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REVIEW

Management of failure after surgery for gastro-esophageal reflux disease



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Summary Surgical treatment of gastro-esophageal reflux disease (ST-GERD) is well-codified and offers an alternative to long-term medical treatment with a better efficacy for short and long-term outcomes. However, failure of ST-GERD is observed in 2–20% of patients; management is challenging and not standardized. The aim of this study is to analyze the causes of failure and to provide a treatment algorithm. The clinical aspects of ST-GERD failure are variable including persistent reflux, dysphagia or permanent discomfort leading to an important degradation of the quality of life. A morphological and functional pre-therapeutic evaluation is necessary to: (i) determine whether the symptoms are due to recurrence of reflux or to an error in initial indication and (ii) to understand the cause of the failure. The most frequent causes of failure of ST-GERD include errors in the initial indication, which often only need medical treatment, and surgical technical errors, for which surgical redo surgery can be difficult. Multidisciplinary management is necessary in order to offer the best-adapted treatment.

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Introduction

Surgical treatment (ST) of gastro-esophageal reflux disease (GERD) (ST-GERD) is well-codified and leads to control of symptoms in at least 80% of patients with satisfactory short and medium term efficacy for 90% of patients [1–4]. A recently retrospective study reported satisfactory results in terms of quality of life and symptom control after more than 30 years in a small series of 24 patients [5].

ST-GERD consists in performing a fundoplication around the abdominal esophagus to reinforce the lower esophageal sphincter (LES) to prevent gastro-esophageal reflux disease (GERD). This fundoplication can be a partial posterior 270° Toupet fundoplication (TF), or a complete circumferential Nissen fundoplication (NF), or a partial anterior 180° Dor fundoplication (DF) [6]. The laparoscopic approach was described for the first time in 1991 [7]; it is currently the standard approach and is associated with a very low morbidity and mortality [8].

In a 2014 meta-analysis, Rickenbacker et al. [2] compared the outcomes of medical vs. surgical treatment for GERD in 11 studies, including seven randomized controlled trials published between 2001 and 2013 with a total of 1972 patients [1,9–17]. This analysis favored fundoplication over medical treatment in terms of quality of life, patient satis-

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faction and control of symptoms of GERD. In the five most recent studies [1, 12–17], surgical treatment was performed via the laparoscopic approach and for six of seven of these studies [1, 9–12, 14–17], the medical treatment was proton pump inhibitors (PPI). More recently, a Cochrane library meta-analysis [18] including 1112 patients originating from four of the controlled trials that were also in the preceding meta-analysis [1, 12, 15, 16] but with more restrictive criteria (only laparoscopy for the surgical arm, limitation of risk of bias) reached the same conclusions. Notwithstanding, the duration of follow-up was heterogeneous in these studies, ranging from one to 12 years, so no clear conclusions can be drawn with regard to long-term outcome. In addition, one other study found that surgical treatment reduced the health care related costs at five years [19], establishing ST-GERD as an unquestionable alternative to medical treatment.

However, in 2–30% of patients undergoing ST-GERD [20–23], disabling symptoms recur or persist. Moreover, management of patients with failure after ST-GERD is complex and poorly standardized. The goal of this update is to provide the reader with the battery of investigations that are necessary for workup and a management algorithm based on an analysis of the literature and our own experience for patients with failed ST-GERD.

Different clinical situation of patients with failure after ST-GERD

From a clinical point of view, there are three types of failure that will guide us through this update (Fig. 1):

- resolution of GERD symptoms followed by recurrence with or without associated dysphagia;
- appearance of secondary effects such as dysphagia or hyper-correction symptoms;
- absence of improvement of symptoms due either to an erroneous indication or a technical error.

Resolution of GERD symptoms followed by recurrence with or without dysphagia

Without dysphagia

GERD usually recurs after an interval of a few weeks to several years without any other clinical manifestation. This situation corresponds most often to patients with a disrupted fundoplication, perhaps favored by a fundoplication made under tension.

With dysphagia

This can be due to intrathoracic migration of the fundoplication (Fig. 2) or a slipped Nissen (Fig. 3) (i.e. herniation of the stomach through the fundoplication that remains in place). Most often, symptoms, dysphagia and/or epigastric pain, appear rapidly if not abruptly, after a certain interval, sometimes quite short [24]. A physical effort, such as coughing during extubation, has often been suggested as a triggering factor, leading some authors to prescribe a routine upper gastrointestinal series (UGIS) in the early postoperative period. This seems to occur more frequently when the hiatus is initially enlarged.

Appearance of secondary effects

The initial procedure can create symptoms that did not exist before the operation; the patient should be informed of this possibility before operation.

Dysphagia

This is the most prevalent symptom and more particularly after NF [25]. Dysphagia usually recedes within a few weeks; it is secondary to fundoplication under tension, an over-tight crural closure, periesophageal fibrosis (possibly secondary to intra-esophageal migration of hiatal prosthetic material), or to a motility disorder that was unrecognized before the operation [26].

Hypercorrection symptoms

These symptoms tend to persist over time and are associated in variable proportions with the gas bloat syndrome (difficulty, or even impossibility to belch or vomit, often associated with flatulence and meteorism, aggravation of dyspepsia or irritable bowel syndrome, or epigastric pain). This is less frequently observed after partial fundoplication [27] but when present, can impair and alter the quality of life [1].

Gastroparesia

This disorder is the result of a vagal injury during the operation and can manifest by postprandial abdominal pain, abdominal meteorism, and anorexia.

Failure of improvement of symptoms

Wrong indication

Campos et al. found that the three main factors of successful NF were the presence of typical symptoms (heartburn and regurgitation) that were relieved by PPI and pH-metric evidence of GERD [28]. In the absence of these indications, the results of ST-GERD are not consistently good. In the above-mentioned meta-analysis of 13 randomized trials [28], the presence of atypical symptoms (respiratory or pharyngeal symptoms) and the resistance to medical treatment were associated with failure in eight of 13 studies. Moreover, obesity with a body mass index (BMI) greater than 30 or 35 kg/m² was associated with a risk of failure in four of these studies. In patients with morbid obesity and GERD, a Roux-en-Y gastric bypass constitutes the procedure of choice whenever this is feasible, because it controls the GERD while simultaneously providing weight loss and correction of co-morbidities associated with obesity [29]. However, fundoplication is recommended in patients without morbid obesity who present de novo symptoms of GERD secondary to weight gain and for whom nutritional support alone is not effective [3].

The existence of psycho-emotional disorders has been described as a predictive risk factor of failure of ST-GERD [30]. Postoperative quality of life and chronic pain disorders were found to be less well-improved in patients with psycho-emotional problems compared to those who do not have any such disorders in case controlled studies [31]. Severe depression was associated with more thoracic pain, gas bloat syndrome and postoperative dysphagia in 38 patients undergoing ST-GERD compared to 38 non-depressive controls [32] notwithstanding an improved GIQLI score at 3 months and one year. These symptoms were more frequently observed

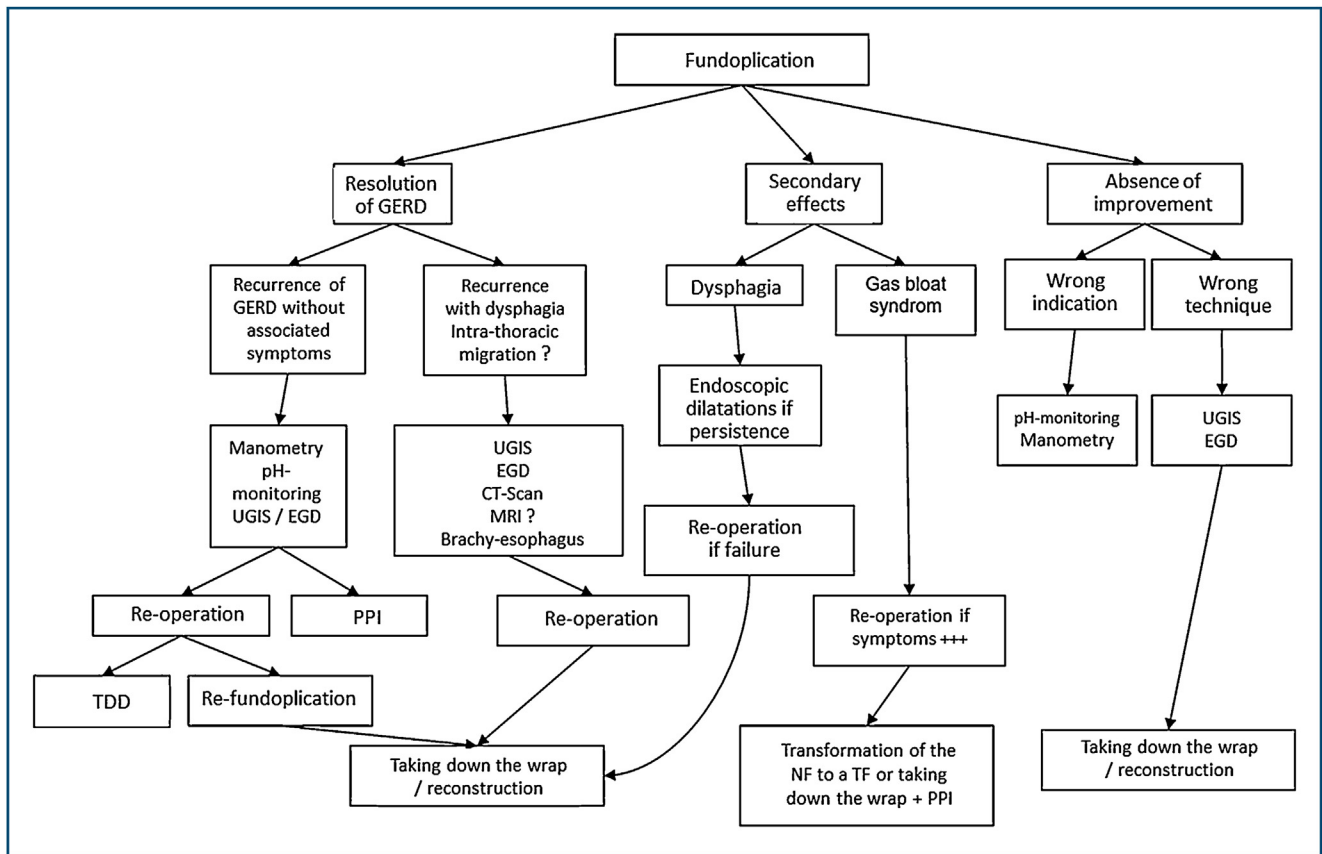


Figure 1. Decision tree in case of failed surgical treatment of gastro-esophageal reflux disease (GERD). UGIS: upper gastro-intestinal series, EGD: eso-gastro-duodenoscopy, PPI: proton pump inhibitors, TDD: total duodenal diversion; NF: nissen fundoplication; TF: toupet fundoplication.

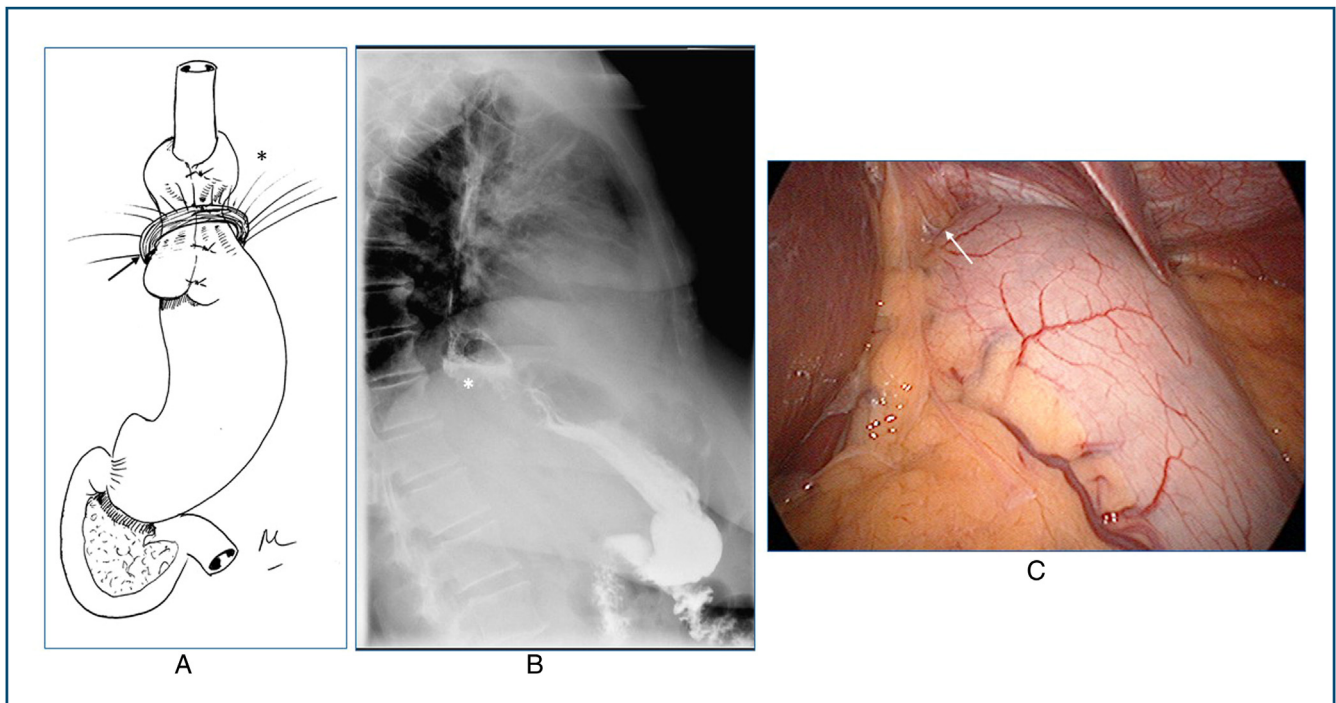


Figure 2. Intrathoracic migration of fundoplication. A. Explanatory diagram. B. Upper gastro-intestinal series. C. Laparoscopic view: the fundoplication is not seen in the abdomen. Arrow: trans-hiatal migration of the fundoplication; *: intrathoracic fundoplication.

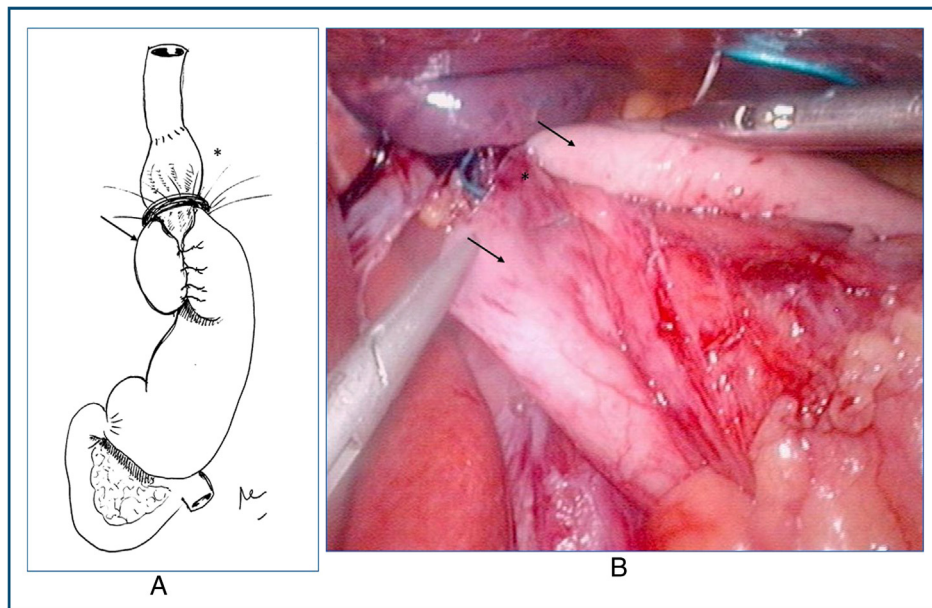


Figure 3. Slipped-Nissen. A. Explicative schema B. Laparoscopic view: the fundoplication is intraabdominal, ascension of a part of the stomach into the thorax. Arrow: intraabdominal fundoplication passage* : portion of stomach is intrathoracic.

after NF in patients with preoperative depression. These authors suggested that patients should be screened for these disorders and they recommended performance of a partial fundoplication even if these patients are good candidates for surgery.

One of the possible causes of incorrect indications is an incomplete initial workup. Recommendations have been established and include [33,34]:

- history taking and appreciation of clinical symptoms with evaluation of the response to PPI;
- esophago-gastro-duodenoscopy (EGD) looking for signs of esophagitis;
- esophageal manometry searching for motor disorders such as achalasia [35] (increasing the pressure of the LES can lead to severe dysphagia in patients with achalasia);
- pH-monitoring if EGD is normal.

If pH-monitoring is performed, anti-secretory treatment should be discontinued for at least 10 days before the investigation to be interpretable. There is no need to perform pH monitoring preoperatively when peptic esophagitis is found on EGD. A preoperative UGIS is used to identify hiatal hernia [34]. Scintigraphy looking for gastric emptying disorders is not performed routinely; pH-impedance monitoring to look for non-acid GERD can be proposed to symptomatic patients with normal pH profiles or those whose symptoms fail to respond to well-conducted anti-secretory treatment [36].

Wrong technique

Faulty technique can lead to inefficient fundoplication. This is the case when the partial fundoplication is too short [37], or when the fundoplication is performed using the anterior portion of the stomach (Fig. 4) or with the gastric corpus rather than the fundus. This creates the illusion of a « floppy », non-narrowing wrap, but is in reality inefficient [38]. In a series of 260 patients followed for six years, Soper et al. found that reasons for anatomical failure included the wrong technique, a large hiatal hernia or early postoperative vomiting [39].

The anatomical technical issues that are important for fundoplication (whether complete or partial) include:

- sufficient posterior mediastinal dissection. It is essential to mobilize at least 2 cm of esophagus below the diaphragm without any tension, in order to eliminate a true brachy-esophagus [40] (in fact exceptional);
- identification and preservation of both vagus nerves during hiatal dissection;
- hiatal closure to prevent the ascension of the wrap into the posterior mediastinum and to reinforce the synergy between the diaphragm and the LES [41];
- fundoplication should involve the fundus only;
- the length of the wrap should be approximately 3 cm (whether complete or partial); if the wrap is too long, there is a risk of dysphagia [8], and if it is too short, there is the risk of being inefficient [37].

There are several other issues that are debated in the literature and therefore do not appear to be essential when creating the wrap. Calibration of the wrap with a 50 to 60 French bougie has been proposed to avoid postoperative dysphagia but without any formal proof that it works [42]. There are no rational arguments to propose tailoring the type of fundoplication to esophageal motility, as suggested in the literature [43,44] (TF or DF in case of motor disorder, NF in all other cases). One meta-analysis has shown that there was no statistically significant difference in functional outcome for GERD repair by either a complete or partial wrap but that there were fewer secondary effects, especially dysphagia, with the partial wrap [25]. Posterior partial fundoplication (TF) was found to be superior to anterior fundoplication (DF) with regard to GERD control [45]. However, the long term outcome of two recent controlled trials, one comparing DF to NF with a 12 year follow-up, [46] and the other comparing DF to TF with 12 month follow-up, [47], found that there were no significant differences in long-term outcomes or patient satisfaction, but fewer patients required ongoing PPI therapy after NF. Our preference is to do a partial posterior (Toupet) wrap because of similar long-term outcome and a lower risk of postoperative dysphagia.

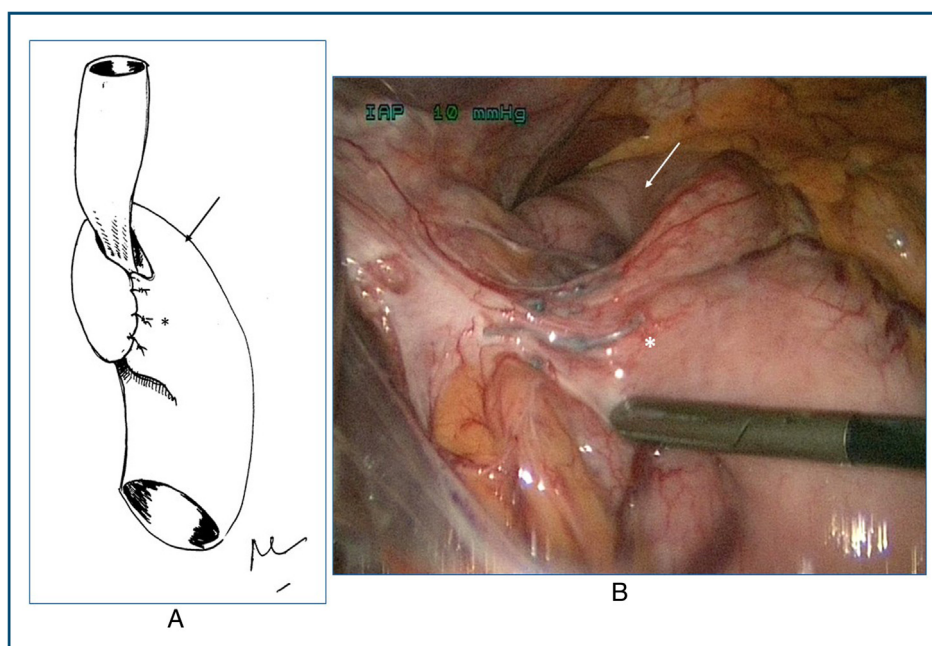


Figure 4. Technical error: mid-gastric fundoplication A. Explicative schema B. Laparoscopic view: fundoplication was constructed with anterior aspect of the stomach (*) instead of fundus (arrow).

Whether or not to divide the short gastric vessels is also a matter of debate. One Australian randomized study did not find any statistically significant difference between patients who underwent division of the short gastric vessels or not with regard to symptom control or dysphagia with a follow-up of 10 years [48], a fact that was confirmed by a meta-analysis published in 2011 [49]. In two of the trials, that included 170 patients who underwent NF with or without division of the short gastric vessels, the authors found an increased prevalence of long-term gas bloat syndrome without any difference with regard to other symptoms such as heartburn, dysphagia or use of PPI [50] when the short gastric vessels were divided. For some [49], preserving the short gastric vessels preserves the fixity of the stomach and avoids the risk of constructing a mid-gastric fundoplication. Of note, the data from the literature concerned only NF. Personally, we always divide at least one or two short gastric vessels to make sure that the fundoplication is without any undue tension and involves the fundus.

Evaluation of patients with failed ST-GERD

Correct evaluation is indispensable to understand the underlying mechanism of failure and to plan management accordingly; this entails precisely defining the symptoms that the patient complains of postoperatively and what symptoms were present before the initial operation (Fig. 1). It is also important to note whether the patient has heartburn, regurgitations, a positional syndrome, dyspepsia, dysphagia or intestinal symptoms. It is also necessary to note the presence and intensity of atypical symptoms such as coughing, laryngeal irritation or pain, and stomatological manifestations. The duration, intensity, consequences on quality of life and nutritional status should be noted with regard to these symptoms. This helps to define the clinical situation and to determine which complementary investigations should be needed. In addition, all previous investigations before the initial operation and the previous operative report should be obtained for review.

Resolution of GERD followed by recurrence with or without dysphagia

In all cases

Recurrence of symptoms or failure to improve must be documented by morphological and functional work-up including

- esophageal manometry looking for pre-existing motor disorders;
- 24-hour pH-monitoring to prove the recurrence of GERD;
- EGD looking for esophagitis;
- an UGIS or a contrast-enhanced CT scan.

Juhasz et al. [51] proposed a standardized description for the results of EGD after ST-GERD. Thus a “normal” fundoplication is one through which the gastroscope passes easily, the eso-gastric junction (EGJ) is not tortuous, and there is no alimentary stasis in the esophagus. The fundoplication is symmetrical when viewed in retrovision. The crura are not visible. High-resolution manometry with measurement of pressures all along the esophagus as well as at the level of the LES by regularly spaced pressure sensors can be of value to evaluate the causes of failure of ST-GERD and in particular to determine the physiological mechanism and select the patients who are candidates for re-do surgery [52,53]. The analysis of the pressure profile can confirm the success of the operation while a double zone of high pressure indicates recurrent hiatal hernia. However, the sensitivity is less than that of imaging to determine the recurrence of hiatal hernia although the positive predictive value is higher. Currently, it could be a complementary investigation that has the potential of identifying the best candidates for re-do surgery, but there is no evidence to prove that it should be used routinely or that it can be used to help choose the type of fundoplication, particularly since the test is not widely available.

With dysphagia

The anatomy of the hiatal region can be determined with precision by an UGIS or contrast-enhanced CT scan or possi-

bly MRI, looking for intrathoracic migration as evidenced by all or a part of the fundoplication being above the diaphragm (Fig. 2) or a slipped Nissen by showing that a portion of stomach has herniated through the fundoplication which has remained in place (Fig. 3). This can lead to suspect a short esophagus; however, only surgical exploration can affirm the existence or not of a true short esophagus, by optimal mediastinal dissection.

A morphological and functional classification of failed Nissen repairs has been proposed according to MRI findings and can be useful [54]:

- fundoplication is said to be in normal position when it is visualized below the diaphragm, seen as a ring-like “pseudotumor” located around the abdominal esophagus while contrast material is seen to pass through in the center of the “pseudotumor”. There is neither herniation above the wrap nor reflux whether spontaneous or stimulated by the Valsalva maneuver;
- intrathoracic migration or hiatal hernia recurrence is when the typical signs of the ring-like “pseudotumor” are seen within the thorax;
- disrupted fundoplication is when the typical “pseudotumor” cannot be visualized. If the fundoplication is partially disrupted, an “open semi-ring” image can be seen on MRI;
- a slipped Nissen is described when part of the stomach not included in the wrap has slipped through and above the fundoplication;
- when either the fundoplication or hiatal repair is too tight, a narrowing of the contrast column is seen: more than 2–3 cm is in favor of a too-tight wrap, less than 1 cm is in favor of too-tight a hiatal repair;
- motor disorders have also been described:
 - delayed bolus progression of a 5 mL bolus of contrast material swallowed in one gulp (more than 20 s between the upper and lower esophageal sphincter);
 - the presence of non-propulsive contractions.

Appearance of secondary effects

The appearance of secondary effects should lead to morphological investigations (UGIS or CT scan) searching for an anatomical anomaly that could explain the symptomatology and identify motor disorders unmasked by fundoplication that were not detected by initial workup before the first operation. Suspicion of gastroparesis due to suspected vagal injury should lead to performance of a gastric emptying scintigraphy study in search of improvement. Once again a complete morphological and functional work-up, as described above, is in order: functional disorders are in favor of a wrong indication while morphological anomalies are indicative of the wrong technique

Management of failed ST of GERD

Resolution of GERD followed by recurrence with or without dysphagia

Without associated dysphagia

The therapeutic options are either a re-do operation or medical therapy (Fig. 1). The decision depends of how well PPI's control the symptoms and on patient desires. The efficacy of fundoplication declines over time, and approximately 30% of patients will have re-appearance of GERD

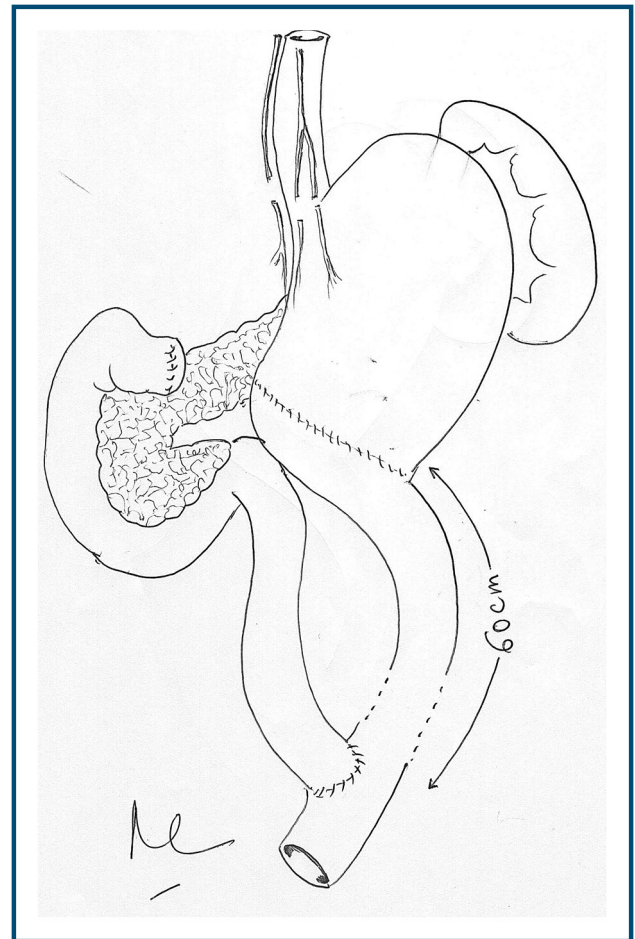


Figure 5. Schema of total duodenal diversion consisting of distal gastrectomy and 60 cm long Roux-en-Y gastroenterostomy and bilateral truncal vagotomy.

within seven to ten years [55,56]. However the cumulative risk of prolonged PPI use is over 50% at 65 years [57], which means that taking PPI once again is not always motivated by a detailed workup as described in the preceding chapter. Moreover, taking PPI once again is most often associated with satisfactory quality of life, most likely better than that of patients taking PPI who had never undergone ST-GERD [2].

If a re-do operation is decided, the surgeon has the choice between a re-do fundoplication or total duodenal diversion (TDD). Re-do fundoplication is valid only if a complete disruption of the wrap has occurred and if the surgical approach to the region is feasible in the face of postoperative scarring changes. The technical points of the re-do operation are discussed below. A TDD (Fig. 5), combining antrectomy with truncal vagotomy, does not involve any dissection of the GEJ except for the vagotomy, constitutes a second-line alternative. In case of difficulties, truncal vagotomy can be performed through a short anterior phrenotomy in line with the hiatus, or by thoracoscopy, either concomitantly or later. TDD provides good results in terms of GERD control but complications related to truncal vagotomy such as postoperative diarrhea and gastroparesis can be seen in nearly 25% of cases. TDD should only be entertained when the hiatus is inaccessible even by a surgeon who has experience with re-do surgery for failed ST-GERD, after several failures of fundoplication: this has become extremely rare [58,59]. Elements that should be considered when choosing this technique are the number of previous operations, which may cause foreseeable difficulties in approaching the EGJ or the

existence of postprandial dyspepsia, which attests to gastric emptying disorder and should lead to consideration of TDD.

The patient should be advised that in the event of difficulty in approach of the EGJ, TDD would be performed instead of the initially planned re-fundoplication. The functional outcome of TDD should also be evaluated at least one year after operation and is, perhaps under these particular conditions, superior to those of re-fundoplication [60,61].

With associated dysphagia

Re-operation should be proposed in case of intrathoracic migration of the fundoplication or slipped Nissen confirmed by the morphological work-up. Re-operation involves the same principles as those described in chapter 4. However, if there is genuine short esophagus (the impossibility of developing at least 2 cm of abdominal esophagus without tension after optimal mobilization of the thoracic esophagus) [62,63], a lengthening gastroplasty such as the Collis-Nissen operation [6,64] may be proposed; this consists of a proximal stapled gastric tubulization followed by a NF using the "lengthened" greater tuberosity. Performance of this technique either by laparoscopy or thoracoscopy has been described. In a retrospective series of 65 patients that compared thoracoscopic Collis-Nissen operation to a NF for short esophagus [65], the mortality was 1.5% for the Collis-Nissen vs. 0% for the NF. The Postoperative morbidity rate was 24% for the Collis-Nissen and 7% for the NF ($P=0.001$). Median follow-up was eight years and patient satisfaction was not statistically significantly different between the two groups. In a small retrospective series of 14 patients with short esophagus who underwent laparoscopic Collis-Nissen paired with 120 controls who underwent a NF, the rate of satisfaction did not differ between the two groups although there was a statistically significant improvement in the quality of life in both groups [66]. In sum, the Collis-Nissen technique is feasible but morbidity is high. There are little data in the literature with regard to management of short esophagus. In our experience we never performed the Collis-Nissen technique, which consists of creating a fundoplication around the prox-

imal stomach, while the true EGJ remains intrathoracic. In case of authentic short esophagus identified after appropriate mediastinal dissection, the alternative is to perform a TDD.

Appearance of secondary effects

Dysphagia

The development of severe dysphagia immediately after the operation and in particular after NF, should suggest an excessively tight wrap or crural closure, or that the upper suture of the fundoplication is too proximal: immediate re-operation to remove the suture or re-do the wrap usually solves the problem [67].

On the other hand, onset of moderate dysphagia is a frequent Postoperative occurrence and usually resolves spontaneously. The persistence of troublesome dysphagia for several weeks may require endoscopic dilatations but at the risk of deteriorating the anti-reflux effect of the fundoplication. The literature does not provide any recommendations as to how many endoscopic dilatations should be tried before resorting to re-operation. This seems to depend on how much clinical improvement can be obtained by dilatation and discussion with the patient with regard to the discomfort felt and the endoscopist as to the degree of improvement that can be expected. In case of failure of dilatations, a re-do operation can be proposed. Dysphagia can also be the consequence of excessively tight closure of the crura (Fig. 6) or periesophageal fibrosis. In case of a too tight NF, our preference is to take down the NF and convert it to a partial posterior wrap (Toupet) to limit the risks of postoperative dysphagia.

Postoperative dysphagia can also be secondary to the use of prosthetic reinforcement of the hiatal repair. One retrospective study found that 22 of 28 patients with complications related to the presence of a prosthetic mesh had dysphagia [68]: esophagectomy was necessary in six, partial gastrectomy in two, total gastrectomy in one, prosthetic mesh removal followed by reconstruction in 13,

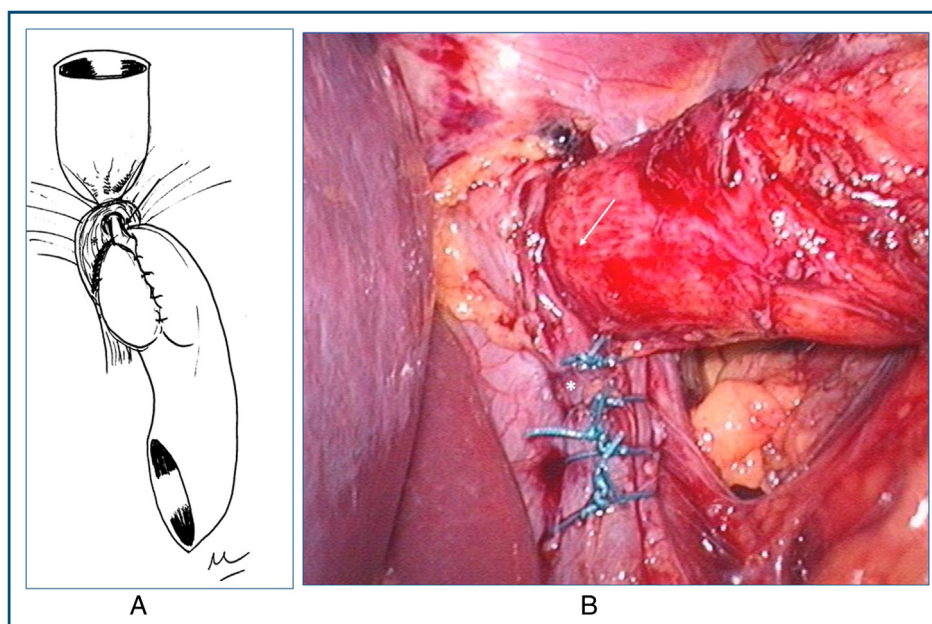


Figure 6. Hiatal stenosis. A. Explicative schema. B. Laparoscopic view (stomach is retracted allowing vision of the hiatus): hiatal and esophageal stenosis (arrow) secondary to excessive crural closure (*).

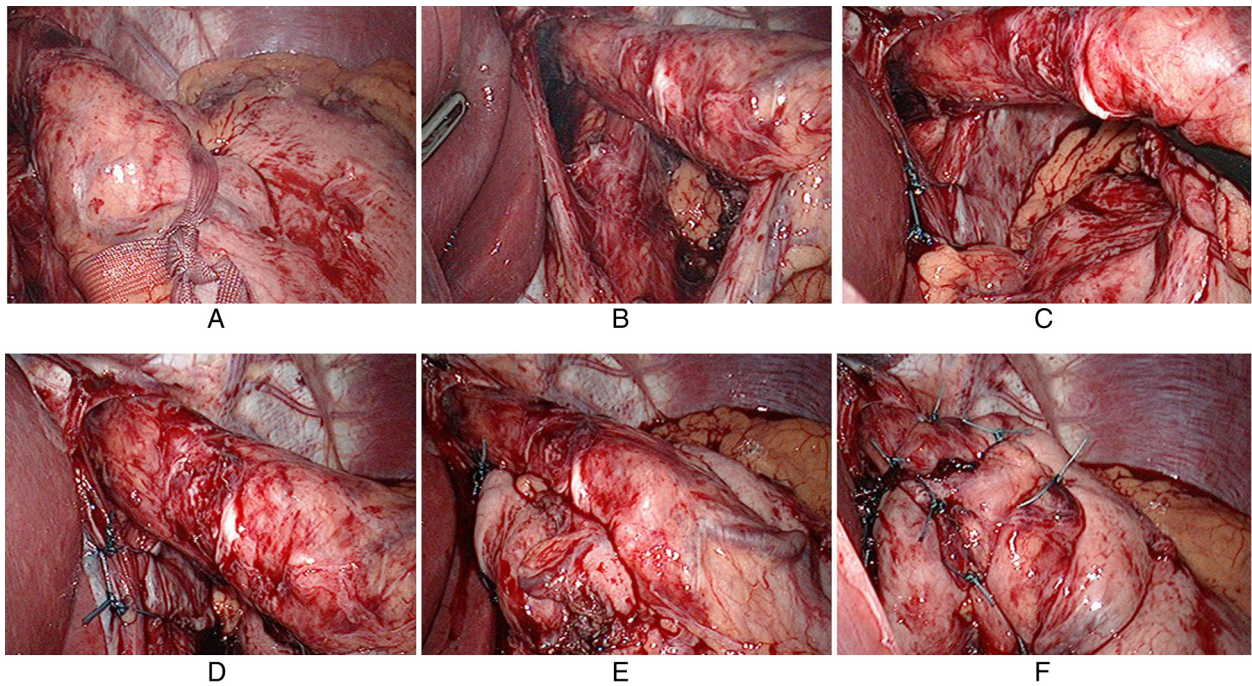


Figure 7. Surgical technique for Toupet fundoplication construction. Laparoscopic views. A. Placement of surgical tape around the esophago-gastric junction. B. Checking for complete dissection to re-establish a native anatomy. C. Posterior crura closure. D. Checking for adequate crural closure relative to the esophagus without tension (the fundoplication remains in place without any need to hold it) and fixation to right crus. E. Retrogastric passage of the fundoplication performed at the expense of the fundus, without tension (the fundoplication remains in place after positioning without the need to hold it) and attachment to the right pillar. F. Final aspect of 3 cm fundoplication attached to esophagus on either side by three sutures avoiding the Latarjet nerve branches.

endoscopic removal of the prosthesis in one, while the five others did not need further intervention.

Hypercorrection symptoms

When bothersome symptoms due to hypercorrection are present, the patients should be informed of the possibility of either transformation of the NF to a TF, or of taking down the wrap and going back to medication therapy. In one retrospective study, Schwameis et al. [69] reported the outcome of 25 patients who had undergone conversion of a NF to a TF wrap for dysphagia or other symptoms of hypercorrection between 2001 and 2014 after a median of 3.7 years without any major intra- or Post-operative complication. With a median follow-up of 27 months, dysphagia and other symptoms of hyper-correction resolved in 87% and 100% of patients, respectively. Two patients had recurrent GERD and underwent a re-do NF; two patients with persistent dysphagia required endoscopic dilatation.

Gastroparesis

Management of gastroparesis after fundoplication is complex. There does not seem to be any place for gastrectomy because of unsatisfactory postoperative functional outcome. Effectively, in a retrospective study of nine patients having undergone gastrectomy for major gastroparesis after fundoplication over a period of 20 years [70], only two patients were truly asymptomatic after a median follow-up of 23 months while six patients still required enteral nutrition.

An alternative might be to perform a pyloroplasty in patients whose symptoms were relieved by endoscopic injection of botulinum toxin into the pylorus. In a series

of 10 patients [71], symptoms of gastroparesis were improved in nine of 10 cases after a median follow-up of 34 months.

Absence of improvement

Wrong indication

If faulty surgery or an esophageal motor disorder has been eliminated, it is preferable to propose medical treatment with specific management of ENT, pulmonary, or psychiatric complications in patients with extra-digestive symptoms or associated psycho-emotional disorders rather than any reoperation that might also end in failure.

Wrong technique

When preoperative workup implicates a faulty surgical technique, re-operation is indicated consisting of a complete dismantling and reconstruction of the wrap.

Surgical technical points

Even though most patients with recurrent symptoms of moderate degree can be treated medically, re-operation is proposed in 3–6% of patients, most often during the first two years [72]. This paragraph exposes the essential technical points and the traps to avoid in case of re-operation for failed ST-GERD when re-fundoplication is envisioned. This is based on our personal experience of 103 patients during 1996 to 2017, out of a series of 1015 patients managed during the same time period.

Table 1 Recent publications studying the impact of re-operation after failed fundoplication.

First author, year of publication and references	Number of patients	Previous operation	Re-operation	Median follow-up (months)	Postoperative mortality (%)	Postoperative morbidity (%)	Failure rate ^b (%)	Quality of life-satisfaction
Del Campo 2017 [86]	46	Mainly NF	NF: 83% TF: 15% Exploratory laps 2%	16	0	17.5	25	82% satisfied
Wilshire 2016 [78]	105	1 PO 89% NF 63%, laps 82% > 1 PO 11% NF 55%, laps 73%	1 PO: NF 39.3%, C-N: 6% > 1 PO: NF 45.5%, C-N: 0%	20	0	10.5 ^a	19 ^a	GIQLI ^a
Banki 2016 [79]	47	NF 85%, recurrence HH 90%	NF 8%, C-N 0%, TF 56%, laps 74%	21	0	38	33	92% satisfied
Awais 2014 [80]	105	C-N 43% Various types of interventions 26% BMI > 30 78%	TDD 100%, laps 77%	23	0	24	14	Excellent median score
Makdisi 2014 [81]	75	NF 80% laps 87% Recurrence HH 63%	NF 76%, TF 17%, Dor 4% C-N 49%	25	0	15	22	78% of excellent functional results
Yamamoto 2014 [82]	183	Various types of interventions: 8%	Group re fundoplication 65% TDD 35% Conversion to laparo 8.2%	53	0	33	34	87% satisfied ^a
Mittal 2013 [60]	130	Various types of interventions: Group re-fundoplication 24% TDD: 36%	Group re- fundoplication 74% TDD 26%	21.318.9	0	2233	28	85% satisfied ^a
Makris 2012 [83]	72	Various types of interventions: 36%	TDD 100%, laps 51%	21	0	46	23	89% satisfied
Musunuru 2012 [84]	38	Various types of interventions: 26%	Laparoscopic NF 84%	35	0	36	21	63% satisfied
Awais 2011 [64]	275	Various types of interventions: 11%	Laps NF 73%, prosthetic reinforcement 8% C-N 43%, TF 15%	40	0	8	11	89% satisfied
Dallemagne 2011 [85]	129	NF 85%	NF 69%, C-N 4%, prosthetic reinforcement 10%, laps 100%	76	0	7	36	Mean GIQLI score 86.4

N: number, laps: laparoscopy; laparo: laparotomy, NF: Nissen fundoplication; TF: Toupet partial fundoplication; 1 PO: one previous operation; C-N: Collis-Nissen; TDD: total duodenal diversion, HH: hiatal hernia, BMI: body mass index.

^a Absence of statistically significant difference between the two groups.

^b Defined as absence of resolution or appearance of new symptoms.

Dissection of the esogastric region

The technique involves complete and meticulous lysis of all adhesions to establish a native anatomy, probably the most important step of the operation. The operation usually starts by freeing the left lobe and caudate (Spiegel) lobe of the liver, preserving the capsule as much as possible. Dissection is then pursued toward the base of the "V" of the crura, remaining in contact with the muscles in order to avoid any vascular injury. It is important to try to preserve the perimysium of the crura as much as possible to optimize crural closure. The fundoplication is then completely taken down; this avoids creating a double plication when the new fundoplication is performed. It is usually easy to find a plane of dissection between the gastric serosa and the esophagus. It is indispensable to identify the vagus nerves at this stage when they are particularly at risk. The most prevalent accidents of dissection include: (i) opening the left pleural cavity (this rarely causes any respiratory repercussion and usually does not require any drainage), and (ii) injury to the esophagus or stomach, most often only of the sero-muscular layers, exceptionally of the mucosa. These injuries should be closed routinely. Testing for patency by injecting methylene blue through the naso-gastric tube is routine to avoid missing an inadvertent full-thickness wound. In our experience, we routinely take down the short gastric vessels if this had not been accomplished during the initial operation.

The presence of a para-esophageal hernia leads to a complex situation, because the peritoneal sac usually has been opened during the index operation and therefore is inexistent.

As a general guideline, when dissection is particularly complex, dissection should remain in contact with the crura, stomach and esophagus, thus limiting the risk of injuring either the vena cava, left gastric vessels or splenic artery. If dissection becomes too dangerous, it is best to resort to TDD.

Reconstruction

Hiatoplasty consists of inserting two or three non-absorbable sutures into the crura behind the esophagus without any tension (Fig. 7). Anterior plication of the crura may be necessary when excessive tension exists on one or the other diaphragmatic pillars or when hiatal closure seems insufficient. Inserting prosthetic material can be avoided in most cases by adequate mobilization and preservation of the crura.

It is important to identify the EGJ to correctly position the fundoplication. Certain teams recommend performing intraoperative EGD scopy to try to localize the EGJ [64,73]. Personally, we prefer to identify the EGJ after removing the fatty tissues around the esophago-gastric angle (of His) rather than by endoscopy.

The new fundoplication is performed only after restoration of normal anatomy.

The fundoplication can now be performed. We recommend a 3 cm partial posterior fundoplication (Toupet) [8,37] to limit the risk of postoperative dysphagia, characteristically more frequent after the NF [25]. There is no evidence in the literature to recommend one particular type of fundoplication in case of re-operation. It is rare, after optimal ligation of the short gastric vessels, that there is inadequate gastric tissue to reconstruct a fundoplication. A distal

esophageal myotomy may be added in patients with pseudo-achalasia.

In order to avoid hypercorrection symptoms such as postoperative dysphagia, we do not calibrate the wrap routinely but adhere to the following key points:

- loose hiatal closure;
- estimate the adequateness of crural closure over the esophagus without tension, by the ability to pass a closed grasper between the esophagus and the crura;
- partial posterior fundoplication.

With regard to postoperative management, we do not drain routinely and a nasogastric tube is left in place only if there has been full thickness digestive tube injury. An early postoperative UGIS, performed routinely, allows appreciation of the morphology of the fundoplication and also may have medico-legal implications. Patients are seen at three months postoperative and are followed by their family physician or gastro-enterologists or surgeon, as they wish.

Results of surgical management

Re-operation in case of failure of ST-GERD is complex and technically difficult, associated with postoperative morbidity and mortality ranging from 4–40% and 0–4.9%, respectively [73–76]. One review found that functional outcome was inferior to that of primary surgery with an average success rate of 81% (in case of recurrence) compared to 84% to 97% for primary repair [77]. Table 1 summarizes the data of the recent literature with regard to re-operation for failed ST-GERD [60,78–86]; it highlights a wide variability of techniques, the absence of standardization of the definition of failure, and evaluation of quality of life (occasionally evaluated by the GIQLI score [87]) and patient satisfaction. Approximately one third of anti-reflux operations are performed via laparoscopy. Little et al. [23] found that 84% of patients undergoing re-operation had satisfactory results and this rate dropped to 42% for patients undergoing three operations or more.

Conclusions

Clinical presentation of failed ST-GERD is multi-faceted, and should be clarified by careful history taking. Management is best ensured by an expert center. A complete work-up is necessary before any treatment; this entails a morphological profile as determined by an UGIS and EGD, and, additionally, a CT scan or MRI to clarify the status of the crura and the hiatus. A thorough functional work-up is also needed. It is indispensable in case of persistent or recurrent GERD to obtain a manometry (to eliminate achalasia initially mistaken for GERD), pH-metry and sometimes pH-impedance monitoring, to prove the recurrence. The best treatment is of course preventive, founded on good sound indications and observance of the principles of functional surgery for GERD at the initial operation. Re-operation can be proposed in selected cases, according to well-established fundamental principles.

Essential points

- Management of failed antireflux surgery requires full workup before any treatment in order to understand the causes of failure.
- The most frequent causes of failure are errors in initial indications, essentially related to insufficient workup, technical errors including slipped (mid-gastric) or too tight fundoplication wraps, faulty crural closure or unrecognized short esophagus.
- The workup profile should include at least a UGIS, EGD, abdominal CT scan or MRI to study the esophageal crura and hiatus.
- Functional workup should include esophageal manometry, pH monitoring, sometimes an esophageal impedance monitoring especially when recurrent or persistent reflux is suspected, in order to rule out achalasia initially mistaken for gastro-esophageal reflux or to confirm recurrence.

Disclosure of interest

The authors declare that they have no competing interest.

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