Learning Curve and Initial Outcomes

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Abbreviations

DI   Distensibility index
EGJ   Esophagogastric junction
FLIP   Functional lumen imaging probe
POEM   Per-oral endoscopic myotomy
SCJ   Squamocolumnar junction

Introduction

Per-oral endoscopic myotomy (POEM) represents the prototype for successful natural orifice surgery; an incisionless, endoscopic approach combined with the precision of a surgical myotomy. Since the initial description by Haru Inoue of the procedure in 2008 and publication of his initial results in 2010, POEM has been adopted at high-volume esophageal centers around the world [1]. The procedure is being performed by both surgical endoscopists and interventional gastroenterologists. This chapter reviews the characteristics and initial experience of early POEM operators, the existing literature regarding the learning curve for POEM, and initial outcomes in published series.

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Early Outcomes

The early global POEM experience was summarized in the International POEM Survey (IPOEMS) [2] and formed the basis for a white paper published by the American Society for Gastrointestinal Endoscopy and the Society of American Gastrointestinal and Endoscopic Surgeons. The survey included initial results from the 16 centers around the world that had performed >30 procedures as of July 2012, when the survey was conducted. IPOEMS confirmed the high success and low complication rates initially reported by Inoue, in addition to outlining the training and techniques of the 25 POEM operators (14 surgeons and 11 gastroenterologists). The majority of the respondents reported having experience with either endoscopic submucosal dissection (ESD) or natural orifice translumenal endoscopic surgery (NOTES) prior to introducing POEM at their institutions. Overall, the operative technique described by the participating centers was similar to that initially described by Inoue [1]: submucosal access through a longitudinal mucosotomy ~10 cm above the squamocolumnar junction, creation of a submucosal tunnel extending 4–5 cm onto the stomach, performance of a selective myotomy of the inner, circular muscle fibers, and finally closure of the mucosotomy with hemostatic clips. Minor variations were reported in instrumentation choice and position on the esophageal wall for the creation of the mucosotomy and entry into the submucosal space. Most centers perform POEM with the patient supine and create the submucosal tunnel and subsequent myotomy in the anterior or right-anterior aspect of the esophageal lumen (the 12–2 o'clock position), with two centers reporting the use of a right-posterior approach (the 5 o'clock position). Ten of the 16 centers included in the survey contributed initial outcomes data for treatment efficacy, in terms of symptomatic relief as assessed by the Eckardt score and objectively in terms of decrease in lower esophageal sphincter (LES) pressure and improved bolus clearance on timed barium esophagram (TBE), and the safety of the procedure. All of the centers reported symptomatic relief in at least 80% of patients, with all but two centers reporting >93% efficacy. Significant decreases were also seen in LES pressure and column height at 5 min on TBE. Adverse events were rare in the combined early experience of the survey participants with rates of postoperative leak and bleeding of 0.2% and 1%, respectively [2].

Learning Curve

Retrospective studies of the POEM learning curve at single centers have evaluated a variety of different components of the procedure [3–6]. Aspects that have been studied include: overall procedure duration, duration of procedure per centimeter of myotomy, time to complete the four main steps of submucosal access, tunnel creation, myotomy and mucosotomy closure as well as the rate of inadvertent mucosotomy creation and number of clips required to close the mucosotomy.

   Kurian and colleagues reported the intraoperative learning curve observed during the first 40 cases performed by a surgeon with extensive endoscopic experience

and by minimally invasive surgery fellows [3]. The senior author (Swanström) performed the first 16 cases and then transitioned to increasing participation by two fellows. Based on decreases in total procedure length, reduced variability in minutes/cm of myotomy, and reduction in the rate of inadvertent mucosotomies, the authors reported a learning curve of approximately 20 cases; their presented data, however, indicate that the last inadvertent mucosotomy during the cases performed by the senior surgeon occurred during case 14, with no additional events over the next seven cases.

Patel and associates at Winthrop University Hospital, in the largest series to date [4], reported the learning curve for a gastroenterologist with expertise in advanced endoscopy including endoscopic submucosal dissection (ESD) (Stavropoulos). In their study, the authors used cumulative sum (CUSUM) analysis and found efficiency to be achieved after 40 cases and mastery after 60 cases.

Recently, El Zein and colleagues reported on the technical aspects of the first 60 cases performed by a single interventional gastroenterologist, using a variety of methodologies to evaluate the learning curve for POEM [5]. Focusing on the learning plateau and learning rate, the authors reported a plateau of 102 min for total procedure time and 10 min/cm of myotomy, with learning rates of 13 and 11 cases, respectively. Analyzing the components of the POEM procedure individually revealed significant decreases in time to completion for each step besides myotomy creation; however, the time per cm of myotomy did decrease significantly over time, reflective of the inclusion of patients with more complex, spastic motility disorders, who received extended proximal myotomies. The learning plateau for each of the four steps of the POEM procedure was attained after performing 14–16 cases. The number of clips required to close the mucosotomy (median 5, range 4–12) also decreased significantly over time.

Teitelbaum and colleagues previously reported on the learning curve for the two minimally invasive surgeons who jointly performed the initial 36 cases at our institution [6]; a component analysis revealed a learning rate of seven cases for achieving submucosal access and performing the myotomy. Submucosal tunnel creation time, the longest component of case, started to "funnel" toward the mean at case 15. Based on these data and similar findings from the Oregon Clinic group, we believe the learning curve for POEM by minimally invasive surgeons with significant achalasia and endoscopy experience is approximately 15 cases.

The potential impact of the learning curve for a technically demanding procedure such as POEM was highlighted in the results of follow-up from the multi-center European POEM trial. In that study, approximately one in five patients had suffered a recurrence of symptoms or required further intervention [7], raising a question of POEM durability. However, half of the failures occurred during the initial ten cases performed at each of the three participating centers, suggesting a learning curve effect that may have biased the rates of long-term treatment success.

Recently, published results from our center for 115 consecutive patients *beyond* the learning curve (initial 15 patients) revealed durable symptomatic relief and physiologic improvement at an average of 2 years of follow-up. The symptomatic relief reported by 92% of patients and objective GERD in ~40% of those studied is

in line with previously published reports on the outcomes following laparoscopic Heller myotomy (LHM) [8]. Limitations of these learning curve analyses include the previously mentioned heterogeneous outcome measures as well as the appropriate exclusion of "difficult" cases during the initial POEM experience at each center.

Measuring EGJ Distensibility During POEM

The functional lumen imaging probe (FLIP), a novel catheter-based test of esophageal function, consists of an 8 cm, compliant balloon that is placed across the LES and can be progressively filled with a saline solution surrounding 17 impedance rings. Utilizing impedance planimetry, the commercially available EndoFLIP (model EF-325N; Crospon Inc., Galway, Ireland) device generates a geometric representation of luminal structures and also includes a solid-state pressure transducer within the balloon. When obtaining measurements with the EndoFLIP at the level of the EGJ, dividing the minimum cross-sectional area by the intra-bag pressure allows the calculation of the EGJ distensibility index (DI). Prior work has shown the EGJ DI to be pathologically low in patients with achalasia and elevated in patients with GERD [9, 10]. During both POEM and LHM, the FLIP can be used to measure stepwise changes in EGJ distensibility following key components of each operation (induction of anesthesia, submucosal tunnel creation/hiatal dissection, myotomy completion and in LHM, construction of a partial fundoplication) [11, 12].

Overall, POEM resulted in a greater increase in distensibility than LHM with a partial fundoplication [12]. Serial measurements of EGJ DI during incremental extension of the esophagogastric myotomy were evaluated to determine the proximal and distal extent necessary to "normalize" distensibility [11]. The greatest increase in EGJ DI during both operations occurred after extension of the myotomy across the EGJ. During LHM, it was observed that proximal extension of the myotomy to 6 cm above the squamocolumnar junction was required to normalize the EGJ DI. The same effect was achieved during POEM with a more limited proximal myotomy. Also during POEM, incremental extension of the distal, gastric myotomy beyond 2 cm below the SCJ did not result in significant additional increases in EGJ DI [11].

The mechanism of distensibility increase following creation of the submucosal tunnel is unclear and may represent only a temporary effect related to CO_2 infiltration of the musculature or disruption of the submucosal tissue architecture, untethering the mucosa. Anecdotally, we have observed increased distensibility driven by both decreases in pressure and increased cross-sectional area following creation of the submucosal tunnel, prior to performing a selective myotomy of the inner, circular muscle layer. Additionally, it is the increase in distensibility resulting from the myotomy that appears to drive symptomatic relief. We have previously shown that the highest rates of "optimal" outcomes following POEM (relief of dysphagia without GERD) are obtained by achieving a final distensibility within the "sweet spot" of 4.5–8.5 mm^2/mmHg [13].

Conclusion

POEM is now an acceptable treatment for esophageal motor disorders which has an initial learning curve of about 20 cases. Beyond the learning curve, comparable results to that of Heller myotomy are expected. Measuring EGJ distensibility is a novel method to ensure an adequate myotomy during POEM and may help surgeons shorten the expected learning curve.

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