During the 1970s and the 1980s, operations for benign esophageal disorders were often withheld or delayed in favor of less effective forms of treatment in an effort to prevent the postoperative discomfort, the long hospital stay, and the recovery time associated with open surgical procedures. For instance, pneumatic dilatation became first-line therapy for achalasia, even though surgical management had been shown to be clearly superior.1

In the first part of the 1990s, it became clear that treatment of benign esophageal disorders with minimally invasive procedures yielded results comparable to those of treatment with traditional operations while causing minimal postoperative discomfort, reducing the duration of hospitalization, shortening recovery time, and permitting earlier return to work.5,6 Consequently, minimally invasive surgery was increasingly considered as first-line treatment for achalasia, and laparoscopic fundoplication was considered more readily and at an earlier stage in the management of gastroesophageal reflux disease (GERD).

Since then, minimally invasive esophageal procedures have continued to evolve, thanks to better instrumentation and improved surgical expertise. In addition, with greater experience and longer follow-up periods, it has become possible to analyze techniques and their results more rigorously. For instance, whereas a few years ago a left thoracoscopic Heller myotomy was considered the procedure of choice for achalasia, the current procedure of choice is a laparoscopic Heller myotomy with partial fundoplication, which has proved to be better at relieving dysphagia and controlling postoperative reflux.4-7 Similarly, whereas total fundoplication and partial fundoplication were initially considered equally effective in treating GERD,8 total fundoplication is now viewed as clearly superior for this purpose and should be used whenever feasible.9

In this chapter, I focus on minimally invasive approaches to the treatment of abnormal gastroesophageal reflux and esophageal motility disorders. The standard open counterparts of these operations are described elsewhere [see 4.7 Open Esophageal Procedures].

Laparoscopic Nissen Fundoplication

PREOPERATIVE EVALUATION

All patients who are candidates for a laparoscopic fundoplication should undergo a preoperative evaluation that includes the following: (1) symptomatic evaluation, (2) an upper GI series, (3) endoscopy, (4) esophageal manometry, and (5) ambulatory pH monitoring.

Symptomatic Evaluation

The presence of both typical symptoms (heartburn, regurgitation, and dysphagia) and atypical symptoms of GERD (cough, wheezing, chest pain, and hoarseness) should be investigated, and symptoms should be graded with respect to their intensity both before and after operation. Nonetheless, a diagnosis of GERD should never be based solely on symptomatic evaluation. Many authorities assert that the diagnosis can be made reliably from the clinical history,10 so that a complaint of heartburn should lead to the presumption that acid reflux is present; however, testing of this diagnostic strategy demonstrates that symptoms are far less sensitive and specific than is usually believed.11 For instance, a study from the University of California, San Francisco (UCSF), found that of 822 consecutive patients referred for esophageal function tests with a clinical diagnosis of GERD (based on symptoms and endoscopic findings), only 70% had abnormal reflux on pH monitoring.12 Heartburn and regurgitation were no more frequent in patients who had genuine reflux than in those who did not; thus, symptomatic evaluation, by itself, could not distinguish between the two groups.

The response to proton pump inhibitors (PPIs) is a better predictor of abnormal reflux. For example, in the UCSF study just cited, 75% of patients with GERD reported a good or excellent response to PPIs, compared with only 26% of patients without GERD.12 Similarly, a study involving multivariate analysis of factors predicting outcome after laparoscopic fundoplication concluded that a clinical response to acid suppression therapy was one of three factors predictive of a successful outcome, the other two being an abnormal 24-hour pH score and the presence of a typical primary symptom (e.g., heartburn).13

Upper Gastrointestinal Series

An upper GI series is useful for diagnosing and characterizing an existing hiatal hernia. The size of the hiatal hernia helps predict how difficult it will be to reduce the esophagogastric junction below the diaphragm. In addition, large hiatal hernias are associated with more severe disturbances of esophageal peristalsis and esophageal acid clearance.14 Esophagograms are also useful for determining the location, shape, and size of a stricture and detecting a short esophagus.

Endoscopy

Endoscopy is typically the first test performed to confirm a symptom-based diagnosis of GERD. This approach has two pitfalls, however. First, even though the goal of endoscopy is to assess the mucosal damage caused by reflux, mucosal changes are absent in about 50% of GERD patients.12 Second, major interobserver variations have been reported with esophageal endoscopy, particularly for low-grade esophagitis.15 In one study, for instance, 60 (24%) of 247 patients with negative results on pH monitoring had been diagnosed as having grade I or II esophagitis.12 Accordingly, I believe that endoscopy is most valuable for excluding gastric and duodenal pathologic conditions and detecting the presence of Barrett’s esophagus.
Ambulatory pH Monitoring

Ambulatory pH monitoring is the most reliable test for the diagnosis of GERD, with a sensitivity and specificity of about 92%. It is of key importance in the workup for the following four reasons:

1. It determines whether abnormal reflux is present. In the UCSF study mentioned earlier, pH monitoring yielded normal results in 30% of patients with a clinical diagnosis of GERD, thereby obviating the continuation of inappropriate and expensive drugs (e.g., PPIs) or the performance of a fundoplication. In addition, it allows proper placement of the pH probe for ambulatory pH monitoring (5 cm above the upper border of the LES).

2. It establishes a temporal correlation between symptoms and episodes of reflux. Such a correlation is particularly important when atypical GERD symptoms are present because 50% of these patients experience no heartburn and 50% do not have esophagitis on endoscopy.17

3. It allows staging on the basis of disease severity. Specifically, pH monitoring identifies a subgroup of patients characterized by worse esophageal motor function (manifested by a defective LES or by abnormal esophageal peristalsis), more acid reflux in the distal and proximal esophagus, and slower acid clearance. These patients more frequently experience stricture formation and Barrett metaplasia and thus might benefit from early antireflux surgery.18

4. It provides baseline data that may prove useful postoperatively if symptoms do not respond to the procedure.

OPERATIVE PLANNING

The patient is placed under general anesthesia and intubated with a single-lumen endotracheal tube. Abdominal wall relaxation is ensured by the administration of a nondepolarizing muscle relaxant, the action of which is rapidly reversed at the end of the operation. Adequate muscle relaxation is essential because increased abdominal wall compliance allows increased pneumoperitoneum, which yields better exposure. An orogastric tube is inserted at the beginning of the operation to keep the stomach decompressed; it is removed at the end of the procedure.

The patient is placed in a steep reverse Trendelenburg position, with the legs extended on stirrups. The surgeon stands between the patient’s legs. To keep the patient from sliding as a result of the steep position used during the operation, a bean bag is inflated under the patient, and the knees are flexed only 20° to 30°. A Foley catheter is inserted at the beginning of the procedure and usually is removed in the postoperative period. Because increased abdominal pressure from pneumoperitoneum and the steep reverse Trendelenburg position decrease venous return, pneumatic compression stockings are always used as prophylaxis against deep vein thrombosis.

The equipment required for a laparoscopic Nissen fundoplication includes five 10 mm trocars, a 30° laparoscope, a hook cautery, and various other instruments [see Table 1]. In addition, we use a three-chip camera system that is separate from the laparoscope.

OPERATIVE TECHNIQUE

In all patients except those with very poor esophageal motility—for whom partial fundoplication [see Laparoscopic Partial (Guarner) Fundoplication, below] is preferable—we advocate performing a 360° wrap of the gastric fundus around the lower esophagus as described by Nissen, but we always take down the short gastric vessels to achieve what is called a floppy fundoplication. This type of wrap is very effective in controlling gastroesophageal reflux.19,20 The operation can be divided into nine key steps as follows.

Step 1: Placement of Trocars

Five 10 mm trocars are used for the operation [see Figure 1]. Port A is placed about 14 cm below the xiphoid process; it can also be placed slightly (2 to 3 cm) to the left of the midline to be in line with the hiatus. This port is used for insertion of the scope. Port B is placed at the same level as port A but in the left midclavicular line. It is used for insertion of the Babcock clamp; insertion of a grasper to hold the Penrose drain once it is in place surrounding the esophagus; or insertion of the clip applier, the ultrasonic coagulating shears, or both to take down the short gastric vessels. Port C is placed at the same level as the previous two ports but in the right midclavicular line. It is used for insertion of the fan retractor, the purpose of which is to lift the lateral segment of the left lobe of the liver well, and the esophagogastric junction. I do not divide the left triangular ligament. The fan retractor can be held in place by a self-retaining system fixed to the operating table. Ports D and E are placed as high as possible under the costal margin and about 5 to 6 cm to the right and the left of the midline so that they are about 15 cm from the esophageal hiatus; in addition, they should be placed so that their axes form an angle of 60° to 120°. These ports are used for insertion of the graspers, the electrocautery, and the suturing instruments.

Troubleshooting If the ports are placed too low in the abdomen, the operation is made more difficult. If port C is too low, the fan retractor will not retract the lateral segment of the left lobe of the liver well, and the esophagogastric junction will not be exposed. If port B is too low, the Babcock clamp will not reach the esophagogastric junction, and when the ultrasonic coagulating

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**Table 1** Instrumentation for Laparoscopic Nissen Fundoplication

<table>
<thead>
<tr>
<th>Instrumentation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Five 10 mm trocars</td>
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<tr>
<td>30° scope</td>
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<tr>
<td>Graspers</td>
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<tr>
<td>Babcock clamp</td>
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<tr>
<td>L-shaped hook cautery with suction-irrigation capacity</td>
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<tr>
<td>Scissors</td>
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<tr>
<td>Laparoscopic clip applier</td>
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<tr>
<td>Ultrasonic coagulating shears</td>
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<tr>
<td>Fan retractor</td>
<td></td>
</tr>
<tr>
<td>Needle holder</td>
<td></td>
</tr>
<tr>
<td>Penrose drain</td>
<td></td>
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<tr>
<td>2-0 silk sutures</td>
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<tr>
<td>56 French esophageal bougie</td>
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</tbody>
</table>

**Esophageal Manometry**

Esophageal manometry provides useful information about the motor function of the esophagus by determining the length and resting pressure of the lower esophageal sphincter (LES) and assessing the quality (i.e., the amplitude and propagation) of esophageal peristalsis. In addition, it allows proper placement of the pH probe for ambulatory pH monitoring (5 cm above the upper border of the LES).

**Ambulatory pH Monitoring**

Ambulatory pH monitoring is the most reliable test for the diagnosis of GERD, with a sensitivity and specificity of about 92%. It is of key importance in the workup for the following four reasons:

1. It determines whether abnormal reflux is present. In the UCSF study mentioned earlier,12 pH monitoring yielded normal results in 30% of patients with a clinical diagnosis of GERD, thereby obviating the continuation of inappropriate and expensive drugs (e.g., PPIs) or the performance of a fundoplication. In addition, it allows proper placement of the pH probe for ambulatory pH monitoring (5 cm above the upper border of the LES).

2. It establishes a temporal correlation between symptoms and episodes of reflux. Such a correlation is particularly important when atypical GERD symptoms are present because 50% of these patients experience no heartburn and 50% do not have esophagitis on endoscopy.17

3. It allows staging on the basis of disease severity. Specifically, pH monitoring identifies a subgroup of patients characterized by worse esophageal motor function (manifested by a defective LES or by abnormal esophageal peristalsis), more acid reflux in the distal and proximal esophagus, and slower acid clearance. These patients more frequently experience stricture formation and Barrett metaplasia and thus might benefit from early antireflux surgery.18

4. It provides baseline data that may prove useful postoperatively if symptoms do not respond to the procedure.
shears or the clip applier is placed through the same port, it will not reach the upper short gastric vessels. If ports D and E are too low, the dissection at the beginning of the case and the suturing at the end are problematic.

Other mistakes of positioning must be avoided as well. Port C must not be placed too medially; because the fan retractor may clash with the left-hand instrument; the gallbladder fossa is a good landmark for positioning this port. Port A must be placed with extreme caution in the supraumbilical area; its insertion site is just above the aorta, before its bifurcation. Accordingly, I recommend initially inflating the abdomen to a pressure of 18 mm Hg just for placement of port A; increasing the distance between the abdominal wall and the aorta reduces the risk of aortic injury. I also recommend directing the port toward the coccyx. Once port A is in place, the intraperitoneal pressure is reduced to 15 mm Hg. A Hasson cannula can be used in this location, particularly if the patient has already had one or more midline incisions. Maintaining the proper angle (60° to 120°) between the axes of the two suturing instruments inserted through ports D and E is also important: if the angle is smaller, the instruments will cover part of the operating field, whereas if it is larger, depth perception may be impaired. Finally, if a trocar is not in the ideal position, it is better to insert another one than to operate through an inconveniently placed port.

If the surgeon spears the epigastric vessels with a trocar, bleeding will occur, in which case there are two options. The first option is to pull the port out, insert a 24 French Foley catheter with a 30 ml balloon through the site, inflate the balloon, and apply traction with a clamp. The advantage of this maneuver is that the vessel need not be sutured; the disadvantage is that the surgeon must then choose another insertion site. At the end of the case, the balloon is deflated. If some bleeding is still present, it must be controlled with sutures placed from outside under direct vision. The second option is to use a long needle with a suture, with which one can rapidly place two U-shaped stitches, one above the clamp and one below. The suture is tied outside over a sponge and left in place for 2 or 3 days.

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

Once the ports are in place, the gastrohepatic ligament is divided. Dissection begins above the caudate lobe of the liver, where this ligament usually is very thin, and continues toward the diaphragm until the right crus is identified. The crus is then separated from the right side of the esophagus by blunt dissection, and the posterior vagus nerve is identified. The right crus is dissected inferiorly toward the junction with the left crus.

**Troubleshooting** An accessory left hepatic artery originating from the left gastric artery is frequently encountered in the gastrohepatic ligament. If this vessel creates problems of exposure, it may be divided; in my experience, doing so has not caused problems. When dissecting the right crus from the esophagus, the electrocautery should be used with particular caution. Because the monopolar current tends to spread laterally, the posterior vagus nerve may sustain damage simply from being in proximity to the device, even when there is no direct contact. The risk of neuropraxia can be reduced by using the cut mode rather than the coagulation mode when the electrocautery is close to the nerve. The cut mode has problems of its own, however, and is not recommended in most laparoscopic procedures. A better alternative is to use the ultrasonic coagulating shears.

**Step 3: Division of Peritoneum and Phrenoesophageal Membrane above Esophagus; Identification of Left Crus of Diaphragm and Anterior Vagus Nerve**

The peritoneum and the phrenoesophageal membrane above the esophagus are divided with the electrocautery, and the anterior vagus nerve is identified. The left crus of the diaphragm is dissected downward toward the junction with the right crus.

**Troubleshooting** Care must be taken not to damage the anterior vagus nerve or the esophageal wall. To this end, 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: Creation of Window between Gastric Fundus, Esophagus, and Diaphragmatic Crura; Placement of Penrose Drain around Esophagus**

The esophagus is retracted upward with a Babcock clamp applied at the level of the esophagogastric junction. Via blunt and sharp dissection, a window is created under the esophagus between the gastric fundus, the esophagus, and the diaphragmatic crura. The window is enlarged with the ultrasonic coagulating shears, and a Penrose drain is passed around the esophagus. This drain is then used for traction instead of the Babcock clamp to reduce the risk of damage to the gastric wall.

**Troubleshooting** The two main problems to watch for 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 caused by dissection done above the left crus in the mediastinum rather than between the crus and the gastric fundus. This problem can be avoided by properly dissecting and identifying the left crus.

Perforation of the gastric fundus is usually caused by pushing a blunt instrument under the esophagus and below the left crus without having done enough dissection. Care must be exercised in taking down small vessels from the fundus when the area behind the esophagus is approached from the right: the anatomy is not as clear from this viewpoint, and perforation can easily occur. Sometimes, perforation is caused by the use of a monopolar electrocautery for dissection. An electrocautery burn can go unrecognized during dissection and manifest itself in the form of a leak during the first 48 hours after operation.

Troubleshooting  

The ultrasonic coagulating shears or the clip applier is introduced through port B. A grasper is introduced by the surgeon through port D, and an assistant applies traction on the greater curvature of the stomach through port E. 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 and the Penrose drain is reached.

Troubleshooting  

Step 5: Division of Short Gastric Vessels

The ultrasonic coagulating shears or the clip applier is introduced through port B. A grasper is introduced by the surgeon through port D, and an assistant applies traction on the greater curvature of the stomach through port E. 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 and the Penrose drain is reached.

Troubleshooting  

Step 6: Closure of Crura

The diaphragmatic crura are closed with interrupted 2-0 silk sutures on a curved needle; the sutures are tied intracorporeally. Exposure is provided by retracting the esophagus upward and toward the patient’s left with the Penrose drain. The lens of the 30° laparoscope is angled slightly to the left by moving the light cable of the scope to the patient’s right. The first stitch should be placed just above the junction of the two crura. Additional stitches are placed 1 cm apart, and a space of about 1 cm is left between the uppermost stitch and the esophagus.

Troubleshooting  

Care must be taken not to spear the posterior wall of the esophagus with either the tip or the back of the needle. So as not to limit the space available for suturing, the bougie is not placed inside the esophagus during this part of the procedure.

Step 7: Insertion of Bougie into Esophagus and through Esophagogastric Junction

The esophageal stethoscope and the orogastric tube are removed, and a 56 French bougie is inserted by the anesthesiologist and passed through the esophagogastric junction under laparoscopic vision. The crura must be snug around the esophagus but not too tight: a closed grasper should slide easily between the esophagus and the crura.

Troubleshooting  

The most worrisome complication during this step is perforation of the esophagus. This can be prevented by lubricating the bougie and instructing the anesthesiologist to advance the bougie slowly and to stop if any resistance is encountered. In addition, it is essential to remove any instruments from the esophagogastric junction and to open the Penrose drain; these measures prevent the creation of an angle between the stomach and the esophagus, which can increase the likelihood of perforation. The position of the bougie can be confirmed by pressing with a grasper over the esophagus, which will feel full when the bougie is in place.

Troubleshooting  

Step 8: Wrapping of Gastric Fundus around Lower Esophagus

The gastric fundus is gently pulled under the esophagus with the graspers. The left and right sides of the fundus are wrapped above the fat pad (which lies above the esophagogastric junction) and held together in place with a Babcock clamp introduced through port B. (The Penrose drain should be removed at this point because it is in the way.) Usually, three 2-0 silk sutures are used to secure the two ends of the wrap to each other. The first stitch does not include the esophagus and is used for traction; the second and the third include a bite of the esophageal muscle. The bougie is passed into the stomach after the first stitch to assess the size of the wrap. If the wrap seems at all tight, the stitch is removed and repositioned more laterally. Two coronal stitches are then placed between the top of the wrap and the esophagus, one on the right and one on the left. Finally, one additional suture is placed between the right side of the wrap and the closed crura.

To avoid the risk of injuring the inferior vena cava at the beginning of the dissection, some surgeons use a different method—the so-called left crus approach. In this approach, the operation begins with identification of the left crus of the diaphragm and division of the peritoneum and the phrenoesophageal membrane overlying it. The next step is division of the short gastric vessels, starting midway along the greater curvature of the stomach and continuing upward to join the area of the previous dissection. When the fundus has been thoroughly mobilized, the peritoneum is divided from the left to the right crus, and the right crus is dissected downward to expose the junction of the right and left crura. With this technique, the vena cava is never at risk. In addition, the branches of the anterior vagus nerve and the left gastric artery are less exposed to danger. This technique can be very useful, particularly for management of very large paraesophageal hernias and for second antireflux operations [see Reoperation for GERD, below].

Troubleshooting  

To determine whether the wrap is going to be floppy, the surgeon must deliver the fundus under the esophagus, making sure that the origins of the short gastric vessels that have been transected are visible. Essentially, the posterior wall of the fundus is being used for the wrap. If the wrap remains to the right of the esophagus without retracting back to the left, then it is floppy, and suturing can proceed. If not, the surgeon must make sure that the upper short gastric vessels have been transected. If tension is still present after these maneuvers, it is probably best to perform a partial wrap [see Laparoscopic Partial (Guarner) Fundoplication, below].

Damage to the gastric wall may occur during the delivery of the fundus. Atraumatic graspers must be used, and the gastric fundus must be pulled gently and passed from one grasper to the other.
Sometimes, it is helpful to push the gastric fundus under the esophagus from the left. The wrap should measure no more than 2 to 2.5 cm in length and, as noted, should be done with no more than three sutures. The first stitch is usually the lowest one; it must be placed just above the fat pad where the esophagogastric junction is thought to be.

If the anesthesiologist observes that peak airway pressure has increased (because of a pneumothorax) or that neck emphysema is present (because of pneumomediastinum), the pneumoperitoneum should be reduced from 15 mm Hg to 8 or 10 mm Hg until the end of the procedure. Pneumomediastinum tends to resolve without intervention within a few hours of the end of the procedure. Small pneumothoraces (usually on the left side) tend to resolve spontaneously, rendering insertion of a chest tube unnecessary. Larger pneumothoraces (> 20%), however, call for the insertion of a small (18 to 20 French) chest tube.

**Step 9: Final Inspection and Removal of Instruments and Ports from Abdomen**

After hemostasis is obtained, the instruments and the ports are removed from the abdomen under direct vision.

**Troubleshooting** If any areas of oozing were observed, they should be irrigated and dried with sponges rolled into a cigarette-like shape before the ports are removed. In addition, if some grounds for concern remain, the oozing areas should be examined after the pneumoperitoneum is decreased to 7 to 8 mm Hg to abolish the tamponading effect exerted by the high intra-abdominal pressure.

All the ports should be removed from the abdomen under direct vision so that any bleeding from the abdominal wall can be readily detected. Such bleeding is easily controlled, either from inside or from outside.

**COMPLICATIONS**

A feared complication of laparoscopic Nissen fundoplication is esophageal or gastric perforation, which may result either from traction applied with the Babcock clamp or a grasper to the esophagus or the stomach (particularly when the stomach is pulled under the esophagus) or from inadvertent electrocautery burns during any part of the dissection. A leak will manifest itself during the first 48 hours. Peritoneal signs will be noted 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 should always be confirmed by a contrast study with barium or a water-soluble contrast agent. Optimal management consists of laparotomy and direct repair. If a perforation is detected intraoperatively, it may be closed laparoscopically.

About 50% of patients experience mild dysphagia postoperatively. This problem usually resolves after 4 to 6 weeks, during which period patients receive pain medications in an elixir form and are advised to avoid eating meat and bread. If, however, dysphagia persists beyond this period, one or more of the following causes is responsible.

1. A wrap that is too tight or too long (i.e., > 2.5 cm).
2. Lateral torsion with corkscrew effect. If the wrap rotates to the right (because of tension from intact short gastric vessels or because the fundus is small), a corkscrew effect is created.
3. A wrap made with the body of the stomach rather than the fundus. The relaxation of the LES and the gastric fundus is controlled by vasoactive intestinal polypeptide and nitric oxide; after fundoplication, the two structures relax simultaneously with swallowing. If part of the body of the stomach rather than the fundus is used for the wrap, it will not relax as the LES does on arrival of the food bolus.
4. Choice of the wrong procedure. In patients who have severely abnormal esophageal peristalsis (as in end-stage connective tissue disorders), a partial wrap is preferable. A 360° wrap may cause postoperative dysphagia and gas bloat syndrome.

If the wrap slips into the chest, the patient becomes unable to eat and prone to vomiting. A chest radiograph shows a gastric bubble above the diaphragm, and the diagnosis is confirmed by means of a barium swallow. This problem can be prevented by using coronal sutures and by ensuring that the crura are closed securely.

Paraesophageal hernia may occur if the crura have not been closed or if the closure is too loose. In my opinion, closure of the crura not only is essential for preventing paraesophageal hernia but also is important from a physiologic point of view, in that it acts synergistically with the LES against stress reflux. Sometimes, it is possible to reduce the stomach and close the crura laparoscopically. More often, however, because the crural opening is very tight and the gastric wall is edematous, laparoscopic repair is impossible and laparotomy is preferable.

**POSTOPERATIVE CARE AND OUTCOME EVALUATION**

Postoperative care and outcome evaluation of laparoscopic Nissen fundoplication are considered elsewhere in conjunction with the discussion of partial fundoplication [see Laparoscopic Partial (Guarner) Fundoplication, Postoperative Care and Outcome Evaluation, below].

**Laparoscopic Partial (Guarner) Fundoplication**

**PREOPERATIVE EVALUATION AND OPERATIVE PLANNING**

Preoperative evaluation and operative planning are essentially the same for partial (Guarner) fundoplication as for Nissen fundoplication. This operation should be performed only in patients with the most severe abnormalities of esophageal peristalsis: it is less effective than a 360° wrap for long-term control of reflux. In addition, laparoscopic partial fundoplication may be performed after laparoscopic Heller myotomy for achalasia [see Laparoscopic Heller Myotomy with Partial Fundoplication, below].

**OPERATIVE TECHNIQUE**

The first seven steps in a Guarner fundoplication are identical to the first seven in a Nissen fundoplication. The wrap, however, differs in that it extends around only 240° to 280° of the esophageal circumference. Once the gastric fundus is delivered under the esophagus, the two sides are not approximated over the esophagus. Instead, 80° to 120° of the anterior esophagus is left uncovered, and each of the two sides of the wrap (right and left) is separately affixed to the esophagus with three 2-0 silk sutures, with each stitch including the muscle layer of the esophageal wall. The remaining stitches (i.e., the coronal stitches and the stitch between the right side of the wrap and the closed crura) are identical to those placed in a Nissen fundoplication.

**POSTOPERATIVE CARE**

Currently, my average operating time for a laparoscopic fundoplication is approximately 2 hours. I start patients on a soft mechanical diet on the morning of postoperative day 1 and usually discharge them after 23 to 48 hours. The recovery time usually ranges from 10 to 14 days.
OUTCOME EVALUATION

The initial results of laparoscopic fundoplication obtained in the early 1990s indicated that the operation was effective in controlling reflux but that postoperative dysphagia occurred more often than had been anticipated. Many experts thought that this problem could be avoided by tailoring the fundoplication to the strength of esophageal peristalsis as measured by esophageal manometry. Accordingly, partial fundoplication (240°) was recommended for patients with impaired peristalsis, and total fundoplication (360°) was recommended for those with normal peristalsis. The short-term results of this tailored approach were promising. Gradually, however, it became evident that partial fundoplication was not as durable as total fundoplication and that total fundoplication did not pose a special problem for patients with weak peristalsis.

Long-term follow-up of patients operated on in accordance with the tailored approach at UCSF between October 1992 and December 1999 indicated that the promising short-term results reported earlier were not maintained over time. After a mean follow-up period of 70 months, 56% of the patients who underwent partial fundoplication had recurrent reflux as documented by pH monitoring, compared with only 28% of those who underwent total fundoplication. (These figures probably overestimate the real incidence of postoperative reflux, in that most of the patients studied had heartburn and very few were asymptomatic.) In addition, more of the patients in the partial fundoplication group needed acid-suppressing medication (25% versus 8%) or a second operation (9% versus 3%). The incidence of postoperative dysphagia, however, was the same in the two groups, which indicated that the completeness of the wrap played no role in causing this largely transient complication. These findings suggest that the initial problems with postoperative dysphagia were primarily attributable to unknown technical factors that were largely eliminated from the procedure as surgeons garnered more experience with it. As a result, total fundoplication is currently considered the procedure of choice for patients with GERD, regardless of the strength of their esophageal peristalsis.

Laparoscopic Heller Myotomy with Partial Fundoplication

Minimally invasive surgical procedures for primary esophageal motility disorders (achalasia, diffuse esophageal spasm, and nutcracker esophagus) yield results that are comparable to those of open procedures but are associated with less postoperative pain and with a shorter recovery time. Today, laparoscopic Heller myotomy with partial fundoplication has supplanted left thoracoscopic myotomy as the procedure of choice for esophageal achalasia. Long-term studies demonstrated that even though left thoracoscopic myotomy led to resolution of dysphagia in about 85% to 90% of patients, it had the following four drawbacks.

1. Gastroesophageal reflux developed postoperatively in about 60% of patients because no fundoplication was performed in conjunction with the myotomy. With the laparoscopic approach, in contrast, a partial fundoplication can easily be performed, which prevents reflux in the majority of patients and corrects many instances of preexisting reflux arising from pneumatic dilatation.

2. The extension of the myotomy onto the gastric wall (clearly the most critical and challenging part of the operation) proved difficult because of poor exposure, with the consequent risk of a short myotomy and persistent dysphagia. With the laparoscopic approach, in contrast, excellent exposure of the esophagogastric junction is easily achieved, and the myotomy can be extended onto the gastric wall for about 2 to 2.5 cm.

3. Double-lumen endotracheal intubation and single-lung ventilation were required, with the patient in the right lateral decubitus position. In contrast, the setting for a laparoscopic myotomy (the same as that for a laparoscopic fundoplication) is much easier for the patient, the anesthesiologist, and the OR personnel. In addition, most surgeons have by now acquired substantial experience with laparoscopic antireflux procedures and thus are more familiar and comfortable with laparoscopic exposure of the distal esophagus and the esophagogastric junction.

4. The average postoperative hospital stay was about 3 days because of the chest tube left in place at the time of the operation and the discomfort arising from the thoracic incisions. After a laparoscopic Heller myotomy, the hospital stay is only 1 or 2 days; there is no need for a chest tube, and patients are more comfortable.

Because of these drawbacks, left thoracoscopic myotomy is now largely reserved for patients with achalasia who have undergone multiple abdominal operations (which may rule out a laparoscopic approach). A laparoscopic Heller myotomy and Dor fundoplication is considered the procedure of choice for achalasia.

PREOPERATIVE EVALUATION

All candidates for a laparoscopic Heller myotomy should undergo a thorough and careful evaluation to establish the diagnosis and characterize the disease. An upper GI series is useful. A characteristic so-called bird’s beak is usually seen in patients with achalasia. A dilated, sigmoid esophagus may be present in patients with long-standing achalasia. A Corkscrew esophagus is often seen in patients with diffuse esophageal spasm. Endoscopy is performed to rule out a tumor of the esophagogastric junction and gastroduodenal pathologic conditions.

Esophageal manometry is the key test for establishing the diagnosis of esophageal achalasia. The classic manometric findings are (1) absence of esophageal peristalsis and (2) a hypertensive LES that fails to relax appropriately in response to swallowing. Ambulatory pH monitoring should always be done in patients who have undergone pneumatic dilatation to rule out abnormal gastroesophageal reflux. In addition, pH monitoring should be performed postoperatively to detect abnormal reflux, which, if present, should be treated with acid-reducing medications.

In patients older than 60 years who have experienced the recent onset of dysphagia and excessive weight loss, secondary achalasia or pseudoachalasia from cancer of the esophagogastric junction should be ruled out. Endoscopic ultrasonography or computed tomography can help establish the diagnosis.

OPERATIVE PLANNING

Patient preparation (i.e., anesthesia, positioning, and instrumentation) is identical to that for laparoscopic fundoplication.

OPERATIVE TECHNIQUE

Many of the steps in a laparoscopic Heller myotomy are the same as the corresponding steps in a laparoscopic fundoplication. The
The myotomy can be extended downward onto the gastric wall for easy identification of the squamocolumnar junction, so that removed, and an endoscope is inserted. The endoscopic view of the myotomy is marked on the surface of the esophagus; proximally, it is extended for about 6 cm onto the gastric wall; distally, it is extended for about 2 to 2.5 cm onto the gastric wall; proximally, it is extended for about 6 cm onto the esophagogastric junction. Thus, the total length of the myotomy, there is always some bleeding from the cut mucosa, and then move upward and downward from there. In the course of the myotomy, there is a risk of mucosal perforation even after a properly performed myotomy. The advantages of the Guarner fundoplication are that (1) it is easier to perform; (2) it keeps the edges of the myotomy well separated; and (3) it might be more effective than a Dor procedure in preventing reflux. Its main disadvantages are that (1) it requires more dissection for the creation of a posterior window and (2) it leaves the esophageal mucosa exposed.

**Step 7: Intraoperative Endoscopy**

The esophageal stethoscope and the orogastric tube are removed, and an endoscope is inserted. The endoscopic view allows easy identification of the squamocolumnar junction, so that the myotomy can be extended downward onto the gastric wall for about 2 cm distal to this point. In addition, if possible mucosal perforation is a concern, the esophagus can be covered with water from outside while air is insufflated from inside; bubbling will be observed over the site of any perforation present.

At the beginning of a surgeon’s experience with laparoscopic Heller myotomy, intraoperative endoscopy is a very important and helpful step; however, once the surgeon has gained adequate experience with this procedure and has become familiar with the relevant anatomy from a laparoscopic perspective, it may be omitted.

**Troubleshooting**

The most worrisome complication during intraoperative endoscopy is perforation of the esophagus. This complication can be prevented by having the procedure done by an experienced endoscopist who is familiar with achalasia.

**Step 8: Initiation of Myotomy and Entry into Submucosal Plane at Single Point**

The fat pad is removed with the ultrasonic coagulating shears to provide clear exposure of the esophagogastric junction. A Babcock clamp is then applied over the junction, and the esophagus is pulled downward and to the left to expose the right side of the esophagus. The myotomy is performed at the 11 o’clock position. It is helpful to mark the surface of the esophagus along the line through which the myotomy will be carried out. The myotomy is started about 3 cm above the esophagogastric junction. Before it is extended upward and downward, the proper submucosal plane should be reached at a single point; in this way, the likelihood of subsequent mucosal perforation can be reduced.

**Troubleshooting**

The myotomy should not be started close to the esophagogastric junction, because at this level the layers are poorly defined, particularly if multiple dilatations or injections of botulinum toxin have been performed. If the preferred starting point, about 3 cm above the esophagogastric junction, the esophageal wall is usually normal. As a rule, I do not open the entire longitudinal layer first and then the circular layer; I find it easier and safer to try to reach the submucosal plane at one point and then move upward and downward from there. In the course of the myotomy, there is always some bleeding from the cut muscle fibers, particularly if the esophagus is dilated and the wall is very thick. After the source of the bleeding is identified, the electrocautery must be used with caution. The most troublesome bleeding comes from the submucosal veins encountered at the esophagogastric junction (which are usually large). In most instances, gentle compression is preferable to electrocautery. A sponge introduced through one of the ports facilitates the application of direct pressure.

**Step 9: Proximal and Distal Extension of Myotomy**

Once the mucosa has been exposed, the myotomy can safely be extended. Distally, it is extended for about 2 to 2.5 cm onto the gastric wall; proximally, it is extended for about 6 cm above the esophagogastric junction. Thus, the total length of the myotomy is typically about 8 cm.

**Troubleshooting**

The course of the anterior vagus nerve must be identified before the myotomy is started. If this nerve crosses the line of the myotomy, it must be lifted away from the esophagogastric junction, and the muscle layers must then be cut under it. In addition, care must be taken not to injure the anterior vagus nerve while removing the fat pad. Treatment with botulinum toxin occasionally results in fibrosis with scarring and loss of the normal function of the esophagus.
anatomic planes; this occurs more frequently at the level of the esophagogastric junction.

If a perforation seems possible or likely, it should be sought as described earlier [see Step 7, above]. Any perforation found should be repaired with 5-0 absorbable suture material, with interrupted sutures employed for a small perforation and a continuous suture for a larger one. When a perforation has occurred, an anterior fundoplication is usually chosen in preference to a posterior one because the stomach will offer further protection against a leak.

**Step 10 (Dor Procedure): Anterior Partial Fundoplication**

Two rows of sutures are placed. The first row (on the left side) comprises three stitches: the uppermost stitch incorporates the gastric fundus, the esophageal wall, and the left pillar of the crus [see Figure 5], and the other two incorporate only the gastric fundus and the left side of the esophageal wall [see Figure 6]. The gastric fundus is then folded over the myotomy, and the second row (also comprising three stitches) is placed on the right side between the fundus and the right side of the esophageal wall, with only the uppermost stitch incorporating the right crus [see Figures 7 and 8]. Finally, two additional stitches are placed between the anterior rim of the hiatus and the superior aspect of the fundoplication [see Figure 9]. These stitches remove any tension from the second row of sutures.

**Troubleshooting**  Efforts must be made to ensure that the fundoplication does not become a cause of postoperative dysphagia. Accordingly, I always take down the short gastric vessels, even though some authorities suggest that this step can be omitted.3,29 In addition, the gastric fundus rather than the body of the stomach should be used for the wrap, and only the uppermost stitch of the right row of sutures should incorporate the right pillar of the crus.30

**Step 10 (Guarner Procedure): Posterior Partial Fundoplication**

Alternatively, a posterior 220° fundoplication may be performed. The gastric fundus is delivered under the esophagus, and each side of the wrap (right and left) is attached to the esophageal wall, lateral to the myotomy, with three sutures [see Figure 10].
Step 11: Final Inspection and Removal of Instruments and Ports from Abdomen

Step 11 of a laparoscopic Heller myotomy is identical to step 9 of a laparoscopic Nissen fundoplication.

COMPLICATIONS

Delayed esophageal leakage, usually resulting from an electrocautery burn to the esophageal mucosa, may occur during the first 24 to 36 hours after operation. The characteristic signals are chest pain, fever, and a pleural effusion on the chest x-ray. The diagnosis is confirmed by an esophagogram. Treatment options depend on the time of diagnosis and on the size and location of the leak. Early, small leaks can be repaired directly. If the site of the leak is high in the chest, a thoracotomy is recommended; if the site is at the level of the esophagogastric junction, a laparotomy is preferable, and the stomach can be used to reinforce the repair. If the damage to the esophagus is too extensive to permit repair, a transhiatal esophagectomy [see 4:7 Open Esophageal Procedures] is indicated.

Dysphagia may either persist after the operation or recur after a symptom-free interval. In either case, a complete workup is necessary, and treatment is individualized on the basis of the specific cause of dysphagia. Reoperation may be indicated [see Reoperation for Esophageal Achalasia, below].

Abnormal gastroesophageal reflux occurs in 7% to 20% of patients after operation.4,5 Because most patients are asymptomatic, it is essential to try to evaluate all patients postoperatively with manometry and prolonged pH monitoring. Reflux should be treated with acid-reducing medications.

POSTOPERATIVE CARE

I do not routinely obtain an esophagogram before initiating feeding. Patients are started on a soft mechanical diet on the morning of postoperative day 1, and this diet is continued for the rest of the first week. Patients are discharged after 24 to 48 hours and are able to resume regular activities in 7 to 14 days.

OUTCOME EVALUATION

The results obtained to date with laparoscopic Heller myotomy and partial fundoplication are excellent and are generally comparable to those obtained with the corresponding open surgical procedures: dysphagia is reduced or eliminated in more than 90% of patients.4-7 Laparoscopic treatment clearly outperforms balloon dilatation and botulinum toxin injection in the treatment of achalasia. Its high success rate has caused a shift in practice, to the
where most referring physicians currently regard surgery as the preferred treatment.32

**Left Thoracoscopic Myotomy**

**PREOPERATIVE EVALUATION**

Preoperative evaluation is essentially the same as that for laparoscopic Heller myotomy.

**OPERATIVE PLANNING**

The patient is placed under general anesthesia and intubated with a double-lumen endotracheal tube so that the left lung can be deflated during the procedure. As for a left thoracotomy, the patient is placed in the right lateral decubitus position over an inflated bean bag. The instrumentation is similar to that for a laparoscopic Nissen or Guarner fundoplication. Instead of conventional trocars, four or five thoracoports with blunt obturators are employed, because insufflation of the thoracic cavity is not required. The myotomy can be performed with a monopolar hook cautery, bipolar scissors, or an ultrasonic scalpel. A 30° scope and a 45° scope are essential for thoracoscopic procedures. In addition, an endoscope is used for intraoperative endoscopy.

**OPERATIVE TECHNIQUE**

**Step 1: Placement of Thoracoports**

Five ports are usually placed [see Figure 11]. Port A, used for the 30° scope, is inserted in the sixth intercostal space about 3.5 to 5 cm behind the posterior axillary line. Port B, used for the lung retractor, is placed in the third intercostal space about 1.25 to 2.5 cm anterior to the posterior axillary line. Port C, used for insertion of a grasper, is placed in the sixth intercostal space in the anterior axillary line. Port D, used for insertion of the instrument employed for the myotomy, is placed in the seventh intercostal space in the midaxillary line. Port E is placed in the eighth intercostal space between the anterior axillary line and the midaxillary line. This port is optional: it is needed in about 30% of cases to allow the surgeon to obtain further exposure of the esophagogastric junction through retraction of the diaphragm.

**Troubleshooting**

A common mistake is to insert port A too anteriorly. This port must be placed well beyond the posterior axillary line to provide the best angle for the 30° scope. Often, the other ports are placed one or two intercostal spaces too high. This mistake hampers the performance of the most delicate portion of the operation, the myotomy of the distal portion of the esophagus and the stomach.

Sometimes, chest wall bleeding occurs as a consequence of port insertion. This bleeding will obscure the operating field and therefore must be stopped before the intrathoracic portion of the procedure is begun. This is accomplished either by using the cautery from the inside or by applying a stitch from the outside if an intercostal vessel has been damaged.

**Step 2: Retraction of Left Lung and Division of Inferior Pulmonary Ligament**

Once the ports are in place, the deflated left lung is retracted cephalad with a fan retractor introduced through port B. This maneuver places tension on the inferior pulmonary ligament, which is then divided. After the ligament is divided, the fan retractor can be held in place by a self-retaining system fixed to the operating table.

**Troubleshooting**

Before the inferior pulmonary ligament is divided, the inferior pulmonary vein must be identified to prevent a life-threatening injury to this vessel. If oxygen saturation decreases, particularly in patients with lung disease, the retractor should be removed and the lung inflated intermittently.

**Step 3: Division of Mediastinal Pleura and Dissection of Periesophageal Tissues**

The mediastinal pleura is divided, and the tissues overlying the esophageal wall are dissected until the wall of the esophagus is vis-
ible. This maneuver varies in difficulty depending on the width of the space between the aorta and the pericardium (which sometimes is very small) and on the size and shape of the esophagus. Large (sigmoid) esophagi tend to curve to the right, which makes identification of the wall difficult. If the esophagus is not immediately apparent, it can be easily identified in the groove between the heart and the aorta by means of transillumination provided by an endoscope [see Figure 11].

**Troubleshooting** The endoscope placed inside the esophagus at the beginning of the procedure plays an important role. In the early stages of the procedure, it allows identification of the esophagus via transillumination. When the light intensity of the 30° scope is turned down, the esophagus appears as a bright structure. In addition, tilting the tip of the endoscope brings the esophagus into view as it is lifted from the groove between the heart and the aorta.

**Step 4: Initiation of Myotomy and Entry into Submucosal Plane at Single Point**

As in a laparoscopic Heller myotomy, it is helpful to mark the surface of the esophagus along the line through which the myotomy will be carried out. The myotomy is started halfway between the diaphragm and the inferior pulmonary vein. Again, the proper submucosal plane should be reached at a single point before the myotomy is extended upward and downward.

**Troubleshooting** Troubleshooting for this step is essentially the same as that for step 8 of a laparoscopic Heller myotomy, with the exception that here the myotomy is started 4 to 5 cm (rather than 3 cm) above the esophagogastric junction.

**Step 5: Proximal and Distal Extension of Myotomy**

Once the mucosa has been exposed, the myotomy can safely be extended proximally and distally [see Figure 13]. I usually extend the myotomy for about 5 mm onto the gastric wall, without adding an antireflux procedure. Typically, the total length of the myotomy is about 6 cm for patients with achalasia.

**Troubleshooting** Proximally, the myotomy is extended all the way to the inferior pulmonary vein only in cases of vigorous achalasia (high-amplitude simultaneous contractions associated with chest pain in addition to dysphagia) or diffuse esophageal spasm; otherwise, it is limited to the distal 5 to 6 cm of the esophagus. If a longer myotomy is needed, the lung is displaced anteriorly and the myotomy extended to the aortic arch.

Distally, the myotomy is continued for 5 mm past the esophagogastric junction. The endoluminal view provided by the endoscope is useful for assessing the location of the esophagogastric junction. Often, the stomach is distended by the air insufflated by the endoscope and pushes the diaphragm upward, thereby limiting the view of the esophagogastric junction. If sucking air out of the stomach does not resolve this problem, an additional port (i.e., port E) may be placed in the eighth intercostal space, and a fan retractor may be introduced through this port to push the diaphragm down.

Because the myotomy of the gastric wall is the most challenging part of the operation, good exposure is essential. It is at this level that an esophageal perforation is most likely to occur. The
risk is particularly high in patients who have undergone pneumatic dilatation or injection of botulinum toxin, both of which may lead to the replacement of muscle layers by scar tissue and the consequent loss of the regular planes. Perforations recognized in the OR can be repaired by thoracoscopic intracorporeal suturing or, if this fails, by thoracotomy and open repair. The gastric fundus can be used to buttress the repair. If it is unclear whether a perforation has occurred, the esophagus should be covered with water and air insufflated through the endoscope as described earlier [see Laparoscopic Heller Myotomy with Partial Fundoplication, Operative Technique, Step 7, above].

Step 6: Insertion of Chest Tube and Removal of Thoracoports

A 24 French angled chest tube is inserted under direct vision through port D or port E. The ports are removed under direct vision, and the thoracic wall is inspected for bleeding.

COMPLICATIONS

As with laparoscopic Heller myotomy, delayed esophageal leakage is a common postoperative complication, and treatment options are similar.

If the myotomy is not extended far enough onto the gastric wall, residual dysphagia occurs. To prevent this problem, the distal extent of the myotomy should be assessed by means of endoscopy with the goal of including 5 mm of the gastric wall. Patients with residual dysphagia must be evaluated by means of esophageal manometry, which will document the extent of the residual high-pressure zone and the pressure within it. The myotomy can be easily extended by a laparoscopic approach, and a Dor fundoplication can be added.

If, on the other hand, the myotomy is extended too far onto the gastric wall, abnormal gastroesophageal reflux occurs. Some patients present with heartburn; others are asymptomatic. It is essential to evaluate patients postoperatively with manometry and prolonged pH monitoring. Mild reflux can be treated with acid-reducing medications, particularly in elderly patients. In younger patients, abnormal reflux should be corrected with a laparoscopic partial fundoplication (e.g., Dor fundoplication).

POSTOPERATIVE CARE

Patients are started on a liquid diet the morning of postoperative day 1; on postoperative day 2, they are started on a soft mechanical diet, which is continued for the rest of the first week. I do not routinely obtain an esophagogram before starting feedings. The chest tube is removed after 24 hours if the lung is fully expanded and there is no air leak. Patients are discharged after 48 to 72 hours and are able to resume regular activities in 7 to 10 days.

OUTCOME EVALUATION

The results obtained with thoracoscopic myotomy are generally comparable to those obtained with open surgical procedures. In a 1999 study from UCSF, 26 (87%) of the first 30 patients with achalasia who were treated in this fashion experienced good or excellent results [see Table 2]. Currently, however, this procedure is rarely used to treat esophageal achalasia: laparoscopic Heller myotomy and Dor fundoplication is now the treatment of choice.

Table 2

<table>
<thead>
<tr>
<th>Results</th>
<th>Patients (% of Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent (no dysphagia)</td>
<td>21 (70)</td>
</tr>
<tr>
<td>Good (dysphagia &lt; once/wk)</td>
<td>5 (17)</td>
</tr>
<tr>
<td>Fair (dysphagia &gt; once/wk)</td>
<td>3 (10)</td>
</tr>
<tr>
<td>Poor (persistent dysphagia)</td>
<td>1 (3)</td>
</tr>
</tbody>
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Right Thoracoscopic Myotomy

A right thoracoscopic myotomy extending from the diaphragm to the thoracic inlet is the preferred procedure for patients who have nutcracker esophagus or diffuse esophageal spasm involving the entire length of the esophagus but whose LES function is normal. On the whole, this procedure is technically simpler than a left thoracoscopic myotomy: because there is no need to go through the esophago gastric junction, perforation, postoperative dysphagia, and abnormal gastroesophageal reflux are largely prevented.

PREOPERATIVE EVALUATION

Preoperative evaluation of patients being considered for right thoracoscopic myotomy is essentially the same as that of patients being considered for left thoracoscopic myotomy.

OPERATIVE PLANNING

Operative planning is similar to that for a left thoracoscopic myotomy. The double-lumen tube is used to deflate the right lung rather than the left, and the patient is placed in the left lateral decubitus position over an inflated bean bag, as for a right thoracotomy. The instrumentation is identical except for the endovascular 30 mm stapler used to transect the azygos vein. A thoracotomy tray should be kept ready in case an emergency thoracotomy is necessary to control bleeding.

OPERATIVE TECHNIQUE

Step 1: Insertion of Thoracoports

Only port B is inserted where it would be for a left thoracoscopic myotomy. All the other ports are inserted one intercostal space higher because the myotomy need not be extended all the way to the stomach but must be extended to the thoracic inlet. Usually, only four ports are placed; however, an additional port may be placed in the fourth intercostal space in the anterior axillary line to facilitate the proximal extension of the myotomy.

Step 2: Dissection of Periesophageal Tissues and Division of Azygos Vein

The periesophageal tissues above and below the azygos vein are dissected away from the esophagus. A tunnel is created between the azygos and the esophagus with a dissector or a right-angle clamp. The vein is then transected with an endovascular 30 mm stapler. (Alternatively, the azygos is spared and simply lifted off the esophagus with umbilical tape.)

Troubleshooting Dissection of the azygos vein is the most critical part of this procedure. I find it easier to transect the azygos vein than to keep the vein lifted away from the esophagus and perform the myotomy under it.

Steps 3, 4, and 5

Steps 3, 4, and 5 of a right thoracoscopic myotomy are virtually identical to steps 4, 5, and 6 of a left thoracoscopic myotomy, with a few minor exceptions. Once the submucosal plane is reached, the myotomy is extended distally to the diaphragm and
proximally to the thoracic inlet. The endoscope plays a less critical role than in a left thoracoscopic myotomy because the esophagus is easily identified and because the myotomy is not extended through the esophagogastric junction. Instead, a 52 to 56 French bougie is placed inside the esophagus; this facilitates division of the circular fibers and separates the edges of the myotomy nicely.

COMPLICATIONS

A delayed esophageal leak is the most common postoperative complication. It should be handled as described earlier [see Laparoscopic Heller Myotomy with Partial Fundoplication, Complications, above].

POSTOPERATIVE CARE

The postoperative course of patients who have undergone this procedure is usually identical to that of patients operated on for achalasia.

OUTCOME EVALUATION

Long-term follow-up has confirmed the excellent results initially obtained for diffuse esophageal spasm with either a thorascopic or a laparoscopic approach. The results for nutcracker esophagus, however, have been disappointing: a number of patients have experienced postoperative dysphagia and recurrent chest pain. In my view, the optimal treatment of nutcracker esophagus remains uncertain. The results of operative management are less predictable with nutcracker esophagus than with other esophageal disorders, and chest pain often is not alleviated.

Reoperation for GERD

At the UCSF Swallowing Center, an increasing number of patients are being seen for evaluation and treatment of foregut symptoms after laparoscopic antireflux surgery. These patients are treated as follows.

PREOPERATIVE EVALUATION

Some degree of dysphagia, bloating, and abdominal discomfort is common during the first 6 to 8 weeks after a fundoplication. If these symptoms persist or heartburn and regurgitation occur, a thorough evaluation (with barium swallow, endoscopy, esophageal manometry, and pH monitoring) is carried out with the aim of answering the following three questions:

1. Are the symptoms attributable to persistent gastroesophageal reflux?
2. Are the symptoms attributable to the fundoplication itself?
3. Can the cause of the failure of the first operation be identified and corrected by a second operation?

Many patients report heartburn after a fundoplication. It is often assumed that this symptom must be the result of a failed operation and that acid-reducing medications should be restarted. In most cases, however, this assumption is mistaken: postoperative pH monitoring yields abnormal results in only about 20% of patients. The value of manometry lies in its ability to document the changes caused by the operation at the level of the LES and the esophageal body. The pH monitoring assesses the reflux status and determines whether there is a correlation between symptoms and actual episodes of reflux. If abnormal reflux is in fact present, the therapeutic choice is between medical therapy and a second operation.

Other patients complain of dysphagia arising de novo after the operation. This symptom is usually attributable to the operation itself and may occur in the absence of abnormal reflux. In addition to manometry and pH monitoring, a barium swallow is essential to define the anatomy of the esophagogastric junction. A study from the University of Washington found that the anatomic configurations observed could be divided into three main types: (1) type I hernia, in which the esophagogastric junction was above the diaphragm (subdivided into type IA, with both the esophagogastric junction and the wrap above the diaphragm, and type IB, with only the esophagogastric junction above the diaphragm); (2) type II hernia, a paraesophageal configuration; and (3) type III hernia, in which the esophagogastric junction was below the diaphragm and there was no evidence of hernia but in which the body of the stomach rather than the fundus was used for the wrap. In 10% of patients, however, the cause of the failure could not be identified preoperatively.

Some patients present with a mix of postprandial bloating, nausea, and diarrhea. These symptoms may be the result of damage to the vagus nerves. Radionuclide evaluation of gastric emptying often helps quantify the problem.

OPERATIVE PLANNING

Patient preparation (i.e., anesthesia, positioning, and instrumentation) for a reoperation for reflux is identical to that for the initial laparoscopic fundoplication.

OPERATIVE TECHNIQUE

I routinely attempt a second antireflux operation laparoscopically, but if the dissection does not proceed smoothly, I convert to a laparotomy. To provide a stepwise technical description that would be suitable for all reoperations for reflux is impossible because the optimal procedure depends on the original approach (open versus laparoscopic), the severity of the adhesions, and the specific technique used for the first operation (total or partial fundoplication). The key goals of reoperation for reflux are as follows.

1. To dissect the wrap and the esophagus away from the crura. This is the most difficult part of the operation. The major complications seen during this part of the procedure are damage to the vagus nerves and perforation of the esophagus and the gastric fundus.
2. To take down the previous repair. The earlier repair must be completely undone and the gastric fundus returned to its natural position. If the short gastric vessels were not taken down during the first procedure, they must be taken down during the second.
3. To dissect the esophagus in the posterior mediastinum so as to have enough esophageal length below the diaphragm and avoid placing tension on the repair.
4. To reconstruct the cardia. The same steps are followed as for a first-time repair. If, after extensive esophageal mobilization, the esophagogastric junction remains above the diaphragm (short esophagus), esophageal lengthening can be accomplished by adding a thoracoscopic Collis gastroplasty to the fundoplication.

To date, however, I have never found this step to be necessary.

COMPLICATIONS

Because the risk of gastric or esophageal perforation or damage to the vagus nerves is much higher during a second antireflux operation, the surgeon must be ready to convert to a laparotomy if the dissection is too cumbersome or the structures are not properly identified. Most perforations are recognized and repaired intraoperatively. Leaks manifest themselves during the first 48 hours. Peritoneal signs are noted if the spillage is limited to the abdomen; shortness of breath and a pleural effusion are noted if spillage also...
occurs in the chest. The site of the leak should always be confirmed by means of a contrast study with barium or a water-soluble agent. Perforation is best handled with laparotomy and direct repair of the leak.

OUTCOME EVALUATION

Whereas the success rate is around 80% to 90% for a first antireflux operation, it falls to 70% to 80% for a second such operation. In my view, a second operation should be attempted by an expert team only if medical management fails to control heartburn or pneumatic dilatation has not relieved dysphagia.

Reoperation for Esophageal Achalasia

Laparoscopic Heller myotomy improves swallowing in more than 90% of patients. What causes the relatively few failures reported is still incompletely understood. Typically, a failed Heller myotomy is signaled either by persistent dysphagia or by recurrent dysphagia that develops after a variable symptom-free interval following the original operation.

A complete workup (routinely including barium swallow, endoscopy, manometry, and pH monitoring) is required before treatment is planned. In addition, it is my practice to review the video of the first operation to search for technical errors that might have been responsible for the poor outcome. Such errors typically fall into one of the following three categories.

1. A myotomy that is too short either distally or proximally. If the myotomy is too short distally, a barium swallow shows persistent distal esophageal narrowing and manometry shows a residual high-pressure zone. If the myotomy is too short proximally, it will be apparent from the barium swallow.

2. A constricting Dor fundoplication. Often, manometry and pH monitoring yield normal results, but a barium swallow shows slow passage of contrast media from the esophagus into the stomach. In one study from UCSF, problems with Dor fundoplications occurred in four (4%) of 102 patients. Analysis of the video records of the first operations showed that in three of the four patients, all the stitches in the right suture row had incorporated the esophagus, the right pillar of the crus, and the stomach, thereby constricting the myotomy. In one patient, the short gastric vessels had not been taken down, and the body of the stomach rather than the fundus had been used for the fundoplication.

3. Transmural scarring caused by previous treatment. In patients treated with intrasphincteric injection of botulinum toxin, transmural fibrosis can sometimes be found at the level of the esophagogastric junction. This unwelcome finding makes the myotomy more difficult and the results less reliable.

There are two treatment options for persistent or recurrent dysphagia after Heller myotomy: (1) pneumatic dilatation and (2) a second operation tailored to the results of preoperative evaluation. In a 2002 study, pneumatic dilatation was successfully used to treat seven of 10 patients who experienced dysphagia postoperatively; of the remaining three patients, two required a second operation and one refused any treatment.

In the UCSF study just cited, however, pneumatic dilatation was effective in only one of the eight patients in whom it was tried. That patient was the one with a short distal myotomy; none of the four patients with dysphagia resulting from a poorly constructed Dor fundoplication derived any benefit. In two patients who had a short proximal myotomy, the myotomy was successfully extended to the inferior pulmonary vein through a left thoracoscopic approach. Of the four patients with a constricting Dor fundoplication, two underwent a second operation during which the Dor was taken down, and one of these two had a second myotomy. Currently, both patients are free of dysphagia; however, they experience abnormal reflux and are being treated with acid-reducing medications.

Reoperation for achalasia is a technically challenging procedure. It is of paramount importance to avoid perforating the exposed esophageal mucosa during the dissection. A small hole can be repaired, but a larger laceration might necessitate an esophagectomy. This option should always be discussed with the patient before the operation.

Overall, about 10% of patients have some degree of dysphagia after a Heller myotomy. Pneumatic dilatation, a second operation, or both should always be tried before a radical procedure such as esophagectomy is decided on.

References


Acknowledgment

Figures 1 through 13  Tom Moore.