



Initial Experience with Endoscopic Pyloromyotomy, with Description and Video of Technique

Herbert Mason Hedberg¹  · JoAnn Carbray² · Michael B. Ujiki²

Received: 31 January 2019 / Accepted: 20 April 2019 / Published online: 6 May 2019
© 2019 The Society for Surgery of the Alimentary Tract

Abstract

Background Gastric per oral endoscopic myotomy (G-POEM) is a recently developed incisionless procedure to address gastroparesis. It has been previously described to treat medical and postsurgical gastroparesis. The present study is a case series of patients undergoing G-POEM for a variety of indications, both elective and urgent.

Methods IRB approval was obtained for retrospective review of a prospectively collected database including patients who underwent G-POEM during a 1.5-year period. Using an upper endoscope, a mucosotomy is made 2 cm proximal to the pylorus on the anterior surface of the stomach. A submucosal tunnel is made to the pylorus muscle, which is completely incised. When possible, Endoflip® was used to evaluate pyloric distensibility before and after the myotomy. Patient demographic factors, additional procedures, and other follow-up were collected by chart review. Elective cases were offered repeat gastric emptying study at 6 months.

Results There were 17 patients available for review. The procedure was technically completed in all cases. There was one gastric perforation recognized on postoperative day two that was addressed with laparoscopy and omental patch. Median length of stay was zero days, and 13/17 (76%) of patients experienced symptomatic relief. Pyloric distensibility significantly decreased intraoperatively from 5.6 (± 1.7) to 10.8 (± 5.0) cm²/mmHg ($p = 0.002$).

Conclusion This limited case series demonstrates G-POEM to be a versatile procedure able to address gastroparesis in a variety of settings. Success rates are congruent with previously published reports, and one serious complication was able to be addressed laparoscopically. Endoflip® was able to verify a successful myotomy intraoperatively. This procedure is an attractive alternative to less effective non-invasive treatments and a more invasive laparoscopic pyloroplasty.

Keywords Gastroparesis · Myotomy · Endoscopic · Submucosal · Pyloromyotomy

Introduction

Gastroparesis is objectively delayed gastric emptying without mechanical obstruction. Symptoms of bloating, nausea, vomiting, and abdominal pain can be debilitating, and about

0.2% of the general population is affected. Most cases are idiopathic, but gastroparesis is associated with several pathologies including diabetes mellitus, Parkinson's, multiple sclerosis, and connective tissue disorders. Postinfectious gastroparesis has been described, and intentional or iatrogenic vagus nerve disruption can cause postsurgical gastroparesis. Non-invasive treatment options include dietary modifications and antiemetic and/or prokinetic medications. Refractory cases can be treated with pharmaceuticals, laparoscopic pyloroplasty, surgical bypass, botulinum toxin injection, stent placement, pneumatic dilation, or electrical gastric stimulation. However, these procedures are invasive, or only offer partial or transient relief.^{1–3}

Endoscopic pyloromyotomy, typically referenced as gastric per oral endoscopic myotomy (G-POEM), is an emerging technique for incisionless pyloromyotomy. The procedure was first described in 2014 as a case report where G-POEM

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11605-019-04237-6>) contains supplementary material, which is available to authorized users.

✉ Herbert Mason Hedberg
herbert.hedberg@uchospitals.edu

¹ Department of Surgery, University of Chicago Medicine, 5841 S. Maryland Avenue, Chicago, IL, USA

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

was used to address gastroparesis following an iatrogenic vagus nerve injury.⁴ This was followed shortly by a case series of seven patients, most with idiopathic gastroparesis. Six of the seven showed improvement, with four of five showing objective improvement by nuclear gastric emptying study.⁵ Since these initial reports, several other case series have been published, demonstrating the safety and efficacy of the procedure. Complications are rare, but include perforation and gastric ulceration.^{6–9} A variety of etiologies have been addressed with G-POEM, including postinfectious, postsurgical (Nissen fundoplication, esophagectomy for cancer, esophagectomy for achalasia), diabetic, and idiopathic gastroparesis.^{10, 11}

Endoflip® (Crospon, Galway, Ireland) allows intraluminal functional imaging of gastrointestinal sphincters. The device utilizes an impedance catheter within an elongated, floppy balloon to generate a visual representation of the luminal contour, as well as to derive sphincter distensibility via pressure and diameter measurements. Distensibility is calculated by dividing cross-sectional in cm² by pressure in mmHg. The device is described as a means to evaluate the lower esophageal sphincter for achalasia and gastroesophageal reflux disease, the pylorus for gastroparesis, and the anal sphincter for fecal incontinence.^{12–15} This device is relatively new and normal distensibilities and standards of use are still being established. Endoflip® was utilized in this case series as an intraoperative, objective means to verify a successful myotomy and to contribute to the ongoing effort of device standardization.

Methods

The institutional review board approved a retrospective review of patients with gastroparesis who underwent G-POEM from April, 2017 through December 2018. Procedures were either elective, or urgently performed on inpatients hospitalized for severe consequences of poor oral intake. Elective cases had upper endoscopy and nuclear gastric emptying study as preoperative workup; emptying study was waived for urgent cases. Abnormal gastric emptying was considered to be $\geq 10\%$ residual bolus present after 4 h on a standardized nuclear medicine TC-99 m sulfur colloid solid-phase gastric emptying study. Patients described their most bothersome symptoms at their initial consultation, and % improvement at their 3- to 4-week postoperative follow-up. Subjective improvement of 75% or greater was considered clinical success for the purpose of this case series. Patients with initial relief but recurrent symptoms within the timeframe of the study were considered clinical failures. All patients are prescribed high-dose proton pump inhibitor therapy for 2 weeks postoperatively for ulcer prophylaxis, and were offered a follow-up gastric emptying study. Student's *t* test was

used to compare preoperative and postoperative Endoflip® measurements.

Technique

G-POEM follows the same general principles as esophageal POEM for achalasia:¹⁶

1. Identification of anatomic landmarks
2. Mucosotomy to gain access to submucosa
3. Submucosal dissection to expose target muscle
4. Myotomy to incise target muscle

The procedure is described in the following section, and demonstrated in the [supplementary video](#).

Cases are performed under general anesthesia with the patient in the supine position. Upper endoscopy is performed using a high definition upper endoscope (GIF-H180, Olympus, Tokyo, Japan), and carbon dioxide is used for insufflation. The stomach and proximal duodenum are inspected and the stomach is cleared of residual contents. When Endoflip (Medtronic, Sunnyvale CA, USA) measurements are taken, the scope is fixed with a snare to guide the functional luminal imaging probe catheter through the pylorus into the duodenum. The balloon is then released from the snare, inflated to 50 ml, and is withdrawn until it straddles the pylorus. Readings are taken, and the balloon is deflated and withdrawn with the snare and scope. A transparent dissection cap is then fitted to the endoscope, and a Gardus Overtube (US Endoscopy, Mentor OH, USA) is advanced over the scope. A mucosotomy site is selected 5 cm proximal to the pylorus on the anterior wall of the stomach. Mucosotomy is facilitated by a submucosal injection of a 5-ml lift solution (normal saline mixed 10 mg/ml methylene blue). A 1–2-cm longitudinal mucosal incision is then performed with a Hybrid knife, (EndoCutQ 3-1-1; ERBE, Tubingen, Germany). The submucosal space is entered, and a submucosal tunnel is created using the Hybrid knife (Forced Coag/Effect 2/50W) to 0.5-cm distal to the pylorus. Tunneling is facilitated by serial injections of lift solution, and care is taken not to injure the overlying mucosa. A myotomy of the pylorus is then performed using the Hybrid knife by hooking the muscle and pulling in a distal to proximal direction away from the mucosa of the duodenum (EndoCutQ 3-1-1). The myotomy continues until the visible pyloric muscle is fully divided as confirmed by its thinning into the duodenal musculature. At the completion myotomy, hemostasis is confirmed and the mucosotomy is closed using endoclips or endoscopic suturing. Repeat Endoflip measurements are taken as described above.

Results

Seventeen patients underwent G-POEM during the study time period and were included for review. All procedures were technically completed successfully. Basic demographics, case urgency, gastroparesis etiology, gastric emptying studies, intraoperative Endoflip® data, and outcomes are summarized for each patient in Table 1. Thirteen patients had their procedure scheduled electively. Four patients were admitted for inability to tolerate oral intake due to gastroparesis, and G-POEM was performed that admission after surgical consultation. Eleven of the 17 patients had a prior esophagectomy, and remaining etiologies were idiopathic or diabetic, and in one case attributed to dermatomyositis. Only one patient with prior esophagectomy had trialed pro-motility agents before G-POEM; given high failure rates of medical management in these patients surgical treatment if preferred at our institution. The patients without prior esophagectomy were all considered to have failed medical management with pro-motility agents due to either medication side effects or lack of symptomatic improvement.

Pre and postoperative Endoflip® data was available for 13 procedures, demonstrating a mean increase in distensibility from 5.6 (± 1.7) to 10.8 (± 5.0) cm^2/mmHg ($p = 0.002$). Only three patients with symptom resolution (1, 5, and 8) elected for repeat gastric-emptying studies, which demonstrated significant improvement of retention at 4 h. Patient 9 had

repeat G-POEM after 1 month for persistent symptoms, and repeat emptying study showed little improvement between the two procedures.

Thirteen of 17 patients (76%) reported significant symptomatic relief. Patient 2 expired before symptoms could be controlled due to complications of metastatic esophageal adenocarcinoma, and patient 4 went on to have laparoscopic paraesophageal hernia repair with pyloroplasty. Patient 7's Endoflip® measurement showed no change despite a technically successful myotomy. He initially reported improved symptoms which recurred after 7 months. He was scheduled for repeat G-POEM outside the timeframe of this study. Patient 9 failed G-POEM twice and is being evaluated for gastric stimulator placement.

Of the elective cases, nine patients went home the same day, four stayed overnight, and patient 3 had a 6-day stay. This patient suffered a gastric perforation, the one operative complication in this series. The perforation was not recognized intraoperatively, and the patient complained of severe upper abdominal pain the next day. Free air was radiologically identified, and the patient was taken to the operating room where a perforation was noted on the distal anterior surface of the stomach. The defect was covered with an omental patch, and the patient was discharged 4 days later. The same patient returned a week after discharge with an upper GI bleed,

Table 1 Summary of case series. Gastric emptying studies (GES) shown as % bolus remaining at 4 h. Functional luminal imaging probe (Flip) distensibility is shown in cm^2/mmHg , and length of stay (LOS) in days

Patient	Age	Gender	Urgent?	Etiology	Concomitant procedure	Pre GES 4 h %	Post GES 4 h %	Pre FLIP dist.	Post FLIP dist.	LOS	Symptoms improved?
1	71	F	N	Idiopathic	Anti-reflux mucosectomy	35	11	NA	NA	0	Y
2	67	M	Y	Post esophagectomy	Pleurodesis	NA	NA	NA	NA	8	N
3	73	M	N	Post Nissen fundoplication	None	18	NA	3.2	9.5	6	Y
4	69	F	Y	Diabetes, post esophagectomy	None	NA	NA	6.2	10.3	3	N
5	77	M	N	Post esophagectomy	None	30	1	9.7	NA	1	Y
6	73	M	N	Post esophagectomy	None	55	NA	6	16.4	0	Y
7	72	M	Y	Post esophagectomy	None	NA	NA	8.8	8.8	1	N
8	48	M	Y	Diabetes	NJ-tube placed	86	20	4.5	NA	3	Y
9a	18	F	N	Idiopathic	None	49	47	4.7	5.4	0	N
9b	18	F	N	1mo persistent Sx	None	47	NA	NA	NA	1	N
10	65	M	N	Post esophagectomy	None	14	NA	5.3	21.1	0	Y
11	72	M	N	Post esophagectomy	None	NA	NA	4.3	17.3	0	Y
12	66	M	N	Post esophagectomy	None	25	NA	3.8	6.0	0	Y
13	47	F	N	Dermatomyositis	None	70% 2 h	NA	7.3	10.1	0	Y
14	38	F	N	Diabetes	None	15	NA	NA	NA	1	Y
15	66	M	N	Post esophagectomy	None	18	NA	8.3	14.6	1	Y
16	65	F	N	Post esophagectomy	None	66	NA	4.7	5.9	0	Y
17	66	F	N	Post esophagectomy	None	71	NA	4.4	6.8	0	Y

and a bleeding ulcer was treated with endoscopic clips. This case illustrates the rationale for performing the pyloromyotomy on the anterior surface of the stomach. In the case of perforation, the injury can be easily identified and addressed laparoscopically. A posterior injury may be harder to recognize and would be difficult to access for surgical repair. The one other complication was experienced by patient 7, who was anticoagulated prior to G-POEM and developed a slow upper GI bleed requiring transfusion. No endoscopic intervention was necessary and bleeding stopped spontaneously.

Discussion

Gastroparesis can be a debilitating condition, and conventional treatment options either lack long-term efficacy or are invasive. The former group includes pharmacologies and endoscopic botulinum toxin injection. Medications such as metoclopramide can have serious side effects and may be contraindicated for long-term use. Pyloric botulinum toxin injection is often successful but symptomatic improvement is limited to an average of 6 weeks. Invasive options include electrical gastric stimulation, which carries a 20% complication rate, and laparoscopic pyloroplasty.¹⁷ A 90% success rate has been reported for laparoscopic pyloroplasty, which has been cited as a reasonable first-line therapy for gastroparesis.¹⁸ However, a recent publication using propensity scoring to compare outcomes between laparoscopic pyloroplasty and G-POEM found similar functional outcomes, but longer length of stay and complications in the laparoscopic group.¹⁹

G-POEM has been demonstrated to be safe and effective in several publications. The present symptomatic success rate of 76% is consistent with the referenced case series. All patients with symptomatic improvement were offered follow-up gastric emptying study 6 months after the procedure, although only three were available at the time of review. It is likely that patients, after experiencing symptomatic improvement, feel no need for further testing and prefer not to have the exam.

It is notable that four of the 17 patients in the present series were inpatients, admitted with inability to tolerate oral intake. Such patients with refractory gastroparesis may typically be treated with a course of gastric decompression and distal enteral feeding in order to prepare for laparoscopic pyloroplasty or surgical bypass. This series suggests that G-POEM may be used in some scenarios to urgently restore food tolerance and avoid periods of complete dependence upon distal enteral feeding while awaiting definitive management.

Conclusions

Results from this series are consistent with the procedural success and safety reported in other publications. Patient 3's gastric perforation illustrates that this complication may be easily addressed when G-POEM is performed on the anterior surface of the stomach. However, one perforation among 17 patients is a relatively high rate of a serious complication. This event was early in the operating surgeon's experience with G-POEM, and demonstrates that even in the hands of those well versed with endoscopic submucosal dissection and esophageal POEM, care must be taken to adapt these skills to different anatomy. It is critical that G-POEM only be undertaken by those with appropriate training in advanced endoscopic techniques at institutions capable of managing potential complications.

Four of the patients in this series had G-POEM after inpatient surgical consultation for food intolerance, demonstrating safety in an acute setting. G-POEM is also shown here to be an effective option for post esophagectomy gastroparesis, which can be a troubling complication of the gastric conduit. This is a limited case series with short follow-up and without validated metric for symptomatic assessment, so no conclusions about long-term efficacy can be drawn. G-POEM may be an excellent first-line option for post-esophagectomy gastroparesis given poor response to pro-motility agents. Non-surgical causes of delayed gastric-emptying follow standard algorithms of care that begin with medical management. Those who fail and are referred for surgical treatment may benefit from G-POEM prior to more invasive options.

Authorship Statement All authors meet the criteria for Authorship as described in the guidelines of the International Committee of Medical Journal Editors (ICMJE).

Compliance with Ethical Standards

Disclaimers The views expressed in the submitted article are the authors' own and not an official position of their respective institutions.

Conflict of Interest Dr. Hedberg and Ms. Carbray have no conflicts of interest to disclose. Dr. Ujjiki receives consulting fees from GORE, Boston Scientific, Apollo Endosurgery, Olympus, and Medtronic, none directly related to the submitted work.

References

1. Camilleri M, Parkman HP, Shafi MA, Abell TL, Gerson L. Clinical guideline: management of gastroparesis. *Am J Gastroenterol*: 2013;108:18–37.
2. Camilleri M, Bharucha AE, Farrugia G. Epidemiology, mechanisms, and management of diabetic gastroparesis. *Clin Gastroenterol Hepatol* 2011;9(1):5–12.

3. Park M-I, Camilleri M. Gastroparesis: clinical update. *Am J Gastroenterol*. 2006;101: 1129–39.
4. Chaves DM, de Moura EG, Mestieri LH, Artifon EL, Sakai P. Endoscopic pyloromyotomy via a gastric submucosal tunnel dissection for the treatment of gastroparesis after surgical vagal lesion. *Gastrointest Endosc*. 2014;80(1):164.
5. Shlomovitz E, Pescarus R, Cassera MA, Sharata AM, Reavis KM, Dunst CM, Swanström LL. Early human experience with per-oral endoscopic pyloromyotomy (POP). *Surg Endosc*. 2015;29(3):543–51.
6. Lebares C, Swanstrom LL. Per-Oral Pyloromyotomy (POP): An Emerging Application of Submucosal Tunneling for the Treatment of Refractory Gastroparesis. *Gastrointest Endosc Clin N Am*. 2016;26(2):257–270.
7. Gonzalez JM, Lestelle V, Benezech A, Cohen J, Vitton V, Grimaud JC, Barthet M. Gastric per-oral endoscopic myotomy with antropyloomyotomy in the treatment of refractory gastroparesis: clinical experience with follow-up and scintigraphic evaluation (with video). *Gastrointest Endosc*. 2017;85(1):132–139.
8. Kahaleh M, Gonzalez JM, Xu MM, Andalib I, Gaidhane M, Tyberg A, Saumoy M, Baptista Marchena AJ, Barthet M. Gastric peroral endoscopic myotomy for the treatment of refractory gastroparesis: a multicenter international experience. *Endoscopy*. 2018 12.
9. Xue HB, Fan HZ, Meng XM, Cristofaro S, Mekaroonkamol P, Dacha S, Li LY, Fu XL, Zhan SH, Cai Q. Fluoroscopy-guided gastric peroral endoscopic pyloromyotomy (G-POEM): a more reliable and efficient method for treatment of refractory gastroparesis. *Surg Endosc*. 2017;31(11):4617–4624.
10. Malik Z, Kataria R, Modayil R, Ehrlich AC, Schey R, Parkman HP, Stavropoulos SN. Gastric Per Oral Endoscopic Myotomy (G-POEM) for the Treatment of Refractory Gastroparesis: Early Experience. *Dig Dis Sci*. 2018 22.
11. Mekaroonkamol P, Li LY, Dacha S, Xu Y, Keilin SD, Willingham FF, Cai Q. Gastric peroral endoscopic pyloromyotomy (G-POEM) as a salvage therapy for refractory gastroparesis: a case series of different subtypes. *Neurogastroenterol Motil*. 2016;28(8):1272–7.
12. Yoo IK, Choi SA, Kim WH, Hong SP, Cakir OO, Cho JY. Assessment of Clinical Outcomes after Peroral Endoscopic Myotomy via Esophageal Distensibility Measurements with the Endoluminal Functional Lumen Imaging Probe. *Gut Liver*. 2018.
13. Kim MP, Meisenbach LM, Chan EY1. Tailored Fundoplication With Endoluminal Functional Lumen Imaging Probe Allows for Successful Minimally Invasive Hiatal Hernia Repair. *Surg Laparosc Endosc Percutan Tech*. 2018;28(3):178–182.
14. Saadi M, Yu D, Malik Z, Parkman HP, Schey R. Pyloric sphincter characteristics using EndoFLIP® in gastroparesis. *Rev Gastroenterol Mex*. 2018 Oct - Dec;83(4):375–384.
15. Zifan A, Sun C, Gourcerol G, Leroi AM, Mittal RK. Endoflip vs high-definition manometry in the assessment of fecal incontinence: A data-driven unsupervised comparison. *Neurogastroenterol Motil*. 2018;30(12):e13462.
16. Pescarus R, Shlomovitz E, Swanstrom LL (2014) Per-oral endoscopic myotomy (POEM) for esophageal achalasia. *Curr Gastroenterol Rep* 16(1):369.
17. Myint AS, Rieders B, Tashkandi M, Borum ML, Koh JM, Stephen S, Doman DB. Current and Emerging Therapeutic Options for Gastroparesis. *Gastroenterol Hepatol (N Y)*. 2018;14(11):639–645.
18. Shada AL, Dunst CM, Pescarus R, Speer EA, Cassera M, Reavis KM, Swanstrom LL. Laparoscopic pyloroplasty is a safe and effective first-line surgical therapy for refractory gastroparesis. *Surg Endosc*. 2016;30(4):1326–32.
19. Landreneau JP, Strong AT, El-Hayek K, Tu C, Villamere J, Ponsky JL, Kroh MD, Rodriguez JH. Laparoscopic pyloroplasty versus endoscopic per-oral pyloromyotomy for the treatment of gastroparesis. *Surg Endosc*. 2018.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations./