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Laparoscopic Total Fundoplication for Refractory GERD: How to Achieve Optimal Long-Term Outcomes by Preoperative Instrumental Assessment and a Standardized Technique

Paolo Limongelli et al.*,**

*Department of General and Hepato-Pancreato-Biliary Surgery S.M.,
Loreto Nuovo Hospital, Naples
Italy*

1. Introduction

Gastroesophageal reflux disease (GERD) is one of the most common gastrointestinal disease among adults in Europe and USA. A recent consensus conference (the Montreal Consensus) defined GERD as "a condition which develops when the reflux of stomach contents causes troublesome symptoms and/or complications". Symptoms were considered to be "troublesome" if they adversely affected an individual's well-being. GERD can lead to both esophageal and non-esophageal symptoms. The most common typical symptoms of GERD are heartburn and regurgitation. Non-esophageal GERD symptoms include chronic aspiration with cough and laryngitis (Shaheen & Ransohoff, 2002). At its core, GERD is the failure of the antireflux barrier, allowing abnormal amounts of reflux of gastric contents into the esophagus (Dodds et al., 1982). The primary treatment modality for GERD is acid suppression therapy, in particular by use of PPI (Castell et al., 2002). However, consideration should be given for surgery if the following indications exist: complications of GERD (such as peptic stricture or Barrett's esophagus), extraesophageal manifestations (chest pain, pulmonary symptoms), failed medical management, or desire to discontinue medical treatment despite adequate symptomatic control. Minimal invasive anti-reflux surgery can be considered an effective GERD therapy, with its mechanical function both in the short and long term period. Several different ways of fashioning a total fundoplication lead to different outcomes. This chapter addresses the technical details of the antireflux technique we adopted without modifications for all patients with GERD. In particular it

* Salvatore Tolone, Gianmattia del Genio, Antonio d'Alessandro, Gianluca Rossetti, Luigi Brusciano, Giovanni Docimo, Roberto Ruggiero, Simona Gili, Assia Topatino, Vincenzo Amoroso, Giuseppina Casalino, Alfonso Bosco, Ludovico Docimo and Alberto del Genio
Second University of Naples, Division of General and Bariatric Surgery, Naples, Italy

**Paolo Limongelli and Salvatore Tolone gave the same contribution to the chapter

aims to discuss the appropriate selection of patients undergoing laparoscopic fundoplication and the relation between wrap and the physiology of the esophagus. In fact, selecting gastroesophageal reflux disease (GERD) patients for surgery on the basis of traditional pH-monitoring or endoscopy, may be challenging, particularly if endoscopy is negative (i.e. NERD patient), or presenting “uncommon” GERD with clinical symptoms (Charbel et al., 2005). Combined multichannel intraluminal impedance pH monitoring (MII-pH) is able to physically detect each episode of intraesophageal bolus movements, enabling identification of either acid or non-acid reflux episodes and thus establish the association of the reflux with symptoms. Since the mechanism of fundoplication is to physically block gastric refluxate to enter into the esophageal lumen by restoring the competence of the lower esophageal sphincter (LES), the routine use of MII-pH in the preoperative evaluation may offer objective parameters for a more accurate indication to surgery. At the same time, some authors assume that a total fundoplication expose the patient to a delayed transit of the swallowed bolus and thus to an increased risk of dysphagia, especially when a peristaltic dysfunction is present. However, few studies have reported the effects of total fundoplication on peristalsis, bolus transit and increased risk of dysphagia by means of objective data; this was mainly due to the exposure to radiations and a difficulty of completing studies by the use of combined manometry and videofluoroscopy.

Multichannel intraluminal impedance combined with traditional esophageal manometry (MII-EM) provides an objective assessment of the transit and clearance of a standardized bolus, and to study the esophageal motility. Montenovo et al. have recently reported the inefficacy of preoperative use of MII and manometry to predict postoperative dysphagia of patients who underwent Nissen fundoplication, based on a postoperative symptom questionnaire. However, no pre- or postoperative evaluation of the effects of fundoplication on the esophageal function has been reported to date.

We undertook the current study to evaluate by means of MII-EM and combined 24-h pH and multichannel intraluminal impedance (MII-pH) the impact of fundoplication on esophageal physiology. An objective demonstration of the impact of the total wrap on the bolus transit may be helpful in refining the correct indications towards partial or total antireflux wrap.

2. Protocol study

The study involved a consecutive cohort of patients undergoing laparoscopic total fundoplication for refractory GERD, with information recorded in a prospectively maintained database, followed up for at least one year. Surgical treatment was offered to PPI-refractory patients with heartburn and regurgitation as their predominant symptoms. Patients were considered PPI refractory if 40 mg omeprazole was insufficient for lasting suppression of symptoms and if, following an increase in dosage to 40 mg two or three times daily, symptoms recurred after return to 40 mg maintenance treatment daily. Patients were included in the present study if upper endoscopy had been performed before surgery, preoperative 24-h combined MII-pH-monitoring demonstrated pathological reflux condition, and objective and subjective outcome had been registered after surgery.

From October 1st 2005 to October 1st 2010, five hundred and twenty-three consecutive patients (298 women and 225 men; mean age 43.7±14.5 years; range 20-65 years) were referred to Esophageal Pathophysiology Center of the First Division of General and

Gastrointestinal Surgery of the Second University of Naples for the suspicion of esophageal diseases. Before subjects entered the study, a specific informed consent was obtained from each.

Surgery was indicated for (1) patients with GERD who were not responding to medical therapy or affected by “nocturnal acid break through” phenomenon; (2) patients not compliant with long-term medical therapy; (3) patients requiring high dosages of drugs; (4) patients too young for lifetime medical treatment; (5) patients performing a particular type of job that does not allow drugs to be taken constantly; (6) patients with atypical GERD who opted for surgery or bile reflux; and (7) patients who decided, in the first instance, for the surgical treatment of typical GERD.

2.1 Clinical evaluation

After a brief interview and examination to assess for the presence and severity of gastrointestinal symptoms and to make anthropometric measurements, all subjects completed a brief symptom assessment questionnaire. The questionnaire incorporated a visual analog scale (modified DeMeester Score) for heartburn, regurgitation, dysphagia, and respiratory symptoms.

2.2 Instrumental assessment

Preoperatively, all patients underwent upper gastrointestinal endoscopy, Combined Multichannel Intraluminal Impedance and Esophageal Manometry (MII-EM) and 24 hours Combined Multichannel Intraluminal Impedance and pH-monitoring (MII-pH), as our routinary preoperative assessment for patients evaluated for antireflux surgery.

Upper gastrointestinal endoscopy was performed according to the international guidelines and the center’s current practice criteria that were adopted for the preoperative study of candidates for antireflux therapy. Reflux esophagitis was graded according to the Los Angeles classification, including nonerosive esophageal reflux disease. Biopsies were performed for the histologic confirmation of the diagnosis of Barrett esophagus or when dysplastic lesions were suspected; Barrett esophagus was categorized according to established criteria.

2.2.1 Combined MII-EM protocol

Each patient underwent esophageal function testing using combined MII-EM with a Koenigsberg 10-channel probe (Sandhill EFT catheter; Sandhill Scientific Inc., Highlands Ranch, CO, USA). The 4.5-mm-diameter catheter design has two circumferential solid-state pressure sensors at 5 and 10 cm from the tip and three unidirectional pressure sensors at 15, 20, and 25 cm. Impedance measuring segments consisting of two rings placed 2 cm apart were centered at 7, 10, 15, 20, 25 from the tip. The EFT catheter was inserted transnasally into the esophagus up to a depth of 60 cm and the collection of impedance and pH data (30 Hz) was initiated. Lower esophageal sphincter (LES) was identified using station pull-through technique and the most distal sensor was placed in the high-pressure zone of the LES. Intraesophageal pressure sensors and impedance measuring segments were thus located at 5, 10, 15, 20 cm above the LES and 2, 5, 10, 15, and 20 cm above the LES, respectively. In the supine position, patients were given 10 swallows of 5 cc normal saline

and 10 swallows of 5 cc applesauce consistency viscous material with standardized ionic concentration (Viscous®, Sandhill Sci.), each 20–30 s apart. Normal saline was used instead of regular water since it has a standardized ionic concentration and provides better impedance changes. Double-swallowing disqualified swallows and these were repeated.

2.2.2 Manometric parameters assessment

Manometric parameters used to characterize swallows included (1) contraction amplitude at 5 and 10 cm above the LES, (2) distal esophageal amplitude (DEA) as average of contraction amplitude at 5 and 10 cm above the LES, (3) onset velocity of esophageal contractions in the distal part of the esophagus (i.e., contraction velocity between 10 and 5 cm above the LES).

During the pull-through distance of both distal border and proximal border of LES were recorded, as the distance in cm from nares. The LES length was measured, as the difference of distal border and proximal border in cm.

The LES residual pressure was measured as the lowest pressure (excluding respiratory artefacts) during swallow-induced LES relaxation, and the LES resting pressure was calculated as the average (mid respiratory) LES pressure over 4–5 s at the level just distal to the pressure inversion point.

Swallows were classified using the traditional manometric criteria as (1) normal, if contraction amplitudes at 5 and 10 cm above the LES were each greater than or equal to 30 mmHg and distal onset velocity was less than 8 cm/s; (2) ineffective, if either of the contraction amplitudes at 5 and 10 cm above the LES was less than 30 mmHg; (3) simultaneous, if the contraction had a distal onset velocity greater than 8 cm/s or retrograde onset and amplitudes at 5 and 10 cm above the LES were each greater or equal to 30 mmHg.

Diagnoses of manometric motility abnormalities were established using criteria published by Spechler and Castell. DES was defined as 20% or more saline swallows with contraction amplitude greater than or equal to 30 mmHg in both distal sites located at 5 and 10 cm above the LES and contraction onset velocity greater than 8 cm/s.

2.2.3 Impedance parameters assessment

Bolus entry at a specific level was identified by the 50% point between 3-s preswallow impedance baseline and impedance nadir during bolus presence. Bolus exit was determined as return to this 50% point on the impedance recovery curve as discussed in previous studies (Fass et al., 1994).

Swallows were classified by MII as showing (1) complete bolus transit if bolus entry occurred at the most proximal site (20 cm above LES) and bolus exit points were recorded in all three distal impedance-measuring sites (i.e., 15, 10, and 5 cm above the LES) and (2) incomplete bolus transit if bolus exit was not identified at any of the three distal impedance measuring sites.

Total bolus transit time was calculated as the time elapsed from bolus entry in the proximal channel 20 cm above the LES to bolus exit in the distal channel 5 cm above the LES when bolus exit present.

Diagnoses of esophageal transit abnormalities were defined as incomplete liquid transit if at least 30% of liquid swallows had complete bolus transit and incomplete viscous transit if at least 40% of viscous swallows had complete bolus transit. These values are based on data from 43 healthy volunteers (Tutuian et al., 2003a).

2.2.4 Combined 24 hour pH-multichannel intraluminal impedance (MII-pH)

Twenty-four-hour ambulatory combined pH-multichannel intraluminal impedance studies were performed to document the presence of GERD. A dedicated MII-pH catheter (with intraluminal impedance segments positioned at 3, 5, 7, 9, 15, and 17 cm above the LES; Sandhill Scientific Inc., Highlands Ranch, CO, USA) was placed transnasally, with the esophageal pH sensor positioned 5 cm above the manometrical determined LES. Patients were invited to signal three or more predominant symptoms that occurred during the recording time, every meal, and changing position in upright or in recumbent, as on the device and a written diary as well. This information was transmitted by the catheter into software integrated into the device (Sleuth System, Sandhill Scientific Inc.). MII-pH data were acquired and analyzed with the Bioview GERD Analysis Software (Sandhill Scientific Inc.). All tracings were carefully reviewed by a single investigator [S.T.] to check correspondence between the results of the computer evaluation and the morphology of each reflux episode. Meal periods and drop in pH, not related to a retrograde movement at impedance (i.e., swallow of acid drink), were excluded from the analysis to improve accuracy of the pH monitoring (Sifrim et al., 2004; Tutuian et al., 2003b). The following variables were assessed: (1) esophageal acid exposure calculated as percentage (%) of time with pH <4 (total, upright, and recumbent), (2) number and quality (acid and non-acid) of reflux detected at MII, and (3) Symptom Index, described according to reported parameters. An abnormal % of time with pH <4 in distal esophagus, a total number of refluxes detected at MII >73, a Symptom Index at least 50%, or the presence of two or all three were considered as parameters useful to indicate antireflux surgery.

Based on the results of MII-pH, the patients were divided into positive pH monitoring (pH+) and negative pH monitoring groups (pH-). This latter were further divided in two sub-groups if the total number of reflux episodes at MII was pathologic (pH-MII+) or the total number of reflux episodes were negative, though the Symptom Index was positive (pH-MII-SI+).

2.3 Surgical technique

Pneumoperitoneum was induced at 12 mmHg via a Verress needle or open Hasson's technique. Five trocars (one 10 mm and four 5 mm) were inserted (one transumbilical, one on the left and one the right emiclavicular line in ipocondrium, one in epigastrium and one between umbilical and the left emiclavicular line). A steep reverse-Trendelenburg position was applied. The aspirator was inserted in the epigastric trocar to retract the left liver. The height of the gastroesophageal junction was localized by transillumination provided by the endoscope. The procedure began with the section of the anterior peritoneal reflection of the gastroesophageal junction, the surgeon being aware to start the section of the lesser omentum high enough not to cut the vagal branch to the liver. To achieve this step, the assistant employed a Babcock grasper positioned at the anterior esophageal fat pad, which

was retracted downward toward the esophagus. After identification of the anterior vagal nerve, the gastrophrenic ligament was sectioned. The dissection was then continued from right to left behind the esophagus until the crura was exposed and the angle of His was abolished, with particular care taken to avoid injury to the posterior vagus.

At this point, an esophageal retractor replaced the Babcock grasper, and a posterior window was created large enough to accommodate fashioning of the wrap. With the help provided by right and left steering of the aspirator, the esophagus was widely mobilized in its mediastinal portion until non-inflammatory periesophageal tissue was reached and the esophagus lay in the abdomen without tension (floppy esophagus). The cruroplasty was accomplished by one simple extracorporeal non-adsorbable knot; only in cases where there a larger defect (>4 cm) were additional sutures required. The 2-cm-long Nissen-Rossetti wrap was fashioned with the anterior wall of gastric fundus passed, if possible, between the esophagus and the posterior vagus nerve. The short gastric vessels were always preserved. The two gastric hemi-valves were sutured with two stitches that never incorporated the esophageal muscular layer. In all cases, to check the calibration of the wrap, at the end of the procedure we performed intraoperative manometry and an endoscopic control (A. del Genio et al., 1997; G. del Genio et al., 2007); whenever a pressure outside the range (20-40 mmHg) was detected or the endoscopic vision of the wrap was not satisfactory (difficult passage of the endoscope through the fundoplication, superior edge of the gastric fundus not included into the wrap), the fundoplication was refashioned correctly.

2.4 Post-operative assessment and follow-up

The same pre-operative questionnaire (incorporating a visual analog scale (0-10) for heartburn, regurgitation, dysphagia, and chest pain) was re-administered to patients at 6 months, 1 and 5 years after surgery. At the 1-year control patients were asked to re-underwent to MII-EM and MII-pH and upper endoscopy when needed.

3. Outcomes

3.1 Patients candidate for laparoscopic total fundoplication

Among 523 patients investigated at MII-pH, 184 patients (35.1%) had one or more MII-pH parameter positive and, for this reason, were submitted to Laparoscopic Nissen-Rossetti Fundoplication and 339 patients (64.9%) had a negative MII-pH exam. Of these, 47.2% of patients complained of abdominal pain, with gastritis at esophagogastroduodenoscopy and underwent eradication of *Helicobacter pylori* infection (14/47.2) and/or started PPI therapy. The remaining 52.7% of patients were non-responders to PPI.

In particular, 19.7% of patients with symptoms related to the presence of hiatus hernia underwent laparoscopic hernia repair, hiatoplasty, and fundoplication. Twenty-three percent of patients complaining of extraesophageal symptoms (i.e., hoarseness, laryngitis, chest pain, and globus) not related to GERD were referred to otolaryngologists, pulmonologists, or other specialists.

In last cases, the symptoms were suggestive for functional dyspepsia (i.e., bloating, delayed gastric emptying), and the patients underwent further clinical-instrumental investigation (i.e., diisopropyl iminodiacetic acid gastric scintigraphy scanning, 24-h intragastric bile

monitoring with the Bilitec), and promotility agents like metocloporamide, domperidone, and erythromycin were started.

Among the 184 patients, 53.3% had abnormal pH monitoring (pH+), 27.4% had a normal pH monitoring and a positive number of MII reflux (>73 episodes; pH-MII+), and 19.3% had a normal pH monitoring and number of MII reflux (<73 episodes) and a positive Symptom Index. Twenty-six percent of patients were positive for all the parameters (e.g., pH-monitoring, number of reflux >73, and Symptom Index). All of them underwent to Laparoscopic Nissen-Rossetti fundoplication.

3.2 Clinical outcomes and follow-up

The evaluations were performed a median of 15 days (range 5-35 days) before the fundoplication then 6, 12 and 60 months afterward.

The pre- and post-operative visual analog scale symptom scoring system is reported in table 1.

Mean symptom score ± S.D.	Pre-operative	Post-operative	p
Hearthburn	2.3±0.8	0.2±0.2	<0.05
Regurgitation	1.8±0.9	0.3±0.2	<0.05
Dysphagia	0.3±0.5	0.4±0.1	N.S.
Chestpain	1.6±0.8	0.3±0.2	<0.05
Respiratory symptoms	1.1±0.9	0.3±0.1	<0.05

Table 1. Mean Pre- and Post-operative DeMeester symptom score (modified).

After surgery the incidence of symptoms related to reflux was statistically decreased; no increase in perception of dysphagia was observed.

At 12 months, 98.3% of patients were satisfied of the procedure and expressed the will to undergo the same operation knowing its effects.

Regarding side effects, among 184 patients, 1.6% of patient complained about bloating and hyperflatulence and 3.8% complained about transient dysphagia, totally resolved in 2 months after surgery. All the patients did not restart taking any anti-acid drugs for symptoms above the wrap.

3.3 Instrumental outcomes

3.3.1 Manometric parameters

At 12 months afterward surgery, mean LES resting pressure raised from the pre-operative value of 16.2±7.5 mmHg to 31.1±6.3 mmHg ($p<0.05$). LES relaxing pressure (%) wasn't affected by the wrap (91.7±3.9% pre-operatively vs. 90.1±6.4% post-operatively).

Mean wave amplitude at 5, 10, 15 and 20 cm above LES wasn't affected by the presence of fundoplication, both for liquid and viscous swallows. Also mean distal esophageal

amplitude (DEA), both for liquid and viscous swallows, didn't show any significant variation after surgery (88.8±34.6 mmHg vs. 86.6±39.1 mmHg for liquid swallows and 86.5±38.7 mmHg vs. 90.4±29.0 mmHg for viscous swallows).

The mean percentage of normal, ineffective and simultaneous waves didn't change significantly, both for liquid than viscous swallows.

Detailed manometrical data are shown in table 2.

	Pre-operative	Post-operative	P
LESP (mmHg, mean ± S.D.)	20.0± 7.5	31.1 ± 6.3	<0.05
LES % relax	91.7±3.9	92.1±6.4	N.S.
Liquid Swallow (N=150)			
Normal	110	108	N.S.
Ineffective	40	41	N.S.
Simultaneous	0	1	N.S.
Amplitude (mmHg, mean ± S.D.) at 20 cm above LES	49.1±24.5	63.5±39.8	N.S.
Amplitude (mmHg, mean ± S.D.) at 15 cm above LES	49.1±20.2	44.5±17.2	N.S.
Amplitude (mmHg, mean ± S.D.) at 10 cm above LES	82.6±33.8	75.8±37.1	N.S.
Amplitude (mmHg, mean ± S.D.) at 5 cm above LES	95.5±47.0	97.6±43.3	N.S.
DEA	88.8±34.6	86.6±39.1	N.S.
Viscous Swallow (N=150)			
Normal	103	123	N.S.
Ineffective	47	27	N.S.
Simultaneous	0	0	N.S.
Amplitude (mmHg, mean ± S.D.) at 20 cm above LES	51.5±29.9	59.6±39.9	N.S.
Amplitude (mmHg, mean ± S.D.) at 15 cm above LES	44.5±24.3	45.1±23.3	N.S.
Amplitude (mmHg, mean ± S.D.) at 10 cm above LES	75.7±36.3	79±28.6	N.S.
Amplitude (mmHg, mean ± S.D.) at 5 cm above LES	97.5±48.0	101.8±36.6	N.S.
DEA (mmHg, mean ± S.D.)	86.5±38.7	90.4±29.0	N.S.

Table 2. Pre- and Post-operative Esophageal Manometry findings.

3.3.2 Impedance parameters

After total fundoplication, esophageal bolus transit patterns detected at impedance were the followings:

The mean percentage of complete liquid bolus transit was not influenced by surgery (68.8±23.1% vs 75.5±21.8%, pre- and postoperative respectively).

The mean percentage of complete viscous bolus transit improved, raising from 64.4±25.0% to 86.6±15.8% ($p<0.05$) pre- and postoperative respectively.

Mean total bolus transit time, both for liquid and viscous swallows, didn't show a statistically significant, changing from 8.4±1.6 seconds to 9.0±1.9 seconds for liquid swallows and from 8.6±1.0 seconds to 9.3±1.8 seconds for viscous swallows, pre- and postoperative respectively.

Detailed impedance bolus transit data are shown in table 3.

3.3.3 MII-pH parameters

The Nissen-Rossetti antireflux procedure produced an improvement in all categories of the MII-pH over the patients' preoperative values. Esophageal acid exposure (%) of time with pH <4 showed a drastically reduction post-operatively in total, upright, and recumbent position. The overall number of GER episodes was statistically reduced in both the upright and recumbent positions ($p<0.05$). This reduction was obtained due to the postoperative control of both the acid ($p<0.05$) and nonacid ($p<0.05$) GER episodes (tab 4).

Postoperatively, symptom occurrence fell considerably. None of the patients had a positive symptom index. The proportion of physical reflux characteristics (liquid, mixed, gas) did not change after surgery.

	Pre-operative	Post-operative	P
Liquid Swallows (N=150)			
Complete bolus transit	123	113	N.S.
Incomplete bolus transit	27	37	N.S.
Total bolus transit time (sec, mean ± S.D.)	8.46±1.64	9.0±1.96	N.S.
Viscous Swallows (N=150)			
Complete bolus transit	96	130	<0.05
Incomplete bolus transit	54	20	<0.05
Total bolus transit time (sec, mean ± S.D.)	8.6±1.0	9.3±1.8	N.S.

Table 3. Pre- and Post-operative Bolus transit patterns at impedance

	Pre-operative	Post-operative	p
Total % time at pH <4	5.9±2.9	0.4±0.3	<0.05
Upright % time at pH <4	6.5±3.5	0.7±0.8	<0.05
Recumbent % time at pH <4	3.3±2.5	0.2±0.2	<0.05
DeMeester Score (pH)	17.4±8.5	1.6±1.5	<0.05
Total number of reflux (MII)	65.2±45.4	4.4±0.5	<0.05
Upright Total number of reflux (MII)	53.1±43.0	3.1±0.5	<0.05
Recumbent Total number of reflux (MII)	12.1±5.0	1.3±0.5	<0.05
Total acid reflux (MII)	33.4±21.4	1.6±0.6	<0.05
Upright Total acid reflux (MII)	26.5±21	1.3±0.6	<0.05
Recumbent Total acid reflux (MII)	6.9±6	0.3±0.8	<0.05
Total non acid reflux (MII)	31.8±34.1	2.8±0.3	<0.05
Upright Total non acid reflux (MII)	26.7±34.2	1.9±0.7	<0.05
Recumbent Total non acid reflux (MII)	5.1±3.7	0.9±0.4	<0.05

Table 4. Pre-and post operative MII-pH findings (Mean ± S.D.)

4. Discussion

There are objective data to demonstrate that MII-pH used as a routine diagnostic tool for patient candidates for surgery provided a satisfaction rate comparable to classic pH monitoring. It is noteworthy that these positive results were obtained extending the indication to surgery in an additional 40% of patients, with negative pH monitoring (G. del Genio et al., 2008). In the pre-MII era, to establish the need for surgery in patients with negative pH monitoring was a challenging decision.

Data on non-acid reflux episodes and a more precise symptom index correlation helps the surgeon to decide for an antireflux operation vs. medical treatment. Moreover, the possibility of following up the patients operated on by MII-pH helps the surgeons to distinguish a surgical failure from gastroduodenal-associated symptoms.

From a clinical practice standpoint, we identified three useful parameters to select patients for antireflux surgery. The first parameter is the presence of an abnormal time of esophageal exposure to pH <4. This data indicates the total exposure of the mucosa of the esophagus to acid, and its importance is known from the standard pH monitoring. MII-pH improves the affordability of this parameters, living the opportunity of detecting and excluding the acidification due to the swallow of acid drinks (i.e., coke, lemonade, and orange juice). The second parameter selected is the total number of reflux episodes detected at MII. This parameter indicates how many times the esophageal mucosa is exposed to refluxate from

the stomach independently from pH. Because PPI therapy is only able to switch reflux from acid to non-acid without modifying the total number of reflux episodes and because the patients with good esophageal clearance are more likely to have negative pH monitoring being more rapid to clean their esophagus, we believe that to find an abnormal number of reflux episodes in nonresponder patients is an indicator for antireflux surgery (Mainie et al, 2006a). This is consistent with our positive outcomes in the group of patients with negative pH monitoring and a positive total number of reflux episodes at MII (pH-MII+) and the fact that Nissen fundoplication protects against both acid and nonacid reflux (G. del Genio et al., 2008). The last parameter, the Symptom index correlation, helps to identify those patients suffering from a specific symptom. In the case of a repeated disabling symptom correlated to reflux, a patient may be offered the opportunity of surgery knowing the chance of solving it, as demonstrated by our positive clinical outcomes in the pH-MII- SI+ group. short-term follow-up and to the absence of a control group. Furthermore, to avoid interferences in pH monitoring, we prefer to perform all MII-pH exams after suspension of anti-acid therapy; this is a not widely accepted method. Moreover, because we use MII-pH to select patients for surgery, the type of reflux (acid vs. non-acid) is not crucial. It is more important to have real quantification of GERD.

Current gastroenterologic research investigating GERD is focused primarily on finding effective drugs for patients not responding to proton pump inhibitors. It is likely that a large portion of these patients are affected by transient lower esophageal sphincter relaxation, nonacid reflux episodes, or both. Currently, the most effective treatment for these patients is antireflux surgery. However, although the effects of fundoplication in eliminating acid reflux and preventing occurrences of transient lower esophageal sphincter relaxation had been reported, its role on nonacid reflux blocking had not been clarified.

Our postoperative data clearly demonstrate that the antireflux wrap acts as an effective functional barrier capable of protecting the esophageal mucosa from both the acid and nonacid GER events, and that this reduction was obtained in both the upright and recumbent positions. This complete protective effect is not surprising. Indeed, the Nissen procedure increases the distal esophageal sphincter pressure to a height three times the preoperative levels and restores the esophagogastric junction competence (Nissen, 1956; M. Rossetti & Hell, 1977). There is no reason to suspect that after the procedure for these patients the acid GER disappears (at pH monitoring) whereas the nonacid GER remains unchanged. This is consistent with the recent observation of Mainie and Castell on the potential worth of fundoplication for patients not responsive to a proton pump inhibitor with a MII-pH positive for nonacid GER (Mainie et al., 2006b).

Furthermore, the MII-pH was a well-tolerated procedure in both the pre- and postoperative settings but added more information than the traditional pH monitoring (e.g., nonacid reflux). Therefore, we suggest its routine use for selecting and following up the candidates for antireflux surgery.

If confirmed by more extensive evaluations, the data of this study may have important clinical implications. Because fundoplication can control also the nonacid reflux, the diagnostic role of MII-pH to identify the correct candidates for surgery is crucial. Indeed, a patient unresponsive to proton pump inhibitors with a pathologic number of nonacid reflux or a positive correlation of the symptoms with nonacid type GER events can be sent to

surgery with an objective indication. For this reason, the mean preoperative DeMeester score may appear surprisingly low. Moreover, the data of this study highlight the fact that patients not responsive to medical treatment and with a diagnosis of nonacid GER at MII-pH need to be addressed with an antireflux procedure until new effective drugs become available.

Laparoscopic total fundoplication is currently accepted as the most effective surgical procedure in controlling gastroesophageal reflux disease. However, in the recent past many authors favored the use of a partial wrap especially for patients with defective peristalsis, as the result of a balanced option between the potential risk of postoperative dysphagia and the benefit of reflux control. Later on, partial antireflux procedures reported less favorable outcomes in assuring a good protection from reflux at long-term follow-up (Patti et al., 2004; Scheffer et al., 2004; Heider et al., 2001; Bessel et al., 2000).

Since early 1970s, our group sustained the idea that a correctly fashioned total fundoplication does not increase the risk of postoperative dysphagia. The technique included an extensive transhiatal esophageal mobilization to restore the LES into the abdomen; the preservation of the lesser omentum and short gastric vessels as important mechanisms of preventing the intratoracic migration, *télescopage* or rotation of the wrap; the routine use of intraoperative manometry and endoscopy to control of the function (i.e. calibration, length) and anatomy of the wrap (the passage through, height in respect of the cardias, and the correct geometry around the probe in reverse vision).

This feature in controlling reflux without increasing the dysphagia is because of the elastic feature of the anterior gastric wall (Nissen-Rossetti), which is able to dilate when the bolus passes through the wrap or to increase the pressure for Laplace's law when the gastric fundus is distended, preventing reflux after a meal (Code, 1968). A practical confirmation can be found in achalasic patients after extended myotomy, suggesting that the total fundoplication itself creates an adequate barrier without impairing the bolus also when the peristalsis is absent and a myotomy has abolished the lower esophageal sphincter pressure (G. Rossetti et al., 2005).

This assumption recently reported by postoperative clinical trials has been based only on postoperative clinical observation of patients with or without a defective peristalsis. We offer objective data to demonstrate that a total fundoplication acts as an effective functional barrier able to protect the esophageal mucosa from both the acid and non-acid events, without affecting the esophageal transit. This is possible because the postoperative restoration of the LES pressure preserves the mechanisms of LES relaxation, that is consistent with the postoperative data of unchanged peristaltic efficiency and amplitude above the wrap, and a preserved bolus transit time.

When checked by semi-solid deglutition, the percentage of complete bolus transit increased. This is not surprising; as previously described it is most probably the consequence of a reduced esophagitis after the antireflux procedure that facilitates itself a better functioning of the esophageal body.

This study did not investigate the esophageal function after a partial fundoplication and did not compare the impact of a total vs. partial wrap in impairing the transit of the bolus. However, because the total fundoplication is largely recognized to be superior in controlling

GERD, an unchanged transit progression of the bolus after the total fundoplication, associated to previous observations of good outcomes at long follow up in patients normal, defective, or absent peristalsis, support the choice of adopting the total fundoplication as a unique antireflux technique based on intention to treat choice. Appropriate preoperative investigation and a correct surgical technique are important in securing these results.

5. Conclusions

Laparoscopic total fundoplication achieved good outcomes and long-term patient satisfaction with few complications and side-effects.

Fundoplication controls both acid and nonacid GER as measured using MII-pH.

Appropriate preoperative investigation and a correct surgical technique are important in securing these results.

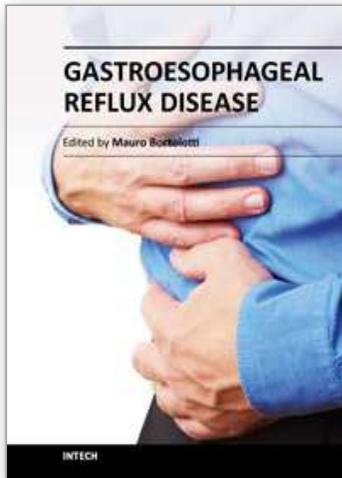
MII-pH provides useful information for an objective selection of patient candidates to antireflux surgery. Nissen fundoplication provides excellent outcomes in patients with positive pH and negative pH and positive MII monitoring or Symptom Index association. More extensive studies are needed to definitively standardize the useful MII-pH parameters to select the patient to antireflux surgery.

Total fundoplication acts as an effective functional barrier able to protect the esophageal mucosa from both the acid and non-acid events, without affecting the esophageal transit

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Gastroesophageal reflux disease affects many patients. This disease not only lowers their quality of life, but it also threatens some of them with an underhand risk of cancer. Additionally, it becomes an economic burden for the patients and society. The aim of this book on gastroesophageal reflux disease is to provide advice and guidance to gastroenterologists to help them understand and manage some aspects of this proteiform disease.

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University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
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InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
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Phone: +86-21-62489820
Fax: +86-21-62489821

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