SCIENTIFIC PAPER

Difficult Myotomy Is Not Determined by Preoperative Therapy and Does Not Impact Outcome

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ABSTRACT

Objectives: The impact of preoperative endoscopic therapy on the difficulty of laparoscopic Heller myotomy and the impact of the difficulty of the myotomy on long-term outcome has not been determined. This study was undertaken to determine whether preoperative therapy impacts the difficulty of laparoscopic Heller myotomy and whether preoperative therapy or difficulty of myotomy impacts long-term outcomes.

Methods: Since 1992, 305 patients, 56% male, median age 49 years, underwent laparoscopic Heller myotomy and were prospectively followed. The difficulty of the laparoscopic Heller myotomy was scored by the operating surgeon for the most recent 170 consecutive patients on a scale of 1 (easiest) to 5 (most difficult). Patients scored their symptoms before and after myotomy using a Likert scale from 0 (never/not bothersome) to 10 (always/very bothersome).

Results: Before myotomy, 66% of patients underwent endoscopic therapy: 33% dilation, 11% Botox, and 22% both. Preoperative endoscopic therapy did not correlate with the difficulty of the myotomy (P=NS). Median follow-up was 25 months. Regardless of the difficulty of the myotomy, dysphagia improved with myotomy ($P<0.0001$). By regression analysis, the frequency and severity of postmyotomy dysphagia correlated with neither preoperative endoscopic therapy nor the difficulty of the myotomy.

Conclusions: Laparoscopic Heller myotomy improves the frequency and severity of dysphagia. The difficulty of laparoscopic Heller myotomy is not impacted by preoperative therapy, and neither preoperative therapy nor difficulty of the myotomy impact long-term outcome.

Key Words: Achalasia, Heller myotomy, Pneumatic dilation, Botulinum toxin.

INTRODUCTION

Achalasia is defined by discoordinated or absent esophageal peristalsis and abnormal lower esophageal sphincter (LES) relaxation secondary to the destruction of the myenteric plexus of the esophagus. Essentially, the swallowing process becomes progressively dysfunctional until patients affected by achalasia are unable to empty their esophagus effectively. Against the functional obstruction of the LES, the esophagus becomes increasingly dilated, patulous and, at end-stage achalasia, can form a hugely dilated serpiginous conduit. Presenting symptoms include dysphagia, regurgitation, chest pain, weight loss, and, occasionally, heartburn. No treatment will restore the motility of the achalasic esophagus, but various treatments have been utilized over the years to relieve the functional obstruction and reduce the pressure gradient across the sphincter.

Broadly categorized, options for treatment of achalasia consist of endoscopic or operative management, each having the same goal of relieving the functional obstruction of the lower esophageal obstruction. Upper endoscopy has been utilized to either dilate the LES with pneumatic balloons or as a vehicle for the injection of botulinum toxin A (ie, Botox) into the LES. Pneumatic dilation forcefully tears the LES and a postprocedure inflammatory response and subsequent fibrosis after the tear will occur.[1] Pneumatic dilation of the nonsurgical therapies provides the most efficacious relief of symptoms, and gastroenterologists continue to undertake this procedure because it is well tolerated, generally requires no hospital stay, and is cost-efficient in the short-term.[2,3] However, recurrence of significant symptoms are estimated at greater than 50% in long-term follow-up.[4,5] Injection of botulinum toxin into the LES inhibits calcium-dependent release of acetylcholine from the nerve

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terminals and has been popularized in the last 10 years by many, including Parischa et al.[6] While gastroenterologists find the technique simple with few side effects, it provides only short-term (eg, several months) relief for as few as 50%.[2,7] Despite this, many patients undergo endoscopic management of their achalasia for years before referral for surgical management.

Laparoscopic Heller myotomy has been proven to be an efficacious and durable therapeutic option for individuals with achalasia.[8–10] However, endoscopic therapy for achalasia continues to be commonly undertaken despite evidence that a laparoscopic Heller myotomy is the most effective management for achalasia. This study was undertaken to determine whether endoscopic therapy, including pneumatic dilation or botulinum toxin injections, or both, with their presumed effects on LES tissue planes and provocation of reactive fibrosis, impacted difficulty of or outcome after laparoscopic Heller myotomy. In addition, this study was undertaken to determine the impact of the difficulty of the myotomy on long-term outcome after myotomy. Our hypotheses were that endoscopic therapy increased the difficulty of laparoscopic Heller myotomy, preoperative endoscopic interventions negatively impacted outcome after myotomy, and difficulty of myotomy inversely correlated with long-term outcome.

METHODS

Achalasia was diagnosed in symptomatic adults by either a timed barium esophagram or esophageal manometry. The classic "bird's beak" appearance of the distal esophagus was noted on esophagrams, often in the presence of esophageal spasm and dysmotility. Loss of esophageal peristalsis with the failure of coordinated LES relaxation was documented by manometry. Esophagogastroduodenoscopy, often with concomitant endoscopic therapy (ie, dilation or botulinum toxin injection), confirmed the lack of mechanical obstruction. Any nonoperative (ie, endoscopic) interventions, including balloon dilation and botulinum toxin injections, undertaken before myotomy were noted. Patient data collection and study design were conducted in concordance with a protocol approved by the Institutional Review Board of the University of South Florida College of Medicine.

Before and after myotomy, patients scored the frequency and severity of their symptoms by using a Likert scale: 0 (never/not bothersome) to 10 (always/very bothersome). In addition, patients were asked to grade their overall outcomes at each postoperative encounter as "excellent" (complete symptom relief), "good" (greatly improved symptoms), "fair" (slightly improved symptoms), or "poor" (no improvement or worsening of symptoms) relative to before myotomy. In addition, they were asked to grade their experience from very unsatisfying to very satisfying and declare whether they would have the operation again knowing what they know now.

Operative Technique

All patients underwent laparoscopic Heller myotomy. The operation was undertaken using a 5-port technique, as previously described.[8,11] A 10-mm port was placed at the umbilicus under direct visualization. A second 10-mm port was placed with videoscopic guidance along the right anterior axillary line at the subcostal margin and was used to insert a fan retractor. This retractor lifted the liver away from the stomach and gastroesophageal junction. The main working port was a 10-mm port placed at the right midclavicular line along the subcostal margin. Another 10-mm port was placed at the subxiphoid position, through which a zero-degree laparoscope was ultimately placed. Finally, a 5-mm port was placed along the left subcostal margin to allow access for the assistant.

First, the gastrohepatic ligament was opened widely in a stellate fashion by using an ultrasonic dissector. The dissection was then carried up and down the right and left crura and into the mediastinum to adequately mobilize the distal esophagus into the peritoneal cavity. It was generally unnecessary to divide short gastric vessels, but the esophagus was freed circumferentially from the esophageal hiatus. Once a sufficient length of esophagus had been mobilized into the abdomen, the myotomy was begun. Using hook cautery, the longitudinal fibers of the esophagus were transected to expose the transverse muscle fibers. The transverse fibers were divided adequately cephalad and caudad to relieve the proximal and distal extent of the esophageal outlet obstruction. The myotomy was carried caudad onto the stomach to relieve the distal extent of the obstruction. To confirm an adequate myotomy, intraoperative endoscopy was routinely undertaken. An adequate myotomy was confirmed when the endoscope passed easily into the stomach, the gastroesophageal junction opened easily with endoscopic air insufflation, and transillumination of the myotomized segment confirmed muscle division well above and below the Z-line without defects in the submucosa.

The difficulty of the myotomy was scored intraoperatively by a single experienced surgeon. The scale of scores was a continuum that ranged from 1 to 5, with "1" being easiest and "5" being most difficult. Assignment of difficulty score

was based on the degree of adherence of the longitudinal and circular muscular fibers to the submucosa and the difficulty of separating the transected muscle fibers off the submucosa. An intraoperative esophagotomy, almost by definition, occurred when the myotomy difficulty was scored as a "5."

Early in our experience, fundoplication after Heller myotomy was selectively constructed. A posterior fundoplication or anterior fundoplication was applied if a patulous hiatal defect, a large hiatal hernia, or an esophagotomy was noted. Later, anterior fundoplications were routinely constructed following publication of a randomized trial supporting application.[12] If anterior fundoplication was constructed, the anterior fundus was first sutured to the left side of the esophagus, lateral to the myotomy. Then the anterior fundus was sutured to the right side of the esophagus, again lateral to the myotomy. Thereby, nearly the entire myotomized esophagus was covered by the anterior fundoplication. The anterior fundoplication was tacked to the right crus to remove tension from the lower esophagus and to prevent the fundoplication from coming undone. The esophageal hiatus was then reconstructed using 0-braided polyester suture. The fascia at each trocar site was closed with monofilament absorbable sutures. The skin was closed with paper strips.

Postoperative Management

With transfer out of the postanesthesia recovery unit, patients underwent esophagography to assure adequate esophageal emptying and absence of esophagotomy. With prompt emptying and no leakage, patients were started on liquid diets per os. Patients were discharged, generally the next morning, with instructions to continue a liquid diet until a follow-up visit in 1 to 2 weeks. At that time, their diets were advanced to a more textured diet. If the postoperative esophagram indicated poor esophageal emptying, it was usually due to self-limited postoperative edema that resolved within 24 to 48 hours. If evidence of poor emptying did not resolve, the possibility of an incomplete myotomy was considered.

Data Management and Statistical Analysis

With Internal Review Board approval, data were maintained on an Excel (Microsoft, Redmond, WA) spreadsheet and analyzed by the Wilcoxon Matched Pairs Test or Mann-Whitney U-test when appropriate using True Epistat (Epistat Services, Richardson, TX) or GraphPad InStat (GraphPad Software, San Diego, CA). Significance was accepted with 95% confidence. Where appropriate, data are presented as median, mean±standard deviation.

RESULTS

Since 1992, 305 patients have undergone laparoscopic Heller myotomies at our institution and have been prospectively followed. The difficulty of myotomy has been scored intraoperatively in our last 170 consecutive patients, and the outcomes of these patients were studied. Of the 170 patients studied, 96 (56%) were male and 74 (44%) were female. The median age of the 170 patients was 49 years (range, 50±17.9) **(Table 1)**. Duration of symptoms varied among patients stratified by difficulty of myotomy **(Table 1)**, but overall median duration of symptoms was 4 years (range, 7±8.6). Median follow-up after myotomy for all 170 patients was 25 months.

Before myotomy, 112 (66%) of the 170 patients underwent endoscopic therapy: 38 patients (22%) had both pneumatic dilation and botulinum toxin injection, 18 patients (11%) underwent botulinum toxin injection alone, 56 (33%) patients underwent pneumatic dilation alone, and 58 patients (34%) had neither **(Table 2)**.

Median length of stay for all patients was 1.0 day, (range, 2.8±4). Median length of stay for patients with myotomies scored at "1" was 1 day, (range, 1±0.0), while for patients with myotomies scored at "5," it was 4 days (range, 4±2.6). Nonetheless, by regression analysis, hospital

Table 1.
Difficulty of Myotomy in 170 Patients With Achalasia Scored on a Scale of 1 to 5

Patient Characteristics	Difficulty Score				
	1	2	3	4	5
Number of Patients (M:F)	2 (2:0)	76 (38:38)	26 (15:11)	55 (35:20)	11 (6:5)
Age (years)	33 (33 ± 0.0)	54 (53 ± 18.6)	52 (54 ± 18.6)	46 (43 ± 15.7)	50 (50 ± 13.2)
Duration of Symptoms (years)	1 (1 ± 0.0)	5 (8 ± 8.7)	4 (8 ± 10.9)	2 (5 ± 5.7)	9 (13 ± 11.2)

Table 2.
Difficulty Scores for 112 Treated With Endoscopic Pneumatic Dilation and Botulinum Toxin Injections Prior to Laparoscopic Heller Myotomy (N=170)

Premyotomy Endoscopic Therapy	Difficulty Score				
	1	2	3	4	5
Total number of patients	1	51	19	34	7
Botulinum toxin only	1	8	3	5	1
Dilation only	0	27	12	14	3
Botulinum toxin and Dilation	0	16	4	15	3

length of stay did not correlate with difficulty score or preoperative endoscopic therapy. Complications related to the myotomies and inadvertent intraoperative events did occur **(Table 3)**. In those patients with myotomies scored at "2", no inadvertent esophagotomies were related to the myotomy. Intraoperative esophagotomies occurred in 4 patients with myotomies scored at "4," and 3 intraoperative esophagotomies occurred in 3 patients with myotomies scored at "5." The most severe complications occurred in 2 patients who underwent concomitant diverticulectomies at the time of myotomy. Though the difficulty of myotomy was scored as "2" in both of these patients, the diverticulectomy site staple lines leaked in both on late esophagography. One of these 2 demonstrated no leakage on repeat esophagography, but ultimately developed pneumonia, respiratory failure, and expired after her family elected to withdraw care.

Table 3.
Complications Categorized by Difficulty Score. More Inadvertent Esophagotomies Occurred With More Difficult Myotomies

Difficulty Score	Complication	N
1	None	2
2	Pneumonia	1
	Esophageal leak after concomitant diverticulectomy	2
	Death	1
	Empyema	1
	Delayed esophageal emptying	2
	Pneumothorax with chest tube	2
	Dysrhythmia	1
3	Leak	1
	Pneumonia	1
4	Leak and empyema	1
	Delayed esophageal emptying	2
	Intraoperative esophagotomy	4
	Urinary retention	2
5	Esophagotomy	3
	Gastrotomy	1

Symptoms of achalasia before myotomy, specifically, dysphagia, chest pain, and heartburn were essentially the same for patients regardless of prior endoscopic dilation or botulinum toxin injections and regardless of the difficulty of myotomy score. By multivariable regression, none of the symptoms correlated with endoscopic treatment or difficulty of myotomy with the exception of heartburn severity. Heartburn was more severe in patients who had undergone both pneumatic dilation and botulinum toxin before myotomy and in those who had not undergone either ($P<0.05$).

Regardless of the difficulty of myotomy, symptoms of dysphagia frequency and severity improved with myotomy ($P<0.0001$) **(Figures 1 and 2)**. With the exception of the 2 patients whose myotomies were scored at a difficulty of "1," heartburn frequency and severity significantly improved after laparoscopic Heller myotomy regardless of difficulty score **(Figures 3 and 4)**. Chest pain frequency and severity improved after laparoscopic Heller myotomy only in those patients whose difficulty of myotomy was scored at "2," "3," or "4." Those patients at either end of

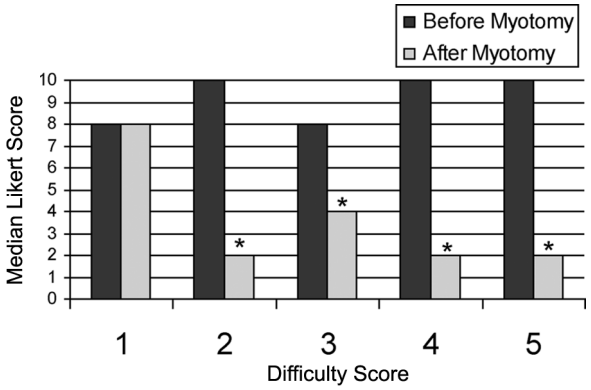

Figure 1. Dysphagia frequency before and after laparoscopic myotomy. A Likert scale was used (0=never to 10=always).*$P\leq0.03$, before vs after myotomy, Wilcoxon matched-pairs test.

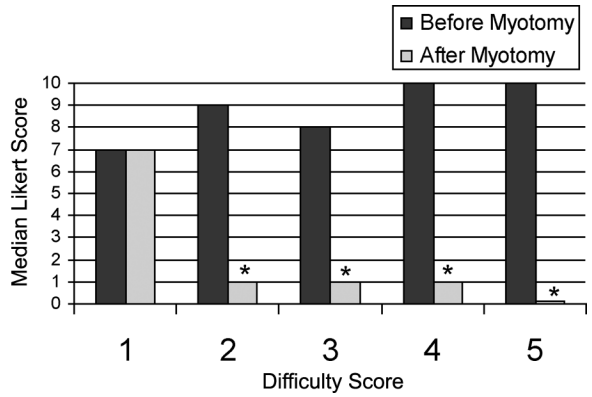

Figure 2. Dysphagia severity before and after laparoscopic myotomy. A Likert scale was used (0=not bothersome to 10=very bothersome). *P≤0.03, before vs. after myotomy, Wilcoxon matched-pairs test.

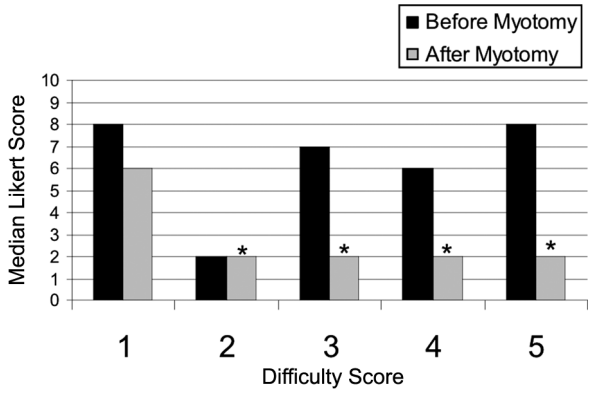

Figure 3. Heartburn Frequency. Patients graded the frequency of their heartburn before and after laparoscopic myotomy. A Likert scale was used (0=never to 10=always). Patients were then stratified by difficulty score. *P≤0.03, before vs. after myotomy, Wilcoxon matched-pairs test.

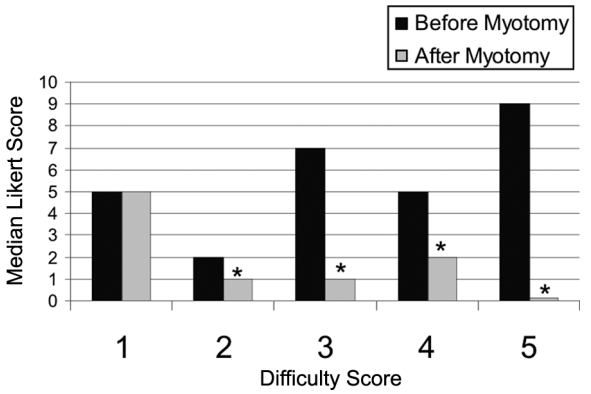

Figure 4. Heartburn Severity. Patients graded the severity of their heartburn before and after laparoscopic myotomy. A Likert scale was used (0=Not Bothersome to 10=Very Bothersome). Patients were then stratified by difficulty score. *P≤0.03, before vs. after myotomy, Wilcoxon matched-pairs test.

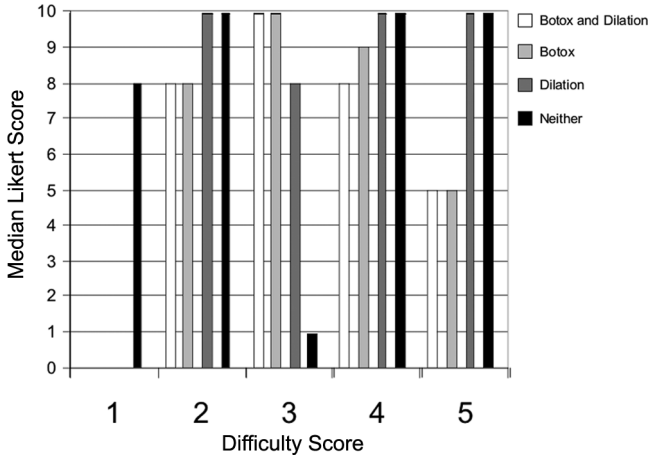

Figure 5. Dysphagia Frequency. The frequency of dysphagia was the same before myotomy regardless of difficulty of myotomy or preoperative endoscopic treatment. A Likert scale was used (0=never to 10=always).

the spectrum of difficulty did not experience a significant reduction in the frequency or severity of symptoms of chest pain after laparoscopic Heller myotomy. By regression analysis, the frequency and severity of postmyotomy symptoms correlated with neither preoperative endoscopic therapy or with difficulty of myotomy **(Figures 5, 6, 7, and 8)**.

Patients were asked at follow-up how they would grade their symptom relief relative to before myotomy. Most (67%) reported "excellent" symptom relief with symptoms almost completely resolved. A smaller number (14%) reported "good" results, with symptoms occurring less than once per month. Fifteen percent noted that their symptom improvement was "fair" with symptoms slightly improved. Finally, only 4% noted "poor" outcomes with no symptom improvement. Overall experience was reported by 89% of patients to be "very satisfying" or "satisfying." When patients were asked whether they would still have the operation knowing what they now know, 92% would still have the operation and only 7% reported that they would not go through the operation again knowing what they know now. By regression analysis, symptom resolution did not correlate with difficulty score or preoperative endoscopic treatment. Whether the patients would repeat the operation knowing what they now know did correlate with preoperative pneumatic dilation or botulinum toxin injections and difficulty score.

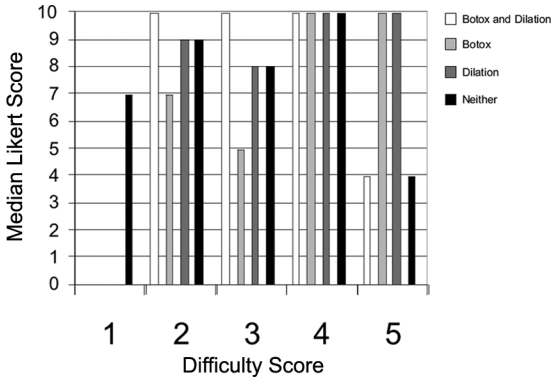

Figure 6. Dysphagia Severity. The severity of dysphagia was the same before myotomy regardless of the difficulty of myotomy or preoperative endoscopic treatment. A Likert scale was used (0=not bothersome to 10=very bothersome).

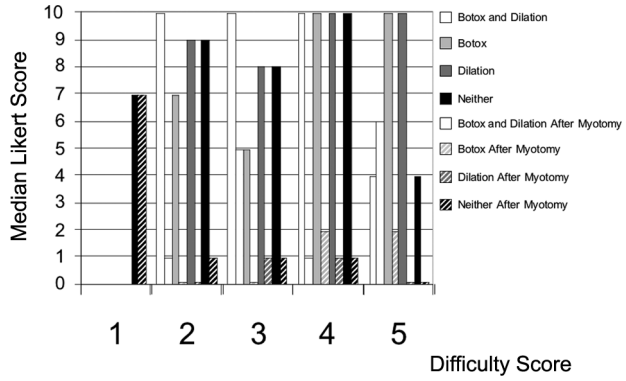

Figure 8. The severity of dysphagia uniformly improved regardless of the difficulty of myotomy or preoperative endoscopic treatment. A Likert scale was used (0=not bothersome to 10=very bothersome).

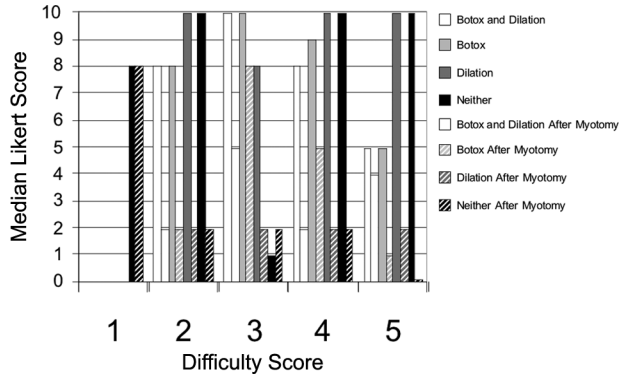

Figure 7. The frequency of dysphagia improved regardless of difficulty of myotomy or preoperative endoscopic treatment. A Likert scale was used (0=not bothersome to 10=very bothersome).

DISCUSSION

Few medical or surgical practitioners amass large experiences with achalasia. Prior to advanced laparoscopic surgical techniques, the first-line therapy was endoscopic pneumatic dilation in preference to the more invasive transthoracic or transabdominal cardiomyotomy, (ie, Heller myotomy). With the advent of advanced minimally invasive techniques, laparoscopic Heller myotomy has proven to be most efficacious with tolerable morbidity for patients with achalasia.[10,11] However, there continues to be some debate between medical and surgical camps regarding the appropriate initial management of otherwise healthy patients with achalasia. Patients with achalasia are often referred for balloon dilation with a 60% to 95% short-term "success" rate quoted in the literature.[4,13] Because of the small, but not insignificant risk, of esophageal perforation with pneumatic dilation, some practitioners still inject "low-risk, low-yield" botulinum toxin as the primary treatment for achalasia. This requires injection of the neurotoxin in multiple areas of the gastroesophageal junction. The gastroesophageal junction is precisely the area of operative intervention in undertaking myotomy, and after botulinum toxin injection, some obliteration of anatomic planes in this area is to be expected. Despite the potential consequences of injection and the lack of long-term durability of botulinum toxin, patients continue to receive this therapy, generally prior to myotomy.[2,13] The role for botulinum toxin injections for achalasia may be in those patients who are poor operative risks with short life expectancies. Herein, we present a large population of patients who underwent preoperative endoscopic therapy before laparoscopic Heller myotomy, were scored intraoperatively for difficulty of myotomy based on tissue adherence, and were examined for respective outcomes.

In this study of 170 patients with achalasia who underwent laparoscopic Heller myotomy, all underwent scoring of difficulty of myotomy intraoperatively. A significant majority of those studied had either endoscopic pneumatic dilation or botulinum toxin injections as primary treatment before surgical intervention. Certainly the difficulty of myotomy for most patients was scored in the middle of the spectrum, but small numbers were scored as the most technically easy ("1") myotomy and as the most technically difficult ("5") myotomy. Possible bias in scoring the difficulty of the myotomy intraoperatively must be acknowledged. However, the scoring was undertaken by a single experienced surgeon who assigned a score based on defined technical parameters. Difficulty score and/or endoscopic treatment with botulinum toxin or pneumatic

dilation had no correlation with preoperative symptoms with the exception of heartburn severity. In addition, endoscopic treatment before myotomy had no bearing on the difficulty of the subsequent myotomy.

Regardless of the difficulty of the myotomy, all patients noted a significant improvement in symptom frequency and severity with few exceptions. Those exceptions were notable for lack of dysphagia or heartburn symptom improvement in the patients whose myotomies were scored as "1." However, there were only 2 patients with myotomies scored as "1." In addition, chest pain frequency or severity did not improve significantly for either those with the easiest myotomies or for those with the most technically difficult myotomies for reasons that are not entirely clear.

Complications or inadvertent events occurred regardless of difficulty score. Certainly, an inadvertent esophagotomy was a more heavily represented complication in those myotomies scored with a "4" or a "5," but the 2 most morbid complications occurred in the 2 patients with myotomies scored at "2." These 2 patients had contained staple-line leaks at concomitant diverticulectomy sites. One of these individuals developed an empyema from a late pneumonia and required decortication, but he ultimately left the hospital. The other was a frail, malnourished octogenarian who developed a small delayed leak at the staple line of the diverticulectomy with no immediate ramifications, but ultimately developed respiratory failure and expired more than 30 days postoperatively when the family elected to withdraw support. These costly complications are undoubtedly secondary to the necessary aggressive dissection into the mediastinum required to resect the diverticulum as well as the addition of a staple line upon the esophagus.

Some have noted that preoperative endoscopic interventions in patients with achalasia influence the difficulty and subsequent morbidity of laparoscopic Heller myotomy.[14,15] Horgan et al[15] noted significant difficulty in identifying submucosal planes in over 50% of the patients who had been treated with botulinum toxin injections preoperatively. Inadvertent esophagotomies occurred in 2 of their 15 patients treated with botulinum toxin, and this was felt to reflect the extensive obliteration and fibrosis present at the gastroesophageal junction secondary to the injections. These same investigators found no correlation with difficulty and preoperative pneumatic dilation. A similar study found that those patients who transiently responded to botulinum toxin injections had the most technically difficult myotomies because of a fibrotic reaction at the gastroesophageal junction, but patients who had experienced no relief with botulinum injections and those who had previous pneumatic dilations had excellent results.[16] Similarly, a recent report notes significantly more intraoperative esophagotomies and morbidities regardless of endoscopic mode of preoperative therapy for achalasia.[14] In addition, these same authors attribute their overall failure rate of 17% after Heller myotomy to preoperative endoscopic therapy, because failure after laparoscopic Heller myotomy was doubled in those who underwent endoscopic therapy preoperatively.

Large numbers of patients with achalasia are treated by endoscopic means before surgical intervention. We have previously noted that degree of fibrosis in the esophageal muscle was not correlated with preoperative endoscopic therapy.[17] Preoperative endoscopic therapy before laparoscopic Heller myotomy did not determine the difficulty of the operation or long-term outcomes in our patients. Though laparoscopic Heller myotomy is a great "salvage" procedure after failed endoscopic therapy, we continue to encourage its "first-line" application because of long-term efficacy.

CONCLUSION

Despite the efficacy and durability of laparoscopic Heller myotomy for achalasia, patients continue to be treated with endoscopic botulinum injections or pneumatic dilation preoperatively. Regardless, preoperative endoscopic interventions for achalasia do not correlate with the difficulty of myotomy or subsequent outcomes after laparoscopic Heller myotomy, and furthermore, the difficulty of the myotomy does not impact the long-term outcome after myotomy.

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