Gastroesophageal Reflux Disease

Alexander S. Rosemurgy, MDa,*, Natalie Donn, BSc, Harold Paul, BSc, Kenneth Luberice, BSc, Sharona B. Ross, MD

Gastroesophageal reflux disease (GERD) has been a significant problem in the United States and around the world for years.1 Millions of Americans are affected by gastroesophageal reflux in many different ways. Virtually everyone has at least occasional gastroesophageal reflux. However, for millions of Americans gastroesophageal reflux is a significant problem. For them, gastroesophageal reflux imparts tremendous morbidity and at significant cost, not only to their personal health care cost but also to the health care costs of the United States. Given the direct cost of health care delivery to patients with reflux, including medication costs, certainly billions of dollars are spent on the care of GERD annually. When the morbidity and impact of GERD are considered, costs are exponentially higher. When determining the latter costs, time off work, changes in lifestyle, changes in eating and sleeping habits, and impairment of quality of life must be considered.

The magnitude of the problem of GERD was brought to light by the introduction of minimally invasive surgery and the advent of the many medications that are effective in acid suppression. In the 1970s, H2 blockers began to appear in the armamentarium of physicians. They were liberally prescribed often without objective indications. Liberal application of acid suppressive pharmacotherapy continues. Despite widespread availability of endoscopy and ambulatory pH testing, acid suppressive therapy is generally applied without objective indications. Furthermore, the advent of minimally invasive surgery and, therefore, a less invasive definitive therapy for reflux, has brought another level of consciousness to GERD in the United States. Minimally invasive surgery has resulted in millions of antireflux operations being undertaken, a dramatic, even explosive, increase in the application of surgery for GERD.

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a Tampa General Hospital Medical Group, 409 Bayshore Boulevard, Tampa, FL 33606, USA
b The Center for Surgical Digestive Disorders, Tampa General Hospital, 2 Columbia Drive, Tampa, FL 33606, USA
c Division of General Surgery, College of Medicine, University of South Florida, PO Box 1289, Suite F-145, Tampa, FL 33606, USA
* Corresponding author.
E-mail address: arosemurgy@tgh.org

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The consequences of GERD cannot be denied. Symptoms of reflux, for example heartburn, can be disabling. Many Americans bothered by reflux change their eating and sleeping habits. Patients with GERD may have voice changes associated with reflux. Hoarseness is common. Cough can be brought about by reflux. Furthermore, many Americans may be afflicted by recurring pneumonias as a consequence of reflux and aspiration. Many seek emergency health care for chest pain caused by noncardiac angina such as esophageal spasms brought about by reflux.

Consequences of reflux can also be noted in the dramatic increase in cancer of the esophagus, and specifically at the gastroesophageal junction, in the United States. Barrett esophagus is ever more common as a consequence of GERD. Patients with Barrett esophagus seem more resistant to medical therapy. Often patients with cancer have known gastroesophageal reflux and have received therapy for an extended period of time. Prolonged reflux may lead to esophageal injury and over time to Barrett esophagus and then to dysplasia, leading to a sequence of changes that results in cancer of the esophagus. Precancerous changes in the esophagus, such as Barrett esophagus, should always be considered when caring for patients with long-standing reflux.

The proliferation of potent antiacid medications, such as proton pump inhibitors (PPIs), has exploded worldwide. In the 1970s, $H_2$ blockers replaced conventional antacid therapy. PPIs have longer half-lives and are more effective in preventing acid secretion than $H_2$ blockers. The use of PPIs costs billions of dollars per year. In 2009, Nexium had sales of $6.3$ billion alone. However, their considerable price transcends beyond just dollars and cents. PPIs increase the risk of community-acquired pneumonia and the risk of *Clostridium difficile* in hospitalized patients. Osteoporosis is a well-recognized complication of prolonged PPI therapy. Given that many patients requiring PPI therapy are women beyond menopause in whom osteoporosis is already a problem, PPI therapy can accelerate their osteoporosis. Osteoporosis with PPI therapy is a problem even in men more than 50 years of age. In addition, PPIs do not stop reflux, they are simply antiacid antisecretory medications. Thus, patients on potent PPI therapy still reflux, although it may not be so acidic. Even if the nonacidic fluid is benign, it can still lead to many complications of reflux including, as has already been mentioned, voice changes, cough, and recurring pneumonia. Furthermore, PPI therapy can prevent the action of some common and important drugs such as Plavix. A proform of Plavix is altered by PPI therapy such that the Plavix is not activated and does not become an active drug. Furthermore, by altering gastric pH, PPIs can interfere with absorption of many drugs and nutrients, such as iron. Cancer associated with the PPI therapy is of increasing concern. PPI therapy can dramatically limit the secretion of gastric acid and ongoing reflux is mostly of unconjugated bile acids. These bile acids are known potent carcinogens and can lead to a sequence of events resulting in adenocarcinoma of the gastroesophageal junction, which is now an epidemic in the United States. PPI therapy can be expensive. Such expense is not limited just to the cost of the drugs but also must include frequent doctor visits for evaluation and care, surveillance endoscopy, and other costs associated with the long-term nonoperative care of reflux, including caring for complications of reflux, such as pneumonia. Viewed in this light, the cost of PPI therapy in the United States is measured in tens of billions of dollars.

**WHY DO PEOPLE GET GERD?**

Although it is apparent that everybody reflexes occasionally, some patients develop GERD, a condition more advanced than gastroesophageal reflux. There are 3 basic reasons why people get GERD.
Poor Clearance

Poor esophageal clearance allows even occasional reflux to become a severe condition. Again, given that everybody refluxes at least occasionally, most people quickly clear reflux material from their esophagus and no harm is done. However, for patients with poor esophageal clearance, even occasional reflux may result in long dwell times, meaning that gastric acid reflux into the esophagus may persist for a considerable period, causing injury to the esophagus.

Poor esophageal clearance is a monumental although generally uncommon cause of GERD. However, there are no good therapeutic options for patients with poor esophageal clearance. The therapeutic options are limited and include limited operative options. For these patients, generally, PPI therapy is a primary option because it is always best to do no harm; for example, do not do something that results in profound dysphagia. The misapplication of antireflux surgery in patients with poor clearance can be devastating. The construction of a potent gastroesophageal valve mechanism in a patient with a poor esophageal clearance results in profound dysphagia.

Although PPIs do not stop reflux, only acid secretion (to varying degrees), they can be a primary therapy for patients with poor esophageal clearance. Poor esophageal clearance must be considered in everybody with GERD before any invasive intervention; esophageal motility must be determined.

There may be many causes of poor clearance, one of which is a primary motility disorder of the esophagus. This disorder may occur for no apparent reason but is particularly common in older patients, particularly after a stroke, or in patients with collagen vascular disorders, such as scleroderma. However, any form of esophageal obstruction can lead to bizarre or altered motility of the esophagus. For example, a large paraesophageal hernia could impair esophageal emptying and, in time, lead to altered esophageal motility. These causes must be considered in patients who have altered motility patterns because relief of obstruction may allow for the return of normal motility, in contrast to patients with achalasia in whom motility disturbance is a sine qua non of the disease.

Poor Gastric Emptying

Poor gastric emptying can cause GERD. If the stomach does not empty as it fills up, ultimately gastric contents spill back into the esophagus. Gastric emptying should be determined in the course of evaluation of patients with GERD. It may not be necessary to undertake a specific test of gastric emptying, like a gastric emptying scan, but poor gastric emptying must be considered when patients have retained gastric contents at the time of endoscopy after a prolonged period of nothing by mouth.

Gastric emptying scans in the evaluation of gastric emptying need to be interpreted with caution. Gastroesophageal reflux caused by a poor lower esophageal sphincter (LES) mechanism can be a cause of prolonged gastric emptying. In patients with severe reflux, gastric pressures are vented up into the esophagus with gastric contents with gastric contractions and increases in intragastric pressures. Emptying backwards into the esophagus may be the path of least resistance, with less resistance than emptying down into the duodenum through the pylorus. Therefore, an antireflux procedure may dramatically improve gastric emptying. It is not gastric emptying that needs to be determined before invasive procedures, but the presence of gastric contractility and antral/pyloric patency. Contrast studies of the upper gastrointestinal (GI) tract, including the esophagus and stomach, and upper endoscopy are helpful in determining anatomic problems that could be confused with primary motility disturbances. Anatomic problems, such as pyloric stenosis, require their specific corrections.
Poor emptying by gastric emptying scan is often reported to be gastroparesis. Gastric emptying scans may show delayed gastric emptying in patients with notable gastroesophageal reflux. An interpretation of gastroparesis must be interpreted with caution. It is our practice to follow an abnormal gastric emptying scan with an upper GI tract contrast study to ascertain gastric contractility and patency of gastric outlet. If the stomach contracts normally with an anatomically normal outlet, and without other concerns such as retained food on gastroscopy, then delayed gastric emptying is attributed to gastroesophageal reflux.

**Poor Gastroesophageal Valve (Poor LES)**

The foremost cause, and usually the cause considered first, of GERD is a poor valve between the esophagus and the stomach. Although this is the usual cause of gastroesophageal reflux and GERD, it is not the only cause; as mentioned earlier, poor esophageal clearance and poor gastric emptying also need to be considered. Conversely, a poor valve is the most easily corrected cause of GERD and therefore most of the attention in the therapeutic considerations of GERD focuses on the construction of a new or better valve mechanism. This is the premise behind antireflux surgery.

There are not many ways to determine the function or integrity of the LES. Manometry and impedance are not commonly used. However, the LES may be manometrically normal and yet not function well because of transient relaxation. A manometrically normal LES should not deter the application of necessary antireflux surgery.

**DIAGNOSIS OF GERD**

**Symptoms of GERD**

The symptoms of GERD are many and can be divided into 2 basic groups: esophageal and extraesophageal symptoms. Esophageal symptoms or manifestations of GERD generally focus on heartburn. Heartburn can occur many times per day. Heartburn may be postprandial or nocturnal. Patients who experience heartburn as a primary symptom generally do best with therapy, medical or operative. Patients with nonesophageal symptoms of reflux often have problems that are the most difficult to treat and ameliorate, particularly because the symptoms may not be acid related but may be related to reflux of even nonacidic material.

Nonesophageal symptoms of reflux can be varied and include, but are not limited to, chest pain, cough, aspiration, pneumonia, hoarseness, sinus problems, and so on. These symptoms may not necessarily be acid related but may be related to reflux of even benign nonacidic fluid. Chronic aspiration associated with nonacid reflux can lead to recurring pneumonias and ultimately pulmonary deterioration. It is important to determine whether or not symptoms of GERD are acid or nonacid related because nonacid-related symptoms do not improve on PPI therapy. These patients require cessation of reflux. Those patients with the best responses to PPI therapy do best with antireflux surgery because they have shown that relief of acid reflux relieves their symptoms. For them, PPI therapy is a successful therapeutic trial.

**Esophagoscopy**

Esophagoscopy is a useful measure in the diagnosis of GERD. Early evidence of GERD may be erythema in the esophagus. In patients with more advanced reflux disease, esophagitis, erosive esophagitis, and even ulcerations within the esophagus may be notable findings. For patients with long-standing disease, strictures within the esophagus may be noted, because ulcerations may have led to healing with
contracture and narrowing of the esophagus. Stricture formation is a finding of chronic reflux and is a disappointing finding with great implications. Often, stricture formation represents end-stage disease and is associated with profound distortion of esophageal motility, which in turn limits application of minimally invasive definitive therapy. It is important for patients with strictures to undergo early and repeated dilation to relieve the stricture and allow for definitive stretching of the esophagus. This practice requires a program of sequential dilation that continues even after cessation of reflux (eg, after fundoplication) with continued dilation until maturation of the scar occurs in a form that allows the patient to be free from dysphagia.

**Upper Gastroesophageal Contrast Studies**

There is much to be gained from an upper GI contrast study, particularly one performed with thought and care by an engaged radiologist. Such a study can detail anatomy, give great insight into esophageal motility, detect gastric contractions, define the anatomy of the gastric outlet, and detect clinically occult diseases, such as an ulcer. The importance of an upper GI contrast study cannot be overemphasized and it is an essential component of our diagnostic algorithm. However, some findings require restraint, for example, the finding of a hiatal hernia.

Hiatal hernia is not a sine qua non of gastroesophageal reflux or GERD. Hiatal hernia is a common finding and tens of millions of Americans have hiatal hernias. A hiatal hernia should be considered anatomically normal in patients more than 50 years of age, particularly those who are overweight. GERD occurs in a few patients with a hiatal hernia. Stated differently, a hiatal hernia is not a disease state but rather a condition of normalcy. The term hiatal hernia was introduced into the lexicon of Americans in the 1950s and is often believed to be significant, but it denotes no significance in the absence of excess acid reflux or esophageal emptying limitations.

We find that having a patient swallow a barium-laden food bolus in a 15°C Trendelenburg position is helpful in determining esophageal motility and emptying. If the bite-size food bolus clears in 2 or fewer stripping motions, esophageal motility is normal. If not, esophageal motility is impaired. We find this study to be more specific than manometry and it is well tolerated by patients.6

**Ambulatory pH Study**

Ambulatory pH studies are an essential part of the diagnosis with patients with reflux. The criteria of normal, as opposed to abnormal, are clear. A DeMeester score is a commonly used measure of reflux.7 A score of more than 14.7 denotes excess acid reflux. The DeMeester score is calculated by using a host of measures, in both the upright and supine position, which include the frequency of episodes of reflux, the percentage of time with a pH less than 4 in the distal esophagus, the duration of the longest episode of reflux, and the number of acid reflux episodes lasting more than 5 minutes. A score of 6.9 or less is normal. A gray zone exists between 6.9 and 14.7. A score of more than 14.7 is abnormal. Other measures of excess acid reflux rather than DeMeester scores are used by some. Nonsurgeons are more inclined to use percentage of time with a pH less than 4 in the distal esophagus, which is a component of the DeMeester score.

The length of ambulatory pH study should be as long as possible. There are advantages to a 48-hour study as opposed to a 24-hour study, because many patients with gastroesophageal reflux may have episodic excess reflux and that may not be picked up with a 24-hour study. Current technology limits us to ambulatory studies of 48 hours. Ambulatory pH studies can be undertaken through a transnasal approach or through an approach that uses a chip placed onto the distal esophagus. The latter
(ie, Bravo pH study) is our preferred approach because it allows patients to assume a more normal lifestyle during the course of study. However, the chip often is associated with notable dysphagia and can render patients uncomfortable during the time of study. However, it seems unlikely that patients with a chip are more uncomfortable than patients with a catheter emanating from their nose. It is important that ambulatory pH studies be undertaken during optimal (ie, usual life activity) circumstances. The patient should be off antacid medications (such as PPI therapy) well in advance of their studies and during the course of their studies. Ambulatory pH studies undertaken with patients on medication may be normal. Excess acid reflux is not detected because the reflux is nonacidic given the suppression of acid by the PPIs. There is generally no reason to study patients on PPI therapy or other antacid antisecretory medications.

Ambulatory pH studies should not be undertaken until patients are ready for intervention. For example, patients who need to lose considerable amounts of weight before intervention should not be studied until after their weight loss. Gastric acid secretion is proportional to body mass. As patients lose weight they secret less acid. Furthermore, gastroesophageal reflux is proportional to intra-abdominal pressures, which are directly transmitted to the lumen of the stomach. Heavy patients have high intragastric pressures that promote gastroesophageal reflux. Excessively heavy patients are not good candidates for antireflux surgery. Therefore, patients should not be studied until they are ready for an operation, for example, until they have lost the necessary amount of weight. Furthermore, ambulatory pH studies should be undertaken under usual life activities. They should not be undertaken in such a way that patients after application of the testing device are sent home to rest and be quiet. Active patients should be active during their period of pH testing so that their usual life activities are reflected in their test results. As a caveat, acid pH testing does not detect nonacid reflux. Patients who have nonacidic reflux and complications of nonacid reflux do not have abnormal ambulatory pH testing.

**Esophageal Impedance Testing**

Esophageal impedance is a relatively new technique developed to detect intraluminal bolus movement. This technique is based on measuring the resistance to alternating current (ie, impedance) of the content of the esophageal lumen.\(^8\) The impedance stays at its lowest point as long as the food bolus is present in the impedance-measuring segment and returns to its baseline once the bolus is cleared by a contraction. Liquid-containing boluses with an increased number of ions conduct higher electrical currents than gases, because of their poor electrical conductance.

Impedance testing is not able to detect the acid content or volume of the intraluminal contents. When combined with pH testing, the detection of both acid and nonacid is permitted and this method is typically more sensitive than pH monitoring alone. Furthermore, when combined with manometry it provides information about both the pressures and bolus transit within the esophagus. Limitations on impedance monitoring can include low baseline impedance values by the mucosa of Barrett esophagus and esophagitis, which make detection of reflux inaccurate in such circumstances. These inaccuracies require manual data correction when using the current automated analysis software.

Impedance testing is most useful in detecting nonacid reflux\(^9\) and is used to detect reflux in patients not responding to PPI therapy or those with normal ambulatory 24-hour or 48-hour pH testing. Impedance testing is also helpful in detecting postprandial reflux, when gastric contents are nonacidic.\(^9\) Impedance testing may provide a superior link between reflux and symptoms than ambulatory pH testing, especially in children.
Manometry

Manometry is generally not an effective tool for a diagnosis of gastroesophageal reflux. Although manometry determines motility patterns that are important in the application of definitive therapy for reflux, reflux and motility patterns of the esophagus may be completely unrelated and unassociated. Therefore, manometry has a role in determining applications of therapy but not in diagnosis of reflux.

INDICATIONS FOR APPLICATION OF DEFINITIVE THERAPY

Symptoms

Control of symptoms is a primary indication for intervention in patients with GERD. The symptoms that indicate intervention must be reflux related. As noted earlier, these symptoms can be divided into 2 groups: esophageal and extraesophageal symptoms of reflux. The differentiation between esophageal and extraesophageal symptoms is an important consideration because they may have different responses to treatment.

Esophageal symptoms of reflux generally mean heartburn. Heartburn is generally relieved with cessation of reflux and acid reflux in particular.

Extraesophageal manifestations of reflux are many and varied. Extraesophageal symptoms include cough, reflux-induced asthma, pulmonary symptoms of aspiration including recurring pneumonia, reflux-induced sinus problems, chest pain, and hoarseness. Relative to heartburn, extraesophageal manifestations of reflux are not so well treated by cessation of acid reflux.10,11

PPI therapy is effective in treating esophageal manifestations of reflux, for example, heartburn. Patients who do best with antireflux surgery are patients who do well with PPI therapy because the cessation of symptoms on medical therapy implies or denotes that sensation of reflux through intervention ameliorates symptoms. Patients with hoarseness and cough have a lower response to therapy than do patients with heartburn.10,11 Nearly 100% of patients with heartburn who respond to PPI therapy have complete relief of symptoms with antireflux surgery. For example, the relief seen in cough is less frequent probably because there are many causes of cough. Only about 70% of patients with excess acid reflux and cough see an improvement in their cough or relief of their cough with relief of the acid reflux through antireflux surgery despite a thorough workup of cough before antireflux surgery. Cough is a symptom that may have many causes, reflux being one, and patients with reflux may also have concomitant allergies or other problems that manifest as cough. Relief of the acid reflux may not provide significant amelioration of cough or other extraesophageal manifestations of reflux despite thorough preoperative evaluation. This observation must be considered in the informed consent process.

Endoscopic Indications

There are endoscopic indications for intervention for reflux. Patients may be asymptomatic and in the surveillance endoscopy they are found to have esophagitis and other findings caused by acid reflux. Patients may not have symptoms because their esophagus is insensate to acid reflux. Patients may not have symptoms but may be noted to have other issues that lead to endoscopy, such as occult GI bleeding. As mentioned earlier, the finding of Barrett esophagus on endoscopy is a more ominous finding than esophagitis.

Esophagitis is a spectrum. It can be found in several different stages, from simple erythema to erosions progressing onto ulcers. Esophagitis is an acute event, in general. The finding of Barrett esophagus denotes long-standing severe reflux. In patients with less than high-grade dysplasia, Barrett esophagus is generally treated
with antireflux measures, including fundoplication. However, patients with high-grade
dysplasia warrant further intervention beyond the cessation of reflux. The risk of
cancer in patients with high-grade dysplasia is such that ablation of the Barrett esoph-
agus or other interventions are necessary. These interventions can include mucosal
ablation, endoscopic mucosal resection, or even, in some patients, esophagectomy.

Complaints of dysphagia or the identification of a stricture on endoscopy in a patient
with reflux are particularly ominous. Any patients complaining of dysphagia in the
presence of reflux have to be considered to have cancer until proved otherwise.
The finding of the stricture denotes long-standing severe reflux. The strictures have
to be dilatable for antireflux measures alone to be considered. For patients with non-
dilatable strictures, esophagectomy is necessary. For a stricture to occur in a patient
while on medical therapy is unacceptable, and the practitioner should be accountable
for the progression of reflux, and the development of such a severe complication while
the patient is under their observation. This situation can be a criticism of medical
therapy.

In considering antireflux surgery, the stricture should be dilatable; dilation should be
frequent and sufficient to allow for dilation to a significant size, for example, a 56-
French to 60-French bougie. In patients undergoing definitive antireflux therapy,
such as a fundoplication, a plan for dilation after fundoplication must be formulated
preoperatively such that dilations after fundoplication are initially undertaken
frequently albeit at an ever-decreasing frequency. This process is so that maturation
of the scar can occur with a lumen of adequate size. Even although the reflux has been
relieved after fundoplication, the healing process continues, reflecting prefundoplica-
tion reflux. Dilation, given the severity of the stricture, may need to continue for up to
several years after eradication of the reflux, albeit in an ever-decreasing frequency.

Persistent Symptoms Despite Medications

Patients may have symptoms caused by reflux despite antireflux medications such as
PPIs. For these patients, definitive resolution of their reflux is important and they
require more than antiacid therapy. These patients need antireflux therapy, not anti-acid
therapy. For patients who have nonesophageal symptoms of reflux their symp-
toms are often related to nonacid reflux, and therefore cessation of reflux, not just
cessation of acid reflux, is important. These patients require more than just PPI
therapy. Their options include endoscopic or laparoscopic fundoplication.

Strictures

Patients with esophageal strictures have developed a severe complication of acid
reflux and we believe they should undergo repeated dilation with definitive resolution
of gastroesophageal reflux. Although patients generally may do well on PPI therapy,
acid suppression is not 24 hours per day. Patients may have therapy twice per day
with PPIs, but then costs become considerable and other complications such as oste-
oporosis become paramount; we believe that patients noted to have strictures caused
by reflux are best served by definitive antireflux intervention and therapy directed at
their stricture, namely dilation. This dilation needs to continue postoperatively to arrest
the structuring process that began preoperatively.

Bleeding Caused by Reflux

Patients noted to have bleeding should undergo endoscopy for documentation of the
cause and the bleeding site, and initiation of PPI therapy. Once patients are stable and
the bleeding is completely under control, the decision for PPI therapy, as opposed to
definitive therapy, needs to be undertaken. Patients with a life-threatening or significant
complication associated with reflux require open-ended long-standing therapy and are exposed to all the consequences associated with prolonged PPI therapy, and therefore are best considered as candidates for definitive antireflux therapy.

**Barrett Esophagus**

Patients with Barrett esophagus are best treated with definitive antireflux therapy. PPI therapy is not uniformly efficacious in acid suppression and these patients require open-ended therapy. Given that there is a path along which esophageal injury occurs, Barrett esophagus represents a relatively advanced manifestation of reflux, and patients are best served by having definitive antireflux intervention. After cessation of acid reflux, regression of Barrett esophagus is possible.\(^{12}\)

**Cost of Care**

The costs of medication, follow-up, medical care, and endoscopy have to be considered in the decision to intervene and provide definitive antireflux therapy. For patients with projected open-ended therapy, the cost, inconvenience, risk of complications, and compliance necessary for long-term care and follow-up are considerable, and definitive antireflux therapy should be given early consideration. If there is a medically treatable cause of reflux or a treatable factor that exacerbates reflux, such as obesity, then PPI therapy seems indicated even in young patients until the treatable causes can be brought under control or treated. However, for young, thin, healthy patients without notable risk factors for GERD, antireflux surgery should be an early consideration.

**Compliance**

Definitive antireflux therapy, and specifically antireflux surgery, should be considered for patients who are unavailable or do not cooperate with ongoing medical care and follow-up.

**General Conditions**

Patients who do best with definitive acid reflux therapy (ie, laparoscopic fundoplication) are patients who do best with PPI therapy. It is also important to consider that before intervention numerous steps should be undertaken. Before intervention is undertaken, medical therapy should be undertaken while treatments of comorbidities are evaluated. As stated earlier, a PPI therapy is a great predictor of patients who do well with definitive antireflux intervention. PPI therapy is, in a sense, a therapeutic trial, particularity given heartburn and other esophageal symptoms of GERD.

If it is possible to ameliorate causative factors associated with reflux before intervention, it should be undertaken. For example, patients who are heavy should lose weight. We look for a body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters) of less than 26 kg/m\(^2\) before any definitive intervention is considered. Weight loss decreases acid secretion, and as mentioned earlier, it decreases intragastric pressures, which leads to less of a driving force for acid gastroesophageal reflux. Patients who smoke should stop. They should change this lifestyle that promotes gastroesophageal reflux. For example, a lifestyle that involves inducing high intragastric pressures should change. Patients should avoid methylated xanthenes (eg, chocolate) and alcohol. Furthermore, they should not function at high altitudes or lower atmospheric pressures, if possible. It is simplistic to say that these measures should be undertaken, but some patients find it impossible; someone cannot move from Denver, Colorado to a city at sea level just to avoid reflux. Intervention may be necessary.
because of a life at higher altitudes. However, if reflux occurs in a patient who only intermittently travels to higher altitudes, where reflux can be excessive, several weeks of PPI therapy per year are a small price to pay to control intermittent reflux.

Once someone has been optimized for intervention, then appropriate evaluation of their reflux should be undertaken. Ambulatory pH studies should not be undertaken while patients are heavy but rather after they have lost the appropriate weight. Esophageal motility needs to be determined.

Patients and their care providers should understand the disease process for each patient. Upper GI contrast studies for determination of causes of symptoms are important. Upper endoscopy should also be undertaken before intervention to rule out other diseases and to evaluate for Barrett esophagus, and to determine gastric emptying (ie, residual food) and gastric outlet. The upper GI study mentioned earlier should be used to look for gastric contractions and gastric emptying. Gastric emptying scans are not necessary in most patients and are often overinterpreted. Delayed gastric emptying in a patient with reflux may simply be caused by excess gastroesophageal reflux. Nonetheless, nuclear medicine physicians generally report delayed gastric emptying as equating to gastroparesis, further complicating the patient’s care. Delayed gastric emptying may not be related to gastroparesis at all. The delayed gastric emptying may be nothing more than a manifestation of notable gastroesophageal reflux.

It is important to understand esophageal motility before intervention. Esophageal motility can be determined through manometry, impedance, or, as in our choice, a barium-laden food bolus with the patient in a 15° head-down position. This position allows us to determine anatomy, esophageal motility, and gastric contractility and emptying. This study requires that a food bolus, like a bite of a marshmallow or bagel, be cleared from the esophagus by 1 to 2 stripping motions. If a barium-laden food bolus is cleared with 2 or fewer stripping motions, patients do well after fundoplication, with a low incidence of dysphagia. We find that this is a better measure of esophageal function than manometry, which seems too sensitive.

Impedance testing, and high-definition impedance testing in particular, is the newest testing modality to be widely studied. Early studies with impedance testing are promising and seem to be sensitive and specific when determining esophageal motility. Such testing can detect nonacidic bolus reflux.

A full evaluation of all comorbidities must be undertaken before any intervention is considered or initiated. Risks of the intervention must be estimated and efforts must be undertaken to decrease risk. For example, for a patient with inducible cardiac ischemia, revascularization with either stenting or bypassing must be undertaken before intervention for reflux disease. In general, medical comorbidities and age should not deter the application of laparoscopic fundoplication.

**Informed Consent**

The informed consent process should be detailed and specific, as before any operation or any intervention. There are 8 complaints that commonly occur after antireflux surgery and we are specific about telling patients about these, which we learned from the more than 1000 patients on whom we have performed fundoplications. These 8 complaints are:

1. Shoulder pain, probably caused by pneumoperitoneum.
2. Dysphagia caused by swelling at the gastroesophageal junction associated with the dissection and construction of the valve mechanism.
3. Bloating associated with aerophagia. Aerophagia is associated with dry swallowing, which patients do excessively preoperatively to induce esophageal motility.
to clear their refluxed material. This is a learned behavior and patients continue to do it after the operation; they swallow a lot of air (ie, aerophagia), which leads to notable bloating and other symptoms. This behavior is unlearned in time. To lessen bloating, patients should not chew gum or drink with straws.

4. Flatulence. This is a consequence as well of aerophagia because patients do not belch or reflux so much after fundoplication. Bloating and flatulence are a consequence of aerophagia and the iatrogenic limitation of belching.

5. Diarrhea. This condition is really better stated as defecatory frequency; whatever it is called, it is a consequence of the aerophagia, bloating, and air in the intestinal tract. As intestinal motility picks up to more rapidly clear the air descending in the bowel, increased flatulence is a consequence, as is defecatory frequency. Attempts to control defecatory frequency with medications such as Imodium increase bloating. Patients cannot be counseled on decreasing aerophagia, it decreases with time. Aerophagia is a subconsciously learned behavior and is unlearned with time.

6. Nausea. Again, this is probably a consequence of aerophagia.

7. Early satiety. Early satiety is a consequence of a smaller gastric reservoir, which is a result of the stomach being used in the antireflux procedure, and is a consequence of notable aerophagia, which may leave the patient with a stomach full of air when the first bite of food is taken.

8. Incisional pain. This complaint is aided by injecting local anesthesia into the umbilicus before the incision is made.

Informed consent must also consider that there are failures in control of symptoms associated with reflux, which is particularly true with patients who have nonesophageal symptoms of reflux. There may also be some new symptoms after fundoplication, such as dysphagia.

INTERVENTION BEYOND MEDICAL THERAPY

Interventions beyond medical therapy can generally be divided into 2 basic groups: endoscopic and laparoscopic. The days of open procedures need to be considered as a thing of the past. However, the possibility of open surgery should be noted in the consent.

Endoscopic

Endoscopic therapy generally is limited to EsophyX (EndoGastric Solutions, Inc, Redmond, WA), often called transoral incisionless fundoplication. EsophyX is a transoral approach to an endoscopic placation of the esophagogastric junction to construct a more prominent gastroesophageal flap valve, much in the manner of an endoscopic Belsey Mark IV procedure. Using EsophyX, a rotational longitudinal esophagogastric fundoplication is constructed. Using EsophyX, a full-thickness esophagogastric fundoplication is constructed with fixation extending longitudinally 3.5 cm above the Z-line and rotationally more than 270° around the esophagus.

Although it has been studied in many different ways manometrically and is often compared with a Nissen fundoplication, EsophyX seems to be more of an endoscopic approach to the Belsey Mark IV procedure. It does not really limit esophageal emptying or act to impede esophageal emptying and in patients with esophageal dysmotility it probably serves as a preferred alternative to other procedures, given documented efficacy, such as Nissen fundoplication. Candidates for EsophyX should be in good health and of ideal body size (eg, BMI <30 kg/m²), as mentioned earlier, and have a hiatal hernia less than 2 cm in size.
Although it is heavily marketed, there are not many data regarding long-term outcomes associated with EsophyX. There are few controlled data. Patients who have undergone EsophyX therapy generally have a reduced use of PPI therapy. Many have control of their acid reflux, although generally only a few. Early results show that 37% to 49% of patients have normalization of acid exposure to the esophagus. Resting pressures of the LES are also improved.

An increasing number of patients are being treated, and results of long-term outcomes are still being determined. Revisions after EsophyX are not problematic, and favorable outcomes can be expected after revisional laparoscopic fundoplications.

Controlled trials of EsophyX would be helpful in determining its place in the armamentarium of antireflux surgery.

Laparoscopic Fundoplication

The gold standard for intervention is laparoscopic fundoplication. What type of laparoscopic fundoplication is chosen is at the discretion of the surgeon. Debate continues as to which is the best type of fundoplication, with many differing opinions. We believe, as do others, that fundoplication controls acid reflux better than PPIs. Generally, normal esophageal motility dictates that a Nissen fundoplication be undertaken and a Toupet fundoplication be undertaken for patients with altered or minimally to moderately impaired esophageal motility. Patients with no esophageal motility would probably do poorly with whatever fundoplication were chosen and are best not operated on. Again, first do no harm. An example of a patient in this category is a patient with scleroderma or a collagen vascular disorder severely limiting esophageal motility. Those patients are best served by avoiding fundoplication in its entirety and continuing to receive therapy with a PPI, if possible. Although PPI therapy may not be perfect or ideal for those patients, dysphagia is a morbid symptom, and patients are unhappy if dysphagia is augmented or induced by fundoplication.

Before undertaking laparoscopic fundoplication, remember that the best candidates for laparoscopic fundoplication are those who are in good health and those who did well with PPI therapy.

The goals of laparoscopic fundoplication are (1) to reduce the hiatal hernia in its entirety, (2) to mobilize 8 cm of esophagus into the abdomen, and (3) to construct a valve mechanism. Furthermore, the gastric outlet needs to be ensured. This objective is best achieved preoperatively by endoscopy or barium study.

Our technique of fundoplication involves several basic steps. The gastrohepatic omentum is opened in a stellate fashion to allow wide visualization of the right crus and to facilitate rolling of the stomach from left to right. The dissection should be carried up and down the right crus, then into the mediastinum, and any hiatal hernia should begin to be reduced. The stomach should then be rolled to the right and the short gastric vessels divided. The dissection should be carried to the left crus, up and down the crus, and then into the mediastinum. The hiatal hernia should be reduced in its entirety and the hiatal hernia sac excised as much as possible, with care not to injure the vagal fibers. The gastroesophageal fat pad should be excised. The esophageal hiatus should be reconstructed with a posterior cruroplasty so that it is snug, but not tight, about the esophagus. Mesh may be necessary to provide for a secure reconstruction of the hiatus. It is not in our routine to use mesh. If mesh is used it should be a bioprosthesis and not polypropylene mesh. We use the bioprosthesis to reinforce an insecure closure or to augment a closure that is not otherwise possible when the left and right crura cannot be opposed. The latter occurrence is very uncommon and the former is relatively uncommon. Some use a bioprosthesis for reconstruction of the hiatus with patients with paraesophageal hernias and some
use it routinely. There are data to support this approach, but the expense of mesh, complications associated with mesh (ie, infection, dysphagia), and the success of our approach have caused us to use mesh infrequently.

Once the hiatus has been reconstructed, a valve mechanism is constructed. Generally we construct a Nissen fundoplication in patients with normal esophageal motility. We construct a Nissen fundoplication, securing the anterior fundus and the posterior fundus to the esophagus twice, with the sutures placed well above the gastroesophageal junction. A third suture approximates the anterior fundus and the posterior fundus at the level of the gastroesophageal junction. This fundoplication is undertaken with a bougie through the mouth in the stomach: size 52 to 56 French in women and size 56 to 60 French in men. Once the valve is constructed and the bougie removed, the posterior fundus is tacked to the right side of the esophagus and then to the right crus so that there is no tension promoting the wrap to come undone or twisting to the esophagus.

It is now our preferred approach to use a laparoendoscopic single-site (LESS) approach. This approach uses only a 12-mm incision at the umbilicus. This incision provides optimal cosmesis and a speedy return to normal functional activities. To operate on patients and leave no notable scar is, by any measure, outstanding. Our results with laparoscopic fundoplications are consistent with many others. Our results with LESS fundoplication are similar to with laparoscopic fundoplication. Millions of patients have undergone laparoscopic antireflux surgery. We believe that results recommend continued application. Success is uniform and durable. However, success is not universal. Patients fail. Under the best of circumstances and in the best of surgical practices, patients fail for many reasons. Some of them may be related to patients’ behavior, such as coughing or vomiting postoperatively. Some of them may be related to some subtle failure in technique that is not apparent to the operating surgeon. For example, in a given patient the fundoplication may be constructed too tight or with too much tension, leading to postoperative dysphagia. In another patient, a secure hiatal reconstruction may fail. Failure may occur for no apparent reason, but on long-term follow-up, unraveling of the wrap or failure of the hiatal reconstruction may be noted. Failure is uncommon. Postoperative paraesophageal hernias occur infrequently. The same is true for sliding hiatal hernias. It should be noted whether they are important and whether they are true failures as opposed to incidental findings. For example, a 2-cm hiatal hernia after fundoplication may be a finding on an upper GI study that has no notable clinical significance. Many would consider this as a normal finding, given that most people more than 60 years of age have at least a small hiatal hernia.

Patients should be followed up with ambulatory pH testing, which should be used as a gold standard for reflux. Patients should be followed up with an upper GI study to be used as a measure of anatomic normalcy. However, ambulatory pH studies are the true measure of acid reflux and findings of upper GI studies must not be considered significant for reflux; anatomic findings on an upper GI study cannot be subtle and important. To be important, findings must be truly notable and noteworthy. An example of a noteworthy finding is a large paraesophageal hernia or a large hiatal hernia, which may lead to other symptoms. A 2-cm hiatal hernia could be an anatomic normalcy and denotes no significance in a postoperative period. Symptomatic control of patients with reflux has proved to be durable and satisfactory.

Control of acid reflux by ambulatory pH testing after fundoplication is noted to be satisfactory and durable, although patients are generally unwilling to undergo surveillance pH testing. Laparoscopic fundoplication has established itself as the gold standard for the control of reflux.
Measures beyond fundoplication such as esophagectomy should be considered in patients only with notable complications, such as cancer or nondilatable stricture formation, as noted earlier.

REFERENCES