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Long-term experience of treating 185 patients with gastroesophageal reflux disease (GERD) by anti-reflux surgery respecting the functional–morphological restoration of the esophagus

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Abstract *Background:* According to anatomical investigations the whole esophagus plays a crucial role as reflux barrier in the pathogenesis of gastroesophageal reflux disease (GERD). Morphologically, the spirally arranged muscle fibres present a tension-dependent “stretch closure” and in the event of any reduction of tension, as for example caused by an axial hiatus hernia, the organ may become inefficient. The aim of this study was to evaluate quality of life as the main success criterion after anti-reflux surgery based strictly on the restoration of functional morphology. *Methods:* Between January 1999 and December 2000, 185 patients with GERD were treated by surgery in accordance with functional–morphological principles. After dissecting the mediastinum, the gastroesophageal junction was displaced into the abdomen with consecutive retensioning the esophagus. The esophageal hiatus was reconstructed with non-absorbable single knot sutures and strengthened with alloplastic material. The application of a 180° fundus cuff around the posterior esophageal circumference served as a “spacer” and also restored the angle of *His*. Preoperatively, all patients underwent endoscopy, pH metry and manometry. During postoperative follow-up, recurrence rate and quality of life were evaluated via a disease-specific

scale. *Results:* Preoperatively, 85% of the patients had an elevated DeMeester Score with a median of 81.4; 64% had reflux esophagitis and 37% had reduced lower esophageal sphincter pressure. All 185 operations were performed without conversion in a median operating time of 74 min. In one patient a lesion of the esophagus was treated during the operation; two patients had lesions of the splenic capsule which were also dealt with during the operation. Postoperatively, pleural effusions occurred in 15 patients and puncture was deemed necessary in one subject. Ninety-three percent were followed up for a median of 45 months and the recurrence rate was 2.3%. The quality of life index was 81.6±12.4 points preoperatively, and had significantly improved to 125.2±12.7 points in the follow-up. *Conclusion:* Through the functional–morphological concept of anti-reflux surgery comprising the restoration of the tension-dependent “stretch closure” of the esophagus, significant long-term improvement in quality of life with a low recurrence rate and perioperative morbidity can be achieved.

Keywords Gastroesophageal reflux disease · Quality of life · Stretch closure · Anti-reflux surgery · Long-term results

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Introduction

Numerous mechanisms and various factors have been proposed as possible causes of heartburn. The sensation of heartburn is directly provoked by stimulation of esophageal chemoreceptors by an abnormal gastroesophageal acid reflux, dependent on the pH of the acid from the stomach and the duration of its action [1–3]. Local irritation of the esophageal mucosa by foodstuffs, stretching of the esophagus by large volumes of reflux, a hypersensitive esophagus and functional complaints are of subordinate importance [4–7].

According to most investigators the functioning of the lower esophageal sphincter (LES) plays a crucial part in the pathogenesis of gastroesophageal reflux disease (GERD) (Fig. 1). In present-day diagnostic investigations it is demonstrated by intra-esophageal measurements of pressure and pH [8–10]. However, the morphological principles of the closure mechanism are, for the most part, unknown, have not been

investigated, or have even been ignored. In 1968 and 1978, Stelzner and Lierse [11, 12] demonstrated that the muscle fibres of muscularis propria of the esophagus run in a spiral and are arranged horizontally with respect to the stomach. An increase in the longitudinal tension of the esophagus produces the so-called “stretch closure”. This can open only if, at a given basic tone, the closure segment can further contract and the fibres can shorten still further. The opening of the closure segment is therefore an active process, but can also occur passively. This happens as the result of a decrease in basic tone caused by shortening of the entire esophagus, for example, in a case of axial hiatus hernia. In this case, the “stretch closure” becomes incompetent. Furthermore, there is a physiological reflux of gastric juice into the esophagus even in healthy people [13]. The postprandial distension of the stomach triggers a transient relaxation of the reflux barrier, which allows the physiological expulsion of swallowed air by belching [14].

These morphological investigations of Stelzner have demonstrated that operative therapy for gastroesophageal reflux disease (GERD) must fulfil the following requirements:

- Retensioning (or restretching) of the esophagus
- Lasting maintenance of esophageal tension
- Allowance of physiological reflux

In the present study, Stelzner’s concept of anti-reflux surgery in terms of the morphological requirements mentioned above was proven for symptomatic patients. The therapeutic goal, namely freedom from long-term symptoms of GERD, especially heartburn, was determined during follow-up by measuring the gastrointestinal quality of life index (GQLI) proposed by Eypasch et al. [15] in a mean follow-up of 4 years.

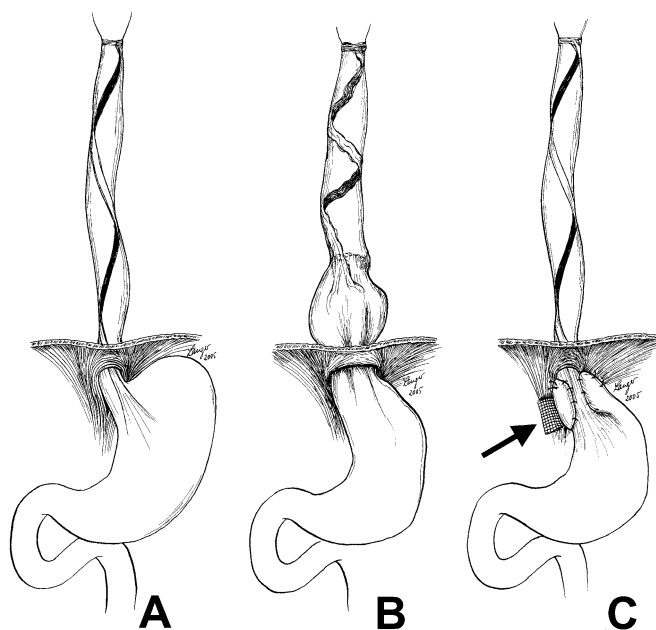


Fig. 1 Suggested pathogenesis of GERD (according to Stelzner [11, 12, 17]). The muscle fibres of the tunica muscularis propria of the esophagus run spirally and are arranged horizontally with respect to the stomach. When the longitudinal tensioning of the esophagus is present (existing), the so-called “stretch closure” results (a). The esophagus can open only if, at a given basic tone, the occluded segment can further contract and the fibres can shorten still more. Any shortening of the esophagus, as may occur in a case of axial hiatus hernia, will lead to diminution of basic tone and with it the active contractile force with consequent incompetence of stretch closure (b). The functional-morphological concept of anti-reflux surgery includes the restoration of this “stretch closure” by retensioning the entire esophagus using three layers (c): the hiatoplasty which is strengthened by a polypropylene mesh (arrow), coaption of diaphragmatic crura and the fundus cuff which acts as a “spacer” between the diaphragm and the cardia and fixes the gastroesophageal junction within the abdomen (“junctionpexy”)

Patients and methods

Between January 1999 and December 2000, 221 patients with symptoms of GERD were treated via surgery. Before the operation, all patients underwent esophagogastrosocopy together with diagnostic testing (pH measurement and manometry). All patients had been treated preoperatively with proton pump inhibitors (PPIs) for at least 6 months.

After excluding those patients who declined to participate ($n=7$) and those with serious pathological changes in the area of the gastroesophageal junction (peptic stricture, $n=3$; Barrett $n=26$), there remained 185 patients who were included in the study. Their mean age was 52.7 years (16–79 years). There were 102 women and 83 men. The duration of the patients’ symptoms was on average 10.5 years (0.5–50 years), while the mean duration of medical treatment was 4.1 years (0.5–40 years). Postoperative questioning was carried out with a standardised questionnaire in the fall of 2003, a median of 45 months after the operation (30–56 months). The follow-up rate was 93% (Table 1).

Table 1 Patient data

Parameter	Patients	Control group
Number	185	50
Female	102	25
Male	83	25
Age (years)	52.7 (1,679)	48 (15–77 years)
Duration of symptoms (years)	10.5 (0.5–50)	–
Duration of medical treatment (years)	4.1 (0.5–40)	–
Pathologic LES pressure (<20 and >50 mmHg)	68/185 (36.7%)	–
DeMeester Score >14.25	158/185 (85.4%)	–
Reflux esophagitis	118/185 (63.8%)	–

Preoperative investigations

Sixty-seven (36%) patients with a history of non-erosive reflux disease (NERD) had no demonstrable mucosal lesions in the esophagus at any time, while 118 patients (64%) had signs of esophagitis of differing severity. At endoscopy performed immediately before the operation, inflammatory changes were still seen in 23 patients, although this was due to the influence of PPI medication. After stopping PPI intake for 5 days, pH measurement was performed in all patients, with the mean duration of data recording amounting to 21.4 h (16.5–25 h). The percentage time with pH of below 4 was 17.7% (1.5% to 96.3%). In view of the physiological reflux phases, a value of less than 4.5% is regarded as normal, while values exceeding 4.5% are considered abnormal. The median DeMeester score was 81.4 (6.5–298.9). A value greater than 14.72 was regarded as abnormal. This method failed to demonstrate abnormal reflux in 27 patients. The median resting pressure in the lower esophageal sphincter (LES) was 19.7 mmHg (4–30.2 mmHg), and in these cases pressures of below 20 [10] or over 50 mmHg [30] were defined as abnormal. No case of achalasia, diffuse esophageal spasm or supersqueezer-esophagus was observed, but in a total of 68 patients there was decreased LES pressure and in some cases additionally a non-specific motility disorder-like decrease in esophageal amplitude of less than 30 mmHg or a propagation speed exceeding 20 cm/s. No abnormal parameters of any kind were found in manometry in 117 patients (63%).

Surgical technique

All operations were conducted by a standardised procedure divided into three steps according to the above-named patho-morphological concept (Fig. 2).

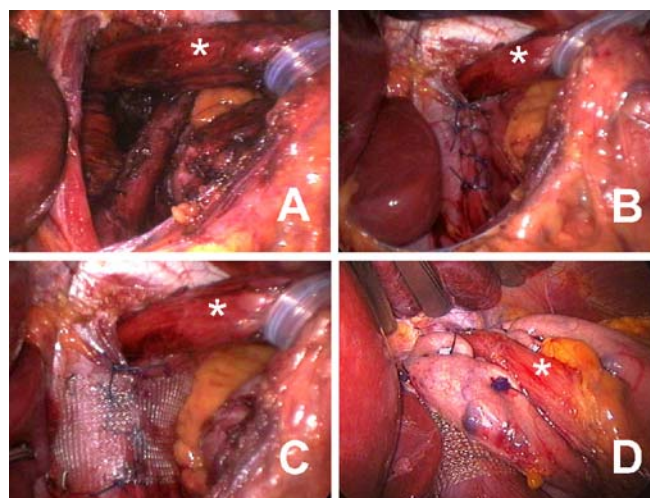


Fig. 2 Essential steps of anti-reflux surgery. Because the esophagus (*) is mobilised over a long distance within the mediastinum (7–10 cm), the gastroesophageal junction can be safely displaced into the abdomen with the aid of a silicone tape, and the esophagus can thereby be retensioned (a). Reconstruction of the gap in the diaphragm dorsal to the esophagus with non-absorbable single knot sutures (b), reinforced by an alloplastic mesh (c) and by the posterior wall of the fundus (d), provides a stable, three-layered cushion (counterfort) for the cuff, which then, acting as a spacer, covers the posterior circumference of the esophagus to an extent of 180° only, and is then fixed on both sides with a short continuous suture to the esophagus ('short floppy Toupet'). In this way, any narrowing of the esophagus by the crura of the diaphragm and by the cuff can be avoided and physiological reflux can be guaranteed

Retensioning of the esophagus

After dividing the lesser omentum in the area of its pars flaccida, the right crus of the diaphragm was exposed. The next step was to reposition the contents of the hernia in front of the aorta, so as to expose the left crus of the diaphragm dorsal to the esophagus, and to follow it ventrally. After ventral dissection of the hernial sac, a silicone tape was passed round the esophagus and the gastroesophageal junction was drawn caudally. In this way, the esophagus could be mobilised under direct vision far into the mediastinum, care being taken to protect the branches of the vagus nerve. The esophagus was dissected free from its mediastinal adhesions around its circumference for a distance of 7–12 cm, so that the gastroesophageal junction was located in the abdomen and the esophagus was kept under tension by traction on the silicone tape.

Permanent maintenance of esophageal tension

To avoid any tendency of the gastroesophageal junction to slide back into the mediastinum and to create an adequate

place for its fixation, a stable dorsal hiatoplasty was performed. This was the essential component of the reconstruction and consists of three layers. First, the two more or less gaping diaphragmatic crura were coated with non-absorbable single knot sutures (Ethibond®, Gauge 0, Ethicon). We took care that the esophagus would not be narrowed by the diaphragmatic crura if traction on the silicone tape was relaxed. The hiatoplasty was then strengthened by a polypropylene mesh (Prolene®, Ethicon) measuring about 3×6 cm, and cut so as to have its cranial margin concave (this prevents any irritation of the esophagus by the mesh). When fixing the net with the hernia stapler (CMS®, Ethicon), care had to be taken that the upper margin of the mesh came to lie below the cranial coaptation suture of the diaphragmatic crura. The third layer consisted of the fundus itself. In order to place it without tension, it was mobilised in the usual fashion by dividing the short gastric vessels. In this way, it could then be placed dorsal to the esophagus onto the hiatoplasty, and is completely covering the polypropylene mesh. To secure it to the left and right of the esophagus in the form of a bilateral fundophrenicopexy, it was fixed to the diaphragm by two single knot sutures. The main purpose of this fixation was to ‘cranialise’ the cuff and thus to prevent any contact between the esophagus and the polypropylene mesh.

Permitting physiological reflux

The distal part of the esophagus and the gastroesophageal junction rested upon the fundus ‘as if on a cushion’. Finally, the distal esophagus was fixed in this site by two short continuous sutures, so that a posterior 180° hemifundoplication is formed and physiological reflux is possible.

Gastrointestinal quality of life index

Gastrointestinal quality of life was determined by standardised questionnaires according to Eypasch [15]. This GQLI consisted of 36 questions regarding symptoms, bodily, mental and emotional well-being, and social relationships, and leads to a score of between 0 and 144 points (Table 2). In all patients the preoperative score was compared with the postoperative score and with the score of the normal population without heartburn (reference group, $n=50$). Differences in quality of life were tested for significance by the Kruskal–Wallis test ($p < 0.05$).

Results

Intra- and postoperative findings

The surgical procedures, 185 in total, were completed without any serious intraoperative or postoperative com-

Table 2 Questionnaire for appraisal of quality of life (modified from [15]), showing mean values for the normal population

Category	Subheadings	Maximum points
1. Symptoms	Abdominal pain	76
	Epigastric sensations of fullness	
	Belching, regurgitation, dysphagia	
	Heartburn	
	Nausea	
	Lack of appetite	
	Diet, restriction of food intake	
	Eating slowly	
	Diarrhoea, tenesmus	
	Constipation	
	Gaseous distension	
	Blood in the stool	
	Uncontrolled defaecation	
	2. Emotions	
Sadness about the disease		
Nervousness, anxiety		
Contentment		
Frustration		
3. Physical factors	Tiredness, feeling unwell	28
	Awaking at night	
	Bodily appearance	
	Strength, stamina, fitness	
4. Social function	Everyday activity, leisure activity	16
	Relations to those close to the patient	
	Sex life	
	Adverse effects of drug treatment	
5. Drug treatment	Adverse effects of drug treatment	4

plications. Intra-abdominal adhesions merely led to some prolongation of operating time, and in two cases an injury to the spleen capsule had to be treated with fibrin glue. In one case an injury to the esophagus was noted during the operation and was oversewn. The median operating time was 74 min (55–157 min). Postoperatively, small pleural effusions were noted in 15 patients, but puncture was necessary in one case only. Six patients developed pneumonia, atelectasis was observed in seven patients, and postoperative lung oedema occurred in two. All these complications were treated conservatively with success.

In the long-term course, 93% were followed up for a median of 45 months. It was necessary to perform an esophago-gastro-duodenoscopy in 12 patients. Three patients had problems due to a diet mistake; in these patients, a food bolus was removed during esophagoscopy. Nine

patients were suspected to have a recurrence of reflux esophagitis and hiatus hernia. In these patients an esophagoscopy and gastrographin swallow was performed with the result of a recurrence in four patients (recurrence rate of 2.3%).

Gastrointestinal quality of life

Preoperatively, all the patients with GERD had a significantly poorer quality of life (81.6 ± 12.4 points) than the normal population (132.9 ± 10.5 points). In particular, the patients had more symptoms in the form of heartburn, sensations of epigastric fullness and abdominal pain (45.3 ± 7 points), and displayed significantly higher emotional lability in the form of sadness, frustration and anxiousness (9.9 ± 2.7 points) than the normal population. The patients also reported significant limitation in their physical activities, affecting, for example, strength, vitality and fitness (14.5 ± 4.5 points), and social activities (10.6 ± 2.7 points) as compared with the normal population (26.3 ± 1.2 points) together with more frequent intake of drugs (Table 3).

At the time of follow-up, the cardinal symptoms of heartburn and acid regurgitation were still reported by 10 patients (Table 4). In four of these patients pH measurements showed objective evidence of renewed abnormal acid reflux and on gastroscopy a gaping cardia, so that laparoscopic re-intervention was indicated (2.3%). The rate of reoccurrence of severe symptoms was 5.8%. Six of these symptomatic patients causally showed a fresh mucosal tear (1), gastritis (3), or a reactive depressive illness with a tendency to somatisation (2). They were treated with proton pump inhibitors, and in some cases a tranquilizer in low doses. A further 21 patients (12.2%) reported that they occasionally took PPIs, usually after dietary indiscretions. Swallowing problems of the nature of dysphagia were a common problem in the early postoperative phase. Many patients also complained of undue flatulence and sensations of fullness in the mid-term. Symptoms were treated by medication. At follow-up more than 3 years postoperatively, these side effects had receded into the background. The operation was successful in significantly improving quality of life (125.2 ± 12.7 points), symptoms (69.1 ± 5.7 points), emotional lability (16.7 ± 3.7 points) and physical (22.8 ± 4.4 points) and social impairment (13.3 ± 2.1 points), where results no longer showed any

Table 4 Initial postoperative symptoms

Symptoms	Preoperative (n=185)	Postoperative (n=172)
Heartburn (every day)	174 (94.1%)	10 (5.8)
Heartburn (occasionally)	5 (2.7%)	21 (12.2)
Regurgitation	153 (82.7%)	1 (0.6)
Retrosternal pain	43 (23.2%)	2 (1.2)
Dysphagia	20 (10.8%)	0 (0)
Chronic cough	31 (15.8%)	3 (1.7)
Hoarseness	17 (9.2%)	5 (2.9)
Flatulence	13 (7.0%)	5 (2.9)
Bloating, sensations of fullness	24 (13.0%)	8 (4.7)

difference between the patients and the normal population (Fig. 3).

Discussion

By means of anatomical investigations, Stelzner and Lierse demonstrated that the reflux barrier is not represented by a well-defined sphincter as known for anorectal continence [11, 12, 16]. It is rather dependent on the longitudinal tension of the muscle fibres, the so-called “angio-muscular stretch-closure”, to such an extent that, at a given basic tone throughout the entire esophagus, it is opened by shortening, e.g. by swallowing and closed in a tensioned condition. The more relaxed the distal esophagus (for example, in a case of axial hiatus hernia), the more incompetent is the muscle spiral, which does indeed possess its own intrinsic tone, but its active contractile power has been largely lost by passive relaxation [17].

Based on these pathophysiological considerations, the functional–morphological concept of anti-reflux surgery must include the restoration of this “stretch closure” by retensioning the entire esophagus. All previously described modifications of the fundus cuff have achieved just such a retensioning of the esophagus. Irrespective of its configuration (180° or 360° cuff), the cuff itself acts as a “spacer” between the diaphragm and the cardia and fixes the gastroesophageal junction within the abdomen (“junction-

Table 3 Quality of life after functional–morphological anti-reflux surgery

Score (points)	Normal	Preoperative score	Postoperative score
Symptoms of disease	70.7±7.9	45.3±7.0 ^{a,b}	69.1±5.7
Emotional status	18.0±3.1	9.9±2.7 ^{a,b}	16.7±3.7
Physical function	26.0±2.4	14.5±4.5 ^{a,b}	22.8±4.4
Social function	14.7±2.2	10.6±2.7 ^{a,b}	13.3±2.1
Outcome of medical treatment	3.5±0.7	1.4±0.5 ^{a,b}	3.4±0.7
Total	132.9±10.5	81.6±12.4 ^{a,b}	125.2±12.7

^a $p < 0.05$ (normal vs preoperative)

^b $p < 0.05$ (preoperative vs. postoperative)

pexy”), thus representing the precondition for a relaxation of the muscle fibres. Improvement of the reflux barrier is therefore explained by the stretching of the muscle fibres in the entire organ rather than by direct conduction of pressure through the fundus cuff or by the influence of the abdominal high-pressure zone.

Traditional measures used to diagnose GERD include pH metry, manometry and endoscopy of the esophagus. In recent years, however, there has been a growing interest in measuring the quality of life for diagnosis and evaluation of the success of either medical or surgical treatment of GERD [24]. In our clinic, pH metry, endoscopy of the esophagus and measurement of quality of life are used for diagnosis and assessment of the outcome of surgical treatment of GERD, whereas manometry is not routinely used. pH metry correlated well with the symptoms of GERD in this study. Preoperatively, 85.4% of all patients showed an increased DeMeester score. In particular, pH metry is a powerful diagnostic tool for patients who are suspected to have functional disorders [4]. However, it should be kept in mind that the sensitivity of pH metry can be restricted in cases of non-compliant patients who have not interrupted their acid-suppressing treatment for at least 1 week before pH metry or in patients with a hypersensitive esophagus [7]. Endoscopy of the esophagus together with a histological examination should be routinely performed in order to exclude patho-morphological findings, e.g. stenosis, bleeding, metaplasia and dysplasia of the esophagus. Patients with these findings were excluded in this study because of the difference in treatment and screening. Among all patients with heartburn as symptom for GERD in this study, only 63.8% showed esophagitis. This poor correlation can be explained by the non-erosive reflux disease (NERD) [22]. Since GERD significantly affects the quality of life of patients, quality of life scales are emerging as an additional important factor in determining the role of surgery in the treatment of GERD and in selecting a treatment option between medical and surgical therapy for these patients. Comparison of generic (e.g. SF-36) and disease-specific quality of life scales (e.g. GERD-HRQL) for GERD suggests that generic instruments are less sensitive in measuring the effects of treatment of GERD [23]. We therefore developed a disease-specific quality of life questionnaire based on the gastrointestinal quality of life score according to Eypasch [15]. This questionnaire could be easily managed in the clinic since it takes less than 10 min to fill out. In this study, all quality of life scales were significantly improved after surgical treatment of GERD, showing no difference when compared with those of the normal population, which indicates that quality of life represents an important endpoint for clinical trials concerning GERD. The importance of lower esophagus sphincter (LES) pressure in the pathogenesis of GERD is at present the subject of controversy [18, 19]. Contrary to the general perception that reduced LES pressure

is responsible for the occurrence of GERD, our results showed that reduced LES pressure was present in only one third of symptomatic patients. Moreover, as has been shown in this and other studies, even patients with normal LES pressure benefit from the improvement in their symptoms after laparoscopic fundoplication [20]; the operation corrects reflux irrespective of the resting LES pressure [21]. We therefore do not use manometry of the esophagus for routine diagnosis of GERD. However, a manometry should be routinely performed in patients who are suspected to have motility disorder of the esophagus, e.g. achalasia, diffuse spasmus of the esophagus or nutcracker esophagus.

Currently, proton pump inhibitors (PPIs) represent the gold standard for treatment of GERD, but as PPIs do not restore the anti-reflux barrier, lifelong medication is required in most cases. Newly developed endoscopic anti-reflux techniques (EAT) have demonstrated potential treatment advantages (e.g. less invasiveness, shorter hospital stay) but failed to show long-term effectiveness, durability, and safety in the treatment of GERD since they do not restore the function and morphology of the esophageal reflux barrier [33, 34]. Therefore, laparoscopic fundoplication can be considered as an attractive alternative to PPIs and EATs, especially in young and fit patients [25, 26]. Nissen fundoplication using a “floppy” 360° wrap is favored by most surgeons around the world, probably because it is easy to perform. The Toupet procedure, a partial posterior 270° wrap, was more recently reported to be as effective as the 360° Nissen procedure but associated with fewer postoperative problems [27–31]. The anatomical investigations of Stelzner and Lierse demonstrated why it is possible to control the gastroesophageal reflux by a fundoplication when the following requirements are fulfilled. The esophagus should be adequately retensioned by mobilizing it in the lower mediastinum and displacing the gastroesophageal junction safely into the abdomen with the aid of a silicone sling. By locating the gastroesophageal junction into the abdomen and performing a fundophrenicopepy, a restoration of the angle of His is also possible. In this context, a Collis gastropasty is not necessary, and any such measure would not be in accordance with the principle of the operation [32]. Reconstruction of the hiatus in the diaphragm dorsal to the esophagus, strengthened by alloplastic material and the posterior wall of the fundus, produces a stable, three-layered bed—a “counterfort” for the cuff, which then functions as a “spacer”, covering only 180° of the posterior circumference of the esophagus (“short floppy Toupet”). Through this technique, any narrowing caused by the crura of the diaphragm and by the cuff can be avoided, so that physiological reflux can be guaranteed after a short adaptation phase. The concept of strengthening the hiatoplasty by a PP mesh originated from our excellent experience with PP meshes in laparoscopic inguinal hernia surgery. In this study no mesh-associated complications, e.g. migration, esophagus perforation, etc. occurred.

In summary, based on anatomical investigations of the pathogenesis of GERD, a causal treatment can only be achieved by anti-reflux surgery that considers the functional morphology of the tension-dependent “stretch-closure” of the esophagus, whereas PPIs and the newly developed EATs represent only symptomatic therapeutic approaches. Due to

the excellent long-term results comprising a significant improvement in quality of life and low recurrence rates, the functional–morphological concept of anti-reflux surgery should be considered as an attractive alternative option, especially in young and fit patients.

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