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REVIEW ARTICLE

Surgical management of gastroesophageal reflux disease

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Abstract

Surgical treatment of gastroesophageal reflux disease (GERD) is used in selected patients who have objective evidence of GERD. Candidates for surgery include the following: 1) heartburn and regurgitation as predominant symptoms; 2) persistent symptoms despite medical therapy; 3) intolerance to proton pump inhibitors or potassium competitive acid blockers, or associated complications; 4) presence of large hiatal hernias; 5) severe erosive esophagitis that is persistent or recurrent; and 6) in the case of extraesophageal symptoms, there should also be accompanying heartburn or regurgitation, a multidisciplinary approach to identify other diagnoses, and preferably positive symptom correlation. Laparoscopic fundoplication is the standard surgical option. The LINX system, consisting of a ring of magnetic beads that reinforces the lower esophageal sphincter, represents a minimally invasive alternative. It is indicated in patients with confirmed GERD, without hiatal hernias larger than 3 cm and without severe esophageal motility disorders. Treatment selection should be individualized, considering the patient's clinical characteristics, underlying pathophysiology, and informed preferences.

Keywords: Gastroesophageal reflux disease. Surgical management of GERD. Esophageal fundoplication. LINX. EndoStim.

Manejo quirúrgico de la enfermedad por reflujo gastroesofágico

Resumen

El tratamiento quirúrgico de la enfermedad por reflujo gastroesofágico (ERGE) se utiliza en pacientes seleccionados que tienen evidencia objetiva de ERGE. Los candidatos a cirugía incluyen los siguientes casos: 1) pirosis y regurgitación como síntomas predominantes; 2) síntomas persistentes a pesar del tratamiento médico; 3) intolerancia a los inhibidores de la bomba de protones o a los bloqueadores ácidos competitivos de potasio, o complicaciones asociadas; 4) presencia de hernias hiatales grandes; 5) esofagitis erosiva grave persistente o recidivante; y 6) en caso de síntomas extraesofágicos debe haber pirosis o regurgitación acompañantes, abordaje multidisciplinario para identificar otros diagnósticos y de preferencia correlación positiva de síntomas. La funduplicatura laparoscópica es la opción quirúrgica estándar. El sistema LINX, compuesto por un anillo de cuentas magnéticas que refuerza el esfínter esofágico inferior, es una alternativa mínimamente invasiva. Está indicado en pacientes con ERGE confirmada, sin hernias hiatales mayores de 3 cm ni trastornos graves de la motilidad esofágica. La selección del tratamiento debe individualizarse, considerando las características clínicas del paciente, la fisiopatología subyacente y las preferencias informadas del paciente.

Palabras clave: Enfermedad por reflujo gastroesofágico. Manejo quirúrgico. Funduplicatura esofágica. LINX. EndoStim.

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Introduction

Gastroesophageal reflux disease (GERD) continues to be one of the most common chronic diseases treated by gastroenterologists, surgeons, and primary care physicians. However, significant advances have emerged in medical, surgical, and endoscopic therapies[1]. Although medical treatment (fundamentally lifestyle and dietary changes, proton pump inhibitors [PPIs], or potassium-competitive acid blockers) is usually effective in most patients, there is a subgroup for whom surgical treatment is indicated. A significant proportion of patients do not achieve adequate control or prefer a long-term solution, which makes surgery a valid and effective option. Severe erosive esophagitis rapidly recurs in the vast majority of patients when medications are discontinued, and many patients feel uncomfortable with the possibility of lifelong PPI treatment. For this reason, some patients prefer to opt for surgical antireflux procedures.

Correct selection of patients who are candidates for surgery is essential to achieve good results. They must always have an objective diagnosis of GERD, either through pH-metry or endoscopy with reflux consequences. These criteria are well defined in the Lyon 2.0 consensus and have been explained in other chapters of this volume. Surgery is performed mainly in patients with esophageal symptoms such as heartburn and regurgitation, but it can also be done in patients who also present associated extraesophageal symptoms (chronic cough, laryngitis, and asthma). Manometry is a study that should be requested in all patients who are candidates for antireflux surgery, especially to detect any motility disorder that could be confused with GERD. Esophagography can also be useful in cases of hernia and stenosis. It is equally important to identify other pathologies or symptoms that are not associated with GERD, since if the patient is not clear about which symptoms will improve and which will not, false expectations can be created, and some other diseases that could have an impact must also be detected (e.g., irritable bowel syndrome).

Laparoscopic fundoplication

Indication

The most accepted indications for antireflux surgery are:

- Failure or prolonged dependence on medical treatment: patients who require high doses of PPIs long-term, with persistent symptomatology or complications despite optimizing doses and habits.
- Intolerance to antisecretory drugs.
- Complications of GERD: severe erosive esophagitis, esophageal stricture, Barrett's esophagus (selected cases).
- Patient preference.
- In some cases, atypical or extraesophageal symptomatology related to reflux: respiratory manifestations (refractory asthma, chronic cough, laryngitis) clearly associated with GERD.
- Associated large hiatal hernia.

Currently, PPI therapy is very effective for treating typical GERD symptoms, and a lack of response to these should be considered a warning sign indicating that reflux may not be the underlying cause[1]. It is necessary to differentiate between partial response and no response to PPIs, since the latter calls into question whether the symptoms are caused by reflux. It is important to note that patients who obtain the best results with antireflux surgery are those with typical GERD symptoms who respond adequately to PPI treatment[2,3]. Fundoplication creates a barrier to reflux of all gastric content, both acid and non-acid, so it should be an effective treatment for any GERD symptom that is related to reflux[1].

Types of fundoplication and indications

Fundoplication is an antireflux surgical technique that seeks to reinforce the competence of the lower esophageal sphincter through partial or total wrapping of the esophagus with the gastric fundus. Since the original description of the Nissen-type fundoplication, various modifications, such as the Toupet and Dor techniques, have allowed individualization of the surgical approach according to preoperative functional findings, with the laparoscopic approach being the standard of care in patients undergoing surgery[4].

Nissen-type fundoplication consists of performing a 360° circumferential wrap around the distal esophagus. In Toupet fundoplication, a 270° partial posterior wrap of the esophagus is made. Dor-type fundoplication is a type of partial anterior fundoplication in which the esophagus is surrounded anteriorly with the gastric fundus at 180°[4].

Short and long-term results

For efficacy in controlling acid reflux, Nissen-type fundoplication is the technique with the highest percentage of distal pH normalization at 1 year (90-95% of patients present acid exposure time < 4% after

correction). Various prospective and randomized studies have shown clinical failure rates (persistent or recurrent reflux documented by pH-metry) of less than 10% at 5 years. Regarding the incidence of postoperative dysphagia, early dysphagia (first 3 months) occurs in approximately 15-20% of cases, and persistent dysphagia (> 3 months) in 5-10%, attributable to a "too tight" fundoplication or cicatricial fibrosis. In relation to gas-related symptoms (inability to belch and bloating), it is recognized mainly as the technique with the greatest predisposition to moderate/high abdominal distention. Reports at 1 year indicate an incidence of predicted abdominal distention in 15-20% of those operated on, although only 5-8% consider it persistently symptomatic. When quality of life and patient satisfaction are evaluated, the validated GERD-HRQL (Gastroesophageal Reflux Disease-Health Related Quality of Life) questionnaire improves on average by 80-90% compared to preoperative, with satisfaction greater than 90% in evaluations at 2 years.

This surgical technique has been shown to provide durable symptomatic control in patients with GERD. Various studies have documented a high rate of normalization of esophageal acid exposure in the first year after surgery. In a study that evaluated 71 patients with Nissen-type fundoplication, significant improvement in symptoms and objective reflux parameters was observed 1 year after surgery. The GERD-HRQL score improved from 28.9 to 13.7, and the DeMeester score decreased from 35.8 to 4.3, with an acid exposure normalization rate of 94.4%. These results highlight the early clinical and physiological effectiveness of Nissen fundoplication and the importance of preoperative evaluation as a predictor of short- and medium-term results[5].

Regarding long-term results, a retrospective cohort study analyzed the results of 645 patients who underwent laparoscopic fundoplication between January 2009 and November 2021. Patients showed sustained improvement with no evidence of deterioration between 2 and 10 years after surgery. In patients operated on between 2017 and 2021, a lower incidence of abdominal distention symptoms at 2 years was observed. Sixty-six percent of patients had a paraesophageal hernia. Patients without a hernia reported significantly worse preoperative scores on the Reflux Symptoms Index and GERD-HRQL, compared to patients with paraesophageal hernia. However, postoperative outcomes were similar in both groups, with a higher prevalence of abdominal distention symptoms at 2 years in the group without a paraesophageal hernia. Postoperative endoscopy was performed in 10.9% of patients, with a median follow-up of 16 months. Only 1.5% of the total presented abnormal scores on the DeMeester scale. The median preoperative DeMeester score was 31, and decreased to 5 in postoperative evaluations. Such findings support the sustained efficacy of laparoscopic fundoplication in controlling GERD symptoms and improving quality of life up to a decade after the intervention[6].

Partial Toupet-type fundoplication is associated with a lower incidence of dysphagia and abdominal distention symptoms compared to complete Nissen-type fundoplication. Although surgical time is longer and DeMeester scores tend to be higher, no significant differences have been observed in terms of perioperative complications, GERD recurrence, need for reoperation, or quality of life. This suggests that Toupet fundoplication is an effective option with good symptomatic tolerance, especially in patients with altered esophageal motility[7].

Costs in the short and long term

The cost of surgical treatment, compared to medical treatment, varies depending on the duration of the therapeutic period. A study in South Korea compared the expenses associated with pharmacological treatment with PPIs and antireflux surgery. During the first postoperative year, surgery costs were ten times higher than those of PPI treatment; however, these expenses progressively decreased as the follow-up period extended, unlike what was observed in the group treated with drugs, whose costs remained constant over time. A cross-sectional analysis found that, during the first 90 days, costs associated with antireflux surgery were 16.9 times higher compared to the group treated with PPIs. However, after this period, no significant differences were observed between the two groups[8]. More studies are needed to evaluate the profitability or cost-effectiveness ratio of antireflux surgery compared to other therapeutic options.

Complications and postoperative management

The Nissen technique has proven to be effective in creating a robust antireflux barrier, but it has also been frequently associated with a higher incidence of dysphagia and symptoms such as abdominal distention, gastric discomfort, and inability to belch[9]. Therefore, partial fundoplication has been proposed as an alternative to avoid these adverse mechanical effects. However, doubts have arisen regarding its efficacy for controlling reflux symptoms in the long term[10].

Table 1. Postoperative complications and degree of satisfaction in patients who underwent Nissen, Toupet, and Dor fundoplication[12]

Results	Nissen Fundoplication (%)	Toupet Fundoplication (%)	Dor Fundoplication (%)
Dysphagia	29.4	5.0	46.3
Heartburn	30.5	46.1	44.4
Regurgitation	28.3	40.0	43.8
Reintervention	12.7	5.6	15.8
Inability to belch	28.7	15.4	16
Abdominal distention	50.3	39.8	50.0
Satisfaction level	90.4	97.2	87.2

Various meta-analyses have been published comparing the efficacy and complications of different types of fundoplication. However, most included only studies with short-term follow-ups (less than 3-5 years), which limits the availability of consolidated data on long-term results. Likewise, it is important to mention that in most of these analyses, no statistically significant differences were found between complete and partial techniques in terms of postoperative complications such as dysphagia or abdominal distention, nor in treatment effectiveness evaluated by reflux recurrence[11]. A network meta-analysis published in 2020 concluded that Toupet fundoplication was the most effective in balancing control of reflux symptoms and adverse effects such as dysphagia. This analysis was based mainly on short-term randomized clinical trials, so it was not possible to establish conclusions about its long-term efficacy[12].

One of the most recent meta-analyses, published by Lee et al.[11], reported that, in absolute terms, the incidence of dysphagia in patients undergoing Nissen, Toupet, and Dor fundoplication was 29.4%, 5.0%, and 46.3% (Table 1), respectively. The highest incidence was observed in patients who underwent the Dor procedure, while the lowest was recorded in those who underwent Toupet fundoplication. Likewise, SUCRA (surface under the cumulative ranking curve) values positioned the Toupet technique (SUCRA=90.08%) as superior compared to Nissen (SUCRA=10.26%) (Table 1). Regarding the incidence of heartburn, this was 30.5% for Nissen, 46.1% for Toupet, and 44.4% for Dor (Table 1). However, network estimates did not reveal statistically significant differences among any of the three intervention groups. Similarly, the incidence of postoperative regurgitation was 28.3% for Nissen, 40.0% for Toupet, and 43.8% for Dor (Table 1), without significant differences among groups, as with heartburn.

The reoperation rate was 12.7% for Nissen, 5.6% for Toupet, and 15.8% for Dor, without statistically significant differences among groups. In relation to inability to belch (28.7%, 15.4%, and 16%, respectively) and abdominal distention (50.3%, 39.8%, and 50.0%, respectively), no statistically significant differences were observed either. Finally, the degree of satisfaction reported by patients was 90.4% for Nissen, 97.2% for Toupet, and 87.2% for Dor, without significant differences among surgical procedures[11] (Table 1).

In conclusion, a greater presence of dysphagia can be observed after partial Dor-type fundoplication, with a significant decrease in patients with partial Toupet-type fundoplication. Postoperative heartburn and regurgitation symptoms were greater for partial fundoplications compared to Nissen-type fundoplication, but without statistically significant differences. On the other hand, the inability to belch was greater in patients undergoing Nissen-type fundoplication. The surgical reoperation rate was higher in patients undergoing a Dor-type procedure, and this, in turn, was the surgery associated with a lower patient satisfaction rate[11].

LINX system

Laparoscopic Nissen-type fundoplication is the gold standard in the surgical treatment of GERD. Despite its safety and efficacy, it is estimated that 25-30% of patients reject fundoplication because of its possible long-term effects. Therefore, the LINX magnetic lower esophageal sphincter augmentation device has emerged as a promising treatment. This system consists of a series of magnetic spheres interconnected by titanium wires, which gives it the ability to expand and contract depending on the pressure exerted. It is implanted laparoscopically around the esophagogastric junction and

generates a magnetic force designed to reinforce the competence of the lower esophageal sphincter, acting as a functional antireflux barrier[13].

Unlike other devices that exert fixed compression, the LINX system responds dynamically to the physiological movements of the esophagus, allowing its natural motility and thus avoiding excessive compression, which reduces the risk of tissue erosion. At rest, when the spheres are in contact, the magnetic force exerted is approximately 40 grams. However, when there is an increase in intraluminal pressure, as occurs during swallowing or the need to release gastric pressure (belching or vomiting), the spheres partially separate, decreasing the closing force to about 7 grams. This mechanism allows the passage of the food bolus and adequate adaptation to physiological pressure changes[13].

Indication

In non-obese patients with a confirmed diagnosis of GERD by 24-hour pH-metry, and with persistent symptomatology despite optimized medical treatment, surgical intervention with the LINX system represents an appropriate therapeutic alternative. Endoscopic exclusion of Barrett's esophagus is essential, as well as demonstration of preserved esophageal motility through high-resolution manometry for safe and effective implantation of the LINX device. Regarding the presence of a hiatal hernia, those with a size less than 3 cm are recognized as a clear indication for performing the procedure, since they do not contraindicate device placement nor interfere with its functionality[13].

Short and long-term results

A systematic review found that between 75% and 100% of patients undergoing the procedure with the LINX system discontinued PPI use after the intervention. Additionally, the DeMeester score decreased from a preoperative range of 33.4-49.5 to a postoperative range of 11.2-15.6. On the other hand, the average score on the GERD-HRQL scale went from a range of 11-27 before surgery to a range of 0-6 after the procedure[13]. Fadel et al.[14] reported that 85% of patients discontinued PPI treatment after LINX system placement. Furthermore, the meta-analysis evaluated patient satisfaction and found that 87% were satisfied with the results of the intervention during the first 2 years following the procedure.

Complications and postoperative management

Among the postoperative complications associated with the LINX system, dysphagia is one of the most frequent. A joint analysis of various studies reported an incidence of dysphagia after device implantation of 4%, and 11% of patients required endoscopic dilation for symptomatic management of this condition. Additionally, cases of vagus nerve entrapment have been documented, either by the device itself or by periprosthetic fibrosis, which can lead to clinical manifestations such as gastroparesis or syncope episodes[14].

On the other hand, esophageal erosion is the most serious complication related to the device[13]. In a multicenter study published by Alicuben et al.[15], which included 9453 devices registered in the global database provided by the manufacturer (Torax Medical), a progression in the cumulative erosion rate was observed from 0.05% at one year to 0.3% at 4 years of follow-up[15].

The postoperative protocol includes an average hospital stay of 24 hours, depending on the center. At hospital discharge, patients are recommended to resume a normal diet, based on frequent small-volume meals, with adequate chewing of food, as well as definitive discontinuation of any previous PPI therapy[13].

EndoStim system

EndoStim is an implantable electrical stimulation system that neuromodulates the function of the lower esophageal sphincter with the goal of improving its basal tone and reducing reflux episodes. It is indicated in patients with GERD who do not respond adequately to PPI treatment, but who do not wish to undergo irreversible surgical procedures that alter anatomy, such as fundoplication[16].

This system is similar in concept to other neurostimulators and consists of three main components: a bipolar stimulation electrode with two fixation points implanted laparoscopically in the lower esophageal sphincter, a pulse generator implanted in a subcutaneous pocket, and an external programmer. Electrical stimulation is administered in 30-minute cycles, between 6 and 12 times a day, with intensity and duration parameters adapted to the individual characteristics of the patient[17].

Unlike the LINX device, EndoStim does not act as a mechanical barrier to reflux, but improves sphincter competence through neuromuscular stimulation[8]. Until 2023, the system had not been approved by the Food and Drug Administration (FDA) of the United States of

America; however, it has been used in various regions, including Europe, Latin America, and Asia. Currently, it has received Breakthrough Device designation from the FDA, which indicates that its neurostimulation technology is considered innovative and promising for the treatment of drug-refractory GERD[18].

Indication

Incomplete symptom control with acid suppressor therapy is one of the main reasons why patients decide to undergo antireflux surgeries. Despite the good safety profile of PPIs, emerging concern about their possible adverse effects drives the search for alternative non-pharmacological therapies for GERD. Fundoplication has been the standard surgical treatment and the main option for patients dissatisfied with pharmacological therapy, either due to deficient symptom control or related concerns. While fundoplication offers effective GERD control, this procedure is associated with other side effects, which have prompted alternative treatments such as electrical stimulation of the esophageal sphincter. EndoStim is considered a particularly appropriate therapeutic option for patients with symptoms of GERD refractory to medical treatment who are not candidates or do not wish to undergo conventional antireflux surgery. This treatment is particularly beneficial in the presence of alterations in esophageal body motility[19]. It is indicated for patients without cardiovascular disease and who have a confirmed diagnosis of GERD, defined by abnormal esophageal pH, who continue with chronic reflux symptoms despite having received medical treatment[20].

Short and long-term results

The EndoStim stimulation system is implanted through a surgical technique that, in the short term, minimizes dissection of the phreno-esophageal attachments and reduces the risk of anterior vagus nerve damage, compared to fundoplication. In an open-label trial that included patients with GERD symptoms, no serious adverse events related to implantation or stimulation, nor abnormal sensations associated with the device were reported[19]. Specifically, no new cases of dysphagia were reported, and 15 patients reported a total of 44 adverse events during the 12 months following; two of them were serious adverse events, unrelated to the device or treatment, and 42 were non-serious adverse events, mostly linked to postoperative symptoms[19]. No patient reported gastrointestinal side effects or onset of dysphagia, abdominal distention, inability to belch, or diarrhea attributable to stimulation. All patients, except one, discontinued PPI treatment. Esophageal manometry showed no effects of stimulation on esophageal body function or residual lower esophageal sphincter pressure after swallowing; nor was a significant increase in basal pressure observed. At 3 years of follow-up, significant improvements were maintained in both GERD-HRQL scale scores and acid exposure, compared to baseline values. Seventy-three percent of patients achieved normalization of distal esophageal acid exposure, and all except four reported discontinuation of regular PPI use[19].

The most recent study that evaluated the EndoStim system was a multicenter, randomized, double-blind, placebo-controlled registration clinical trial, proposed and accepted by the FDA in 2016. This study was suspended after an analysis that evidenced marked variability in clinical response according to geographic location and surgical technique employed in the different participating centers. Additionally, inaccuracies were identified in the data analysis process, which were reported to the FDA by the study sponsor. Currently, the FDA has expressed its willingness to consider, in some form, the use of existing data from the trial, and future discussions with the regulatory agency are planned with the objective of evaluating the possibility of resuming patient recruitment within the original study[19].

Complications and postoperative management

Possible adverse effects related to implantation include pulmonary embolism, partial ileus, peritonitis, esophageal perforation, infections, inflammation, intra-abdominal organ injury, intravenous puncture site complications, pneumonia, bleeding, incisional hernia, pain, and fever. On the other hand, potential adverse effects during EndoStim use include electrode displacement or erosion, esophageal or gastric perforation, diaphragmatic or abdominal muscle stimulation, inflammatory or allergic reactions, hematomas, infections, dysphagia, odynophagia, arrhythmias, and discomfort. There is also a risk of malfunction, damage, or infection of any of the system components, which may require non-invasive interventions or surgical resection for replacement, repositioning, or removal[20].

Regarding follow-up and postoperative management, it is essential that the patient carefully follow the surgeon's instructions after the intervention. It is recommended to avoid activities that involve physical effort, such as

lifting heavy objects or bending over. The patient should begin light walking progressively, according to tolerance. The surgical incision wounds must be kept clean and dry to prevent infections. The use of an elastic abdominal binder over the implantation site is recommended during the first 30 days to reduce postoperative inflammation and the risk of infections. During the recovery period, it is important to ensure adequate rest and avoid contact with people who may transmit infections. It is recommended to avoid intense physical exercise for 2 weeks, or as indicated by the surgeon. Patients should remain alert to symptoms such as general malaise, fever, redness, swelling, or discharge in the incision areas, in order to contact or visit the treating physician. Similarly, it is suggested to avoid direct friction of the skin over the implantation site in order not to damage the surrounding tissue[20].

Conclusions

The surgical treatment of GERD, based fundamentally on laparoscopic fundoplication, represents an effective and safe option for those patients with persistent reflux despite medical treatment, with esophageal complications, or with symptomatic hiatal hernia. Adequate candidate selection, performance of a comprehensive preoperative evaluation (endoscopy, barium study, manometry, pH-metry), and standardization of the technique are pillars to guarantee an optimal result.

The variants of fundoplication (total or partial) and the use of meshes or magnetic devices (LINX) allow adjusting the technique to individual characteristics, especially to esophageal motility and hiatal hernia size. The laparoscopic approach, currently considered the gold standard technique, offers clear advantages in terms of less postoperative pain, shorter hospital stays, and rapid return to daily life.

Despite low mortality rates, the surgeon and multidisciplinary team must be attentive to possible complications (dysphagia, hernia recurrence, etc.) and to the need to review the technique in cases of dissatisfaction or failure. In summary, surgical treatment, when well indicated, provides lasting results, improves quality of life, and can avoid the adverse effects of chronic PPI use.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical considerations

Protection of people and animals. The authors declare that no experiments were conducted on human beings or animals for this research.

Confidentiality, informed consent, and ethical approval. The study does not involve personal patient data nor require ethical approval. SAGER guidelines do not apply.

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