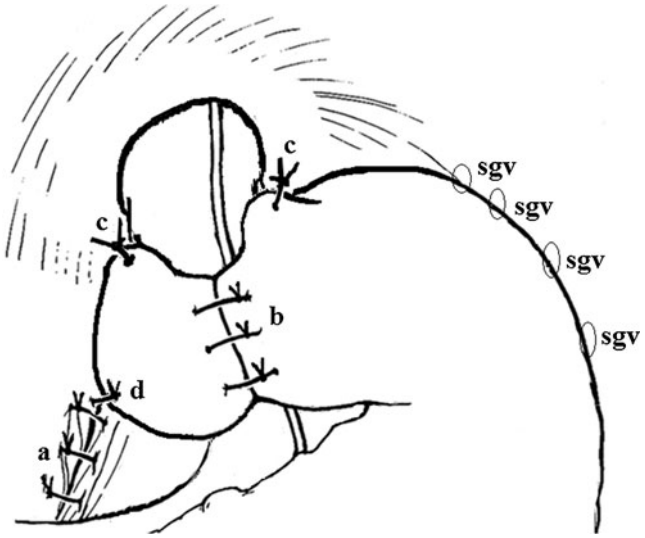

Fig. 6 Total fundoplication; *a* closure of crura, *b* wrap, *c* coronal sutures, *d* posterior suture; *sgv* divided short gastric vessels

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.

If an increased peak airway pressure (because of a pneumothorax) or neck emphysema (because of a pneumomediastinum) are observed, the intra-abdominal pressure should be reduced from 15 mmHg to 8 or 10 mmHg until the end of the procedure. Pneumomediastinum tends to resolve spontaneously within a few hours after the end of the procedure. Small pneumothoraces (usually on the left side) tend to resolve without any intervention, while larger pneumothoraces must be treated by insertion of a chest tube.

Table 2 Technical elements of fundoplication

Extent of fundic mobilization (short gastric vessels division)
Location of gastroesophageal junction
Size of bougie
Closure of hiatus
Type of wrap
Length of wrap
Space around wrap
Anchoring of wrap to the esophagus
Anchoring of wrap in the abdomen

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

After hemostasis is achieved, the instruments and the trocars are removed from the abdomen under direct vision.

Postoperative Course

Patients are fed the morning of the first postoperative day with clear liquids and then a soft diet, 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 total 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.

Almost every patient 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.[12] In case of a too-tight wrap, endoscopic dilatation represents the initial therapy in most cases,[13] while redo surgery is an alternative option in case of endoscopic failure.
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.[11]
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.
4. Choice of the wrong procedure. A partial wrap is preferable in case of severely impaired esophageal peristalsis,[14] because a 360° wrap may be the cause of postoperative dysphagia and gas bloat syndrome.

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 use of coronal suture and the closure of the crura reduce the risk of this complication.[11,15]

The incidence of paraesophageal hernia may be increased if the closure of the crura is not performed or if it is too loose.[11] We believe that this step not only is essential for reducing the risk of paraesophageal hernia[15–17] but also it is important from a physiologic point of view, as it helps to strengthen the LES preventing reflux.

Conclusions

The minimally invasive approach to antireflux surgery allows control of GER in a safe manner without troublesome side effects. Long-term outcomes are excellent. The key for success is a careful preoperative evaluation and the performance of an operation that takes into account the important technical elements[18] (Table 2).

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

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