Laparoscopic Rossetti Fundoplication

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A fundal wrap of the abdominal segment of the esophagus, transposed from the Rossetti modification[1] of the classic Nissen fundoplication,[2,3] is the operation of choice for surgical treatment of gastroesophageal reflux refractory to medical therapy. Previously validated by open anti-reflux surgery, fundoplication has also proven reliable, effective, and reproducible when performed by laparoscopy,[4] a technique the authors have used routinely since 1989 thanks to the experience gained in vagotomy by a transhiatal approach.[5,6,7,8]

BASIS OF TREATMENT

The procedure is aimed at restoring the three mechanisms governing competence of the cardioesophageal junction[9,10,11,12]:

- sphincteric function: the cardia is repositioned by bringing down the abdominal esophagus and reducing any associated hiatal hernia. This restores sphincteric tone in the lower esophagus where a physiologic pressure barrier is established between the esophagus and the stomach.
- diaphragmatic function: the pinch-cock action of the diaphragm that helps maintain this pressure barrier is reinforced by approximating the diaphragmatic crura posterior to the abdominal esophagus, thus closing the hiatus. This also prevents mechanical complications such as re-elevation of the abdominal esophagus, loosening of the surgically created unit, or mediastinal impaction of the flap valve system.
- valvular function: total (360 degrees) fundoplication is achieved by mechanical application of the fundus around the entire esophageal sphincter zone. Use of the anterior aspect of the

fundus, as suggested by Rossetti, provides sufficient material for a complete wrap (Figure 1). This prevents supercompetence, a cause of postoperative dysphagia. It also obviates the need for division of the short gastric vessels, thereby avoiding injury to the spleen (Figure 2).

PROCEDURE

Preoperative evaluation, general anesthesia with intubation, and perioperative care are similar to open antireflux surgery. Likewise, creation and maintenance of a pneumoperitoneum, utilization of video-endoscopy, irrigation-suction, electrocoagulation, and laser are the same as for other laparoscopic surgical operations. Thus this discussion has been limited to features specific to this procedure, and in particular, patient positioning, instrumentation, trocar placement, exploration, and laparoscopic technique.

1. Patient positioning (Figure 3)

Laparoscopic gastroesophageal reflux surgery is performed with the patient in the same position as for vagotomy. The operating table should allow 15-degree elevation of the trunk and, depending on requirements, a 15-degree tilt to the right or left. In addition, a 10-cm roll is placed under the tip of the shoulder blades.

After general endotracheal anesthesia and insertion of a nasogastric tube, the patient is placed in a supine position. The surgeon stands between the legs of the patient; the scrub nurse stands to the left with the video-endoscopy unit and suction-irrigation device. A second video monitor is placed to the right, with the laser and the electrosurgical unit. Two assistants are helpful: one to the left, the other to the right of the patient.

2. Instrumentation

In addition to the basic instrumentation required for laparoscopic surgery, fundoplication is facilitated by the following equipment:

- for exposure of the operative field: a 30-degree telescope or Cuschieri endoretractor-laparoscope (Karl Storz GmbH).
- for wall suspension: a Microfrance endoretractor.
- for dissection: an electrosurgical hook knife with a channel for evacuation of smoke, a sponge-holding forceps for blunt dissection, curved coagulating scissors (USSC), and a dissector, a curved instrument (Karl Storz GmbH) or a variable curvature dissector (Roticulator®).
- for hemostasis: a single-clip applier (Ligaclip®) or a multiple-clip applier (Endoclip®).
- for suturing: two needle drivers (Karl Storz GmbH, Microfrance), round curved needles (32 mm and 26 mm) and ski-shaped needles (USSC) mounted with 2-0 and 4-0 nonabsorbable sutures.

3. Placement of trocars (Figure 4)

In general, 5 trocars are introduced under electronically controlled CO_2 pneumoperitoneum at a pressure of 14 mmHg. The first trocar, used to accommodate the video laparoscope, is placed 2-finger breadths above and to the right of the umbilicus. This port allows insertion of the other trocars under visual control. The second trocar is placed in a xiphoid position for the palpation probe. The third trocar, placed in a right subcostal position, and the fourth trocar, placed in a left subcostal position, are used to insert the grasping forceps. The fifth trocar is placed 2-finger breadths above and to the left of the umbilicus for the working channel. Use of 10-mm trocars for the video laparoscope, the working channel, and the left subcostal port facilitates movement of the instruments, thereby improving vision, especially of the gastroesophageal angle.

Wall suspension, completed by a moderate pneumoperitoneum (8 mmHg), is recommended to avoid risks of pneumomediastinum or pneumothorax when a long procedure is anticipated, such as with obese patients for treatment of large or complicated hernias, or if previous surgery has resulted in viscerolysis.

4. Exploration (Figure 5)

Immediately after insertion of the trocar, which accommodates the video laparoscope, mobilization of the patient and elevation of the left lobe of the liver allows a thorough exploration to verify that the procedure can be performed safely by laparoscopy. If diffi-

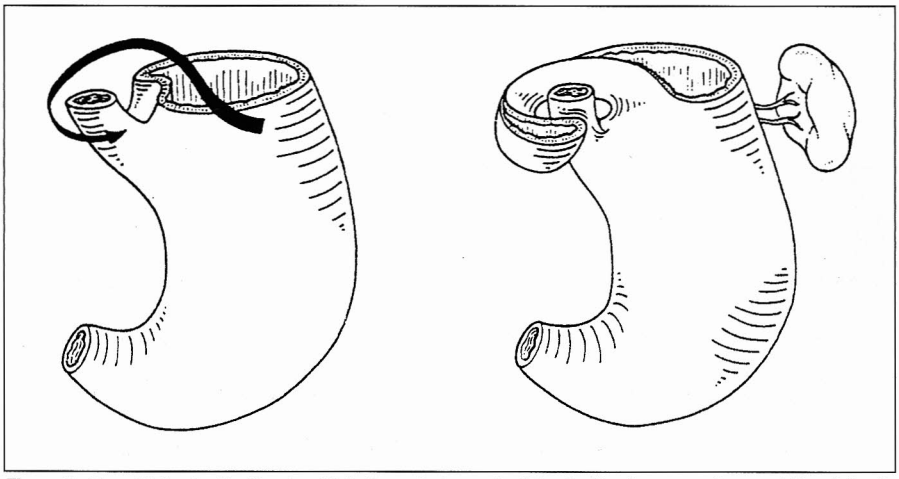

Figure 1. Rossetti fundoplication in which the anterior wall of the fundus is wrapped around the abdominal esophagus.

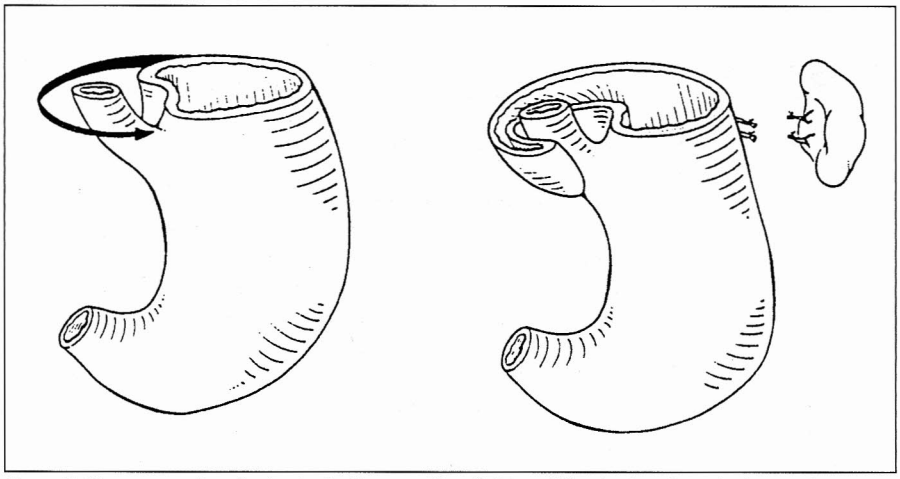

Figure 2. Nissen procedure for fundoplication requiring division of the short gastro-splenic vessels.

culties are anticipated, conversion to open surgery is indicated; thus informed consent specifically mentioning this possibility is essential. Conducted in a "check-list" fashion, exploration confirms the existence and type of any hiatal hernia (sliding or mixed hernia, or mere cardiac-fundal malposition) and determines the length of the abdominal esophagus and the size of the fundus. A left hepatic artery, fatty infiltration of the liver or a peritoneal sac, in the case of mixed hernias, can also be seen. The orientation of the spleen, lying more or less against the fundus, the size of the hiatal orifice, and the thickness of the crura must all be assessed. Exploration is best performed by indirect bimanual palpation with the aid of an atraumatic straight grasping forceps and a palpation cannula or sponge-holding forceps, and must include a search for any associated gastroduodenal lesions (ulcer) and supra- or inframesocolic extragastric lesions (adhesions, cholecystitis, biliary cyst, appendicitis, diverticulitis, genital lesions in women).

5. Laparoscopic technique

• sharp dissection with an electrosurgical hook knife or electrocoagulating scissors facilitates opening of the phrenoesophageal membrane around the hiatus.

• blunt dissection with a sponge-holding forceps facilitates downward mobilization of the abdominal esophagus,

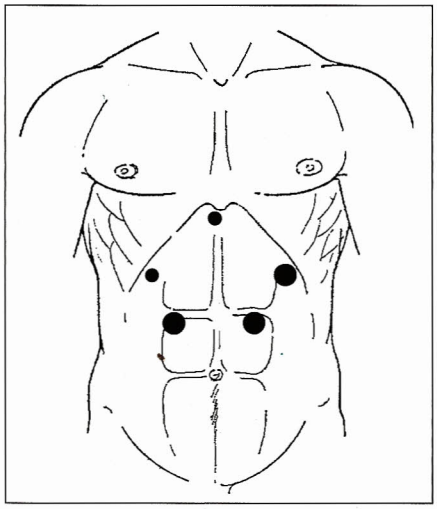

Figure 4. Trocar placement: five ports (three 10-mm trocars and two 5-mm trocars) are used for the video laparoscope, the palpation probe, the right and left grasping forceps, and the working channel. Use of 10 mm trocars facilitates movement of the camera, allowing operation under constant visual control.

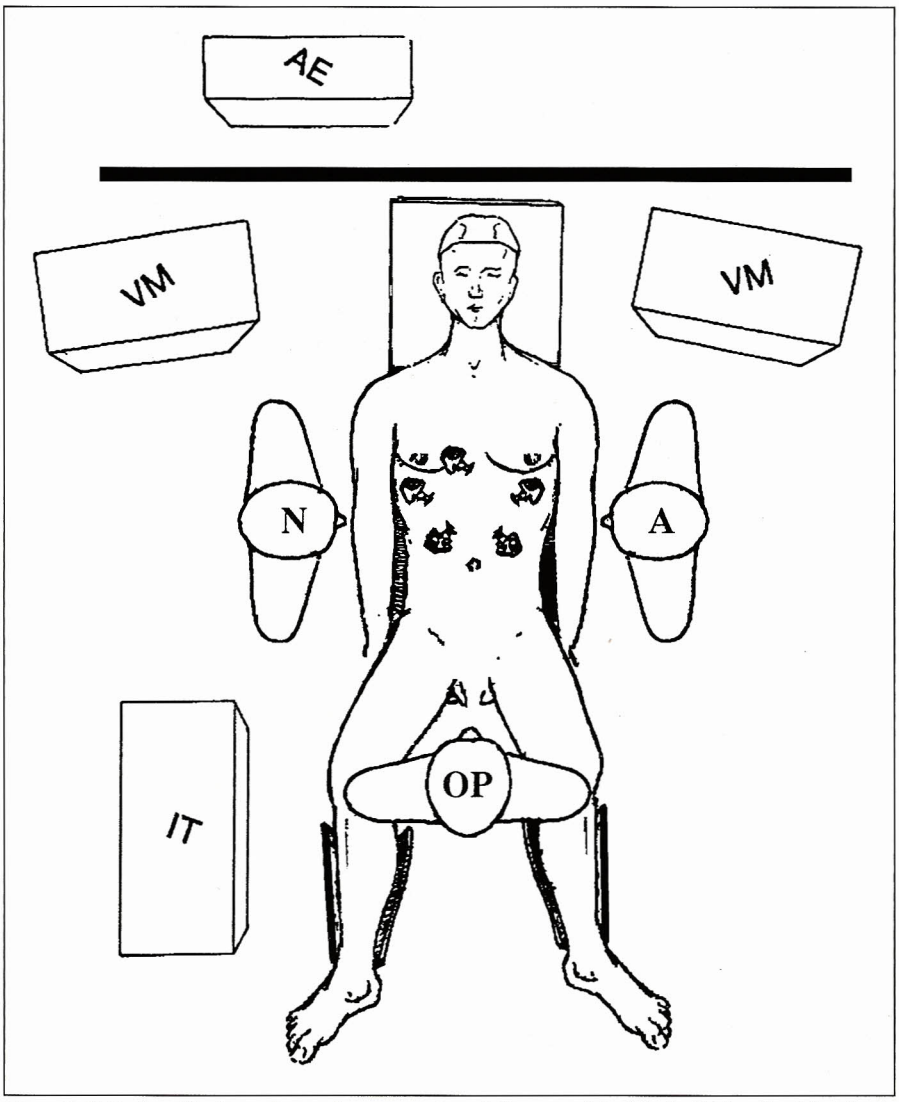

Figure 3. Patient positioning and operating room setup : S-Surgeon ; A-Assistant ; AE-Anesthesiologist ; N-Nurse ; VM-Videomonitor ; IT-Instrument Table.

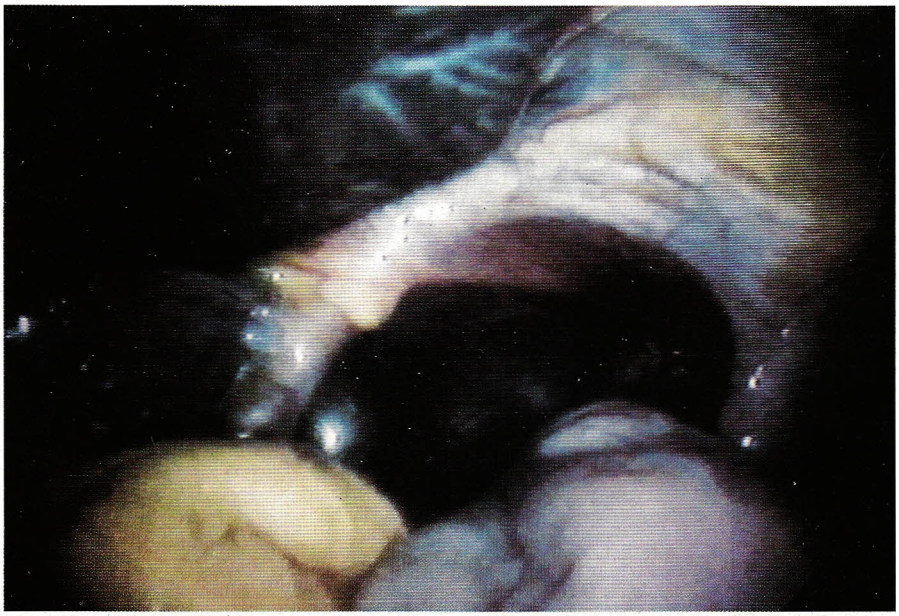

Figure 5. Lesion exploration: retraction of the left lobe of the liver provides access to the hiatal region. The key landmarks are the caudate lobe of the liver and the right crus of the diaphragm, which are identified after the superior portion of the lesser omentum has been opened.

especially posteriorly, along the lower posterior mediastinum.

• hemostasis is achieved by electrosurgery for small vessels and by a clip or ligature for larger vessels.

• tissue approximation is performed by suturing, using round curved needles or ski-shaped needles. Knots may be tied either intra- or extracorporeally (requires specific training). Staplers are not recommended because currently available models do not allow close supervision of stable positioning, which produces risks of mucosal perforation.

OPERATIVE TECHNIQUE

The procedure involves three phases: approach of the hiatus and repositioning of the cardia, approximation of the diaphragmatic crura for closure of the hiatus, and complete wrapping, by fundoplication, of the abdominal esophagus (Figure 6).

1. Approach of the hiatus and repositioning of the cardia (Figure 7)

Following elevation of the left lobe of the liver by the xiphoid palpation probe, the surgeon gains access to the hiatal region above the pars nervosa of the lesser omentum. This direct approach preserves the hepatic branches of the anterior vagus nerve and any coronary-hepatic pedicle. The key landmark is the right crus of the diaphragm, whose prominent arch is picked up by the right grasper, stretches the peritoneum and thereby exposes the phrenoesophageal membrane. Peritoneal incision starts along the right crus; the dissection is continued across the anterior wall of the esophagus, at the level of the hiatal arch, and descends along the left crus. Incision of the peritoneum and the attached anterior phrenoesophageal membrane provides access to the virtual periesophageal space. Cleavage of this space is facilitated by the pneumo-dissection and by moving the abdominal esophagus to the left and to the right with the graspers and the palpation probe, which are advanced progressively as the dissection continues. This procedure avoids touching the anterior pneumogastric nerves lying on the anterior wall of the abdominal esophagus. The mesoesophagus and the posterior esophageal wall are then freed by opening the esophageal bed: the right grasper picks up the right crus at its midpoint and pulls it vertically upward, while the left grasper, used like a palpation cannula, draws the abdominal esophagus upwards and to the left. This diverging action opens the dihedral angle behind the esophagus, allowing identification of the pearly white trunk of the posterior (right) vagus at the apex. The posterior wall of the esophagus is freed by blunt dissection, being careful to protect the vagus nerve and not to continue mobilization too high—in order to avoid pneumomediastinum by gas suffusion or pneumothorax due to pleural perforation.

Using a dissector or a curved instrument, a sling is introduced and inserted around the abdominal esophagus, which has now been almost completely mobilized. The abdominal esophagus can then be brought down by moderate traction on the esophagus with the tube in situ. All remaining hiatal attachments are taken down by blunt dissection from top to bottom (by displacing the hiatal ring of the phrenoesophageal membrane) and laterally (being especially careful to free

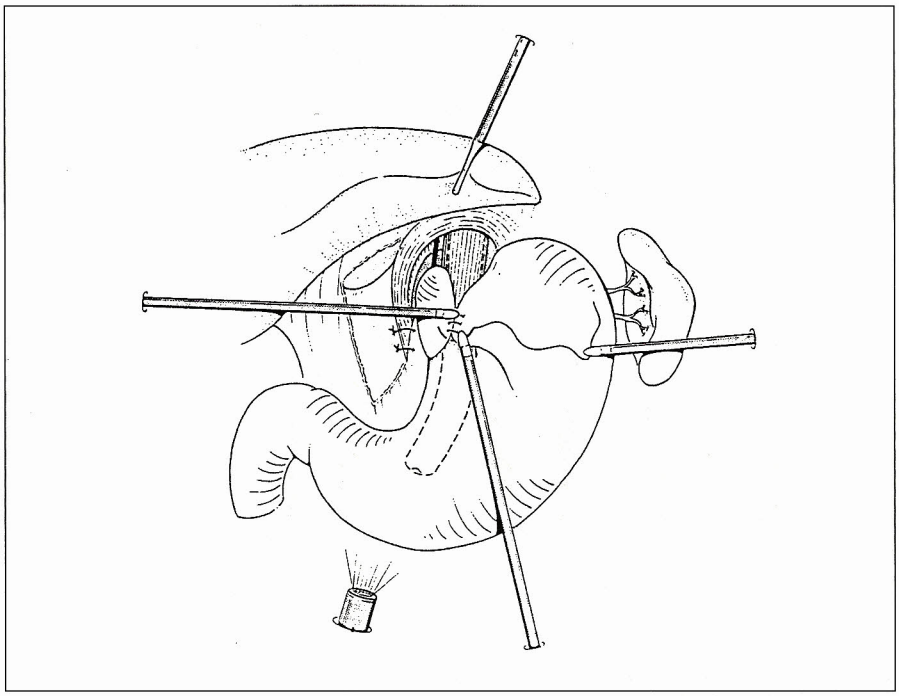

Figure 6. The three steps in laparoscopic Rossetti fundoplication.

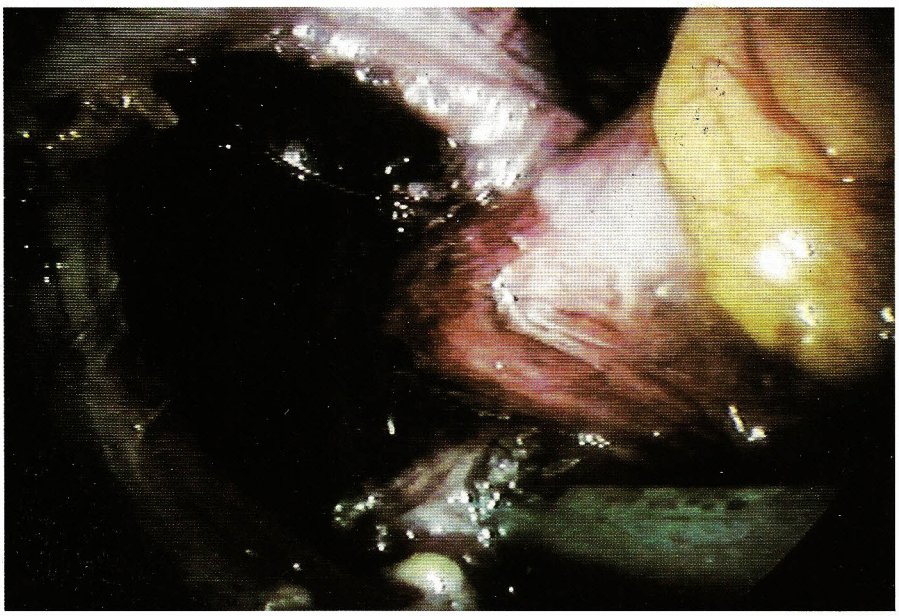

Figure 7. The cardia is repositioned and the abdominal esophagus is brought down after complete mobilization of the hiatus. Traction on a sling inserted around the esophagus facilitates this maneuver.

the gastroesophageal angle up to the first short gastric vessels). A 30-degree video laparoscope is helpful for this purpose; if unavailable, the telescope initially positioned beneath the umbilicus can be transferred to the left port so that the procedure can be continued under constant visual control. This is especially important for large spleens lying close against the fundus.

Resection of any fatty infiltration in the gastroesophageal angle, or a peritoneal sac in a mixed hernia, is indispensable to obtain a sufficient length of abdominal esophagus for satisfactory valve construction. Resection is performed by electrosurgery, completing hemostasis by a hemoclip or pretied ligature (Endo-loop®) if necessary.

2. Closure of the hiatus by approximation of the diaphragmatic crura (Figure 8)

Upward traction on the sling draws the esophagus up to the hiatal orifice. The crura takes on a V-shape, with the open angle at the top. The right (sagittal) crura is exposed by traction, the left (frontal) crura by pulling the esophagus to the left with the palpation probe. The hiatal orifice is reduced by suturing the crura, taking deep bites in their mass with a 32-mm curved needle or an endoski needle mounted with 2-0 nonabsorbable suture and handled with two needle drivers. When placing the sutures, the tip of the needle driver and the needle itself must constantly remain under visual control to avoid injury posteriorly to the abdominal aorta, which is sometimes very prominent, or to the caudate lobe of the liver on the right (intra- or extra-corporeal).

Knot tying must ensure perfect tissue approximation without excessive tension, which could cause muscular ischemia. The knots can be secured by a serrated resorbable clip. One to three sutures are required depending on whether a hiatal hernia is present; supercompetence is avoided by insertion of a 60-French orogastric tube.

3. Fundoplication by a complete wrap of the abdominal esophagus (Figure 9)

The esophagus is brought down by exerting 45-degree traction on the sling. The right grasper is passed posteriorly to grasp the anterior wall of the fundus, which is drawn backwards and to the right with a height equal to the distance between the upper and lower margins of the hiatus. Mobilization of the lesser curvature is unnecessary. The posterior (right) valve is then reunited with the anterior (left) valve: this 360-degree wrap of the anterior surface of the fundus from left to right completes fundoplication. The right and left valves are abutted by an atraumatic multi-jaw forceps or a Babcock clamp, which maintains the assembly. Three or four nonabsorbable sutures are then placed over a 1.5- to 2-cm interval using 26-mm curved swaged needles or endoski needles mounted with 4-0 nonabsorbable sutures. Knots may be tied intra- or extracorporeally. If the fundus is fragile, the result of hematomas or abrasion, small Teflon strips may be applied over the sutures, as suggested by DeMeester.[13] Here again, supercompetence is avoided by insertion of a 60-French orogastric tube. Following verification of hemostasis, irrigation and suction, the puncture wounds are closed after CO_2 evacuation from the peritoneum and infiltration of a local anesthetic.

INTRAOPERATIVE CARE

Preservation of the vagus nerves must be a constant preoccupation, in particular during dissection of the segment of intraabdominal esophagus.[1] At

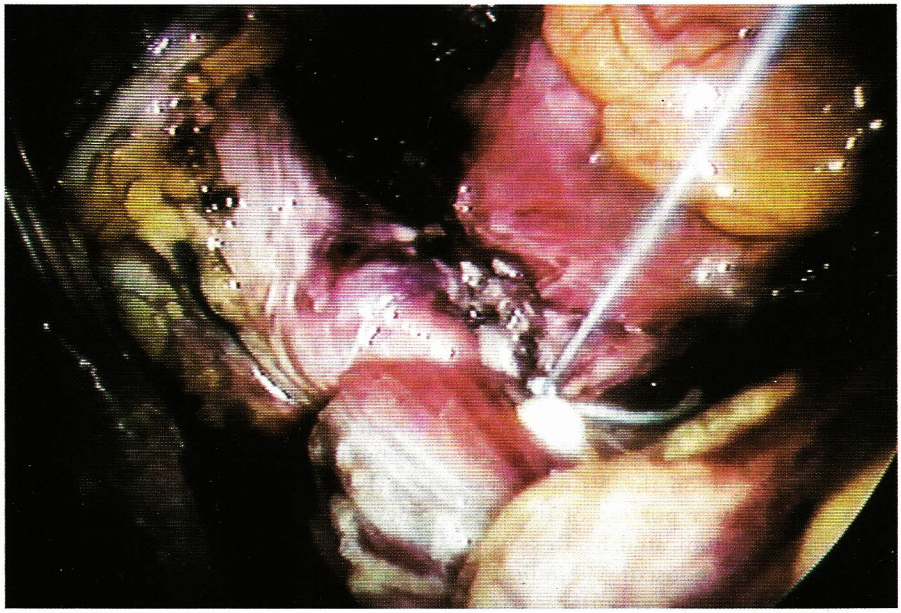

Figure 8. Closure of the hiatus by approximation of the diaphragmatic crura.

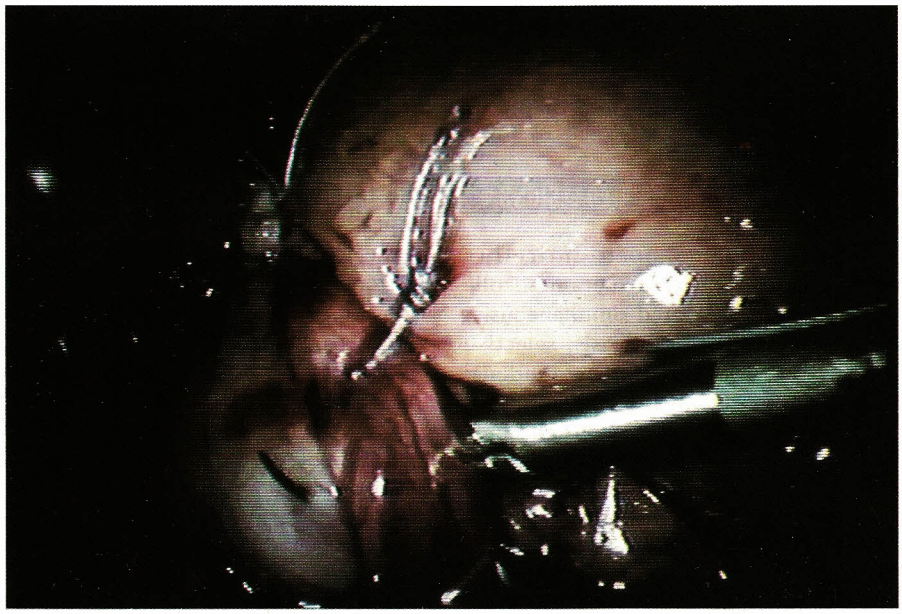

Figure 9. Fundoplication over a 2 cm esophageal segment.

this point, the vagal nerves lie in the virtual peri-esophageal space covered by the phrenoesophageal membrane. When the hiatal peritoneum is opened, CO_2 diffusion results in actual pneumodissection, permitting cleavage of this space, but the anterior and posterior nerves remain attached to the esophagus. Dissection and isolation of these nerves (and especially the posterior nerve) should be avoided because of the associated risk of a gas bloat syndrome with delayed gastric emptying.

Once sutured, the assembly created by fundoplication must be carefully checked to prevent supercompetence. For this purpose, a 60-French orogastric tube is inserted. To make sure the valves are not too tight, a sponge holder or the suction tube is introduced between the body of the stomach and the wrapped assembly.

To be sure the fundoplication will not come undone due to suture loosening, displacement, or re-elevation, 150 cc of fluid are injected through the orogastric tube while the gastric antrum is compressed with a palpator; the valves should swell smoothly, without any folds or irregularities. If necessary, complementary fixation may be achieved by placing one or two sutures on the esophagus, at the upper portion of the fundoplication as recommended by Nissen,[2,3] or on the lesser curvature, at the lower portion of the fundoplication as indicated by Rossetti.[1] Intraoperative endoscopy is indicated to ensure that the valvular system functions properly, but intraoperative manometry remains controversial because general anesthesia is usually performed with muscle relaxants and because of operative conditions required for maintenance of pneumoperitoneum.

TREATMENT OF ASSOCIATED LESIONS

Just as during open antireflux surgery, any associated supramesocolic lesions must be treated simultaneously: cholecystectomy for lithiasis, selective vagotomy (Taylor type) for duodenal ulcer, fenestration for biliary cysts, release of adhesions, etc.—to cite only some of the most commonly encountered lesions. Wall suspension with a low-pressure pneumoperitoneum is particularly helpful in such situations to prevent the adverse effects of prolonged CO_2 insufflation.

RESULTS

The authors' experience covers 107 patients aged 18 to 80, who were operated on by this technique between January 1, 1990, and February 28, 1992. All patients had severe gastroesophageal reflux that persisted for 2 to 20 years despite appropriate medical treatment, including lifestyle and dietary recommendations, antacids, histamine H2 antagonists, and proton-pump inhibitors for at least 6 months A total of 84 patients had a sliding hernia, 5 had a large mixed hernia, and 18 had solitary gastroesophageal reflux. Endoscopic assessment of esophagitis included grade 1 (13 cases), grade 2 (14 cases), grade 3 (76 cases), and grade 4 (4 cases, including one large hemorrhagic ulcer). Nineteen patients had an associated pathology that was treated at the same time as fundoplication: 5 ulcers managed by a Taylor operation, 11 gallbladder stones treated by cholecystectomy, 2 solitary cysts removed by fenestration, and 1 lymphoma for which the patient underwent staging.

Surgery lasted a mean of 140 minutes (range 120–220 minutes). There were 6 cases of hypercapnia, 3 of which required conversion. There was no mortality. The immediate postoperative course was particularly uneventful, as is usually the case with laparoscopic procedures. Pain was minor because of the minimal parietal access and infiltration of the puncture site with a local anesthesia, which eliminated the need for systemic administration of antalgics. Ambulation was very early because there was no need for any specific postoperative care. The nasogastric tube was removed on discharge from the operating room, and patients were kept in the intensive care unit for only 24 hours. After gastroesophageal competence was demonstrated the day after surgery using an iodine solution, food was immediately given in the form of small, frequent meals. Patients were discharged from the hospital between the 3rd and the 5th day, just like after open surgery, but this interval could be undoubtedly shortened. Morbidity was limited to 1 pneumothorax requiring drainage, 4 respiratory tract infections, and 21 cases of transient dysphagia.

Follow-up for 12 to 36 months did not reveal symptomatic recurrence of reflux in any patient. Postoperative endoscopy performed for 25 patients revealed cure of the esophagitis. Manometric surveillance, which was only possible for 12 patients, demonstrated a rise in the pressure in the lower esophageal sphincter zone from 6 to 15 mmHg. Only 1 of these 12 patients had isolated asymptomatic episodes of reflux detected by pH monitoring.

Surgeons who have performed the Nissen procedure laparoscopically, such as Dallemagne[14] and Hinder,[15] as well as those who have utilized variants such as Cuschieri,[16] Bagnato[17] and Geagea,[18] have all published encouraging initial results identical to those of open surgery. Thus the long-term results of Nissen type fundoplication can be expected to be similar, with a cure rate at 10 years in the order of 90 percent. Multi-institutional trials must, nevertheless, confirm these prospects by analyzing data for homogeneous populations operated on by identical techniques, including anonymous evaluation of preoperative video recordings and comparison of pre- and postoperative endoscopic, manometric, pH monitoring, and radiologic studies. The scientific and medicolegal needs for such procedures must obviously be carefully explained to patients.

DISCUSSION

Several remarks are warranted concerning the laparoscopic technique, patient selection, and indications for antireflux surgery.

Surgical correction of gastroesophageal reflux is based on restoration of a valvular system.[12,13,19] Three types of procedures have classically been described: First, mere repair of the angle of His Lortat-Jacob.[9, 19] Second, anterior partial fundoplication (between 180 degrees and 330 degrees) by creation of a Dor-type anterior valve,[20] a Toupet-type posterior valve,[21] or by gastroesophageal submersion as proposed by Hill[22] and Belsey.[23,24,25] Third, total (360 degrees) fundoplication of the Nissen type.[2, 3,19, 26] The efficacy of these procedures depends on the nature of the valve created (from 0 degrees to 360 degrees).[26] While the Nissen operation is unquestionably the most effective technique,[11,13,19,27,33]

intraoperative splenic injury during mobilization of the fundus is a fairly frequent complication, and there have been rare reports of esophageal or gastric perforation.[4,16,34,41] Likewise, postoperative complications range from recurrence of reflux in the fundoplication assembly due to sleeping to permanent dysphagia as the result of supercompetence and even a gas bloat syndrome following injury to the vagus nerves, which results in gastric dilatation with delayed gastric emptying.

These potential complications have prompted several authors to try and improve the procedure: Segol,[28] Cordiano[34] and Stoppa,[35] for example, all calibrate the dimensions of the fundoplication, while Donahue[35] advocates a total loose fundoplication, the "floppy" Nissen. After clearing the lesser curvature, we prefer to create a low-set wrap that restores competence while permitting eructation and vomiting.[37] Menguy has described a similar technique.[38] DeMeester,[13] faithful to the Nissen procedure, has defined the anatomic conditions governing the height and width of fundoplications. In fact, the most decisive progress must be credited to Rossetti,[1] who proposed wrapping the esophagus with the anterior surface of the fundus. This technique limits gastroesophageal dissection, obviates the need for division of the gastrosplenic vessels on the right, and makes it unnecessary to continue mobilization to the lesser curvature—thereby preserving the gastrohepatic branches of the anterior vagus nerve. Preservation of these structures, which serve as anchoring points during fundoplication, helps maintain fixation and prevents subsequent displacement.

Three components of the laparoscopic procedure in particular warrant special discussion:

• fixation of the fundoplication to the anterior esophageal wall, advocated by Nissen,[2,3] DeMeester,[13] and Siewiert[33] during open surgery, and by Dallemagne[14,39] during laparoscopy, is considered both unnecessary and dangerous by Rossetti[1] during open surgery and by Geagea[18] for laparoscopic procedures. These last two authors merely fix the fundoplication to the lesser curvature. In our opinion, fixation to the anterior esophageal wall prevents slippage of the fundoplication, especially in case of endobrachyesophagus. In fact, laparoscopy facilitates placement of sutures for fixation because image magnification assists identification of the anterior vagus plexus, which can be safely avoided.

• passage of the posterior valve behind the esophagus and the vagus nerve or through a window opened between the nerve and the esophagus has been suggested by Nissen[2,3] and DeMeester[13] in open surgery and by Hinder[15] for laparoscopic operations to avoid injury to the nerve along its course within the fundoplication. In our opinion, however, there is a risk of injury to the nerve due to dissection and creation of gas bloat symptoms. We have similar reserves concerning Hinder's suggestion that the crus be sutured in front of the posterior nerve.[15] In our opinion, it is easier to leave the posterior nerve lying close against the esophagus, surrounded by its vasa nervosum (just like the anterior branches), and to include them within a well-calibrated, amply constructed fundoplication to avoid compression.

• closure of the hiatus by approximating the diaphragmatic crura behind the esophagus is not considered essential by Nissen.[2,3] Like other teams, however, we have found that this component of the procedure not only allows physiologic sphincter function of the lower esophagus in the intraabdominal pressure zone, but also prevents elevation of the wrapped esophageal segment or its impaction in the hiatal orifice, which can lead to ulceration or even strangulation.[13,15,30,33,37]

Whether the patient has a hiatal hernia or not, selection criteria for laparoscopic cure of gastroesophageal reflux are similar to those for open surgery, and are based on both a general pretherapy workup to assess risk factors as well as specific investigations of reflux disease, including upper gastrointestinal endoscopy, imaging studies, evaluation of gastric secretion, and function tests. Endoscopy can confirm the diagnosis of reflux, determine the grade of esophagitis, and demonstrate any associated lesions (hiatal hernia, orificial ulcers of the esophagus, the hiatal ring and/or the duodenum). Barium swallows remain a valuable source of information on gastroesophageal junction morphology, while providing functional data concerning esophageal clearance and gastric emptying (which is best assessed by isotope studies). Function tests include esophageal pH monitoring to evaluate the severity of preoperative reflux and especially esophageal manometry to assess lower esophageal sphincter function (pressure in this zone is usually below 5 mmHg). Thorough preoperative evaluation can distinguish between patients with obvious gastroesophageal reflux (good candidates for laparoscopic cure) and those with motility disorders responsible for defective esophageal clearance or delayed gastric emptying. This is the price to pay to avoid therapeutic failures. This full battery of tests must be repeated postoperatively to make sure fundoplication is effective. While this may seem excessive and sometimes invasive, thorough checkups remain indispensable at this stage in the evaluation of laparoscopic surgery.

A change in the surgical indication for laparoscopic surgical treatment is being debated. After all, current indications, like those for open antireflux surgery, are admittedly restrictive—limited to patients with severe gastroesophageal reflux—despite appropriate, supervised medical therapy including antacids, H_2 blockers, and proton-pump inhibitors for over 6 months.

Wider indications can be envisaged, therefore, especially since the benefits of laparoscopy can be decisive in treatment of this pathology, which essentially involves mechanical factors. A new variable, however, must be taken into consideration when establishing a treatment plan: the patient's preference. In selecting a strategy to manage their disease, patients should be given the choice between simple and effective (but repetitive and even long-term) medical therapy, with all the inherent risks of disease evolution and potential iatrogenic complications, and minimally invasive laparoscopic treatment that provides a rapid, durable cure with a negligible complication rate.

CONCLUSION

Laparoscopic gastroesophageal reflux surgery is a simple, effective, and reproducible procedure that provides the same results as open surgery. It has the added advantage of being minimally invasive and suitable for routine use. Controlled prospective studies remain indispensable, however, to define criteria for patient selection, to determine the best means for intraoperative verification of the procedure, and to evaluate long-term results. STI

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