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Laparoscopic Surgical Treatment for Patients With Short- and Long-Segment Barrett's Esophagus: Which Technique in Which Patient?

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Laparoscopic antireflux surgery is very successful in patients with short-segment Barrett's esophagus (BE), but in patients with long-segment BE, the results remain in discussion. In these patients, during the open era of surgery, we performed acid suppression + duodenal diversion procedures added to the antireflux procedure (fundoplication + vagotomy + antrectomy + Roux-en-Y gastrojejunostomy) to obtain better results at long-term follow-up. The aim of this prospective study is to present the results of 3 to 5 years' follow-up in patients with short-segment and long-segment or complicated BE (ulcer or stricture) who underwent fundoplication or the acid suppression–duodenal diversion technique, both performed by a laparoscopic approach. One hundred eight patients with histologically confirmed BE were included: 58 patients with short-segment BE, and 50 with long-segment BE, 28 of whom had complications associated with severe erosive esophagitis, ulcer, or stricture. After surgery, among patients treated with fundoplication with cardia calibration, endoscopic erosive esophagitis was observed in 6.9% of patients with short-segment BE, while 50% of patients with long-segment BE presented with positive acid reflux, persistence of endoscopic esophagitis with intestinal metaplasia, and progression to dysplasia (in 5% of cases; $P = 0.000$). On the contrary, after acid suppression–duodenal diversion surgery in patients with long-segment BE, more than 95.6% presented with successful results regarding recurrent symptoms and endoscopic regression of esophagitis. Regression of intestinal metaplasia to the cardiac mucosa was observed in 56.9% of patients with short-segment BE who underwent fundoplication and in 61% of those with long-segment BE treated with the acid suppression–duodenal diversion procedure. Patients with long-segment BE who experienced fundoplication alone presented no regression of intestinal metaplasia; on the contrary, progression to dysplasia was observed in 1 case ($P = 0.049$).

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Patients with short-segment BE can be successfully treated with fundoplication, but for patients with long-segment BE, we suggest performance of fundoplication plus an acid suppression–duodenal diversion procedure.

Key words: Barrett's esophagus – Laparoscopic treatment – Fundoplication acid suppression – Follow-up

The definitive treatment for patients with Barrett's esophagus (BE) secondary to severe and prolonged reflux disease remains controversial. For gastroenterologists, medical treatment with proton pump inhibitors (PPIs) leads to good results in terms of relief of symptoms, regression of intestinal metaplasia, and control of progression to dysplasia or adenocarcinoma. The addition of laser ablation associated with medical treatment is another option. On the other hand, surgeons believe that antireflux surgery, currently performed through a laparoscopic approach, leads to low morbidity and mortality and better results at early follow-up compared with medical treatment. However, results at long-term follow-up are different, and discussion concerning these topics is ongoing.[1–14]

In the literature, loss of competence of the antireflux barrier has been reported, and high rates of subjective and objective recurrence have been observed after 5 to 10 years' follow-up of patients undergoing Nissen fundoplication or other laparoscopic procedures.[6–10] During the open surgery era, we performed Nissen fundoplication or cardial calibration for patients with short-segment BE and for those with complicated or long-segment BE; we performed an acid suppression + duodenal diversion procedure added to the antireflux procedure (antireflux procedure + vagotomy + antrectomy + Roux-en-Y gastrojejunostomy) to ensure long-term good results, while avoiding recurrence or progression of the disease.[6–10] Consequent to this philosophy, we now perform the same procedure by a laparoscopic approach.

The aim of this prospective study is to present the technique employed by a laparoscopic approach and the results observed in patients with short-segment or long-segment (complicated) BE with ulcer or stricture treated with fundoplication or an acid suppression–bile diversion technique, both performed by a laparoscopic approach, while evaluating the presence of reflux symptoms, the endoscopic and histologic presence of erosive esophagitis, manometric incompetent lower esophageal sphincter (LES), and positive acid reflux into the distal esophagus.

Patients and Methods

Patients

From January 1993 to December 2009, 108 patients with histologically confirmed BE (the focus of this prospective study) were enrolled. This study included 58 patients with short-segment BE (<3 cm columnar epithelium at the distal esophagus + intestinal metaplasia) and 50 patients with long-segment BE, 28 of whom had complicated BE (>3 cm of columnar epithelium with the presence of ulcer or stricture) and underwent antireflux surgery plus an acid suppression and duodenal diversion technique.

Protocol of study

All patients underwent a complete evaluation according to our protocol, including endoscopic/histologic study, manometry, 24 hour pH monitoring, and radiographic evaluation with barium swallow, for evaluation of the anatomic characteristics of the esophageal mucosa and the esophagogastric junction (EGJ), and for functional evaluation of LES resting pressure, esophageal body motility, and acid reflux, according to methods published elsewhere.[7]

Surgical technique

The surgical procedures performed in these patients are shown in Table 1: (1) antireflux surgery alone (fundoplication with cardia calibration was employed in 80 patients, 58 with short-segment BE and 22 with long-segment BE), and (2) fundoplication with cardia calibration plus acid suppression–duodenal diversion surgery (this was performed in 28 patients, in all cases because of long-segment or complicated BE with ulcer or stricture). Patients with high-grade dysplasia were excluded from this study.

Fundoplication with cardial calibration and crura closure were performed according to the laparoscopic technique described previously. This technique uses 5 trocars. The cardia, the abdominal esophagus, and the diaphragmatic crura were

Table 1 GER symptoms before and after surgery in patients with Barrett's esophagus undergoing laparoscopic antireflux surgery

	Barrett's esophagus (n = 108)					
	Short-segment (n = 58)		Long-segment or complicated (n = 50)			
	Fundoplication + cardial calibration (n = 58)		Fundoplication + cardial calibration (n = 22)		Acid suppression + duodenal diversion (n = 28)	
Symptoms	Before	After	Before	After	Before	After
Heartburn	58 (100%)	3 (5.2%)	22 (100%)	8 (36.4%)[a]	28 (100%)	1 (3.5%)
Regurgitation	54 (100%)	3 (5.2%)	20 (90.9%)	8 (36.4%)	28 (100%)	-
Dysphagia	0	0	2 (9.1%)	0	4[b] (14.3%)	
Chest pain	0	0	-	-	1	

[a]*P* for A versus B = 0.003; *P* for B versus C = 0.05; *P* for A versus C = not significant.

[b]Preoperative dysphagia due to stricture after surgery for endoscopic dilatation.

exposed. Crura closure was achieved by 2 to 3 stitches with nonabsorbable suture. Fundoplication with cardial calibration was performed with 5 to 8 nonabsorbable stitches over an F32 intraluminal bougie, and posterior gastropexy of the cardia was performed as described in an earlier study.[7]

Laparoscopic selective vagotomy, an antireflux procedure, and antrectomy with Roux-en-Y gastrojejunostomy were performed with 5 trocars. After completion of the antireflux procedure using the Ligasure device (Covidien, Mansfield, Massachusetts), we proceeded to perform division of the distal gastric gastroepiploic vessels along with the greater curvature, as well as division of the gastrohepatic ligament and Latarjet's branches of the vagal nerves. Thereafter, we proceeded to divide and close the duodenal stump with the use of an Endo GIA 60 mm blue cartridge (Covidien). Distal gastrectomy was completed by applying 2 charges with the Endo GIA device. After division with Ligasure of one vascular jejunal arcade, a Roux-en-Y 60 cm long limb antecolic was ascended for end-to-side gastrojejunostomy with a 45 mm Endo GIA blue cartridge. Side-to-side jejunojejunoanatomosis was performed with a white Endo GIA device.[8,9]

Follow-up

Patients were controlled for at least 5 years after surgery by following the same preoperative protocol for evaluation using clinical, endoscopic, radiologic, and esophageal functional tests to assess results after surgery.

Definition of failure or recurrence

1. *Radiology:* enlargement of the cardia, hiatal hernia, disruption of the fundoplication, and other postsurgical abnormalities are causes of an ineffective antireflux wrap associated with positive reflux during evaluation with barium sulfate.
2. *Manometry:* postoperative LES resting pressure less than 12 mmHg was considered hypotensive LES.
3. *Endoscopy:* persistence of proximal erosive esophagitis above the Z line and the presence of ulcer or stricture progression of the length of the columnar epithelium after surgery are considered unequivocal signs of recurrent disease.
4. *Histology:* presence of erosive esophagitis with inflammation with eosinophils, lymphocytes, monocytes, or leukocytes associated with intestinal metaplasia (goblet cells) or dysplasia was considered active BE.[10]
5. *24 hour pH monitoring:* should be done if positive acid reflux according to DeMeester's score is observed after surgery.

Results

The postoperative course of all patients included in this study was uneventful, with no morbidity or mortality.

Among patients who underwent fundoplication with cardial calibration for short-segment BE, 3 (5.2%) presented with symptoms of reflux after surgery. On the contrary, among patients with long-segment BE undergoing fundoplication, 8 of 22 (36.4%) presented with reflux symptoms after the procedure had been completed ($P = 0.003$). Most of these patients were treated with omeprazole 20 mg/d. Among patients treated with the acid suppression–duodenal diversion procedure, 1 (3.5%) had reflux symptoms after surgery ($P = 0.05$). Dysphagia and retrosternal pain

Table 2 Endoscopic-histologic evaluation before and after surgery in patients with BE undergoing laparoscopic antireflux surgery

	Barrett's esophagus					
	Short-segment (n = 58)		Long-segment or complicated (n = 50)			
	A		B		C	
	Fundoplication + cardial calibration (n = 58)		Fundoplication + cardial calibration (n = 22)		Acid suppression + duodenal diversion (n = 28)	
	Before	After	Before	After	Before	After
Intestinal metaplasia with esophagitis[a]	58	4 (6.9%)	22	11[a] (50%)	28	1 (3.6%)
• Ulcer	-	-	4	4[b] (18.1%)	5	0
• Stricture	-	-	-	-	2	0
Without esophagitis		21		10		12
Regression		33 (56.9%)		0		17 (60.7%)
Progression to dysplasia		0		1[c] (4.5%)		0

[a]*P* for A versus B = 0.000; *P* for B versus C = 0.010; *P* for A versus C = not significant.

[b]Patients who underwent reoperation with the acid suppression–duodenal diversion technique.

[c]Low-grade dysplasia.

due to persistence of esophageal ulcer and stricture improved after the acid suppression–duodenal diversion procedure (Table 1).

Among 58 patients with short-segment BE who underwent fundoplication with cardial calibration, endoscopic/histologic evaluation revealed proximal erosive esophagitis associated with inflammation in 4 cases (6.9%). Intestinal metaplasia remained unchanged in 25 patients, and regression of intestinal metaplasia to cardiac mucosa was observed in 33 patients (56.9%). On the contrary, among patients with long-segment BE treated with this technique, erosive esophagitis with intestinal metaplasia persisted in 11 cases (50%) within 4 patients ($P = 0.000$). Ten of these patients received medical treatment with PPIs; 8 were treated with argon plasma ablation, and 4 patients with esophageal ulcer underwent reoperation using the acid suppression–duodenal diversion procedure. No regression to cardiac mucosa was observed in these patients, and later progression to dysplasia was observed in 1 patient (4.5%) treated also with argon plasma ablation and conversion to the acid suppression–duodenal diversion procedure.

Among patients with long-segment BE in whom acid suppression–duodenal diversion surgery was performed, erosive esophagitis was present in 1 patient (3.5%) ($P = 0.01$), ulcer or stricture was resolved in all patients, intestinal metaplasia not associated with inflammatory cells persisted in 7 patients, and regression was observed in 17 patients (60.7%). Ulcer or stricture improved after this surgery in all patients. Some patients were treated with endoscopic argon plasma ablation of Barrett's mucosa associated with PPI treatment (Table 2). Figure 1 shows a patient with long-segment BE with esophageal ulcer who underwent fundoplication with the acid suppression–duodenal diversion procedure before and after surgery, as well as complementary argon plasma ablation to reduce the metaplastic epithelium.

Table 3 shows manometric and 24 hour pH monitoring findings before and after surgery. Manometric results were significantly better after any type of surgery performed, even in the group with recurrence of proximal esophagitis or persistence of intestinal metaplasia. Hypotensive LES was observed in 2 of 58 patients (3.4%) who underwent cardial calibration for short-segment BE; however, 7 of 22 patients (31.8%) with long-segment BE treated with fundoplication and 6 of 28 patients (21.4%) treated with acid suppression–duodenal diversion surgery presented with hypotensive LES. After fundoplication, positive acid reflux was present in 12 patients, as well as in 8 of 58 patients (13.8%) with short-segment BE and in 9 of 19 patients (47.3%) with long-segment BE. After the acid suppression–duodenal diversion procedure was performed, positive acid reflux was seen in 1 patient (4.4%) with defective LES.

Table 4 summarizes results observed after cardial calibration or the acid suppression–duodenal diver-

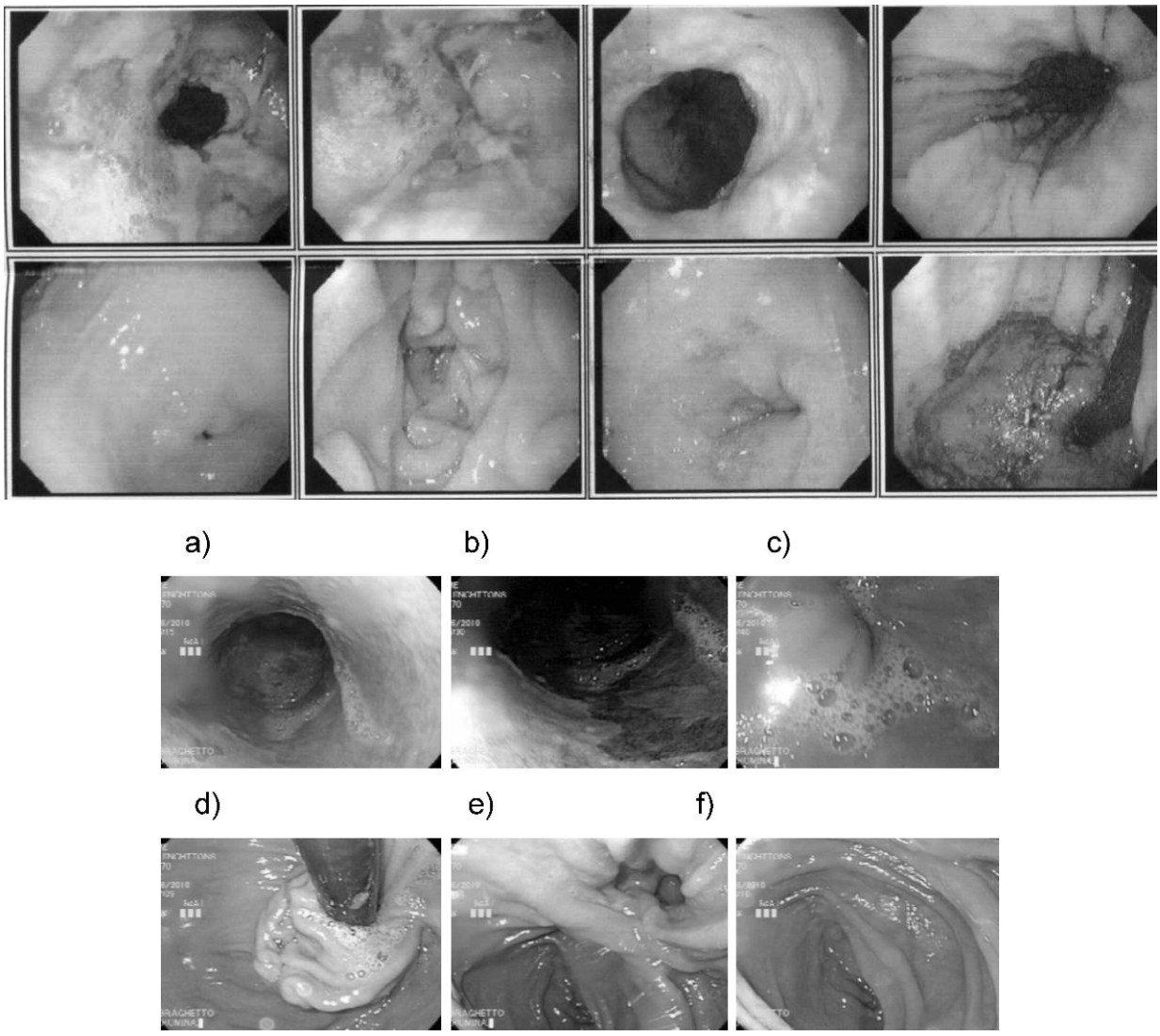

Fig. 1 Patient with long-segment BE with severe erosive esophagitis and ulcer, undergoing fundoplication with calibration of the cardia and antrectomy + Roux-en-Y gastrojejunostomy. (1) preoperative endoscopy: severe esophagitis, BE, and ulcer. (2) postoperative endoscopy shows (a) tongue of residual columnar epithelium after 1 session of argon plasma ablation, (b) absence of erosive esophagitis or ulcer, (c) calibrated cardia, (d) an endoscopic ''U'' turn demonstrating an excellent antireflux valve, (e) gastrojejunal anastomosis, and (f) jejunal loop without bile content.

sion procedure. In patients with short-segment BE, symptomatic, radiologic, endoscopic and manometric, and acid reflux studies were performed in 5.2%, 3.4%, 6.9%, and 13.8% of patients, respectively. Among patients with long-segment BE who underwent fundoplication with calibration of the cardia, unsatisfactory results were noted in 36.4%, 27.3%, 50%, and 40.9% of patients, respectively ($P = 0.049$). After acid suppression–duodenal diversion surgery, symptomatic or objective failure was observed in 4.4% of cases.

Discussion

Among patients with BE, the goals of surgical treatment are (1) to improve reflux symptoms over the long term, (2) to create a permanent antireflux barrier for acid and duodenal refluxate, and (3) to avoid progression of disease to dysplasia and adenocarcinoma.

Two treatment options for BE have been advocated: (1) medical treatment with PPIs given on a long-term basis with or without the addition of laser ablation

Table 3 Functional tests before and after surgery in patients undergoing laparoscopic antireflux surgery

	Barrett's esophagus					
	Short-segment (n = 58)		Long-segment or complicated (n = 50)			
	Fundoplication + cardial calibration (n = 58)		Fundoplication + cardial calibration (n = 22)		Acid suppression + duodenal diversion (n = 28)	
Manometry	Before	After	Before	After	Before	After
Resting LES pressure, mmHg	7.1	15.1	5.9	13.1	5.4	16.1
Total length, cm	3.5	3.8	2.8	4	3	4
Abdominal length, cm	0.2	1.2	0.3	0.9	0	1
Incompetent LES, n	58	2 (3.4%)	22	7 (31.8%)	28	6 (21.4%)
24 hour pH monitoring time with pH <4	18.4	3.9	14.5	7.01[a]	12.5	3.3
DeMeester score	64.2	16.5	50.7	26.7	59.3	12.8
Abnormal reflux, n	58	8 (13.8%)	22	9 (40.9%)	28	1 (3.6%)

(this is under evaluation) (medical therapy is often insufficient to relieve symptoms completely; even if symptoms disappear, abnormal reflux may persist[11,12,14,15]); and (2) surgical treatment with Nissen fundoplication alone, with calibration of the cardia, or with addition of the acid suppression–duodenal diversion technique. The Collis-Nissen procedure has been proposed but is less frequently indicated.

In contrast to medical treatment, which only blocks acid secretion and decreases reflux, Nissen fundoplication or cardial calibration creates an antireflux barrier that can be completed with the addition of highly selective vagotomy to diminish acid secretion.

Considerable controversy has arisen over whether these operations achieve these goals, because patients with BE have more defective LES function, more severe anatomic distortion of the EGJ, greater amounts of acid reflux, and the presence of bile reflux, which leads to more severe esophageal injury. Therefore, surgery becomes difficult and complex, complications are more frequent, and competency of the new antireflux barrier decreases over time, resulting in less relief of symptoms, less successful results at long-term outcome, and progression of the disease.[16–18]

An antireflux operation must stop chronic damage to the esophageal mucosa, fix the anatomic alteration of the EGJ and hiatal hernia or dilatation of the cardia as causes of incompetence of the LES, and avoid progression of the metaplastic epithelium. After surgery, normal His angle, adequate length of the intra-abdominal esophagus, and fixation of the cardia are restored, thus improving the competency of the LES.

However, in patients with long-segment BE, it is very difficult to abolish permanently acid and duodenal reflux because of very important anatomic and functional defects of the EGJ. In fact, papers have reported abnormal 24 hour pH monitoring after fundoplication, despite no or minimal residual symptoms. Patients with long-segment BE have been evaluated 8 to 10 years after fundoplication, with a positive finding on the pH monitoring reflux test in very high proportions of them, ranging from 17% to 60%.[3,7,19–21]

Table 4 Symptomatic and objective failures after surgery in patients treated with different laparoscopic procedures

	Symptoms, n (%)	Radiologic failure, n (%)	Endoscopic failure, n (%)	Incompetent LES, n (%)	Positive reflux, n (%)
SSBE cardial calibration (n = 58)	3 (5.2)	2 (3.4)	4 (6.9)	2 (3.4)	8 (13.8)
LSBE cardial calibration (n = 22)	8 (36.4)	6 (27.3)	11 (50)[a]	7 (31.8)	9 (40.9)[b]
Acid suppression duodenal diversion (n = 28)	1 (3.6)	1 (3.6)	1 (3.6)	6 (21.4)	1 (3.6)

LSBE, long-segment Barrett's esophagus; SSBE, short-segment Barrett's esophagus.

[a]11 erosive esophagitis, 4 esophageal ulcer, 1 progression to dysplasia.

[b]*P* for A versus B = 0.000; *P* for B versus C = 0.049.

Therefore, our group has proposed a complete operation, which involves performance of an antireflux procedure plus abolition of acid and duodenal reflux by the addition of vagotomy-antrectomy and Roux-en-Y gastrojejunostomy.[21,27] In recent years, we have performed this procedure through a laparoscopic approach.

Why has our group proposed this operation? Experiences reported with Nissen fundoplication and other operations have not demonstrated satisfactory results at long-term follow-up in patients with long-segment BE.[6–10] Low, Jobe, and Horvath reported their results after complete or partial fundoplication or Hill's procedure and confirmed poor results in terms of recurrence of symptoms, acid reflux, and progression of the disease in 50% of patients.[20–25] The most important observation involves histologic regression of BE as a marker of good or poor results after surgical treatment. DeMeester and colleagues reported their results in patients with BE compared with non-BE patients after Nissen fundoplication. Loss of intestinal metaplasia among patients with short-segment BE was 59%; Bowers *et al* and Oeschlager *et al* reported regression in 33% and 55% of patients, respectfully.[10,27,39–41] More recently, Zaninotto, Csendes, and others published findings of regression of the intestinal metaplasia only in patients with short-segment BE.[38–40] Laparoscopic antireflux surgery in patients with BE provides excellent control of symptoms and esophageal acid exposure; in addition, intestinal metaplasia regresses in a high proportion of patients. This successful result has been observed in patients with short-segment BE; therefore laparoscopic antireflux surgery should be recommended for these patients.[38]

However, for patients with long-segment BE, in terms of the same parameters studied, the results are worse. In terms of the length of the columnar mucosa, complete regression occurs rarely; this topic remains controversial and is in continuous discussion. Some publications have reported that no decrease in Barrett's mucosa occurred; others have reported only partial regression.[5,7,11,25–37] Csendes described progression to dysplasia and the appearance of adenocarcinoma very late after fundoplication. In other reports, progression to dysplasia was observed in nearly 18% of cases at 5 years' follow-up.[37–46]

We agree that in patients with short-segment BE, a classic antireflux procedure through a laparoscopic approach is an excellent option. However, in patients with long-segment BE, the only operation that has shown objectively better results in terms of control of symptoms and control of progression of the disease is acid suppression–duodenal diversion. Csendes reported regression of BE with intestinal metaplasia to cardial or fundic mucosa in about 60% of cases with long- or short-segment BE after vagotomy-antrectomy and Roux-en-Y gastrojejunostomy. This operative procedure is very effective in controlling both acid and duodenal reflux; these are important factors in the pathogenesis of progression of intestinal metaplasia to dysplastic changes and the appearance of adenocarcinoma. Regression of low-grade dysplasia to nondysplastic mucosa is possible in 65% of patients.[43–48]

Finally, interesting recent reports have described obese patients with BE who demonstrated very successful results in terms of regression of recalcitrant symptoms, esophagitis, and regression of the length of the intestinal metaplasia after laparoscopic gastric bypass in which acid suppression and bile diversion were attained; these investigators have confirmed our belief regarding the best surgery for patients with long-segment BE.[47–54] Gastric bypass is an excellent antireflux operation in patients with BE and morbid obesity; this has been proved by the disappearance of symptoms and the healing of endoscopic esophagitis or peptic ulcer in all patients, followed by an important regression to cardiac mucosa that is length dependent and time dependent.[51–55] Houghston[55] confirmed these results, and patients experienced a decrease in the length of BE, complete disappearance of BE or improvement in the degree of dysplasia, complete or partial regression of BE, and improvement in reflux symptoms. These study findings suggest that Roux-en-Y gastric bypass might be the procedure of choice in morbidly obese patients with BE requiring surgical treatment for gastroesophageal reflux disease, because with this procedure, it is possible to stop esophageal reflux of gastroduodenal contents (acid and bile) that contributes to the development of BE and progression in the dysplasia-carcinoma sequence. Fundoplication with distal gastrectomy and Roux-en-Y gastrojejunostomy is feasible and safe to perform by laparoscopy. We anticipate the same successful results using this approach as were observed during the open surgery era.

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