OBJECTIVE ASSESSMENT OF GASTROESOPHAGEAL REFLUX AFTER SHORT ESOPHAGOMYOTOMY FOR ACHALASIA WITH THE USE OF MANOMETRY AND pH MONITORING

The role of an antireflux procedure as an adjunct to esophagomyotomy for achalasia remains a subject of controversy. Little objective documentation exists of this operation's effect on sphincteric competence and the degree of postoperative gastroesophageal reflux. This report of esophageal manometry and 24-hour pH monitoring on 14 patients with esophageal achalasia whom we had previously treated by a short esophagomyotomy without an antireflux procedure provides such documentation. Esophagomyotomy reduced lower esophageal sphincter pressure by 12% to 71% (mean 41%) from a preoperative mean of 26.7 mm Hg to a postoperative mean of 14.6 mm Hg. The number of postoperative episodes of acid reflux per patient in 24 hours was fewer than 29 (normal <49) in 13 patients, with a median of 12 episodes for the entire group. Esophageal acid exposure, measured as percentage of total time with pH less than 4.0 (normal <4.5%), was below 4.5% in 10 patients, six of whom had values less than 1%. Among the four patients with values greater than 4.5%, only one had a temporal correlation of symptoms with an episode of acid reflux. Multivariate analysis showed that esophageal acid exposure time correlated only with the level of residual lower esophageal sphincter pressure during the relaxation phase of deglutition. A pressure less than 8 mm Hg was predictive of normal acid contact time ($p < 0.001$). Mean lower esophageal sphincter pressure, percent reduction in lower esophageal sphincter amplitude, postoperative vector volume, and length of the lower esophageal sphincter did not significantly correlate with amount of esophageal acid exposure. We conclude that a short esophagomyotomy without an antireflux procedure results in a competent lower esophageal sphincter in most patients. Increased esophageal acid exposure, when it occurs, is due to slow clearance of esophageal acid from relatively few reflux episodes and is more likely to occur when there is a high residual pressure during deglutition after myotomy. These findings suggest that the addition of an antireflux procedure to a short esophagomyotomy would not be expected to improve clinical results. (*J THORAC CARDIOVASC SURG* 1996;111:107-13)

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The modified Heller myotomy has been used successfully for decades to palliate the symptoms of achalasia. Some surgeons, concerned with reports of the prevalence of gastroesophageal reflux after esophagomyotomy, have recommended the addition of an antireflux procedure to the operation to prevent acid reflux through the surgically weakened lower esophageal sphincter (LES). Whether an antireflux procedure is a useful adjunct to esophagomyotomy remains a subject of controversy. Although clinical reports show the incidence of severe gastroesophageal reflux after short esophagomyo-

Table I. Symptoms

Pt. No.	Age (yr)	Preop. duration of symptoms (mo)	Results of operation	Postop. symptom	Duration of follow-up (mo)
1	55	18	Excellent	None	25
2	81	24	Excellent	None	25
3	67	72	Good	None	43
4	38	4	Fair	Dysphagia, heartburn	13
5	33	6	Fair	Heartburn	125
6	54	24	Good	None	16
7	42	240	Good	Heartburn	223
8	25	6	Excellent	None	4
9	58	12	Excellent	Heartburn	59
10	67	60	Excellent	Heartburn	259
11	36	18	Fair	Heartburn	72
12	35	36	Excellent	Chest pain	19
13	41	12	Excellent	None	5
14	59	24	Excellent	None	4

tomy to be as low as 4%,¹ little objective information exists regarding the degree of gastroesophageal reflux after esophagomyotomy. This study was undertaken to objectively assess the effect of esophagomyotomy on the LES as a barrier to acid reflux.

Patients and methods

Patients. From November 1990 to October 1994, 14 patients with esophageal achalasia who had previously undergone a short primary esophagomyotomy without an antireflux procedure by us at the Duluth Clinic, the Lahey Clinic, and the Deaconess Hospital were evaluated with esophageal manometry and 24-hour pH monitoring. The diagnosis of achalasia was established clinically, radiographically, and with esophageal manometry in all patients. Eight were female and six were male, their ages ranging from 25 to 81 years (median 41 years). Six of the patients had undergone forceful dilation of the LES before the operation. The operation of esophagomyotomy without an antireflux procedure was performed on all patients and the details of the technique have been previously published by us.^{2,3} In brief, it is performed through a left thoracotomy with limited mobilization of the distal esophagus. A 5 to 7 cm esophagomyotomy is performed, extending caudally 3 to 9 mm onto the gastric wall. The transition from esophageal to gastric submucosa is marked by prominent transverse veins on the gastric side. One patient in this study underwent a proximal extension of the myotomy to a total length of 13 cm. One other patient had excision of an epiphrenic diverticulum at the time of esophagomyotomy. Patients had been operated on from 10 days to 18 years before postoperative manometry and pH testing (median 8 months). Seven of the patients underwent pH monitoring because of symptoms suggesting acid reflux, usually chest pain. Those who described their symptom as "heartburn" or substernal burning are listed in Table I as having heartburn. Those

whose symptom was more vaguely defined as chest discomfort are listed as having chest pain. The remaining seven had no symptoms of heartburn or chest pain and underwent pH testing to evaluate the competence of the LES.

Manometry and pH monitoring. Postoperative esophageal manometry was performed in all patients by means of a water-perfused system (Arndorfer Specialties Inc., Milwaukee, Wis.) and an 8-lumen manometry catheter, the four distal ports placed 1.0 cm apart and at 90-degree radial intervals (Mui Scientific, Toronto, Ontario, Canada). Analyses were performed with manometric software (Gastrosoft Polygram, Synectics Medical, Stockholm, Sweden). The LES was evaluated with both a rapid pull-through technique and a station pullback method in 0.5 cm increments, with several swallows at each station. In two patients, it was impossible to pass the recording catheter across the LES before the operation. Relaxation of the LES was recorded as the highest amplitude of the pressure nadir during several swallows at each station. This value was the mean of pressures recorded in all four distal ports and was related to a gastric baseline pressure. Normal resting LES pressure was 15 to 40 mm Hg.

All patients underwent 24-hour pH monitoring after esophageal motility studies, with the use of a pH electrode and recording device (Digitrapper, Synectics Medical, Stockholm, Sweden) positioned 5 cm above the manometrically identified LES. Chest pain, heartburn, regurgitation, and other symptoms were identified by the patient electronically during the recording period. All medications affecting gastric acidity and esophageal motility were terminated at least 3 days before the study. An acid reflux event was defined as a drop in esophageal pH below 4.0. Normal values for reflux frequency and duration were those established by Jamieson and colleagues.⁴

Data analysis. Factors significantly affecting esophageal acid exposure time were identified by logistic regression in a multivariate analysis. The significance of differences between mean values was calculated by Student's *t* test.

Results

Clinical results. Table I lists the clinical data of the 14 patients, the postoperative results, and also the symptom, if any, that prompted 24-hour pH monitoring. Clinical results were categorized as *excellent* if the patient was free of symptoms and ate an unrestricted diet; *good* if the patient had occasional dysphagia when eating hurriedly or while under stress; *fair* if the patient was in improved condition after the operation but had persistent symptoms of dysphagia or was troubled by heartburn that required medical therapy; and *poor* if the patient's symptoms were unrelieved by the operation, if severe heartburn developed that was unrelieved by usual medical means, or if a problem developed necessitating reoperation. If a patient's postoperative symptom of heartburn or chest pain

Fig. 1. Preoperative and postoperative LES lengths, both total and intraabdominal, are shown.

Table II. Results of manometric evaluation

Pt. No.	Preop. LES				Postop. LES			
	Amplitude (mm Hg)	Residual pressure (mm Hg)	Total length (cm)	Intraabdominal length (cm)	Amplitude (mm Hg)	Residual pressure (mm Hg)	Total length (cm)	Intraabdominal length (cm)
1	19.0	15	1.9	1.0	15.2	0	2.0	1.0
2	22.5	15-18	3.2	1.0	10.8	3	1.6	1.5
3	31.9	20	2.0	0.5	13.9	8	1.4	1.0
4	20.6	10-14	3.0	1.0	15.6	0	1.5	1.0
5	19	Incomplete			15	Incomplete		
6	25.5	10	2.9	0.8	16.9	0	1.4	0.5
7					11.2	1	1.5	1.0
8	30	8	1.8	0.8	15	5	1.3	0.8
9	21				10	0	1.5	1.2
10	38.6				20.6	12	1.8	1.2
11					18	9	1.0	0.8
12	20		4.0	1.5	16	9	1.5	1.0
13	34	8	2.2	0.7	10.8	0	1.2	0.6
14	18.8				14.4	0	1.2	1.0

proved on pH testing to be unrelated to acid reflux, it was discounted as a factor in determining the clinical result.

Manometry. The results of manometric evaluation of the LES after the operation are shown in Table II. The amplitude of the LES was reduced an average of 41% by esophagomyotomy (range 12% to 71%), from a preoperative mean of 26.7 mm Hg to a postoperative mean of 14.6 mm Hg. The length of the distal high-pressure zone was reduced by an average of 42% from a preoperative mean of 2.6 cm to a postoperative mean of 1.5 cm. As would be expected, virtually all of this reduction occurred in the intrathoracic portion of the sphincter, with the

intraabdominal segment of the LES remaining about 1 cm in length (Fig. 1). The degree of LES relaxation was recorded as the mean residual pressure in the LES during deglutition and ranged from 0 to 12 mm Hg.

Manometric studies in all patients demonstrated low-amplitude, simultaneous contractions in the body of the esophagus during deglutition. Mean amplitudes ranged from 10 to 44 mm Hg (mean 25 mm Hg).

pH monitoring. The results of 24-hour pH monitoring are shown in Table III. Duration of testing in the 14 patients ranged from 21 to 24 hours (mean 22.8 hours). The number of reflux episodes was less

Table III. Results of pH monitoring

Pt. No.	Postop. pH monitoring			
	No. of episodes pH <4.0	Percent time pH <4.0		
		Total	Upright	Supine
1	28	0.1	0.1	0
2	0	0.0	0.0	0.0
3	20	11.6	18.0	0.0
4	9	0.3	0.3	0.2
5	72	26.0	11.0	37.5
6	11	4.3	6.5	1.0
7	2	0.8	1.1	0.0
8	4	0.6	1.2	0.1
9	15	2.0	4.1	0.0
10	12	3.5	5.7	0.0
11	22	17.5	17.3	17.7
12	17	7.3	3.9	12.4
13	4	0.3	0.4	0.0
14	13	1.2	1.9	0.0

than 29 in 13 of the patients (normal less than 49) (Fig. 2). Esophageal acid contact time was considered normal if the pH remained less than 4.0 for less than 4.5% of the duration of the study. Acid contact time was normal in ten patients and abnormal in four patients (Fig. 3). Of the four with abnormal acid contact time, only patient 5 had correlation of chest pain with a recorded acid reflux event. Even though the total time with pH less than 4.0 was 26%, he had no endoscopic evidence of esophagitis. Only one patient with normal acid contact time complained of significant dysphagia. His postoperative LES pressure was 15.6 mm Hg with a negligible residual pressure, and a barium esophagogram showed no evidence of obstruction.

Multivariate analysis was performed to determine what factors correlated with abnormal esophageal acid contact time. Preoperative and postoperative mean LES amplitude, degree of reduction of LES pressure, postoperative LES length (both total and intraabdominal), amplitude of esophageal body contractions, and LES vector volume and radial asymmetry were not significantly correlated with the degree of esophageal acid exposure. Only the residual pressure of the LES during deglutition showed a correlation, a residual LES pressure of 8 mm Hg or greater being highly correlated with abnormal acid contact time in the esophagus ($p < 0.001$). The mean residual LES pressure of those patients in whom pH was less than 4.0 for less than 4.5% of the study period was 2.1 mm Hg, compared with a residual pressure of 8.7 mm Hg for those in whom pH was less than 4.0 for more than 4.5% of the study

period ($p < 0.0001$). When those with a residual pressure of less than 8 mm Hg were compared with those with a pressure of 8 mm Hg or more, the percent total time during which the pH remained less than 4.0 was 1.0% and 9.9%, respectively, a highly significant difference ($p < 0.001$).

Discussion

The modified Heller esophagomyotomy without an antireflux procedure has been criticized for being too difficult to properly calibrate, too short a myotomy leading to residual dysphagia and too long a myotomy excessively weakening the sphincter and leading to gastroesophageal reflux. This criticism has prompted some surgeons to recommend the routine use of an antireflux procedure in conjunction with esophagomyotomy. Our results, however, show that a short esophagomyotomy usually results in a competent LES with good relief of dysphagia, a conclusion reached by Thomson,⁵ Shoenut,⁶ and their colleagues in two smaller studies. A myotomy of sufficient length to adequately relieve dysphagia does not commonly result in frequent episodes of gastroesophageal reflux. Abnormal esophageal acid exposure, when present, is usually asymptomatic and is due not to an over-zealous myotomy and excessive disabling of the sphincter, but rather to a high residual deglutition pressure in the LES caused by incomplete relaxation and resultant poor esophageal clearance of relatively few episodes of acid reflux (Fig. 4). Other than residual LES pressure, no factor appeared to be significantly correlated with esophageal acid exposure, including postoperative LES amplitude, length, or the amplitude of esophageal body contractions.

To be sure, the makeup of this study group was affected by some selection biases, but probably as much in favor of strengthening the conclusions as not. Those patients with gastroesophageal reflux severe enough to cause stricture or high-grade esophagitis would have been identified radiographically or endoscopically and likely would not have undergone postoperative pH testing. The incidence of such severe complications is low, about 5% in our experience.⁷ Patients with good postoperative results and no symptoms suggesting heartburn are unlikely to have undergone pH testing. They are understandably reluctant to submit to an uncomfortable test and commonly refused to do so. Our study group would, therefore, be expected to have an unrepresentatively high incidence of patients with mild to moderate acid reflux symptoms. The finding

Fig. 2. Total number of reflux episodes during the recording period is displayed. The bold vertical line at 49 marks the upper limit of normal.

Fig. 3. Total esophageal acid exposure time is shown for each patient. The dark vertical line at 4.5% marks the upper limit of normal.

of one patient (7%) with objectively documentable heartburn supports the clinical impression that this is an uncommon problem.

The LES that remains after a short esophagomyotomy is relatively low in amplitude and mostly intraabdominal in location. Such a low-amplitude sphincter nonetheless can remain competent for a long time, up to 18 years as evidenced by one patient in this study. Whether patients with asymptomatic acid reflux eventually develop symptoms or those with normal acid contact time will eventually have asymptomatic acid reflux cannot be answered by this

study and must be determined through long-term clinical follow-up, including pH monitoring. Previously published evidence on this point is conflicting, although one report of 10- to 20-year follow-up suggests that the late occurrence of severe reflux is uncommon.⁸

Why the LES after myotomy should display more complete relaxation in some patients than others remains unexplained. The intrathoracic portion of the LES in some patients may be the segment that is most responsible for preoperative incomplete relaxation. It is also possible that differing degrees of LES

Fig. 4. The 24-hour pH monitor record of patient 12 is shown, displaying a representative example of infrequent acid reflux episodes and slow esophageal acid clearance.

relaxation among patients before the operation account for the differing postoperative residual pressures, but our preoperative data are not complete enough to make that determination. Csendes and colleagues,⁹ who perform a myotomy similar in extent to that described herein and to that add a partial fundoplication, have found, as we did, a reduction but not obliteration of postoperative residual LES pressure. Complete division of the entire LES and reconstruction with a partial fundoplication may result in uniformly negligible residual LES pressure, but such a practice also may lead to a high rate of late gastroesophageal reflux, as noted in one report.¹⁰

The finding of high residual LES pressure in some patients after myotomy is of importance only in defining the cause of increased esophageal acid exposure, namely, poor distal esophageal acid clearance. Modifications of our operation, which produces more than 90% clinical improvement with a low incidence of clinical gastroesophageal reflux, do not seem warranted on the basis of these data. Specifically, the addition of an antireflux procedure, which would likely increase the amplitude of the distal high-pressure zone and thereby possibly impair esophageal acid clearance, would not be expected to improve the clinical result in most cases.

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Discussion

Dr. Mark K. Ferguson (Chicago, Ill.). Surgery for achalasia has been characterized for many years by a lack of objective data used to assess its results. The authors are to be congratulated for this attempt to provide objective data that could be correlated with their excellent clinical outcomes. That these data are hard to acquire is evident by the fact that the patients presented in this study represent fewer than 10% of the total number of patients operated on at their institution in the past 2 decades.

The authors found that the mean postoperative resting LES pressure was, on average, 15 mm Hg. In comparison,

the postoperative mean resting pressure after combined myotomy and fundoplication in patients at our institution was about 8 mm Hg, only half of the value reported here. What is more worrisome is the finding of an elevated residual pressure during deglutition in 36% of the patients in this study. The presence of these high pressures suggests that esophageal emptying may be delayed. Dr. Streitz, can you speculate on what anatomic structure is most responsible for the postoperative residual LES tone in these patients? Do you think that any of these patients had an incomplete myotomy?

The results of pH analysis are also interesting. The authors found that 29% of their patients had abnormal acid contact time. In comparison, there was no abnormal esophageal acid exposure in the postoperative period in any of our patients operated on for achalasia in whom pH monitoring was performed. The present findings are highly abnormal. I do not dismiss them as easily as Dr. Streitz appears to have done. I wonder whether potential reflux problems may have been missed because of the small numbers of patients presented.

A combined myotomy and fundoplication operation is not just a modification of the Heller-type myotomy described by Dr. Ellis and his group. I suggest that the speculation regarding the lack of utility of an added fundoplication is unfounded.

What I am left with is the impression that the two operations produced similar clinical results but that the combined myotomy and fundoplication provides superior objective results. What is of great interest to me is the impact of these findings on thoroscopic operations for achalasia, which use concepts based on the open myotomy as described here. Should we be concerned about a high incidence of esophageal acid exposure? Dr. Pellegrini's group reported a 63% incidence of abnormal exposure among eight of their first 22 patients. Although this exposure is not clinically important in the short term, perhaps Dr. Streitz could comment on how this might affect patients over the long term and whether he or his coauthors are now using this technique.

Dr. Streitz. The myotomy that we perform is anatomically incomplete by design so that we can leave a short intraabdominal portion of the LES to prevent reflux. In terms of the number of reflux episodes, the LES appears to be highly competent. Incomplete myotomy in the sense of requiring reoperation for residual dysphagia is an uncommon event occurring less than 1% of the time. Your proposal that the poor acid clearance in some of our patients represents a form of clinically incomplete myotomy is an interesting one. Nonetheless, the argument is not so much whether asymptomatic acid reflux may occur with a short myotomy, but rather whether the ultimate long-term clinical result is good for the patient, and we

argue in circles on that matter. We believe that the clinical results are comparable, even though insignificant asymptomatic reflux may occur in some patients without antireflux procedures. For this reason, we favor a simpler, less meddlesome operation with comparable results, and this is our argument for continuing to perform a short myotomy.

In answer to your question regarding residual pressure, it has been demonstrated by us and others that a short esophagotomy with or without an antireflux procedure leads to variable degrees of sphincter relaxation. Nonetheless, in most patients the residual pressure is negligible. Certainly when a complete myotomy is performed with disruption of all the hiatal attachments, no functioning high-pressure zone will remain and an antireflux procedure is essential. It has been demonstrated, as you point out, that the Belsey antireflux procedure accompanying a myotomy results in a sphincter that relaxes completely. However, there are long-term clinical problems with reflux after this operation, as has been recently reported. The Nissen fundoplication has been shown to result in a sphincter that does not completely relax when associated with esophagomyotomy, and by this mechanism may lead to increased acid retention in the esophagus. Given the choice of the three possibilities, we choose the simplest of the procedures to achieve the same long-term clinical result, recognizing that some patients may have clinically significant impairment of esophageal acid clearance.

You rightly point out that the numbers presented here are small. However, it is a group over-represented by patients with presumed reflux symptoms and would, therefore, more likely than not over-represent the reflux problem that exists in the entire group of patients operated on. It should be pointed out that 93% of the patients presented here had relatively few reflux episodes compared with the normal population, indicating that a highly competent barrier remains to acid reflux after short myotomy.

As far as thoroscopic myotomy is concerned, none of these data support the use of intraoperative manometry to guide the length of the myotomy that is performed. We have shown that the resting amplitude of the LES does not correlate with the pH monitoring result, and only the nadir of pressure during swallowing in the LES predicted acid exposure, something that cannot be measured during the operation. I have been unhappy with the thoroscopic myotomies I have performed, because I do not have the same anatomic landmarks guiding the distal extent of myotomy that I have when doing the procedure in an open fashion. Given the long history of good clinical results after short myotomy alone, and the fact that we are trying to provide a lifetime of palliation for the patient, I continue to favor the open technique.