

Surgical treatment of gastroesophageal reflux disease

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Abstract

Background Gastroesophageal reflux disease is by far the most prevalent disorder of the foregut. For a long time during the twentieth century, surgical therapy was the mainstay of treatment and the only chance for cure for patients with severe symptoms. Later, after introduction of proton pump inhibitor therapy in the early 1990s, surgical therapy was considered widely a second choice option due to its potential morbidity and side effects. More recently, however, there is growing evidence that long-term antisecretory therapy might be associated to a number of adverse effects such as osteoporosis and increased risk of cardiovascular events. This is the rationale why interventional and surgical options are coming back into focus.

Purpose The purpose of this review is to analyze and to discuss the current spectrum of surgical therapy of gastroesophageal reflux disease.

Keywords Gastroesophageal reflux disease · Partial fundoplication · Total fundoplication · Hiatal hernia · Crural closure · LINX

Introduction

Heartburn and regurgitation are the hallmark symptoms of gastroesophageal reflux disease (GERD). GERD is an extremely common problem in western communities with approximately 40 % of the adult population reporting

regular symptoms [1, 2]. The efficacy of medical therapy in the treatment of heartburn has been documented in the short- [3], and long-term [4–6] therapy of GERD. In this context, proton pump inhibitors (PPI) have the highest efficiency, followed by H₂-receptor antagonists and placebo [3]. Therefore, there is strong agreement that medical therapy actually represents the treatment of choice for the vast majority of patients.

However, complete treatment response cannot be achieved by conservative therapy in a substantial subset of patients, and about 30 % with medical treatment as documented in a recent patient survey of the American Gastroenterological Association in more than 1,000 individuals [7]. Symptom control appears to be particularly difficult in those patients with regurgitation of gastric contents as part of their symptomatology [8]. In addition, population-based studies have evidenced that long-term antisecretory medication with PPI exposes patients to an increased risk of osteoporosis, pneumonia, cardiovascular events, and possibly even neoplastic disease [9].

Total 360°-fundoplication, as devised by Rudolf Nissen in 1956 [10] and first performed laparoscopically by Dallemagne in 1991, [11] represents by far the most popular surgical alternative to medical therapy in the treatment of GERD. Both effectiveness and durability have been proven in a recent Cochrane analysis [12] and by the 5-year results of a randomized controlled trial (LOTUS) [6]. Generally, best results of antireflux surgery are achieved in carefully selected patients operated in centers of excellence with a high case load [13]. On the other hand, high rate of recurrent reflux symptoms, reoperations, and up to 62 % of patients requiring antisecretory (PPI) medication have been reported in randomized trials [14]. Also, concerns have been raised about the rather high incidence of unwanted symptoms such as dysphagia, gas-bloat, meteorism, and flatulence among

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surgical patients [6]. In an attempt to improve results and to reduce unwanted effects, various procedures (partial fundoplication, peroral endoscopic techniques, and implants) have been developed and invented and pushed into the market. The aim of this review is to evaluate the actual literature and to provide orientation for patients, gastroenterologists, and surgeons in the challenging therapy of GERD.

Basic concepts of surgical therapy

The key rationale for the surgical approach towards reflux disease is the idea of the mechanical incompetence of the lower esophageal sphincter (LES). This incompetence of the valve is caused by a progressive retrograde effacement of the LES during gastric distension. T. Bombeck from Chicago was the first to show that this phenomenon can be neutralized by a simple suture placed around the LES [15]. We know today that mechanical incompetence of the LES can be both permanent and transient. Permanent weakening of the LES may be caused by a number of factors such as hiatal hernia, and/or a reduced length or pressure of the LES at manometry. In contrast, the pathophysiology of transient sphincter incompetence, which predominantly occurs in the postprandial phase, is not exactly known. Actually, there are two hypotheses to explain this phenomenon. First, LES relaxation might be mediated via a vago-vagal reflex that is triggered by gastric distension and involves the dorsal motor nucleus of the vagus nerve located in the brainstem [16]. In contrast, a mechanical concept has recently been proposed by the DeMeester group [17]. The authors argue that progressive retrograde effacement of the LES occurs along with progressive gastric distension during the prandial phase, comparable to the mouthpiece of a balloon during insufflation. According to the authors, the mechanical system of the LES collapses when a critical sphincter length (<2 cm) is reached, allowing for subsequent reflux of subcardial gastric contents [17].

In this context, surgical therapy is generally designed to restore the mechanical capacities of the esophagogastric anatomy. Core issues of antireflux surgery involve the mobilization of the distal esophagus to a sufficient intraabdominal length and closure of the hiatal crura in cases with hiatal hernia, the restoration of the angle of His, and the mechanical stabilization of the LES.

In highly selected patients, deviation of gastric contents by subcardial gastric transection and reconstruction according to Roux-en-Y represents an alternative concept for the surgical treatment of GERD [18]. This procedure has a long tradition in the treatment of complex GERD [19], particularly if reflux of bile is the alleged pathogenetic caustic agent, as in peptic stenosis [20], or Barrett's esophagus [21]. Also, poor motility of the tubular esophagus exposing patients to a high risk of

dysphagia after hiatoplasty and fundoplication, or complicated cases with a history of multiple previous antireflux operations might justify such an approach [22]. Gastric diversion with Roux-en-Y reconstruction can be carried out with or without resection of the distal stomach. More recently, the latter procedure has been used extensively in patients with morbid obesity and GERD with excellent results in terms of weight loss and reflux control [23].

What is the preferred surgical strategy?

Open or minimally invasive surgery

Since the first report on laparoscopic Nissen fundoplication by Dallemagne in 1991 [11], there is an ongoing discussion about the pros and cons of minimally invasive antireflux surgery (MIS). Its proponents advocate improved patient comfort, a reduced hospital stay, and quicker return to normal activities; its opponents claim that MIS might be associated to a higher risk of intraoperative complications, a longer operating time, and a higher rate of symptomatic recurrence. Indeed, an early randomized multicenter trial from the Netherlands was stopped because of a significantly higher risk of reoperation for dysphagia after MIS compared with the open surgery group [24]. However, this study was criticized for a number of weak points in the study protocol (doubtful indications for surgery, no esophageal bougie during wrap formation used) and a low case load (<10) in eight of nine participating centers.

So far, 12 randomized studies comparing open and minimally invasive antireflux surgery have been published, providing an excellent body of evidence of more than 1,000 patients and a follow-up of up to 10 years. A recent meta-analysis of all randomized data confirmed that MIS is an effective and safe option for patients with GERD with similar symptomatic outcome, a shorter hospital stay, a quicker return to normal activity, and a significant reduction in the odds of complication rates compared with conventional surgery. However, the meta-analysis also showed that operating time is longer and, more importantly, the frequency of reoperations is significantly higher in the MIS group [25].

A number of studies have been conducted to analyze cost-efficiency of open and minimally invasive antireflux surgery; however, no study was able to show a clear advantage for a specific surgical approach [26].

Which type of fundoplication: Total or partial? Anterior or posterior?

Although very effective for reflux symptoms, overcorrection of the mechanically incompetent LES by Nissen fundoplication is a feared and troublesome experience. The most

prevalent complaints are dysphagia and the inability to belch, causing so-called “gas-bloat”, meteorism, and flatulence. In this context, the reported prevalence of dysphagia, gas bloat, and flatulence was 11, 40, and 57 %, respectively, 5 years after Nissen fundoplication in the randomized LOTUS-trial [6]. Moreover, results of endoscopic dilatation in dysphagic patients after fundoplication are generally poor with less than 50 % success rate [27]. In 1962, two surgeons from France introduced partial (180–270 °) posterior (Toupet) and partial (180 °) anterior (Dor) fundoplication with the aim to reduce the risk of mechanical overcorrection of the LES [28, 29]. Another partial anterior (240 °) fundoplication, which is constructed via left thoracotomy, had been devised before by Belsey in 1952 [30]. Other names associated with original or modified partial techniques are A. Watson [31], L.D.Hill [32], and J.Lind [33].

However, although effective in reducing postoperative dysphagia and gas-bloat, those partial techniques have been associated for a long time with a higher rate of symptomatic recurrence, especially after long-term follow-up. At present, there is an excellent body of evidence available to compare the outcome of total and partial fundoplication: 20 randomized studies with a mean follow-up of up to 18 years [34] and four recent meta-analyses of prospective randomized trials [35–38] have been published.

Meta-analyses confirm that partial fundoplication is a safe and effective technique with the advantage of a lower rate of mechanical problems (dysphagia, bloating, and flatulence) compared with Nissen fundoplication; also, the rate of reoperations seems to be lower after partial fundoplication [38]. On the other hand, no differences were found for the incidence of postoperative acid reflux, heartburn, and resolution of esophagitis. However, conclusions may be hampered by publication bias, the questionable methodological quality, and the relatively short follow-up of most included studies. In addition, there was no advantage for the partial technique in a recently published randomized trial comparing Nissen with the Toupet technique in 137 patients. In this study with an extremely long follow-up (mean follow-up of 18 years), no difference for the incidence of dysphagia, bloating, and flatulence could be demonstrated; also, long-term control of reflux symptoms was similar with both techniques [34].

The question whether an anterior (Dor) or a posterior (Toupet or Nissen) fundoplication would produce better outcomes was addressed in a recent meta-analysis of randomized controlled trials [39]. Seven studies totaling 345 patients after anterior (AF) and 338 patients after posterior repair were analyzed. After short-term follow-up (6–12 months), dysphagia rates were significantly less frequent after AF; however, this positive result was undermined by increased acid exposure at pH-metry, heartburn, and reoperations rate in patients with AF. In studies with a long

follow-up (2–10 years), patients with AF still had a significantly higher incidence of heartburn and reoperations; nevertheless, dysphagia rates were similar. Therefore, we can conclude that there is level 1a evidence that AF is not recommended for routine treatment of patients with GERD.

Is division of the short gastric vessels necessary?

In contradiction to a widespread myth, neither the original technique of Nissen [10] nor the modification of his co-worker Rossetti [40] entailed a routine division of the short gastric vessels to mobilize the gastric fundus during formation of total fundoplication. The technique of fundic mobilization by division of the short gastric vessels was popularized in the 1980s by T. DeMeester who claimed in a large and detailed follow-up study that acid clearance of the distal esophagus was improved and complete relaxation of the LES was more probable in those patients who had their short gastrics divided [41]. Since then, there has been much argument about the significance of this technical detail. Proponents argue that a large diameter loose wrap is preferably constructed after fundic mobilization; opponents claim that the latter maneuver leads to a higher incidence of bloating. Today, most surgeons agree that construction of a sufficiently loose wrap is possible in most patients without division of the gastrosplenic ligament using either the posterior (original Nissen) or anterior (Rossetti modification) gastric wall. Five randomized controlled studies [42–46] have failed to show any advantage of fundic mobilization, and a recent meta-analysis brought together the data sets of two large randomized studies, concluding that fundoplication with division of the gastrosplenic ligament was associated to a higher risk of gas-bloat [47]. Therefore, it can be concluded that there is actually no evidence available that supports division of the short gastric vessels as a routine part of fundoplication.

Mesh reinforcement for crural closure?

GERD often is associated to hiatal hernia and there is a broad agreement among surgeons that best functional results are achieved with a fundoplication that is placed below the diaphragm. Therefore, crural closure is part of the operation in most centers, even if no or only a small hiatal hernia is present. This attitude may derive from the experience that recurrent herniation is a relatively frequent (up to 42 % in paraesophageal hernia [48]) and potentially troublesome complication after antireflux surgery. Typical complaints are dysphagia, reflux, or a combination of both symptoms [18]. Often, patients report sudden onset of symptoms in combination with acute retrosternal pain; occasionally, acute increase of intraabdominal pressure (heavy lifting, accidents) can be identified as the pathogenetic mechanism.

However, both radiological and endoscopic diagnosis is rather doubtful and dependent on the experience of the investigator, particularly in small recurrent hernias [49]. Also, many patients with thoracic migration of the valve have mild symptoms that do not require reoperation and are preferably managed conservatively.

Hiatal repair is usually performed over a large esophageal bougie with the use of two to four non-absorbable sutures that assemble the posterior (retroesophageal) right and left pillars of the right diaphragmatic crus, forming the esophageal hiatus. Anterior crural closure has also been described, and a recent randomized study that compared anterior and posterior approaches did show significantly less dysphagia for lumpy foods in patients undergoing the anterior hiatal repair [50].

In an attempt to further reduce the risk of wrap migration, prosthetic reinforcement of the hiatus has been recommended as a routine measure, or selectively depending on the opening size of the hiatus, the tension on the crura, or the quality of the muscular tissue [51]. However, intraoperative objective assessment of these parameters is difficult and there are insufficient data to support tailored prosthetic reinforcement of the hiatus. The situation is further confused by the magnitude of methods of mesh placement and different designs (horseshoe, keyhole, heart shaped, crural onlay, or tension-free cruroplasty) actually in use. Also, a large variety of diverse non-absorbable (polypropylene, Dacron, and PTFE) and biological (bovine pericardium, porcine small intestine submucosa, and acellular dermal matrix) meshes are on the market.

Since the introduction of hiatal mesh reinforcement, there has been much argument about its potential side effects. Although the incidence of complications may not be high [52], a whole range of dramatic situations has been reported, including fibrotic stenosis, mesh erosion into the esophageal lumen, and esophageal perforation, sometimes necessitating major esophageal and/or gastric resections with a high morbidity [53]. Therefore, the use of prosthetic hiatal reinforcement was recommended for experienced upper-GI surgeons only in a recent comprehensive review of the literature [51]. Also, mesh closure is probably most efficient if used on a selective basis in patients with weak muscular pillars; paraesophageal hernia, or in revisional surgery; however, criteria to identify patients at risk for wrap slippage do not actually exist.

Complex antireflux surgery: the short esophagus

Short esophagus (SE) is caused by an inflammatory shrinkage of the esophageal muscle coat, so that the gastroesophageal junction is located in the mediastinum and cannot be repositioned below the diaphragm by surgical means [54]. SE is associated with long-standing GERD [55, 56] and reflects end-stage reflux-induced transmural inflammation.

A prevalence of about 6 % of short esophagus has been reported in patients referred for antireflux surgery [54, 55, 57]. Surgical irreducibility of the gastroesophageal junction below the diaphragm may be suspected at preoperative contrast radiography if the junction between the upper gastric folds and the esophageal surface is above the hiatus in both the erect and the supine position in combination with a non-tortuous and straight appearance of the tubular esophagus; however, a definite diagnosis can only be made during intraoperative endoscopy after extended surgical mobilization of the esophageal tube up to the aortic arch. Various surgical procedures have been suggested for SE, including forward transposition of the hiatus [58], intrathoracic Nissen fundoplication [54], esophageal lengthening according to Collis [59, 60], and transabdominal Maillet fundoplication [61] (i.e., a 360 ° fundic wrap placed around the subcardial area of the stomach). None of these procedures is ideal: intrathoracic Nissen fundoplication leaves a gastric pouch in the chest, the Collis-Belsey or Collis-Nissen fundoplication creates a columnar-lined neo-esophagus above the subdiaphragmatic wrap, and the Maillet fundoplication combines both drawbacks. Another surgical option consists of total duodenal diversion including subcardial gastric transection and Roux-en-Y gastroenterostomy with or without distal gastrectomy [19, 62]. This procedure does not require any dissection of the fixed hiatal hernia, but it may expose patients to post-gastrectomy symptoms which may take over from those related to GERD.

Revisional antireflux surgery

Long-term observational studies have shown that up to 4–8 % of patients undergoing fundoplication will complain of recurrent symptoms refractory to conservative treatment necessitating revisional surgery [63]. Typically, patients complain about reflux symptoms with or without dysphagia, fullness, bloating, and epigastric/retrosternal pain; atypical symptoms as cough, asthma, and hoarseness are encountered less frequently [18]. There are many potential causes for failure of antireflux surgery; this should be kept in mind when revisional surgery is considered. Moreover, symptoms and serious psychological strain can be caused by either a technical error during primary surgery, by a secondary defect, or even by a technically sound fundoplication. Therefore, it has to be stressed that a comprehensive and targeted work-up, analysis of surgical reports, and a thorough history taking are mandatory for a successful surgical management.

In general, five anatomic key patterns of failure can be identified during reoperation: thoracic migration of the repair, slippage of the wrap around the stomach (telescoping), too snug a repair, partial or total disruption of the wrap, or a bilobed stomach (utilization of the greater curvature instead of the gastric fundus for creation of the wrap). In experienced

hands, laparoscopic redo surgery is a safe procedure with successful outcomes in most patients [63]; however, it has to be stressed that an individual treatment concept for every patient is needed due to the complexity of the situations. Surgeons should be aware that these situations are not uncommon and may necessitate mastering of complex antireflux procedures such as the Collis-procedure, an intrathoracic Nissen fundoplication, or even total duodenal diversion by a gastric bypass procedure [18].

Significance of surgical antireflux implants

The idea of prosthetic augmentation of the LES was first introduced by Jean P. Angelchik, who, in the early 1970s, developed a doughnut shaped silicone device to be fixed around the lower esophagus. The intention was to provide an easy to perform and standardized surgical procedure that was less dependent on the experience and surgical skills than traditional antireflux surgery. The first series of 46 successfully treated GERD patients was published in 1979 [64]. The prosthesis was widely used between 1979 and 1990 and a modification was introduced later for minimally invasive purposes [65]. Three randomized studies have confirmed efficient and durable symptom control similar to traditional Nissen fundoplication in GERD patients [66–68]. However, concerns have been raised about its potential complications, including severe dysphagia, migration, and erosion into the esophageal lumen, even after long-term follow-up. Thus, surgical removal of the prosthesis was necessary in 10–20 % of patients because of intractable dysphagia. Therefore, most surgeons agree that the continued use of the Angelchik prosthesis cannot be recommended today [69].

In 2010, Bonavina reported a series of 44 patients that underwent surgical augmentation of the LES with the LINX[®] device [70]. After minimal dissection of the retroesophageal space, the LINX[®] is placed around the LES, thus, avoiding major damage to the esophagogastric anatomy. The device consists of a series of titanium “beads” with magnetic cores that are interlinked by wires, and can be adapted to a patient’s individual esophageal diameter. The idea is that the magnetic force between the beads is strong enough to prevent the retrograde effacement of the mechanical barrier that occurs during gastric distension, thus preventing gastroesophageal reflux. According to the manufacturer, the LINX[®]-device is designed to be flexible enough to allow belching, vomiting, and a smooth passage of solid foods through the augmented LES. Excellent short-term outcomes (2 years of follow-up) have been reported, but long-term follow-up is actually not available. Therefore, results of a multicentric observational trial that is currently underway are needed to fully understand the impact of this new device on surgical therapy of GERD. Nevertheless, the experience with other foreign material to be placed at the

gastroesophageal junction (prosthetic meshes, Angelchik’s device, or gastric band) taught us that initial enthusiasm often ended up in disillusion. In particular, we are curious about the mechanical ability of the device to accomplish the balancing act between sealing and opening the valve. Dysphagia after an antireflux operation is a terrible experience for both the patient and the surgeon, and even mild dysphagia can be a major problem, especially in psychologically unstable individuals.

Summary

Data currently available from controlled studies show that antireflux surgery is a safe and reliable option for patients with GERD. Symptom control can be achieved in 80–90 % after 5 years and longer. Bearing in mind that long-term PPI treatment exposes the patient to an undefined risk of major side effects, antireflux surgery appears to be a valuable alternative.

On the other hand, we know that the outstanding results of surgical treatment are coming from large studies conducted by centers of expertise with a high case load and may not reflect clinical reality. The outcome after surgery is highly dependent on both a good patient selection and the expertise of the surgeon, and it is common knowledge that a good indication for surgery and a proper surgical technique may have prevented the ordeal of many patients that have undergone multiple futile surgical interventions without any relief from their symptoms. As a consequence, antireflux surgery should probably be restricted to centers of excellence. This is particularly true if redo surgery is planned, because for successful treatment of these patients, complete understanding of the pathophysiological background and mastering of complex surgical strategies are mandatory.

Conflicts of interest None.

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