Surg Endosc (2017) 31:1550–1557
DOI 10.1007/s00464-016-5130-4

Outcomes in patients with over 1-year follow-up after peroral endoscopic myotomy (POEM)

Marc A. Ward[1] · Matt Gitelis[2] · Lava Patel[2] · Yalini Vigneswaran[1] · Joann Carbray[2] · Michael B. Ujiki[1,2]

Received: 18 March 2016 / Accepted: 13 July 2016 / Published online: 17 November 2016
© Springer Science+Business Media New York 2016

Abstract
Background Peroral endoscopic myotomy (POEM) is a promising therapy in the treatment of achalasia. The study was designed to report outcomes, including quality of life, in patients with at least 1-year follow-up.
Methods Patients from an institutional review board-approved protocol underwent POEM and were followed prospectively. Health-related quality of life was measured preoperatively and 1 year post-operatively using Short Form-36 Health Survey version 2 (SF-36v2). Comparisons were made with patients from a prospective database who underwent laparoscopic Heller myotomy (LHM) over the same period. Paired *t* tests were used to analyze all normally distributed data, while Wilcoxon signed-rank tests were used to analyze SF-36 data, as it does not follow a normal distribution.
Results We analyzed 41 consecutive POEM patients with at least 1-year follow-up. Significant improvements in quality of life between baseline and 1 year were found in role limitations due to physical health (81.8 ± 25.8 vs. 65.9 ± 31.6, $p = 0.01$) and social functioning (83 ± 19.1 vs. 64.6 ± 31.3, $p = 0.01$). When compared to 24 patients who underwent LHM, there was no difference in average Eckardt scores (0.9 ± 1.6 vs. 1.0 ± 1.3, $p > 0.05$) or incidence of PPI use (43.5 vs. 47.5 %, $p = 0.71$). However, when looking at just type III patients, POEM patients had a higher remission rate (100 vs. 62.5 %) and significantly lower post-operative Eckardt scores at 1 year (1.1 vs. 3.1, $p < 0.05$). The average myotomy length of type III achalasia patients undergoing POEM was 18.6 cm (± 6.9) compared to 10.3 cm (± 1.0) in LHM patients ($p < 0.01$), which may have contributed to this difference.
Conclusion POEM provides a significant quality of life benefit at 1 year while having similar relief of dysphagia and post-operative PPI use compared to LHM. Type III achalasia patients may have better outcomes with POEM compared to LHM.

Keywords Achalasia · Peroral endoscopic myotomy (POEM) · Eckardt score · Type III achalasia · Laparoscopic Heller myotomy

Achalasia is a primary esophageal motility disorder that is characterized by the absence of esophageal peristalsis and the failure of the lower esophageal sphincter to relax. This disease develops due to the degeneration of the myenteric plexus within the esophagus; however, the etiology of why this occurs is still unknown. Approximately 90 % of patients with achalasia suffer from solid and/or liquid dysphagia. Sixty percent of these patients also experience symptoms of weight loss, heartburn, regurgitation, and chest pain [1]. Non-surgical therapies have been described, such as endoscopic botulinum injection and pneumatic dilation; however, these options have limited long-term efficacy compared to surgical myotomy [2–5].

The development of high-definition endoscopes and endosurgical tools led to the creation of performing an endoscopic esophageal myotomy for the treatment of achalasia. In 2009, Inoue completed the first peroral endoscopic myotomy (POEM), in which the circular

Presented at the SAGES 2016 Annual Meeting, March 16–19, 2016, Boston, Massachusetts.

✉ Marc A. Ward
marcward314@gmail.com

[1] Department of Surgery, University of Chicago, 2523 N. California Ave. Apt 3, Chicago, IL 60647, USA

[2] Department of Surgery, NorthShore University HealthSystem, Evanston, IL, USA

muscle of the LES is divided, while leaving the longitudinal muscle alone [6]. The procedure takes advantage of a submucosal tunneling technique, by creating a protective mucosal flap that can be closed using standard endoscopic clips [7]. This technique provides a margin of safety and focuses on treating only the dysfunctioning mechanics of the disease (circular muscle of the esophagus), thereby limiting potential life-threatening complications such as mediastinal leaks. Although POEM is a relatively young procedure, it is gaining popularity as an alternative surgical option to the laparoscopic Heller myotomy with partial fundoplication (LHM) in the treatment of esophageal motility disorders.

LHM has been the gold standard surgical therapy for the treatment of achalasia for years. As a long-standing treatment, this procedure has demonstrated good long-term efficacy and quality of life improvements [8–10]. Due to the low incidence of achalasia and the relative young age of POEM, data showing long-term outcomes following POEM is limited. Several publications have shown that POEM is a safe and reasonable treatment for achalasia [11–16]. In fact, short-term data do show that POEM may be as efficacious as LHM in terms of post-operative recurrence of dysphagia and GERD.

The excitement that surrounds POEM is due to the fact that it offers the efficacy of surgery with the cost and morbidity of purely an endoscopic procedure. However, the follow-up in POEM patients is short and the long-term efficacy of the procedure is still unknown. This study was designed to report outcomes, including quality of life, in patients with at least 1-year follow-up and compare those results in patients undergoing LHM when possible.

Methods

Since 2011, all patients who presented to our institution seeking treatment for manometrically confirmed achalasia were offered POEM. Exclusion criteria for POEM included: age less than 18 years, coagulopathy, active esophagitis, esophageal varices, pregnancy, and known gastrointestinal malignancy. Patients who consented to the POEM procedure were followed prospectively according to an approved Institution Review Board protocol as previously described [17].

A thorough history and physical was performed in these patients, where comorbidities, allergies, and prescription drug therapies were documented and evaluated as we perform this procedure under general anesthesia. During this process, these patients were specifically evaluated for dysphagia and gastroesophageal reflux disease (GERD). Patients were staged using the Eckardt scoring system (Table 1), a validated tool used in the evaluation of dysphagia, to determine preoperative severity as well as post-operative success/failure following intervention [18]. In addition, patients underwent a full preoperative workup, including an esophagram, esophageal manometry, and esophagogastroduodenoscopy (EGD) as part of their initial evaluation.

At our institution, patients who undergo POEM are brought to the operating room, given preoperative antibiotics, and are induced under general anesthesia. The site of the initial mucosotomy occurs at least 10 cm proximal to the z line of the GE junction depending on the Chicago class of achalasia. Given that type III achalasia patients experience spasms all along the esophagus, we create the initial mucosotomy as proximal as possible in these patients. Once the mucosotomy site is confirmed, a 2-cm vertical incision in the mucosa is generated along the anterior wall of the esophagus. At this location, a submucosal tunnel is constructed, which allows access to the circular muscle fibers of the esophageal wall. The myotomy of only the circular fibers of the esophagus is performed using either an endoscopic triangular tip knife or a hybrid knife that extends at least 3 cm beyond the LES on the lesser gastric curvature. The proximal extent of the myotomy begins 3 cm from the mucosotomy to ensure an adequate protective mucosal flap is created. Once the myotomy is completed, the mucosal defect is closed using endoscopic clips.

Following the operation, patients were admitted overnight for observation. A water-soluble contrast swallow was performed on post-operative day one to ensure no mucosal leak was present. Patients were seen in the office 2–3 weeks following discharge and were evaluated using GERD questionnaires, dysphagia scores, reflux severity index, and Short Form-36 (SF-36). These data were obtained at short term (3 weeks, 6 months) and yearly intervals and stored in our prospectively maintained database.

Comparisons were made with patients from a prospective database who underwent LHM over the same period. We perform this surgery using 5 ports. All patients either had a Dor or Toupet fundoplication after the myotomy was performed. The decision to perform a Dor versus a Toupet was done randomly; however, if there was any concern for mucosal injury the Dor was chosen. The myotomy length in our LHM patients was standardized regardless of which type of achalasia they were diagnosed with. A 10- to 11-cm myotomy was constructed along the length of the esophagus and 3 cm along the lesser curve of the stomach. All LHM patients had an EGD done intraoperatively to confirm relaxation of the gastroesophageal junction, and to make sure, no perforation was present.

Normally distributed data were analyzed using paired t tests, with a p value less than 0.05 to be considered

Table 1 Eckardt Symptom scoring and staging [18]

Score	Dysphagia	Regurgitation	retrosternal pain	Weight loss (kg)
0	None	None	None	None
1	Occasional	Occasional	Occasional	<5
2	Daily	Daily	Daily	5–10
3	Every meal	Every meal	Every meal	>10
	Stage 0	Stage 1	Stage 2	Stage 3
Score	0–1	2–3	4–6	>6
Sum	(Remission)	(Remission)	(Treatment failure)	(Treatment failure)

statistically significant. However, the use of SF-36 in the general surgery population does not follow a normal distribution for the surgical population [19]. Thus, domains of the SF-36 were expressed as medians with interquartile ranges and analyzed using the Wilcoxon signed-rank test, a paired nonparametric statistical technique.

Results

Table 2 describes the demographics of our 41 POEM patients with at least 1-year follow-up and the 24 LHM patients used for comparison. The two groups show no differences in terms of age, sex, BMI, ASA classification, duration of symptoms, smoking status, or previous esophageal interventions. Previous LHM was not a contraindication for inclusion into the study, as these patients were represented in both groups. Patients undergoing POEM following a previous LHM had the myotomy performed on the right lateral position of the esophagus in order to avoid the previous anterior myotomy site.

Short-term perioperative outcomes between the two groups are shown in Table 3. The length of stay following the operation and the day at which pain medication was stopped was not different between the two groups. However, there was significantly less pain at discharge as well as a quicker return to activities of daily life (ADL) in the POEM patients compared to LHM group. Although not statistically significant, patients, who received POEM, also returned to work earlier.

There was no significant difference in post-operative Eckardt scores (0.9 ± 1.6 vs. 1.0 ± 1.3, $p > 0.05$) or incidence in PPI use (47.5 vs. 43.5, $p = 0.714$) between the two groups with at least 1-year follow-up as shown in Table 4. However, 3/23 patients (one patient was lost to follow-up) in the LHM group failed to achieve appropriate relief (Eckardt score > 3) from the operation compared to 1/41 from the POEM group. All three of the failed LHM patients suffered from type III or spastic achalasia. When looking just at type III patients, POEM patients had a higher remission rate (100 vs. 62.5 %) and a significantly lower post-operative Eckardt scores at 1 year (1.1 vs. 3.1, $p < 0.05$) (Table 5). The average myotomy length of type III achalasia patients undergoing POEM was 18.6 cm (± 6.9) compared to 10.3 ($\pm 1.$) in LHM patients ($p < 0.01$), which may have contributed to this difference. No differences were seen in Eckardt scores between the two groups of patients with either type I or type II achalasia

Table 2 Demographic comparative data

Demographics	POEM	Lap Heller	*p* value
n	41	24	
Age (mean, SD)	63.0 ± 17.9	61.5 ± 19.3	0.76
Sex (m/f)	25/16	14/10	0.83
BMI (mean, SD)	26.3 ± 6.2	26.9 ± 5.8	0.73
ASA class (median, range)	2 (1-3)	2 (1-3)	0.36
Duration of symptoms years (mean, SD)	6.8 ± 9.8	10.4 ± 10.4	0.22
Smoking status (N/F/C)	21/18/2	8/11/2	0.55
Previous interventions (#)			
Botox	9	2	
Dilation	12	5	
Botox & dilation	4	0	
Heller myotomy	7	3	
Prior interventions (#)	28	10	0.58

ASA American Society of Anesthesia, *BMI* body mass index

Table 3 Intraoperative and post-operative clinical outcomes

Post-operative	POEM	Lap Heller	*p* value
Length of stay days	2.0 ± 3.3	2.5 ± 2.6	0.53
Pain at discharge	2.4 ± 2.6	4.9 ± 2.9	0.01
Pain med. stopped POD	2.6 ± 5.5	3.1 ± 2.1	0.66
Return to ADL POD	3.3 ± 4.9	6.2 ± 2.7	0.01
Return to work POD	6.4 ± 3.4	10.8 ± 5.9	0.08

POD post-operative day

Table 4 Eckardt scores and rate of PPI use after the procedure in all achalasia patients with at least 1-year follow-up

Eckardt score summary	POEM	Lap Heller	*p*
Dysphagia			
Pre-op (mean, SD)	2.2 ± 0.9	2.3 ± 0.8	
Post-op (mean, SD)	0.4 ± 0.7	0.4 ± 0.7	
Regurgitation			
Pre-op (mean, SD)	1.7 ± 0.8	1.4 ± 0.9	
Post-op (mean, SD)	0.2 ± 0.6	0.1 ± 0.3	
Restrosternal pain			
Pre-op (mean, SD)	0.9 ± 0.9	1.1 ± 1.1	
Post-op (mean, SD)	0.1 ± 0.3	0.2 ± 0.4	
Weight Loss			
Pre-op (mean, SD)	1.8 ± 1.3	0.7 ± 1.1	
Post-op (mean, SD)	0.2 ± 0.4	0.3 ± 0.6	
Eckardt score total			
Pre-op (mean, SD)	6.7 ± 2.4	5.5 ± 2.5	
Post-op (mean, SD)	0.9 ± 1.6	1.0 ± 1.3	$p > 0.05$
Remission (ES ≤ 3)	40/41	20/23	
PPI use after procedure (%)	47.5 %	43.5 %	$p = 0.71$

SD standard deviation, *ES* Eckardt score, *PPI* proton pump inhibitor

Table 5 Average myotomy length and post-operative Eckardt scores in Type III achalasia patients with at least 1-year follow-up

Eckardt score summary	POEM	Lap Heller	*p*
Average myotomy length (cm)	18.6 ± 6.9	10.3 ± 1.0	<0.01
Dysphagia			
Pre-op (mean, SD)	1.6 ± 0.7	2.0 ± 0.9	
Post-op (mean, SD)	0.6 ± 0.7	0.6 ± 1.1	
Regurgitation			
Pre-op (mean, SD)	1.4 ± 0.7	1.1 ± 0.8	
Post-op (mean, SD)	0.2 ± 0.4	0.8 ± 0.7	
Restrosternal pain			
Pre-op (mean, SD)	0.6 ± 0.7	1.0 ± 1.1	
Post-op (mean, SD)	0.1 ± 0.3	1 ± 0.9	
Weight loss			
Pre-op (mean, SD)	2.2 ± 1.0	0.9 ± 1.2	
Post-op (mean, SD)	0.1 ± 0.3	0.8 ± 0.9	
Eckardt score total			
Pre-op (mean, SD)	5.8 ± 1.4	5.0 ± 0.0	
Post-op (mean, SD)	1.1 ± 0.9	3 ± 2.1	<0.05
Remission (ES ≤ 3)	9/9	5/8	

SD standard deviation, *ES*, Eckardt score

as shown in Table 6. High-resolution manometry was not available at our institution before some of these operations; therefore, the exact achalasia type is known in only 37/41 POEM patients and 17/23 LHM patients.

SF-36 data were obtained for 25 of the 41 POEM patients (60 %) at 1 year. These results are described in Table 7 and Fig. 1. Significant improvements in quality of life between baseline and 1 year were found in role limitations due to physical health (81.8 ± 25.8 vs. 65.9 ± 31.6, $p = 0.002$) and social functioning (83 ± 19.1 vs. 64.6 ± 31.3, $p = 0.002$). Although not statistically significant, role limitations due to emotional problems, energy/fatigue, emotional well-being, pain, and general health all improved on average in patients following POEM at 1 year.

Although patients who suffer from achalasia do not typically have reflux, their clinical symptoms of dysphagia are often similar to those who suffer from severe GERD. As a result, reflux severity index (RSI), GERD HRQoL, and Dysphagia scores were obtained to evaluate clinical outcomes following POEM. Scores in all three domains were significantly improved at 1 year compared to their baseline as seen in Fig. 2.

Discussion

The pathogenesis of achalasia is unknown, and as a result, treatment is designed at improving esophageal emptying in an effort to relieve symptoms of GE junction obstruction. The two most common interventions for these patients are pneumatic dilation (PD) and surgery. A recent randomized controlled trial by Boeckxstaens and colleagues found that the two therapies are equivocal in treating achalasia at 2 years [20]. However, other studies have shown that although PD may be the most effective non-surgical therapy in the treatment of dysphagia, it is far less effective in the long term compared to surgery [21].

Historically, LHM with a partial fundoplication has been the gold standard surgical treatment for achalasia patients. Advancements in endosurgical technology have led to the development of POEM as an alternative surgical

Table 6 Post-operative Eckardt scores in Type I and II achalasia patients with at least 1-year follow-up

Eckardt score summary	POEM type I	Lap Heller type I	*p*	POEM type II	Lap Heller type II	*p*
Dysphagia						
Pre-op (mean, SD)	2.4 ± 1.0	2.2 ± 0.8		2.5 ± 1.0	2.5 ± 1.0	
Post-op (mean, SD)	0.6 ± 1.0	0.4 ± 0.5		0.2 ± 0.4	0.3 ± 0.5	
Regurgitation						
Pre-op (mean, SD)	1.7 ± 0.9	1.8 ± 0.8		1.8 ± 0.9	1.3 ± 1.0	
Post-op (mean, SD)	0.4 ± 0.9	0.2 ± 0.4		0.1 ± 0.3	0.0 ± 0.0	
Restrosternal Pain						
Pre-op (mean, SD)	1.1 ± 0.9	1.0 ± 1.1		0.9 ± 1.0	1.0 ± 1.2	
Post-op (mean, SD)	0.2 ± 0.4	0.4 ± 0.5		0.1 ± 0.3	0.0 ± 0.0	
Weight loss						
Pre-op (mean, SD)	1.5 ± 1.4	0.5 ± 1.2		1.8 ± 1.4	0.3 ± 0.5	
Post-op (mean, SD)	0.3 ± 0.6	0.4 ± 0.9		0.0 ± 0.0	0.0 ± 0.0	
Eckardt score total						
Pre-op (mean, SD)	6.7 ± 2.3	5.5 ± 2.6		7.0 ± 2.4	5.0 ± 0.0	
Post-op (mean, SD)	1.4 ± 2.6	1.4 ± 0.0	**>0.05**	0.4 ± 0.6	0.3 ± 0.0	**>0.05**
Remission (ES ≤ 3)	11/12	5/5		16/16	4/4	

SD standard deviation, *ES* Eckardt score

Table 7 Short Form-36 domain scores preoperative and at 1-year follow-up in POEM patients

	Preoperative	1 year	*p*
Physical Functioning	75.4	70.8	0.33
Role limitations due to physical health	65.9	81.8	0.01
Role limitations due to emotional problems	69.2	78.8	0.2
Energy/fatigue	54.9	60.7	0.29
Emotional well-being	67.3	71.3	0.41
Social functioning	64.6	83	0.01
Pain	67.3	76.9	0.15
General health	66.1	70.7	0.3

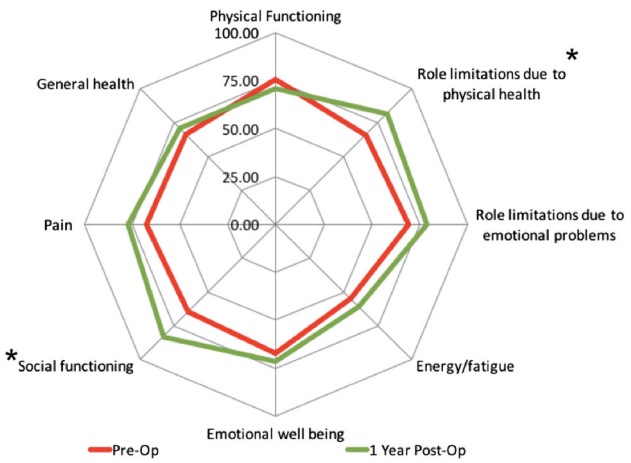


Fig. 1 Short Form-36 scores before and after POEM procedure in patients with at least 1 year follow-up (*$p \leq 0.05$)

option. Symptom relief following POEM is excellent with resolution of dysphagia and chest pain at rates of 98 and 92 %, respectively [22]. Although the data regarding the effectiveness of POEM is relatively young with short-term follow-up, the overall failure rate has been reported as low as 2 % [23, 24]. The main criticism directed toward the use of POEM is the incidence of post-operative GERD. Unlike LHM, POEM is not followed by a fundoplication. As a result, controversy exists as to the frequency and long-term development of reflux in this patient population. Although these data have been obtained in patients undergoing LHM and in the short term with POEM patients, more long-term QOL and symptomatic outcome results like in this paper are needed.

In this study, we prospectively collected outcomes in our POEM patients, including QOL, validated scoring models based on post-operative symptoms, and remission rates in patients with at least 1-year follow-up. When

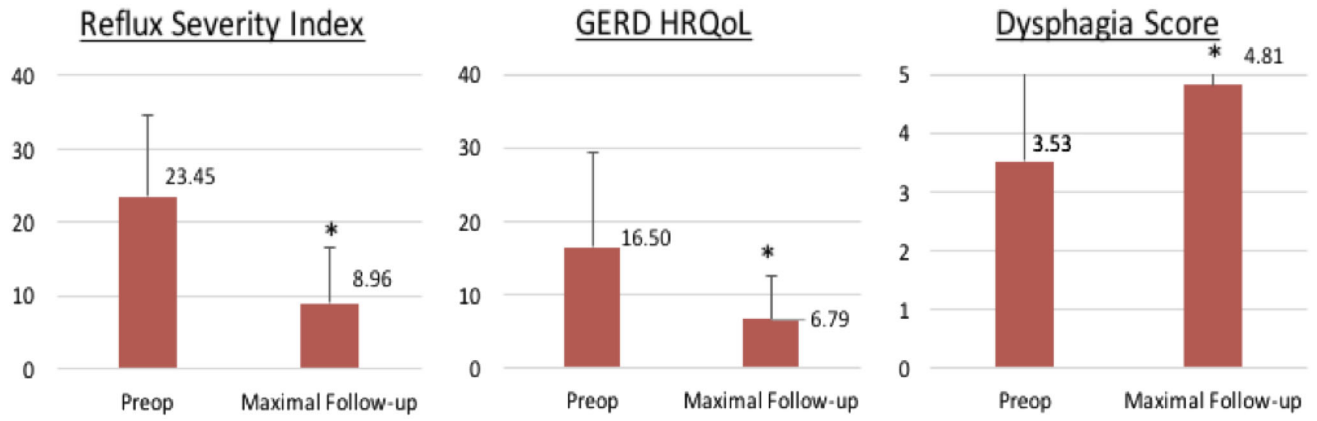


Fig. 2 Clinical outcomes after POEM measured by commonly used assessment tools. The following graphs represent the changes in Reflux Severity Index, Gastroesophageal Reflux Disease (GERD) Quality of Life, and Dysphagia (higher score = less symptoms) compared to baseline at maximal follow-up in patients at least 1 year from their operation (*$p \leq 0.05$). Higher dysphagia scores indicates less dysphagia on a 5-point scale

possible, we compared these results to patients in our database that underwent LHM. Despite no significant differences between the two groups as shown in Table 2, POEM patients had a quicker return to ADLs as well as significantly less pain at discharge. This confirms what we have previously shown, albeit with a much larger sample size [17]. It lends support to the idea that the morbidity surrounding POEM compares to a purely endoscopic procedure. At our institution, we are currently discharging many of our POEM patients the same day as their procedure, and although it is not shown in this study, we predict the length of stay in our POEM patients will be significantly less as more patients enter our database.

We have previously reported that symptom resolution, rates of post-operative dysphagia, and Eckardt scores were equal between POEM and LHM; however, this comparison was done in fewer patients and with shorter follow-up [17]. We show here that the benefits from POEM persist in patients at least 1 year after surgery. In addition, we may have identified POEM as a potential improvement over LHM in the treatment of a specific subset of achalasia patients. The Chicago classification of achalasia has determined that within the diagnosis of achalasia, three different manometric patterns exist [25–27]. Type III achalasia patients suffer spastic contractions anywhere along the esophagus in addition to a tight LES. Type III achalasia is the least common form of achalasia (<10 %) and is associated with the highest failure rate following LHM [26, 28]. This lack of success is often attributed to anatomic barriers that limit the proximal extension of the myotomy when approached laparoscopically. These barriers do not exist in patients undergoing POEM. As a result, we were able to perform an extended myotomy in these patients roughly 18.6 cm on average compared to 10.3 cm in those patients who underwent LHM (<0.05). This increase in the length of myotomy appears to be advantageous in these patients as post-operative Eckardt scores, and post-operative failure rate (0 vs. 38 %) was significantly lower in the POEM group. These data support the notion that these patients benefit from an extended myotomy, which may be more easily approached endoscopically.

Despite being an area of controversy, the rate of PPI use between the two groups was not significant. It is our practice to prescribe PPIs in both patient populations based on symptoms. In the literature, it has been shown that roughly 40 % of POEM patients develop GERD according to 24-h pH studies, even though only 50 % of these patients experience symptoms [12, 22, 24]. As a result, we prescribe PPIs if our LHM and POEM patients develop any reflux-like symptoms. Our study is consistent with what has been shown by Rawlings and colleagues, that even in patients with LHM and partial fundoplication; the development of reflux occurs in approximately 40 % of patients. Since achalasia patients are more likely to get esophageal cancer [30], we perform an EGD in these patients within 5 years of the operation and look for evidence of esophagitis at that time.

In this study, we prospectively collected QOL information through SF-36 questionnaires. These surveys ask a variety of questions related to eight domains that affect QOL. At 1 year, POEM patients experienced on average improvements in seven of these eight domains, with physical functioning showing no difference. Although only 2 of these improvements are statistically significant from baseline, these findings are comparable to those seen by others after LHM [31]. Unlike QOL studies after LHM, we saw significant improvement in social functioning [31, 32]. Although achalasia patients often seek medical attention due to problems associated with social functioning, it is not clear why POEM patients appear to have significant

improvement in this area compared to LHM. We speculate that our type III achalasia patients appear to have better results with POEM, which may have impacted the results of social functioning at 1 year, but more data need to be collected to confirm this hypothesis. This improvement does support POEM as an effective therapy, especially since this finding has not been seen in the LHM literature.

Although gastroesophageal reflux disease is uncommon in achalasia patients, symptoms of reflux often mimic those of dysphagia, which include regurgitation and heartburn. As a result, we evaluated our POEM patients with a number of clinical questionnaires including RSI, GERD HRQoL, and dysphagia scores. As expected, these scores were all significantly improved from preoperative baseline values at 1 year and further demonstrate the effectiveness of POEM at relieving symptoms.

The outcomes at 1 year in our experience with POEM as the primary treatment for achalasia are encouraging and comparable to the current gold standard. However, there are some limitations to this study. First, the data are not randomized. Second, pH monitoring is not routine following these procedures, which may affect the true incidence of GERD as well as PPI need in both groups. Lastly, compliance with SF-36 forms is low, with only 60 % of our patients at 1 year returning the survey. Early in our experience, compliance with these questionnaires was poor, but has improved with implementation of an electronic form.

In conclusion, POEM continues to show promise in adequately treating achalasia at intermediate time intervals compared to the current standard of care. Patients who undergo POEM experience less post-operative pain, a quicker return to ADLs and have equal success at alleviating symptoms and improvements in QOL. In addition, it appears an extended POEM has better remission rates and symptom resolution than LHM in type III achalasia patients. These results are encouraging and show that POEM is a suitable endoscopic option for the treatment of achalasia.

Funding There are no funding sources to disclose in relation to this project.

Compliance with ethical standards

Disclosure Dr. Ward, Mr. Gitelis, Dr. Patel, Dr. Vigneswaran, Mrs. Carbray, and Dr. Ujiki have no conflicts of interest or financial ties to disclose.

References

1. Francis DL, Katzka DA (2010) Achalasia: update on the disease and its treatment. Gastroenterology 139:369–374
2. Annese V, Basciani M, Perri F, Lombardi G, Frusciante V, Simone P, Andriulli A, Vantrappen G (1996) Controlled trial of botulinum toxin injection versus placebo and pneumatic dilation in achalasia. Gastroenterology 111:1418–1424
3. Allescher HD, Storr M, Seige M, Gonzales-Donoso R, Ott R, Born P, Frimberger E, Weigert N, Stier A, Kurjak M, Rösch TT, Classen M (2001) Treatment of achalasia: botulinum toxin injection vs. pneumatic balloon dilation. A prospective study with long-term follow-up. Endoscopy 33:1007–1017
4. Leyden JE, Moss AC, MacMathuna P (2006) Endoscopic pneumatic dilation versus botulinum toxin injection in the management of primary achalasia. Cochrane Database Syst Rev 4:CD005046
5. Kroupa R, Hep A, Dolina J, Valek V, Matyasova Z, Prokesova J, Mrazova J, Sedmik J, Novotny I (2010) Combined treatment of achalasia–botulinum toxin injection followed by pneumatic dilatation: long-term results. Dis Esophagus 23:100–105
6. Inoue H, Minami H, Kobayashi Y, Sato Y, Kaga M, Suzuke M, Satodate H, Odaka N, Itoh H, Kudo S (2010) Peroral endoscopic myotomy (POEM) for esophageal achalasia. Endoscopy 42(4):265–271
7. Rajan E, Gostout CJ, Feitoza AB, Leontovich ON, Herman LJ, Burgart LJ, Chung S, Cotton PB, Hawes RH, Kalloo AN, Kantsevoy SV, Pasricha PJ (2004) Widespread EMR: a new technique for removal of large areas of mucosa. Gastrointest Endosc 60(4):623–627
8. Parise P, Santi S, Solito B, Pallabazzer G, Rossi M (2011) Laparoscopic Heller myotomy plus Dor fundoplication in 137 achalasic patients: results on symptoms relief and successful outcome predictors. Updates Surg 63:11–15
9. Kilic A, Schuchert MJ, Pennathur A, Gilbert S, Landreneau RJ, Luketich JD (2009) Long-term outcomes of laparoscopic Heller myotomy for achalasia. Surgery 146:826–831 **(discussion 831–833)**
10. Zaninotto G, Costantini M, Rizzetto C, Zanatta L, Guirroli E, Portale G, Nicoletti L, Cavallin F, Battaglia G, Ruol A, Ancona E (2008) Four hundred laparoscopic myotomies for esophageal achalasia: a single centre experience. Ann Surg 248:986–993
11. Inoue H, Minami H, Kobayashi Y, Sato Y, Kaga M, Suzuki M, Satodate H, Odaka N, Itoh H, Kudo S (2010) Peroral endoscopic myotomy (POEM) for esophageal achalasia. Endoscopy 42:265–271
12. Hungness ES, Teitelbaum EN, Santos BF, Arafat FO, Pandolfino JE, Kahrilas PJ, Soper NJ (2013) Comparison of perioperative outcomes between peroral esophageal myotomy (POEM) and laparoscopic Heller myotomy. J Gastrointest Surg 17:228–235
13. Eleftheriadis N, Inoue H, Ikeda H, Onimaru M, Yoshida A, Hosoya T, Maselli R, Kudo SE (2012) Training in peroral endoscopic myotomy (POEM) for esophageal achalasia. Ther Clin Risk Manag 8:329–342
14. Swanstrom LL, Rieder E, Dunst CM (2011) A stepwise approach and early clinical experience in peroral endoscopic myotomy for the treatment of achalasia and esophageal motility disorders. J Am Coll Surg 213:751–756
15. Costamagna G, Marchese M, Familiari P, Tringali A, Inoue H, Perri V (2012) Peroral endoscopic myotomy (POEM) for oesophageal achalasia: preliminary results in humans. Dig Liver Dis 44:827–832
16. von Rahden BH, Filser J, Reimer S, Inoue H, Germer CT (2014) Peroral endoscopic myotomy for treatment of achalasia: literature review and own initial experience. Chirurg 85(5):420–432
17. Ujiki MB, Yetasook AK, Zapf M, Linn JG, Carbray JM, Denham W (2013) Peroral endoscopic myotomy for treatment of achalasia: literature review and own initial experience. Chirurg 85(5):420–432
18. Eckardt AJ, Eckardt VF (2011) Treatment and surveillance strategies in achalasia: an update. Nat Rev Gastroenterol Hepatol 8:311–319

19. Velanovich V (2007) Behavior and analysis of 36-item Short-Form Health Surveydata for surgical quality-of-life research. Arch Surg 142(5):473–477 **(discussion 478)**
20. Boeckxstaens GE, Annese V, des Varannes SB, Chaussade S, Constantini M, Cuttitta A, Elizalde JI, Fumagalli U, Gauric M, Rohof WO, Smout AJ, Tack J, Zwinderman AH, Zaninotto G, Busch OR (2011) European Achalasia Trial Investigators. Pneumatic dilation versus laparoscopic Heller's myotomy for idio-pathic achalasia. N Engl J Med 364:1807–1816
21. Campos GM, Vittinghoff E, Rabl C, Takata M, Gadenstatter M, Lin F, Ciovica R (2009) Endoscopic and surgical treatments for achalasia: a systematic review and meta-analysis. Ann Surg 249:45–57
22. Sharata AM, Dunst CM, Pescarus R, Shlomovitz E, Wille AJT, Reavis KM, Swanstrom LL (2015) Peroral endscopic myotomy (POEM) for esophageal primary motility disorders: analysis of 100 consecutive patients. J Gastrointest Surg 19:161–170
23. Starvropoulos SN, Modayil RJ, Friedel D, Savides T (2013) The international per oral endoscopic myotomy survey (IPOEMS): a snapshot of the global POEM experience. Surg Endosc 27(9):3322–3338
24. Von Renteln D, Fuchs KH, Fockens P, Bauerfeind P, Vassiliou MC, Werner YB, Fried G, Breithaupt W, Heinrich H, Bredenoord AJ, Kersten JF, Verlaan T, Trevisonno M, Rosch T (2013) Peroroal endoscopic myotomy for the treatment of achalasia: an international prospective multicenter study. Gastroenterology 145(2):309–311
25. Pandolfino JE, Ghosh SK, Rice J, Clarke JO, Kwiatek MA, Kahrilas PJ (2008) Classifying esophageal motility by pressure topography characteristics: a study of 400 patients and 75 controls. Am J Gastroenterol 103:27–37
26. Pandolfino JE, Kwiatek MA, Nealis T, Bulsiewicz W, Post J, Kahrilas PJ (2008) Achalasia: a new clinically relevant classification by high-resolution manometry. Gastroenterology 135:1526–1533
27. Bredenoord AJ, Fox M, Kahrilas PJ, Pandolfino JE, Schwizer W, Smout AJ (2012) International High Resolution Manometry Working Group: Chicago classification criteria of esophageal motility disorders defined in high resolution esophageal pressure topography. Neurogastroenterol Motil 24:57–65
28. Rohof WO, Salvador R, Annese V, Bruley des Varannes S, Chaussade S, Elizalde JI, Gaudric M, Smout AJ, Tack J, Busch OR, Boeckxstaens GE (2003) Outcomes of treatment for achalasia depend on manometric subtype. Gastroenterology 144:718–725 **quiz e13-4**
29. Rawlings A, Soper NJ, Oelschlager B, Swanstrom L, Matthews BD, Pellegrini CA, Pierce RA, Pryor A, Martin V, Frisella MM, Cassera M, Brunt LM (2012) Laparoscopic Dor versus Toupet fun- doplication following Heller myotomy for achalasia: results of a multicenter, prospective, randomized-controlled trial. Surg Endosc 26:18–26
30. Leewenburgh I, Scholten P, Alderliesten J, Tilanus HW, Looman CWN, Steijerberg EW, Kuipers EJ (2010) Long-term esophageal cancer risk in patients with primary achalasia: a prospective study. Am J Gastroenterol 105(10):2144–2149
31. Youssef Y, Richards WO, Sharp K, Holzman M, Sekhar N, Kaiser J, Torquati A (2007) Relief of dysphagia after laparoscopic Heller myotomy improves long-term quality of life. J Gastrointest Surg 11:309–313
32. Katilius M, Velanovich V (2001) Heller myotomy for achalasia: quality of life comparison of laparoscopic and open approaches. J Soc Laparoendosc Surg 5:227–231