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Anti-reflux procedures: complications, radiologic findings, and surgical and gastroenterologic perspectives

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Abstract

This article provides an overview of the current surgical anti-reflux procedures and their imaging findings, as well as the surgical complications. Accurate and timely clinical assessment requires an engaged radiologist fluoroscopist who understands the perspectives of their interdisciplinary colleagues, including the surgeon and gastroenterologist. The complex pathophysiology calls for an interdisciplinary approach, and the radiologist needs to tailor their evaluation to answer the specific questions posed by their clinical colleagues and by the presenting symptomatology.

Key words: Fluoroscopy—Reflux—Fundoplication—Motility

Gastroesophageal reflux disease (GERD) is one of the most common conditions seen and evaluated by gastroenterologists, gastrointestinal surgeons, and abdominal radiologists. Effective and time-honored treatments include both pharmacologic suppression of gastric acid production and surgical fundoplication, which is usually performed laparoscopically.

Although published literature describes imaging evaluation before and after anti-reflux surgery [1, 2], many cases (and patients) are complex and demand an integrated multidisciplinary approach to problem solving. Understanding the surgical approach and imaging evaluation is key; however, this alone is not enough. During the barium swallow examination as part of the preoperative evaluation, the radiologist must not only correctly identify stricture, hiatal hernia, and motility disorders, but she or he must also be keenly aware of findings indicating a short esophagus and more subtle dysmotilities. Failure to do this can predispose to surgical failure and worsening symptoms.

Formalized interdisciplinary collaborations, such as with an Esophageal Conference, can lead to a collective experience which helps clarify subtle nuances of clinical presentations and postoperative imaging. Moreover, the art of performing fluoroscopic esophagography is as important as its interpretation, perhaps even more so. An engaged fluoroscopist is a key ingredient of the interdisciplinary team. In this paper, we consider the normal postoperative appearances and complications that can occur after fundoplication. The management and radiologic assessment of these complications is discussed from the standpoint of the surgeon, gastroenterologist, and radiologist. Newer, less invasive alternatives to laparoscopic fundoplication are also described.

This article is an attempt to synthesize our collective experience about this important and challenging group of patients.

Anti-reflux procedures

Therapy for GERD that is not well controlled with medication typically involves hiatal hernia repair, if present, in association with one or more anti-reflux operations, primarily laparoscopic fundoplication. These operations are aimed at correcting the anatomic and functional abnormalities of the esophagogastric junction (EGJ) that result in gastroesophageal reflux (GER). Corrective measures include reduction of hiatal hernia, if present, construction of a fundal wrap to augment the lower esophageal sphincter (LES) and increase its resting pressure, and approximation of the diaphragmatic crura [3].

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The efficacies of both laparoscopic Nissen and Toupet fundoplications have been well established [4, 5]. The choice of which of these two procedures to perform relies primarily on the preoperative manometric and radiologic assessment of esophageal peristalsis, as well as the underlying severity of the reflux disease. In the setting of normal or minimally abnormal esophageal motility, most surgeons will choose a Nissen fundoplication which involves a 360° fundal wrap. The Toupet (a posterior 270° wrap) fundoplication forms a looser wrap and is typically performed in patients with diminished esophageal peristalsis in an effort to minimize the likelihood of prolonged postoperative dysphagia [6, 7]. This is not a simple choice as we know that weak and ineffective esophageal peristalsis sometimes improves with the anti-reflux surgery [8].

The long-term success rate for laparoscopic fundoplication is greater than 90%. In a review of 10,735 cases, Carlson and Frantzides [5] reported mortality after laparoscopic fundoplication to be exceedingly low, only 0.08%. Mild bloating is common immediately after surgery, but it typically subsides within 1 month. More significant immediate perioperative complications are rare, which include early wrap herniation (1.3%), pneumothorax (1.0%), perforation (0.78%), wound infection (0.11%), and splenectomy (0.06%) [5].

Known risk factors that increase the likelihood of failure for both Nissen and Toupet fundoplications include large hiatal hernia, diminished esophageal motor function, and obesity. Mesh has been used to reinforce hiatal closure with improvement in short-term, but not long-term outcomes [9]. In obese patients with a BMI in excess of 35, most surgeons recommend bariatric surgery over fundoplication. The laparoscopic Roux-en-Y gastric bypass is the bariatric procedure of choice in these patients as sleeve gastrectomy has been shown to decrease gastric compliance and exacerbate reflux symptoms [10].

Esophageal lengthening procedure (Collis procedure or Collis variants)

Knowledge of the surgical procedure that was performed is essential to accurate postoperative radiologic interpretation. It is important that the preoperative barium swallow examination accurately identifies reflux-induced strictures due to transverse scarring and longitudinal scarring, resulting in a short esophagus. A Collis gastroplasty is sometimes performed when the portion of the esophagus below the diaphragm is too short to allow the gastric fundus to be wrapped around it while still remaining in the abdomen. To avoid creation of an intrathoracic fundoplication, an esophageal lengthening procedure may be performed. The traditional Collis gastroplasty consists of a double staple line in the gastric fundus, parallel to the left border of the distal esophagus. To adapt this procedure to a laparoscopic approach, a wedge of fundus parallel to the left esophagus is removed, effectively creating an intraabdominal tubular segment or "neoesophagus." The gastric fundus is then plicated around this tubular segment below the diaphragm [11, 12]. Knowledge of the radiologic appearance of this procedure (Fig. 1) is important to avoid the misdiagnosis of a malpositioned (too low) fundoplication [4].

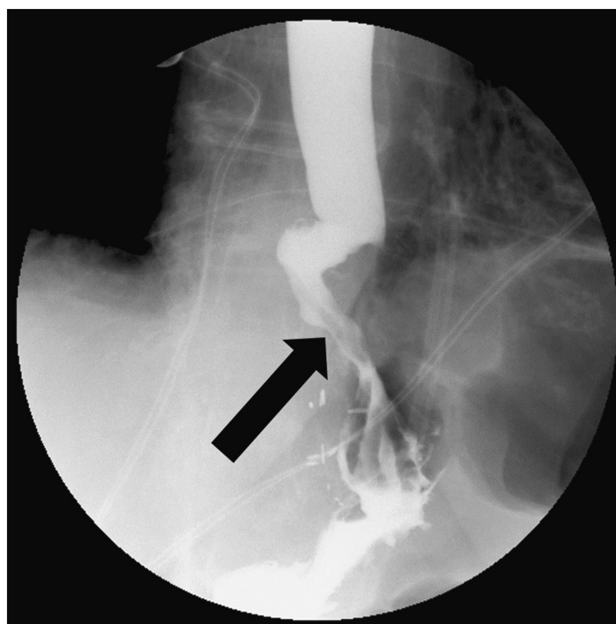

Fig. 1. Normal post-fundoplication with Collis esophageal lengthening procedure. Fundoplication encircles gastric folds (arrow) within the neoesophagus, not to be confused with a slipped fundoplication.

Newer advances in treatment of GERD

While laparoscopic fundoplication is currently the gold standard for the treatment of GERD, some novel endoscopic treatments have been introduced over the past two decades, most notably the Stretta® procedure, and some innovative endoscopic approaches to endoluminal fundoplication now offer alternatives to laparoscopic fundoplication [13]. The Stretta® procedure is a minimally invasive endoscopic procedure in which the LES and gastric cardia are heated to a target temperature of up to 85 °C by radiofrequency energy delivered through electrodes on the end of an esophageal catheter [14]. The tissue heating results in thickening and possibly neurolysis of the LES, which presumably accounts for the observed post-procedural improvement in reflux symptoms. In a study of 20 patients before and 6 months

after Stretta® procedure for GERD, there was a significant decrease in the frequency of postprandial transient LES relaxations and an increase in mean basal LES pressure [15]. Stretta® also reduced the number of reflux events and decreased the esophageal acid exposure times from 10.6% to 6.8%. While Stretta®-induced reduction in acid exposure has been found to be relatively modest [16, 17], it is worth noting that even proton pump inhibitor (PPI) therapy does not normalize esophageal pH in up to 50% of patients whose GERD symptoms are controlled with PPIs [18]. Because the lasting effects of Stretta® procedure on the lower esophagus are largely functional and not morphologic, one would not expect it to cause substantial changes on esophagography performed after early, transient post-procedural luminal irregularity and narrowing have subsided.

Other currently available endoscopic treatments for GERD utilize a variety of devices that are now on the market, with Esophyx® being the most commonly used device in the U.S. [18, 19]. This transoral procedure uses an endoscopic vacuum device to retract small (< 3 cm) hiatal hernias back into the abdomen. The same vacuum device is then used to assist in the creation of a 200° or greater fundoplication. The fundal wrap is held in place with endoscopically placed fasteners. The risk profile of this procedure is quite low, with few reported cases of esophageal or gastric perforation at the time of the procedure. Symptoms of GERD and the need for PPIs decreased significantly in patients undergoing transoral endoscopic fundoplication with the Esophyx® device. The morphology on postoperative radiologic studies would be expected to show an intact fundoplication encircling the lower esophagus, resembling that of a laparoscopic Nissen fundoplication.

Another of the newer surgical procedures to receive attention is an implantable magnetic sphincter augmentation device known as the LINX® [20]. The device consists of a string of titanium magnetic beads that is placed around the distal esophagus, typically using a laparoscopic approach. This procedure is suitable for patients with pathologic reflux, normal esophageal motility, hiatal hernia smaller than 3 cm, and the absence of obesity. It has been reported to bring about significant reductions of GERD symptoms and PPI use. The device was designed to address early dysphagia and gas bloat that can occur following fundoplication, and these symptoms are reported to be significantly less frequent after placement of the magnetic device than after laparoscopic Nissen fundoplication [21]. There has not been widespread adoption of LINX® over laparoscopic fundoplication due to limitations in the patient eligibility and concerns over the risk of erosion of the device into the gastrointestinal tract over time. We have found no reports on postoperative radiologic studies in patients with LINX® to date.

Routine versus selective use of early postoperative esophagography

Water-soluble contrast esophagography is performed routinely in many, but not all, centers within the first few days after anti-reflux procedures [22]. Where its use is not routine, there is general agreement that water-soluble contrast esophagography should be performed if there is clinical suspicion of perforation, early wrap herniation, or other cause of greater than expected bloating.

In a retrospective review of 1894 subjects, Tsunoda et al. reported finding 15 (0.8%) asymptomatic patients who were shown radiographically to have complications requiring reoperation [23]. Shahzad et al. retrospectively studied the routine versus selective use of esophagography after fundoplication [24]. In a group of 125 patients who routinely underwent postoperative esophagography, 32 showed abnormalities, but only one of those patients required redo surgery. In their comparison group of 115 patients who were studied radiographically only if there was heightened clinical suspicion of postoperative surgical complication, ten esophagograms showed four complications, none of which required reoperation. The routine use of early postoperative imaging did not differ significantly from the symptom-driven, selective use in the detection of the need for reoperation, possibly related to the small number of serious complications in both groups. Not surprisingly, therefore, opinions continue to differ on whether the use of early postoperative water-soluble contrast esophagography should be routine or symptom-driven.

Early postoperative imaging after fundoplication

An initial postoperative esophagogram may be performed with water-soluble contrast material as early as the first postoperative day. At our institution, approximately 50 mL of 60% low-osmolar iodinated contrast material is administered followed by a barium agent if no leak is initially detected. Published literature supports the use of a barium contrast agent after a negative water-soluble leak study [25, 26], but the authors are unaware of studies comparing the benefits of high- versus low-density barium agents. A history of iodinated contrast reaction (enteric or intravenous administration) is a relative contraindication as contrast absorption across gastrointestinal mucosa into the bloodstream is well established [27, 28], and anaphylactoid reaction to enteric iodinated contrast has been documented [29].

When performing esophagography within the first few days after fundoplication, it is important to study patients in both the standing and recumbent positions in order to present contrast material to all luminal surfaces in the surgical bed. The standing position also allows for assessment of esophageal emptying, which, in the early

postoperative period, is sometimes delayed due to postoperative edema or a "tight" wrap.

The examination begins with the patient standing erect if tolerated or semi-erect if not. A preliminary, noncontrast radiographic spot image (scout image) is obtained, centered on the EGJ. The radiologist may watch the initial swallow in the lateral view as it courses through the pharynx, particularly in those patients thought to be at high risk for aspiration. This risk of pulmonary complications associated with aspiration has been significantly reduced with the transition to low-osmolar agents. The lower esophagus and proximal stomach are examined for leakage and obstruction. Additional videofluoroscopic and spot images are then obtained in the area of interest with the patient in erect, supine, and both oblique positions while the patient swallows the remainder of the 50 mL dose of contrast material. If no contrast leakage is seen, additional spot images of the operative area are obtained by having the patient drink barium sulfate suspension and rolling the patient from side to side to facilitate coating of the wrap with contrast material. Esophageal and gastric emptying should also be assessed. Care should be taken not to end the study with large contrast residual in a poorly emptying esophagus or stomach, particularly in an obtunded patient, because of risk of gastroesophageal or intraesophageal reflux and aspiration after the procedure. We suggest passage of a soft rubber catheter via the nose to suction this contrast and have found careful passage of a soft catheter to the distal esophagus to be safe in these postoperative patients.

Expected postoperative appearance

The uncomplicated fundoplication wrap appears as a 2- to 4-cm "pseudomass" with a smooth contour defect in the gastric cardia (Fig. 2) [1, 2]. The distal esophagus is usually narrowed mildly where it courses though the central portion of the wrap, but it should not be so narrow that it obstructs the passage of the barium tablet [3, 11]. Marked narrowing of the distal esophagus therefore may indicate tight fundoplication wrap or a postsurgical stricture in the region of the wrap (Fig. 3) [30]. The wrap should encircle the gastroesophageal junction and be located entirely below the diaphragm, without a hiatal hernia. Failure to recognize a short esophagus preoperatively can lead to a wrap that is placed inappropriately too low, sometimes inaccurately referred to as a "slipped wrap" or predispose to herniation of wrap into the chest. When the patient is erect, the wrap may appear as a defect forming an acute angle with the opacified stomach. During the motility phase, there should be no ballooning of the distal esophagus or retrograde esophageal bolus transit as these may be signs that the wrap is too tight [30]. In the upright position, there should be no delay in esophageal emptying. A qualitative assessment of gastric motility should also be made to identify potential causes of postprandial bloating or early satiety.

After transoral incisionless or endoluminal fundoplication, the radiologic appearance is similar to that of laparoscopic fundoplication. One can expect to see the wrap as a smooth round or ovoid filling defect in the gastric cardia, narrowing of the lower esophagus where it passes through the fundoplication, reduction or disappearance of elicited reflux, and improvement of esophagitis [31, 32].

Immediate postoperative complications

Dysphagia is common in the immediate postoperative setting, typically due to either postoperative edema, transiently diminished strength of esophageal contraction, or both. In the immediate postoperative period, both nausea and vomiting should be evaluated by an esophagogram as either may be signs of early disruption or other significant complications.

The purposes of early postoperative esophagography are primarily to detect perforation (Fig. 4), early wrap herniation, and unusual tightness or length of the wrap. Most complications detected at this stage turn out to be self-limited, tight fundoplications due to edema. A few, however, are more serious and may require reoperation. Perforation is rare and occurs most often in the lower esophagus or gastric fundus. Its early recognition is important in determining when the patient may safely resume eating. Early wrap herniation can also occur and may have a paraesophageal component which can be detected by either contrast esophagography or computed tomography (CT) [33, 34].

Late postoperative imaging after fundoplication

Two factors are paramount to a successful anti-reflux operation. First is control of the presenting symptoms, and second, control of refluxate exposure. These are typically accomplished at the same time; however, each is uniquely important with regard to outcome. For instance, in a patient with both heartburn and Barrett metaplasia, symptom control is obviously important, but so is the control of reflux to prevent further damage and inflammatory response in the distal esophagus. Neither ambulatory pH testing nor barium esophagography has been universally accepted as a means of ensuring that reflux is controlled; therefore, neither is used routinely and most practitioners rely on good control of reflux symptoms as a marker for effectiveness. After a successful laparoscopic fundoplication, many gastroenterologists and surgeons do not continue to follow patient long term unless there were preoperative conditions that require surveillance, e.g., Barrett metaplasia.

If symptoms recur or if new foregut symptoms arise, including recurrent reflux symptoms, atypical or extrae-

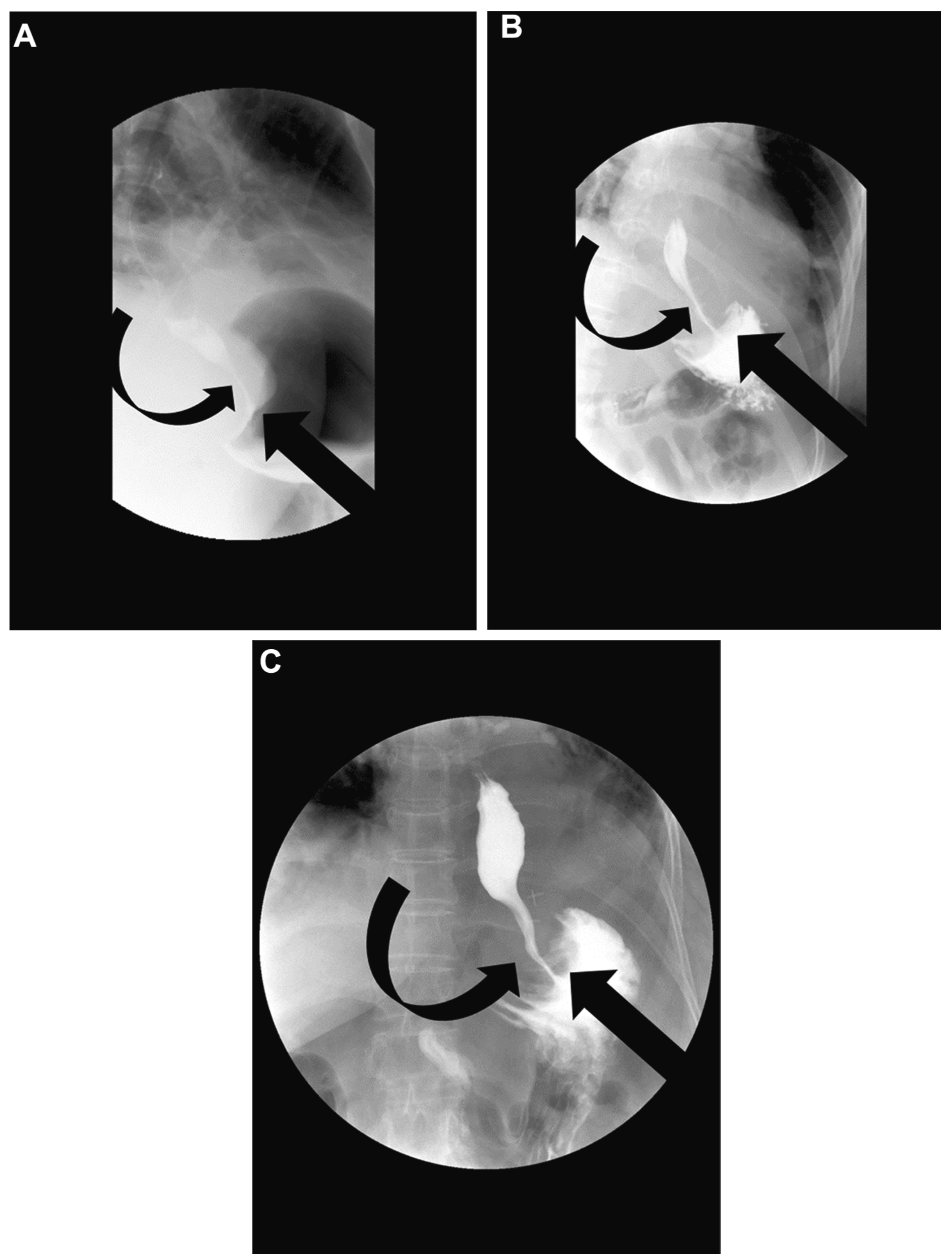

Fig. 2. Normal post-fundoplication appearance in three different patients. Fluoroscopic images (**A, B, C**) demonstrate pseudomass appearance of fundoplication (arrows) with expected narrowing of the distal esophagus and EGJ (curved arrows).

sophageal reflux symptoms, dysphagia, or gas-bloat syndrome, the surgeon or gastroenterologist will typically investigate further. Multiple diagnostic options are available, including endoscopy, esophageal motility testing, and ambulatory pH/impedance monitoring; however, barium esophagography is often used for the initial assessment as it concomitantly gives both anatomical and functional data.

Our standard barium swallow technique includes single-contrast and double-contrast (bi-phasic) videofluoroscopic evaluation including spot images of the pharynx, esophagus, and proximal stomach. A detailed protocol for this examination has previously been reported [35]. The examination typically begins with the patient in the standing position while drinking a swallow of low-density barium suspension. If obstruction or significantly delayed esophageal emptying is seen, the slow esophageal emptying is documented with spot images of the column of barium in the esophagus at 1, 2, and 5 min after the last swallow of barium. Although this technique was developed for the assessment of achalasia [36], we find its objective and reproducible assessment of esophageal emptying helpful in the post-fundoplication setting as well.

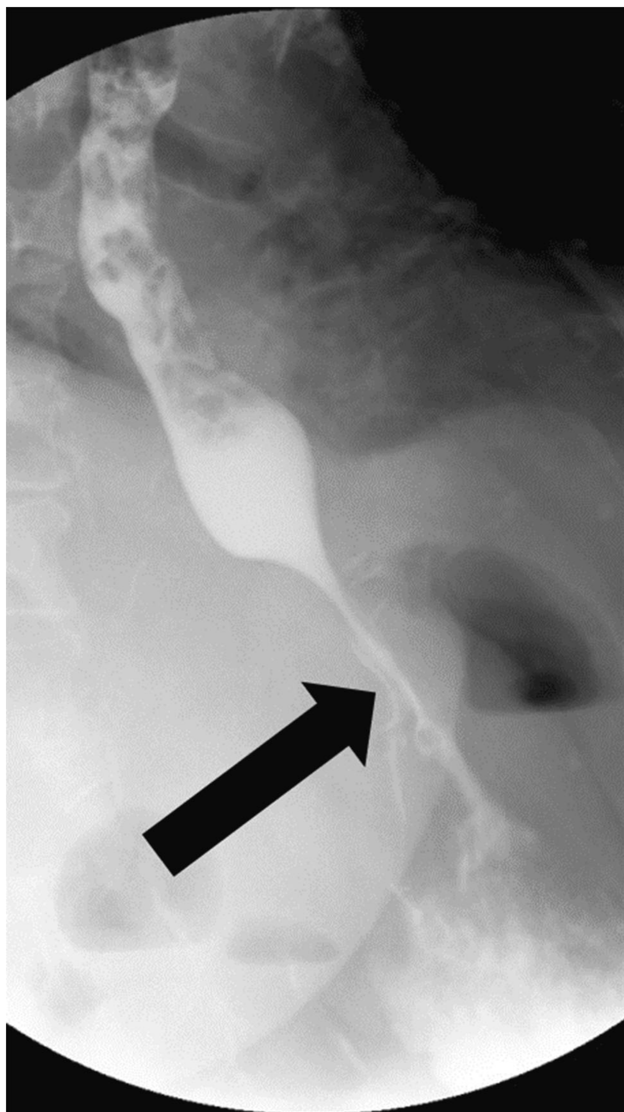

Fig. 3. Patient status post-Nissen fundoplication. Standing LPO image reveals too tight wrap (arrow) with narrowed and elongated distal esophagus and EGJ. Note the retained contrast and particulate food in the distal esophagus above the wrap in this patient who was fasting.

If the esophagus empties normally in the erect position, double-contrast esophageal images are obtained with a high-density barium suspension after distending the esophagus with an effervescent agent. Esophageal peristalsis is then evaluated in the right anterior prone-oblique position while the patient takes three separate swallows of barium suspension. While still lying horizontal, the patient then rolls to the supine position and is rocked gently from side to side as needed to assure barium coating of the fundal wrap. Adequate barium coating of the fundoplication is essential to facilitate demonstration of the location of the wrap and gastroesophageal junction, and the integrity of the wrap [30]. Next, attempts are made to elicit gastroesophageal reflux [37]. Finally, the patient swallows a ½-inch barium tablet with water while standing erect unless the luminal caliber of the esophagus at the level of the wrap was already well shown by this point in the study.

Symptom-based approach to the postoperative patient

Although the fluoroscopic approach to the post-fundoplication patient is somewhat protocol-driven, the engaged radiologist should determine the focus of the study and, depending on the presenting symptoms, should investigate the pertinent radiologic observations.

Dysphagia

One month or more after laparoscopic fundoplication, the most common side effects are persistent bloating, recurrent reflux, and dysphagia. Dysphagia that persists longer than 3–4 months occurs in 3%–24% of patients and should be investigated with a barium esophagogram [38, 39]. Both dysphagia and bloating can be caused by a tight wrap, the etiology of which varies from a fundoplication that is too long (longer than 2 cm) or too tight (Fig. 3), to a crural closure that is too binding, or possibly a slipped fundoplication. At operation, the fundoplication is created with a 54–60 Fr esophageal dilator in place to minimize the likelihood of the wrap being too tight. In addition, division of the short gastric vessels aids in the creation of a looser wrap and is reported to lessen post-fundoplication dysphagia [39–41]. The radiographic findings of a tight wrap include smooth narrowing of the distal esophagus where it passes through an intact fundoplication, retention of contrast material or barium tablet in the esophagus, and delayed esophageal emptying. The esophageal lumen above the wrap may be dilated. If tight crural apposition is the problem, the esophagogram may show an indentation on the esophagus above the wrap. A slipped fundoplication will reveal gastric cardia above the fundoplication.

In patients who complain of dysphagia when drinking liquids, the esophagogram should include an upright timed assessment to check for barium stasis as achalasia-like pathophysiology may develop with a fundoplication that is overly tight or long. In a small number of patients, this secondary achalasia with absent distal esophageal peristalsis in the setting of normal preoperative motility has been attributed to prolonged mechanical obstruction from a too tight wrap or vagal injury during the surgery itself [42]. Esophageal peristalsis should also be analyzed as both the strength of esophageal peristalsis and the basal pressure of the EGJ are increased after anti-reflux surgery [8]. The evaluation of bolus transit by barium esophagography is also important and should be done with care. It correlates well with the assessment of esophageal bolus transit as seen with esophageal impedance

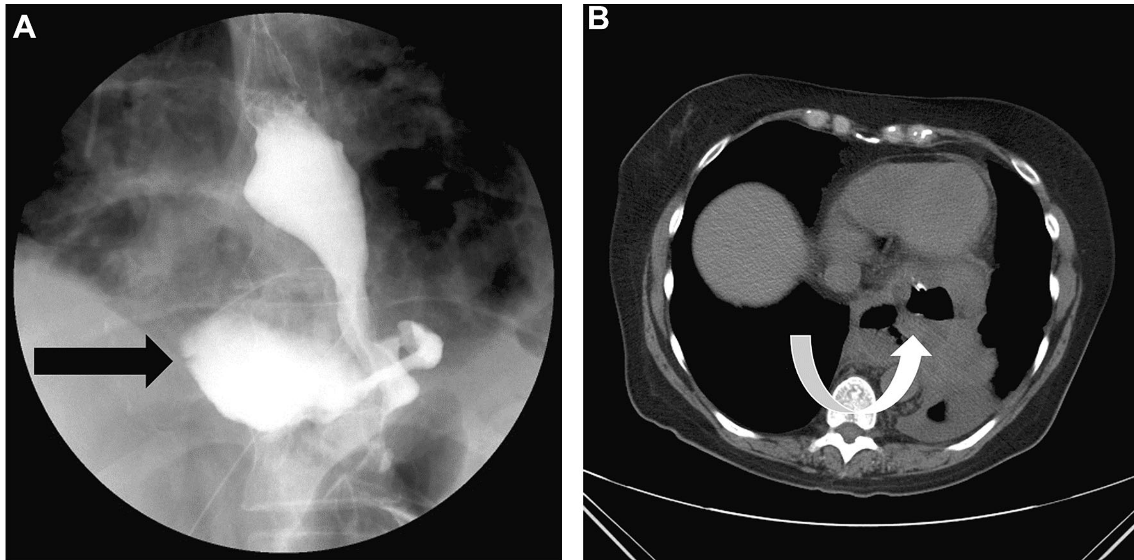

Fig. 4. Postoperative leak with mediastinal collection in a patient status post-fundoplication with hernia reduction. Erect frontal fluoroscopic spot image **A** reveals extraluminal contrast collection (arrow) adjacent to the wrap. CT **B** confirms gas and fluid collection surrounding the intact wrap (curved arrow).

testing, which is often performed along with esophageal manometry [43].

When questions arise as to whether dysphagia is due to esophageal dysmotility or to a tight fundoplication, then the barium swallow examination should include videofluoroscopic study while the patient swallows a barium tablet or eats solid food coated with barium sulfate. We usually leave the choice of what food to bring to the fluoroscopy suite to the patient who is instructed to bring a food that reliably elicits dysphagia. These solid-bolus additions to the routine barium swallow study often clarify the level at which the dysphagia originates.

Esophageal dilation is typically the first therapeutic option used in patients with persistent postoperative dysphagia, especially if there is evidence of obstruction at the EGJ/fundoplication. Anatomical malposition or fundoplication disruption can also present as dysphagia; however, these conditions more often present with recurrent reflux symptoms than dysphagia.

Early satiety and nausea

Delayed onset of nausea and early satiety can result from impaired fundal relaxation due to the fundoplication itself, mechanical obstruction, or vagal nerve injury. The prevalence of gastroparesis after anti-reflux surgery is low, with one study reporting 0.9% at 3 months [44]. A barium esophagogram can indicate delayed gastric emptying by the observance of retained food in the stomach or even delayed clearance of liquid barium from the stomach. A radionuclide gastric emptying evaluation is sometimes indicated if gastroparesis is suspected.

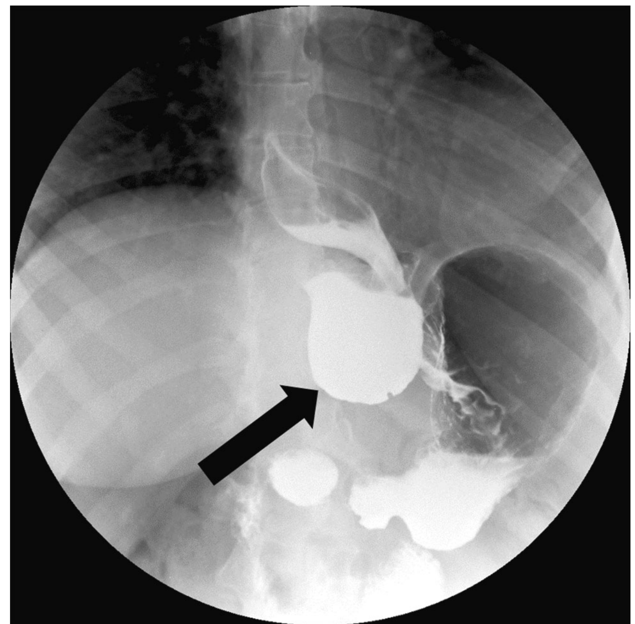

Fig. 5. This patient status post-Nissen fundoplication which has mostly dehisced (Hinder type I). Contrast is filling what remains of the encircling wrap (arrow). There was spontaneous gastroesophageal reflux throughout the examination.

Disruption and migration of fundoplication

The most common indications for reoperation to correct "failed" fundoplication are dysphagia and recurrent reflux that is not well controlled by medication. The reoperation rate for fundoplication is approximately 2.7%, and the most common operative finding during

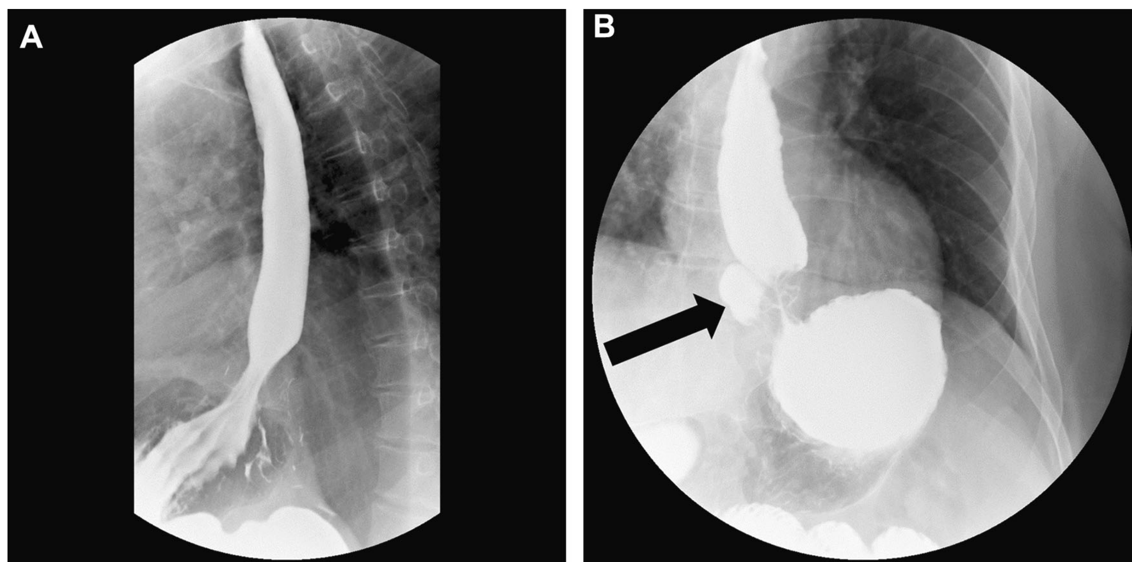

Fig. 6. This supine right lateral fluoroscopic image **A** reveals Hinder type I dehiscence. The recurrent hernia (arrow) is only visualized with the patient in the supine position (**B**).

Table 1. Hinder classification of failed fundoplication

Type	Description
I	Disrupted wrap, partial or complete
II	Infradiaphragmatic wrap with supradiaphragmatic slip of stomach
III	Infradiaphragmatic wrap and slipped stomach
IV	Supradiaphragmatic herniation of intact wrap

redo fundoplication surgery is migration of the fundoplication wrap. Other possible operative findings include tight wrap, slipped wrap, disrupted wrap, malpositioned wrap, esophageal stricture, and loose wrap [5].

Various types of fundoplication disruption can occur. Simple wrap disruption is characterized by partial or complete breakdown of the sutures or staples holding the fundoplication in place around the lower esophagus. On barium esophagography, the fundoplication defect may appear absent, small, or eccentric (Fig. 5). A recurrent hiatal hernia may also be observed, with or without reflux (Fig. 6). This is referred to as Hinder type I failure (Table 1) [3, 45]. It should be noted that seeing a small amount of barium within the wrap on esophagography is normal and does not indicate significant dehiscence.

Alternatively, the stomach may slip superiorly through an intact fundoplication, with the wrap remaining in the abdomen and the body of the stomach migrating through the wrap into the chest (Hinder type II failure) (Fig. 7). These patients have dysphagia due to constriction of the stomach by the crural closure or the wrap. They may also have GE reflux as well as intraesophageal reflux.

When the stomach slips superiorly through the wrap but remains below the diaphragm (Hinder type III failure), dysphagia is usually present due to constriction of the mid stomach. In addition, in the postprandial state, the distended gastric fundus can compress the distal esophagus which is located above the wrap but below the diaphragm. Both Hinder Types II and III failures may be associated with an unrecognized short esophagus, and both may require surgical repair if symptomatic.

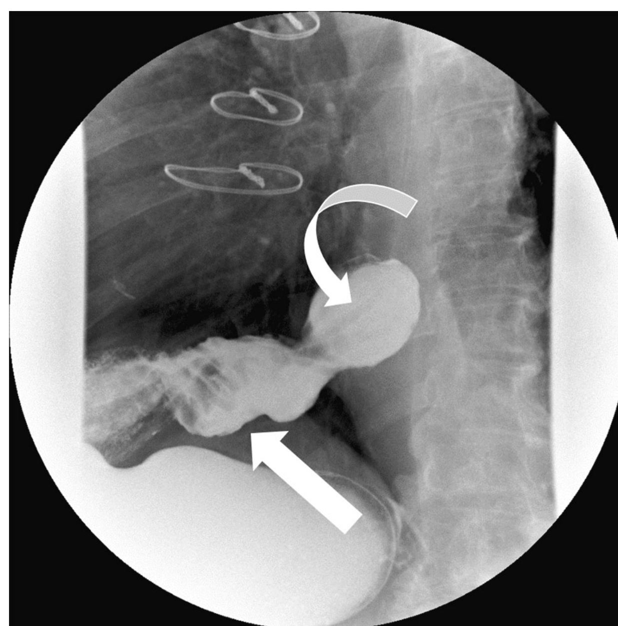

Fig. 7. Fluoroscopic image in supine right lateral position reveals Hinder II fundoplication failure with inappropriately low wrap (arrow) encircling gastric folds with fundus extending superiorly into the chest (curved arrow).

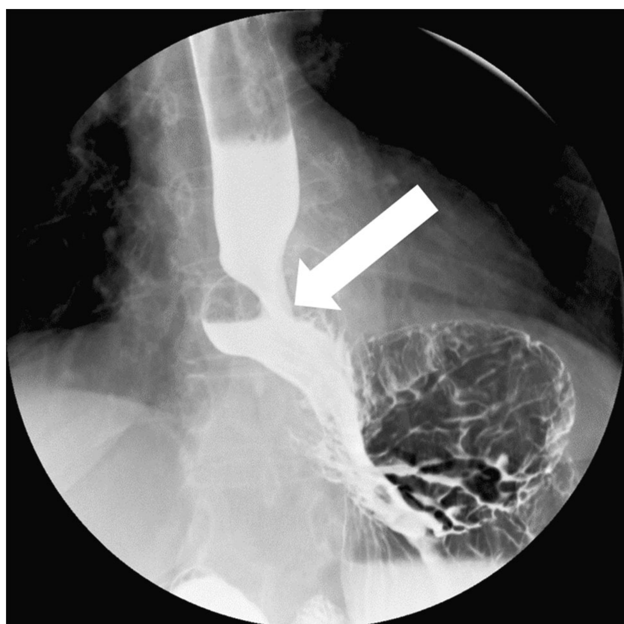

Fig. 8. In this patient status post-fundoplication, the wrap is intact with narrowed EGJ but has herniated (arrow) into the chest (Hinder IV).

Migration of the fundoplication wrap into the chest (Hinder type IV failure) may also develop in the setting of an unrecognized short esophagus (Fig. 8) [46]. In this situation, esophagography reveals an intact wrap without recurrent hiatal hernia or slippage of the stomach, but the wrap is located in the hiatus (transthoracic migration type 1) or in the chest (transthoracic migration type II) [47]. These patients tend to have recurrent reflux and may also have dysphagia.

Recurrent GER

Symptoms of recurrent reflux are common after fundoplication, and rates of postoperative patients taking anti-reflux medications vary from < 20% to 62% [48, 49]. The rates of pathological reflux as determined by pH testing are typically low but an abnormally positioned fundoplication has a 52.6% increased risk of abnormal esophageal acid exposure [50]. Several things stand out as important to demonstrate and analyze in patients with recurrent GERD symptoms after anti-reflux surgery. As in the case of evaluation for postoperative dysphagia, the integrity of the fundoplication is of interest and multiple failure patterns have been described [51]. Is the wrap intact or is it partially or completely disrupted? What is the location of the fundoplication in relationship to the EGJ and the diaphragm? The length and tightness of the fundal wrap and the presence or absence of a recurrent hiatal hernia are salient features that should be analyzed and commented on in the radiologic report [1]. Esophagograms in these patients may require imaging in multiple patient positions to ensure that the fundoplication is adequately coated with barium. Depending on the symptom burden and on whether reflux is confirmed on repeat ambulatory pH monitoring, reoperation may be indicated.

In patients with reflux symptoms that recur immediately after surgery, the fundoplication might have been created too loosely, leaving it patulous or incompetent. In this case, a typical fundoplication defect is radiographically visible in appropriate position below the diaphragm, but gastroesophageal reflux is observed [3].

Atypical GERD symptoms

The use of anti-reflux surgery in the management of atypical reflux symptoms, including cough, hoarseness, dysphonia, and chronic throat clearing has been controversial, but multiple parameters have been identified which may predict a successful outcome. The concomitant presence of typical heartburn symptoms and a percent pH < 4 greater than 12% on ambulatory pH testing are associated with a positive outcome [52]. Postoperatively, if atypical symptoms recur, then a barium pharyngoesophagogram should be considered, not only to assess the integrity and placement of the fundoplication, but also to reevaluate motility, coordination, and anatomy of the pharynx. Examination of the pharynx is a routine part of the standard barium swallow in most centers, but special attention should be requested based on these presenting symptoms [35].

Conclusion

Imaging before and after anti-reflux surgery plays a key role in the evaluation and management. The complex pathophysiology calls for an interdisciplinary approach, and the radiologist needs to tailor their evaluation to answer the specific questions posed by their clinical colleagues and by the presenting symptomatology.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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