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Short esophagus: how much length can we get?

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Abstract
Introduction Laparoscopic antireflux surgery requires an adequate length of intra-abdominal esophagus. Short esophagus can cause wrap herniation and poor clinical outcomes. The aim of the study is to measure maximum length of esophageal elongation with transhiatal mediastinal dissection.
Methods This is a review of a prospective database created in the tertiary referral center between 2003 and 2006. One hundred and six patients with gastroesophageal reflux disease and suspected short esophagus on barium swallow were studied. Patients underwent antireflux surgery with extended transhiatal mediastinal dissection to elongate short esophagus. Routine measurement of intra-abdominal esophageal segment length with intraoperative esophagogastroscopy and laparoscopy was utilized to define the gastroesophageal junction (GEJ) in order to quantify total intra-abdominal esophageal length. Postoperative 24-h pH manometry, UGI series, and symptom scores were recorded to document the clinical outcomes. The aim of the dissection was to mobilize $\geq$3 cm of intra-abdominal esophagus.
Results Total esophageal elongation was achieved with a mean of 2.65 (range 2–18) cm. Resultant intra-abdominal esophageal length was measured with a mean of 3.15 (range of 3 to 5) cm. None of the preoperative "short esophagus" required Collis' gastroplasty post extended mediastinal dissection. All preoperative symptom scores showed significant improvements with mean follow-up of 18 (9–36) months. Mean distal esophageal acid exposure normalized in all patients studied postoperatively.
Conclusion Short esophagus can be safely elongated with extended mediastinal esophageal dissection. This technique can obviate the need for Collis' gastroplasty and improve overall outcome after antireflux surgery. We recommend that extended transhiatal mediastinal dissection be performed to establish 3 cm of intra-abdominal esophagus at the time of antireflux procedures.

Keywords Short esophagus · GERD · Nissen fundoplication

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A shortened esophagus is defined as the inability to reduce the gastroesophageal junction (GEJ) below the diaphragm. It is surmised by some that a shortened esophagus is the result of long-standing, severe, gastroesophageal reflux disease (GERD), resulting in transmural inflammation and contractions in some patients [1]. Some have suggested that the inability to reduce the GE junction into the abdomen is a result of minimal esophageal mobilization [2].

A critical component of any antireflux procedure is the reduction of the GEJ below the diaphragm without tension. If this is not achieved, it will invariably result in recurrent reflux. Although this is easily accomplished in most patients, and those with a shortened esophagus, it can be challenging. A fundoplication created around an intrinsically shortened esophagus will invariably result in intrathoracic migration or disruption of the fundoplication and the possibility of misplacing the wrap around the stomach rather than the esophagus. Inability to gain adequate intra-abdominal esophagus mandates an esophageal lengthening procedure [3, 4]. Multiple alterations have been proposed to address this issue, the most prominent

being Collis' gastroplasty [5]. In addition, a short esophagus has been addressed by a transthoracic fundoplication secondary to the ideal exposure provided by entering the chest [6, 7]. With the administration of laparoscopic antireflux surgery and its refinement, transhiatal mediastinal esophageal mobilization is now possible [1, 3, 8, 9]. This has raised the questions of the amount of excess intra-abdominal esophagus that can be gained in using this technique and if gastroplasty is necessary.

In this study, all patients underwent routine extended transhiatal mediastinal dissection with the goal of establishing 3 cm of intra-abdominal esophagus prior to performing a fundoplication in order to quantify the amount of intra-abdominal length that could be gained by such a technique.

Methods

Patients

All patients undergoing laparoscopic antireflux procedure and paraesophageal hernia repair between 2003 and 2006 were evaluated. A total of 106 patients were entered into the study. A prospective database (IRB #042-05) was maintained, consisting of pre- and postoperative symptom scores, esophageal pH and manometry studies, and intraoperative measurements data.

Preoperative evaluation

All subjects underwent preoperative barium upper gastrointestinal radiological studies in order to delineate their esophageal anatomy and to screen for evidence of hiatal herniation. In addition, a postoperative barium swallow was performed if recurrent reflux or dysphagia was reported in follow-up.

Routine preoperative esophageal gastroduodenoscopy (EGD) was completed on all patients to screen for sequelae of GERD. Ambulatory 24-h esophageal pH measurements were obtained on all subjects preoperatively. Patients were asked to repeat this study at their 6-month follow-up visit. This evaluation was performed while off all prokinetic and gastrointestinal antisecretory agents. The data was obtained by a dual-probe catheter placed transnasally with a distal probe located 5 cm proximal to the upper border of the distal high-pressure zone. The proximal probe was 10 cm above the distal probe. A portable digital data logger (Synetics Medical, Shoreview, MN) was used to record pH fluctuations while the patient recorded symptoms in an event diary.

Ambulatory esophageal manometry was performed using a water-perfused capillary system with an eight-port, radial manometry catheter. Patients were examined in the supine position. The catheters were perfused with distilled water at a constant rate of 0.06 ml/s (Medtronic, Shoreview, MN). The lower esophageal sphincter (LES) was measured using a station pull-through technique, averaging the pressure from four radially placed channels over three to five respiratory cycles. With a linear arrangement of four channels the esophageal body was evaluated with ten wet swallows of 5 ml water.

Symptoms of regurgitation, chest pain/discomfort, dysphagia, heartburn, and hoarseness were scored by all subjects preoperatively in the following manner: 0 = never, 1 = once a month, 2 = once a week, 3 = once a day, or 4 = several times a day [10]. Any reported frequency that fell between two parameters was assigned to the subsequent higher category. Symptoms scores were repeated 6 months after surgery for comparison with preoperative values.

Surgical procedure

Patients were placed in the supine position with both arms tucked. Four ports, plus a liver retractor through the epigastria, were introduced. The standard left crus approach was used to expose the hiatus and esophagus. Subsequent intraoperative upper endoscopy (IEGD) was performed and the squamo-columnal junction (SCJ) location measured from the incisors. In addition, a single stitch was placed laparoscopically to mark the exact location of the GE junction from the laparoscopic view point for later identification. Extended transhiatal mediastinal dissection (ETMD) was undertaken until the previously placed suture was at least 3 cm below the hiatus. We used a standard technique described previously [9]. We performed mediastinal dissection with the help of both blunt and sharp dissection under 30° camera control. In order to have an adequate work space we placed our ports high and used extra-long instruments. We used both ultrasonic sheers and a cautery hook. We stayed on the esophagus and carefully dissected in the mediastinal plane without violating the pleura which kept us out of the v. azygos. Posterior, anterior, and lateral attachments were divided, with careful preservation of the two main branches of the intrathoracic vagus trunks. We did not have to resect the vagus nerve as we found that, by mobilizing the esophagus in the mediastinum, we had adequate length. The vagus could be left on the esophagus but dissected free from some of the mediastinal adhesions. The endpoint was to achieve adequate mobilization in order to have 3 cm of intra-abdominal esophagus.

Intraoperative measurements

We conducted measurements during the procedure in order to quantify the additional length gained following the

mediastinal dissection. The first measurement of the intra-abdominal esophagus was done immediately after hiatal opening and a second measurement was done after dissection was completed. We used a small ruler placed intra-abdominally while axial instrumental traction to the esophagus was released completely to have an esophageal segment measured without tension. Endoscopic measurement of the distance between the incisors and the SCJ was performed twice: before and after the dissection. Finally, a fifth measurement to define the extent of mediastinal dissection was done. It was measured from the hiatus to the most cephalad extent of our dissection by using the same intra-abdominal ruler. Upon completion of final measurements an appropriate intervention such as Nissen fundoplication was completed in a standard fashion [10, 11, 12, 13].

Statistical analysis

Statistical analysis was performed via the SPSS 13.0 student version statistic program. The paired *t*-test was utilized to compare pre- and postoperative independent continuous values, and a Mann–Whitney *U*-test was used for nonparametric data. Statistical significant was deemed present if the *p*-value was less than 0.05.

Results

The median follow-up was 18 months (ranged 9–36 months). No patient withdrew from the study during follow-up. There were 59 men and 47 women with symptomatic GERD included into the study; see Table 1 for the demographics. Preoperative symptoms prevalence and manometry studies results are shown in Tables 2 and 3, respectively.

A total of 106 patients underwent esophageal lengthening. The mean intra-abdominal esophageal segment length obtained was 3.15 cm. No short esophagus was encountered after the dissection. The results of measurements performed with intraoperative EGD confirmed appropriate esophageal elongation. Initial median esophageal length was 38 cm (range 35–41 cm). After ETMD was completed we had a median of 41 cm of esophageal length (range 39–43 cm). This gave an overall mean of 2.65 cm of additional esophageal length as measured from the incisors to the SCJ (Table 3). There was no significant difference between laparoscopic and endoscopic data ($p = 0.08$). Most patients in this series ($n = 47$) had a large (>5 cm) hiatal hernia that required an extensive mediastinal esophageal mobilization. The extent of the dissection was anywhere from 18 to 3 cm (mean 7.0 cm) transhiatally (Table 3).

All patients had abnormal preoperative pH study results. Postoperatively, the median percentage time with pH < 4 and the median DeMeester score were significantly decreased. Median distal acid exposure improved from 22.76% to 1.43% ($p < 0.001$) (Table 4).

Postoperatively, all 106 patients have demonstrated improvement of symptom scores in comparison with their preoperative records ($p < 0.001$), as shown in Fig. 1.

Median operating time was 102 (58–182) min. There were no conversions to an open procedure. There were no major intraoperative or postoperative complications. Minor postoperative complications developed in 19 (18%) patients. Of those, postoperative atelectases were seen in seven patients and ten patients had urinary retention; two patients suffered a postoperative ileus that lasted 2–3 days and resolved spontaneously.

Table 1 Patient demographics

Age (years)	52.3 (33–75)
Sex ratio (male/female)	59/47
Weight (kg)	80.8 (43.0–110.0)
Height (cm)	174 (158–182)
Duration of symptoms (months)	59 (9–307)

Table 2 Preoperative manometry findings ($n = 106$)

LES pressure (mmHg)	12.1 (7.3–21.6)
LES length (cm)	2.4 (1.8–3.1)
LES relaxation (%)	95.5 (82–98.7)
LES residual relaxation (mmHg)	2.6 (1.2–7.8)
Peristalsis (%)	88 (60–100)
Mean esophageal amplitude (mmHg)	91 (67–135)

LES, lower esophageal sphincter

Table 3 Total esophageal elongation

Extension of transhiatal dissection (THD) (cm)	Number of patients	Total esophageal elongation (mean TEE) (cm)
3.0	12	1.2
4.0	21	1.3
5.0	17	1.6
6.0	10	2.0
7.0	12	2.2
8.0	8	2.2
9.0	7	2.3
10.0	4	2.7
11.0	6	2.8
12.0	3	3.3
13.0	2	3.5
14.0	2	3.5
15.0	1	4.0
18.0	1	5.0
Total	106	2.65

Table 4 pH study results

Distal esophageal probe	Preoperative ($n = 106$)	Postoperative ($n = 56$)
Upright time with pH < 4 (%)	24.81 (0.5–90.8)	1.68 (0.0–4.5)*
Supine time with pH < 4 (%)	18.31 (0.0–89.9)	1.1 (0.0–1.6)*
Total time with pH < 4 (%)	22.76 (4.4–99.8)	1.43 (0.0–3.8)*
DeMeester score	67.76 (30.2–204.0)	5.03 (0.3–12.4)*

* Significant improvement between pre- and postoperative scores ($p < 0.001$)

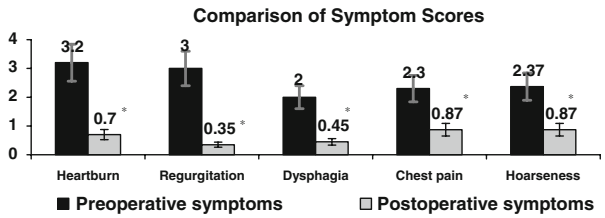

Fig. 1 Pre and postoperative symptoms are shown in this graph. Note all the symptoms improved after antireflux surgery. * ($p < 0.05$).

Fourteen patients (13.2%) experienced postoperative dysphagia. Postoperative barium swallowing studies revealed moderately prolonged esophageal transit time with narrowing at the GEJ in seven (6.6%) patients who subsequently underwent esophageal dilation with good results. The remaining seven patients had mild postoperative dysphagia. Two of them reported new onset of dysphagia with a severity score of 1 (on a 1–4 scale). The other five had transient worsening of dysphagia from a score of 2 to 3 postoperatively. Four patients continued experiencing chest pain with the same scores as preoperatively. Barium swallowing studies revealed no deformities or recurrences and esophageal transit time was normal in all symptomatic patients with mild dysphagia and chest pain. They were followed conservatively on soft/liquid diet until their symptoms resolved within 2 months.

Discussion

Esophageal shortening is a recognized phenomenon related to severe, untreated GERD [14, 15]. It is hypothesized that excessive distal esophageal acid exposure results in transmural inflammation, leading to axial contraction and scarring of the esophagus [3]. Although the true incidence of this entity is unknown, there is little doubt that it exists. To effectively alleviate reflux surgically the GE junction must be reduced below the hiatus without tension. This is a monumental task in those with a shortened esophagus. Multiple operative alterations have been employed to address this problem, the most popular being Collis gastroplasty [3, 6, 8, 14–16]. Extended transmediastinal dissection for short esophagus has been shown to be an effective alternative to gastroplasty [9]. This series quantitates the amount of intra-abdominal esophagus that can be gained via extended mediastinal esophageal dissection, which we believe to be to be superior to Collis in dealing with a shortened esophagus. We used blunt and sharp technique for transhiatal dissection to achieve maximal esophageal mobilization. The final endpoint of the mediastinal dissection depended upon how much dissection had to be performed in order to obtain adequate intra-abdominal esophagus. As a result, there was no relationship between the length of mediastinal dissection and intra-abdominal esophagus since mediastinal dissection was guided by the endpoint of 3 cm intra-abdominal esophagus. Because most patients had a hiatal hernia and therefore inadequate intra-abdominal esophagus, we had to perform esophageal lengthening. On average, we could get up to 3 cm of intra-abdominal esophagus with mediastinal dissection. However in some patients with a 5-cm hiatal defect and a GEJ 2 cm above the hiatus that meant that we elongated the esophagus by a total of as much as 5-cm. Once that was done, a standard Nissen fundoplication was performed with a 1.5-cm Nissen floppy wrap immediately above the GE junction, which was ensured by intraoperative EGD. We include herein the actual endoscopic measurements performed both pre- and postoperatively, showing that the esophagus was truly elongated with this procedure.

Several authors have documented good subjective results with Collis gastroplasty and fundoplication, however postoperative pH testing in these studies revealed that 30–50% of those patients continued to have abnormally high distal esophageal acid exposure [3, 14]. The authors postulated that this is a result of active parietal cell mucosa in the neoesophagus and amotility of the newly constructed segment with a rigid line of staples, which in combination with a fundoplication creates a high outflow resistance leading to slowed distal esophageal acid clearance. This theory was supported by Jobe et al. when all distal neoesphageal biopsies post gastroplasty revealed oxyntic-acid-producing mucosa proximal to the fundoplication [3]. In our series all patients with pH studies in follow-up had normal DeMeester score, and there was no radiologic evidence of wrap migration or hiatal hernia recurrence. We encountered no truly short esophagus after ETMD. Obviously, this eliminates the possibility of having acid-producing cells proximal to the wrap and stasis in a gastroplasty neoesophagus reducing distal esophageal acid exposure. In addition, it effectively alleviates undue tension on the GE junction, reducing the risk of wrap migration or hiatal hernia recurrence. We perform laparoscopic transhiatal esophagectomies and have a fairly large experience with esophageal mobilization. With a large 10-cm hiatal hernia, obtaining an additional 8 cm of

esophagus dissected is not impossible. Our technique is to place our ports high, use extra-long instruments, stay on the esophagus and carefully dissect in the mediastinal plane without violating the pleura, which keeps us out of the v. azygos. We do not resect the vagus nerve as we find that, by mobilizing the esophagus in the mediastinum, we have adequate length. Of note, in open fundoplication it is often difficult to stay right on the esophagus and therefore helpful to transect the vagus nerves to obtain extra esophageal length. By using the laparoscopic transhiatal approach the vagus can be left on the esophagus but dissected free from some of the mediastinal adhesions.

This technique can be utilized in patients with normal esophagus. It merely needs to be tailored to the length already available, because it is likely that any patient with hiatal hernia will require some degree of hiatal dissection. We performed this mediastinal dissection in all-comers who required a Nissen fundoplication. Clearly, when the esophagus is shortened there is a benefit to this procedure. This has been reported in the past but no-one has actually quantified how much dissection was needed in order to get adequate esophagus and how much could be performed.

The 5.5% occurrence of postoperative dysphagia requiring dilatation encountered in this study is comparable to that in other published series for Nissen fundoplication [15–18]. Postoperative dysphagia following Collis gastroplasty and fundoplication may be more common. Some authors encountered about 15% overall dysphagia rate following gastroplasty and fundoplication [3, 16]. This may be attributed to a relatively amotile gastric tube proximal to the distal high-pressure zone created by the wrap around the stomach.

The surgical management of gastroesophageal reflux disease in the setting of a shortened esophagus continuous to be a challenge. The multiple antiphysiologic features of a Collis gastroplasty make it a subideal procedure. We recommend that a laparoscopic transhiatal mediastinal dissection be carried out as far cephalad as possible in order to achieve adequate intra-abdominal esophagus. We were able to dissect up to 18 cm (mean 7 cm) in the mediastinum and reduce the GE junction at least 2–3 cm below the hiatus in all of our cases, obviating the need for a Collis. If this dissection fails to provide acceptable, tension-free intra-abdominal esophagus, alternatives, including but not limited to Collis gastroplasty, can then be considered.

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