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Review Article

Peroral Endoscopic Myotomy (Poem) As A Safe, Effective, And Durable Therapy For Adult Achalasia.

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Abstract

Background: Achalasia cardia is a primary esophageal motility disorder characterized by impaired relaxation of the lower esophageal sphincter (LES) and loss of esophageal peristalsis. Traditional therapies, including pneumatic dilation and laparoscopic Heller myotomy (LHM), offer symptom relief but carry limitations regarding durability and postoperative reflux. Peroral Endoscopic Myotomy (POEM), first introduced in 2008, has revolutionized management through a minimally invasive natural orifice transluminal endoscopic approach.
Objective: To review the current evidence on indications, safety, efficacy, and long-term outcomes of POEM in adult achalasia patients, and to compare its performance with conventional therapies.
Methods: A narrative synthesis of published randomized trials, meta-analyses, and large multicenter studies was performed, focusing on clinical success, manometric outcomes, and adverse event profiles of POEM.
Results: Across major series, POEM achieved >90% clinical success with sustained symptom remission beyond 5–7 years. Significant reductions in LES pressure (20–30 mmHg) were consistently demonstrated. The pooled adverse event rate was 7.5%, with most complications being minor and conservatively managed. Compared to LHM, POEM showed equivalent efficacy and safety with shorter operative time, less blood loss, and faster recovery. However, postoperative reflux occurred in up to 50% of cases, though mostly controlled with proton pump inhibitors.
Conclusion: POEM is an established, safe, and durable treatment for achalasia, offering superior symptom relief and quality-of-life improvement with minimal invasiveness. Its expanding indications to complex and spastic motility disorders, along with comparable long-term efficacy to surgical myotomy, affirm its role as the preferred therapeutic modality for adult achalasia.

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INTRODUCTION

Achalasia cardia is a chronic esophageal motility disorder characterized by impaired relaxation of the lower esophageal sphincter (LES) combined with absent or severely disturbed peristalsis of the esophageal body [1–4]. Patients typically present with progressive dysphagia for solids and liquids, regurgitation, chest pain, weight loss, and sometimes respiratory complications due to aspiration [1–4]. The incidence of achalasia is relatively low, estimated at approximately 1–3 cases per 100,000 persons per year in adults, with prevalence peaking between ages 30 and 60, though cases occur in both younger and older populations [1,4,5]. Etiology is not fully understood. Primary (idiopathic) achalasia appears related to degeneration of inhibitory ganglion cells in the myenteric (Auerbach's) plexus, possibly involving autoimmune and infectious triggers [1,2,4]. Secondary causes (less common) include Chagas disease, infiltrative disorders, or surgical damage [1,2,4].

Diagnosis is established via clinical history, barium swallow imaging (showing esophageal dilation and "bird's beak" narrowing at the esophagogastric junction), endoscopy to exclude obstructing lesions, and, critically, high-resolution esophageal manometry (HREM) [1,2,4,6]. HREM not only confirms absent or ineffective peristalsis and elevated integrated relaxation pressure (IRP), but also allows classification into three achalasia subtypes (I [classic], II [compression], III [spastic]) which have prognostic and therapeutic implications [1,2,4,6].

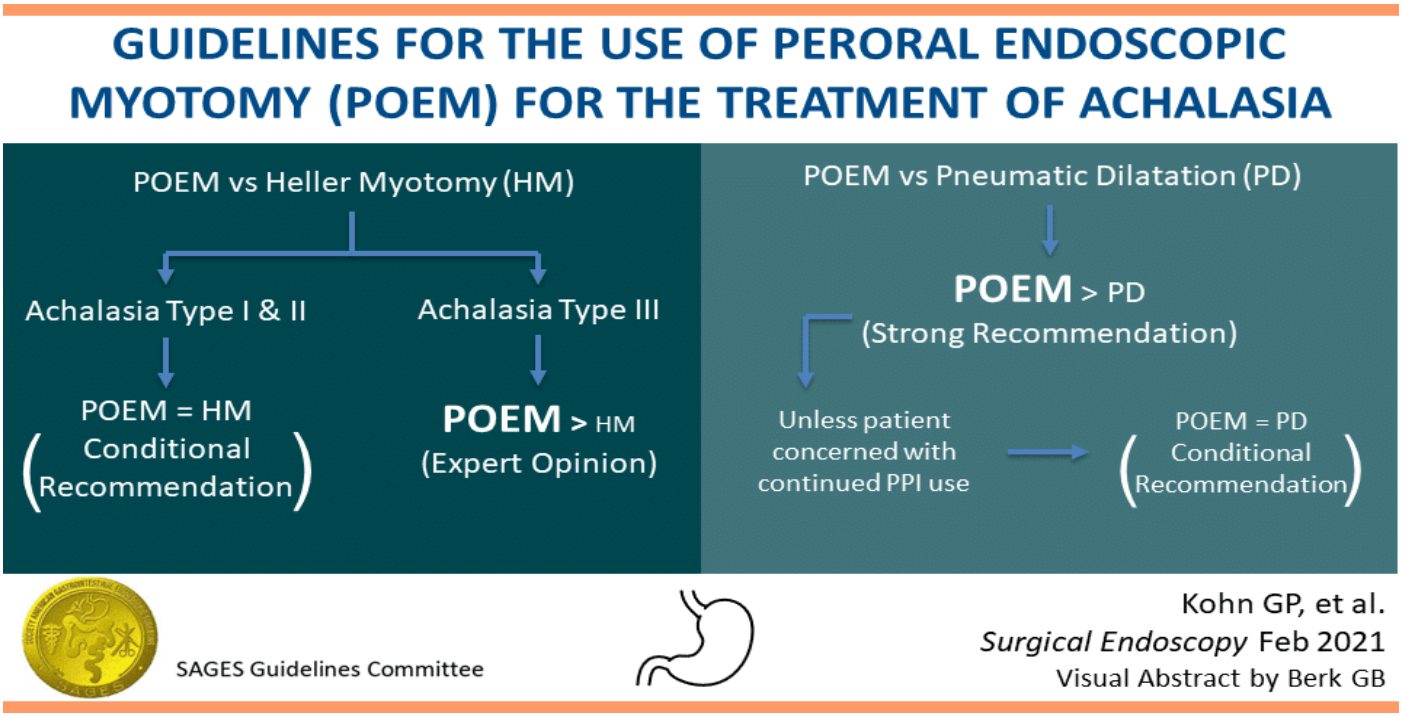
Historically, treatment has been palliative rather than curative, aimed at reducing LES pressure and improving bolus passage. Traditional interventions include pneumatic dilation (PD), laparoscopic Heller myotomy (LHM) often with fundoplication, and botulinum toxin injections. Each has trade-offs: efficacy, durability, invasiveness, risk of complications, and postoperative gastroesophageal reflux disease (GERD) [1,3,4,6,7].

Peroral Endoscopic Myotomy (POEM), first performed in 2008, represents the first successful natural orifice transluminal endoscopic surgery (NOTES) procedure and has since gained global acceptance for achalasia management [8,9]. Its safety, efficacy, and expanding use in spastic motility disorders such as diffuse esophageal spasm and jackhammer esophagus underscore its versatility and durability [8]. POEM is a safe and effective minimally invasive therapeutic option which can substitute surgical myotomy, having a high success rate and a low rate of adverse events in short, medium and long-term [10–18].

POEM has emerged as a novel endoscopic technique whereby a submucosal tunnel is created and an internal myotomy of the LES (and sometimes part of the lower esophageal body) is performed. POEM combines minimal invasiveness of endoscopy with the functional goal similar to surgical myotomy [1,2,4,9].

The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) update suggests that, for adults with achalasia, POEM is a safe and effective treatment; POEM is favored over pneumatic dilation and is comparable to Heller myotomy with fundoplication for many patients, with perhaps a preference toward POEM in subtype III achalasia [6,19–21] as shown in **Figure 1**.

Figure 1. Reproduced from Kohn GP et al (2021). SAGES strongly recommends POEM over pneumatic dilation for achalasia and conditionally favors POEM over Heller myotomy, especially for type III achalasia. [6].



The evolution of procedural modifications, such as posterior wall incision and water-jet–assisted dissection, has expanded POEM's applicability to complex and recurrent cases, underscoring its growing role as a versatile, minimally invasive therapy for achalasia [22]. Recent pooled analyses reinforce that POEM is a safe and effective therapy for achalasia, achieving substantial symptomatic and physiological improvement with low major complication rates [23–27]. Comparative evidence further suggests that POEM offers outcomes equivalent to laparoscopic Heller myotomy, with a trend toward shorter hospitalization, cost effective option and comparable procedural safety [28–33]. A recent meta-analysis emphasized that while POEM has become an established treatment for achalasia, procedural standardization remains lacking, particularly regarding optimal myotomy length [34]. The pooled data suggest an average total myotomy length of approximately 10.4 cm, underscoring the need for consensus and further refinement of technique across achalasia subtype [34]. A study demonstrated that POEM remains feasible and safe even in complex achalasia cases, including those with prior myotomy, multiple treatments, or sigmoid-type esophagus [35,36]. The introduction of the POEM Difficulty Score (PDS) provided a structured way to assess procedural complexity, showing strong correlation with operative time and technical challenges, thus aiding in pre-procedural planning and outcome prediction [35]. Multiple observational studies and systematic reviews suggest that POEM has high technical success rates (>90–95%), marked improvements in symptom scores (Eckardt score), and significant reductions in LES pressure [3,4]. Short- to medium-term safety outcomes are generally favorable, though complications like mucosal perforation, pneumomediastinum, pneumoperitoneum have been described [3,4,7,37,38].

A large international multicenter study involving 1,826 patients confirmed POEM's excellent safety profile, reporting only a 7.5% overall adverse event rate and rare severe complications [39]. Factors such as operator experience, sigmoid-type esophagus, and instrument choice were identified as key predictors of procedural risk [39]. Recent evidence suggests that post-POEM timed barium esophagram (TBE) findings at 3–6 months can effectively predict esophageal emptying and waspiration risk during follow-up endoscopy. A 5-minute barium column height <7 cm and successful tablet passage were strong indicators of adequate post-procedural clearance [40]. Recent evidence suggests that peroral endoscopic myotomy (POEM) achieves comparable clinical and technical success in both Eastern and Western populations, though differences in procedure time and hospital stay exist [41]. Understanding these regional variations can help optimize outcomes and standardize care globally [41]. Comparative data show that POEM offers equivalent clinical efficacy and safety to robotic Heller myotomy while significantly reducing procedural costs [42]. POEM was noninferior to laparoscopic Heller myotomy with Dor fundoplication for symptom control in achalasia at 2 years, though it had a higher rate of reflux esophagitis [43].

Long-term follow-up data demonstrate that POEM provides durable symptomatic relief and improve quality of life with majority of achalasia patients maintaining clinical success [1,2,5,12,13,17,44–53]. However, mild symptom recurrence and reflux-related complications highlight the need for ongoing surveillance post-procedure [12,45–47,49,54,55].

Therefore, this study aims to systematically compare clinical and technical outcomes of POEM in Eastern and Western populations, identifying potential regional variations in efficacy, safety, and procedural parameters. Understanding these differences will help refine patient selection, optimize procedural protocols, and contribute to global standardization of POEM practice.

Indications of Peroral Endoscopic Myotomy (POEM)

Peroral endoscopic myotomy (POEM) has emerged as a versatile and effective therapeutic modality for a broad spectrum of esophageal motility disorders. While idiopathic achalasia remains the absolute indication for POEM, its application has significantly expanded [56]. POEM is indicated for all subtypes of achalasia (Type I, II, and III), as classified by high-resolution manometry (HRM), including complex cases such as tortuous, dilated sigmoid achalasia that are traditionally considered contraindications for surgical myotomy [57–59]. POEM is also suitable for pediatric achalasia and cases complicated by prior Roux-en-Y gastric bypass [60,61]. Importantly, previous failed interventions—such as Heller myotomy, pneumatic balloon dilation, prior POEM, or botulinum toxin injections—do not preclude successful POEM and are not considered contraindications [57–59,62]. Beyond achalasia, POEM has demonstrated efficacy in treating hypertensive esophageal motor disorders, including diffuse esophageal spasm and jackhammer esophagus [58,59,63–66]. Similarly, non-achalasia motility disorders such as EGJ outflow obstruction and nutcracker esophagus have been addressed using POEM techniques [59]. The indications have further evolved to include achalasia with diverticulum and Zenker's diverticulum [60,67]. More recently, cricopharyngeal achalasia , reflecting the procedure's expanding clinical utility and adaptability [68] (**Table 1**).

Table 1. Indications of Per Oral Endoscopic Myotomy (POEM).

1. Idiopathic achalasia [56]
2. Achalasia (Type I, II, and III) [57,59]
3. Sigmoid achalasia [57]
4. Pediatric achalasia [60]
5. Cases complicated by prior Roux-en-Y gastric bypass [67]
6. Previous failed interventions—Heller myotomy, pneumatic balloon dilation, prior POEM, or botulinum toxin injections[57–59,62]
7. DES and Jackhammer esophagus [58,59,63–66]
8. EGJ outflow obstruction and nutcracker esophagus [59]
9. Achalasia with diverticulum [60,67]
10. Cricopharyngeal achalasia [68]
POEM indications have expanded beyond classic achalasia to include complex and secondary esophageal motility disorders.

Contraindications of Peroral Endoscopic Myotomy (POEM)

Peroral Endoscopic Myotomy (POEM) is absolutely contraindicated in patients with significant systemic illnesses that render the administration of general anesthesia or endotracheal intubation unsafe [69]. Likewise, individuals with a history of extensive therapeutic interventions involving the esophageal mucosa—such as wide areas of endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), radiofrequency ablation, or prior radiation therapy—should not undergo POEM due to the increased risk of procedural complications [65]. The presence of a large ulcer in the distal esophagus is also considered an absolute contraindication, as it may compromise the integrity of the esophageal wall during myotomy. Furthermore, severe pre-existing gastroesophageal reflux disease (GERD) is regarded as a relative contraindication. In such cases, laparoscopic Heller myotomy with concomitant fundoplication may be a more appropriate approach, as it offers the advantage of reducing postoperative reflux [59] (**Table 2**).

Table 2. Contraindications of Per Oral Endoscopic Myotomy (POEM)

1. General anesthesia not possible [69]
2. Endoscopic mucosal resection (EMR), Endoscopic submucosal dissection (ESD), Radiofrequency ablation, or Prior radiation therapy [65]
3. Distal esophagus ulcer [59]
4. Severe preexisting GERD [59]
Contraindications are based on procedural safety, mucosal integrity, and patient comorbidities affecting anesthesia tolerance.

DESCRIPTIVE ANALYSIS OF THE POEM PROCEDURE IN ADULTS WITH ACHALASIA

Preoperative preparation and anesthesia considerations

Peroral endoscopic myotomy (POEM) is performed under general anesthesia with endotracheal intubation, ensuring airway protection and controlled intraluminal pressure. Exclusive use of carbon dioxide (CO_2) insufflation is recommended due to its rapid absorption and low risk of mediastinal emphysema or pneumoperitoneum [70].

Preoperative optimization includes a clear liquid diet for 24–48 hours, esophageal lavage in patients with food retention, and administration of broad-spectrum antibiotics before incision [71]. Antiplatelets and anticoagulants are withheld where possible. Recent consensus guidelines emphasize pre-procedural endoscopy to exclude malignancy or severe esophagitis that could alter tunnel planning [70].

Patients are positioned supine or left lateral according to endoscopist preference. Adequate control of CO_2 ventilation and low insufflation pressure minimize hypercarbia and tension phenomena [72].

Endoscopic equipment and setup

A high-definition therapeutic gastroscope with water-jet and CO_2 channels and a transparent distal cap ensures optimal visualization [72].

Commonly used dissection knives include the Triangle-Tip, insulated-tip, Hybrid, and Dual knives. The Hybrid knife, which integrates injection and cutting, enhances procedural efficiency. Comparative analyses show that knife type affects speed and hemostasis rather than long-term outcomes [73].

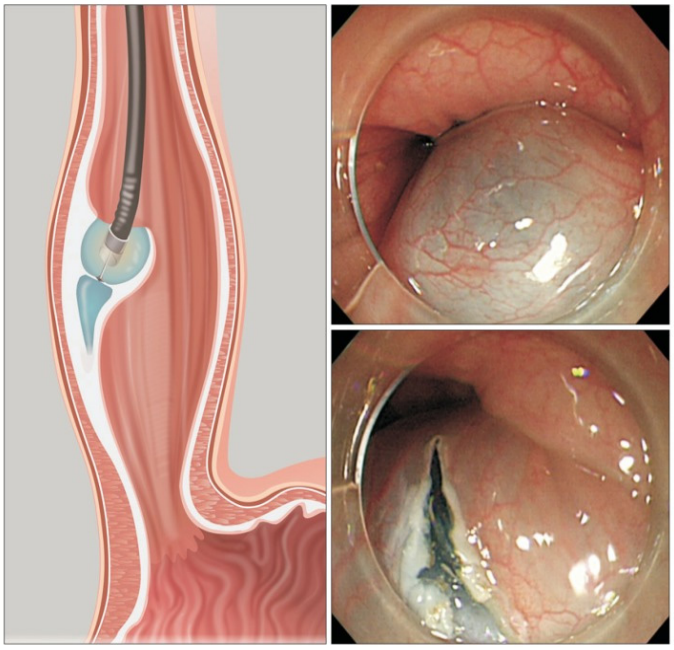
Submucosal injection typically combines saline and dye; adding hydroxyethyl starch prolongs lifting and facilitates safe dissection [74]. Novel visualization aids such as red dichromatic imaging and near-infrared endoscopy may improve submucosal plane identification [75,76].

Mucosotomy: creation of mucosal entry

After identifying the gastroesophageal junction (GEJ), the mucosal incision is typically created approximately 10–15 cm proximal to it [74].

A 1.5–2.5 cm longitudinal mucosotomy provides adequate access for tunneling, and coagulation of visible vessels before incision keeps the field clear. Some operators favor oblique incisions for easier closure, though leak rates are similar (**Figure 2**) [77].

Figure 2. Reproduced from Youn YH et al (2016). Entry to the submucosal space. After submucosal injection of saline and 0.3% indigo carmine mixture, a 2-cm longitudinal mucosal incision is made at the mid-esophagus [78].

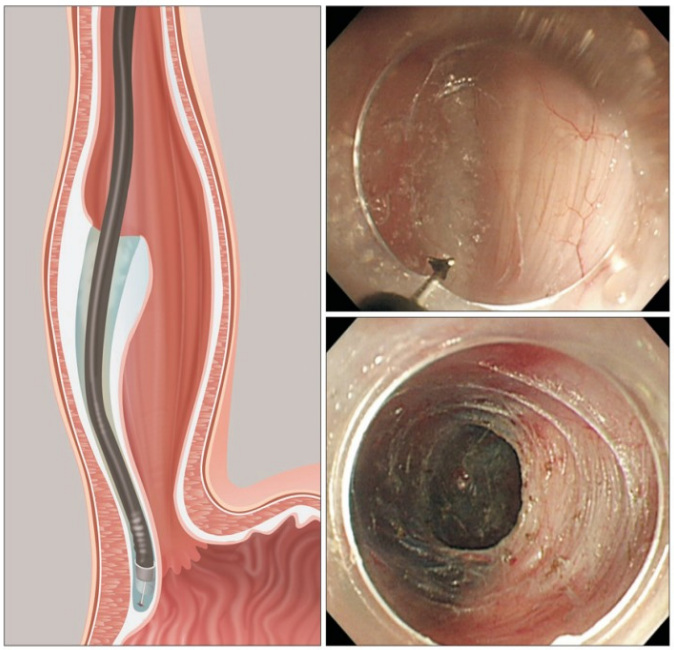


Submucosal tunneling

The submucosal tunnel is created by dissecting the areolar tissue between mucosa and muscularis propria, extending at least 2–3 cm below the GEJ into the gastric cardia to ensure full LES division [79]. The stained blue submucosal layer should remain intact to prevent mucosal injury.

Typical landmarks confirming GEJ traversal include narrowing then widening of the tunnel, visualization of palisading vessels, and a tactile "give-way" sensation. Adjuncts like EndoFLIP or fluoroscopy help confirm distal extension.Published series place the learning-curve plateau for POEM technical efficiency at approximately 20–40 procedures [78], [80]. (**Figure 3**)

Figure 3. Reproduced from Youn YH et al (2016). Submucosal tunneling. A long submucosal tunnel is created 2–3 cm distal to the esophagogastric junction. The circular muscle fibers are oriented perpendicular to the longitudinal axis of the tunnel [78].

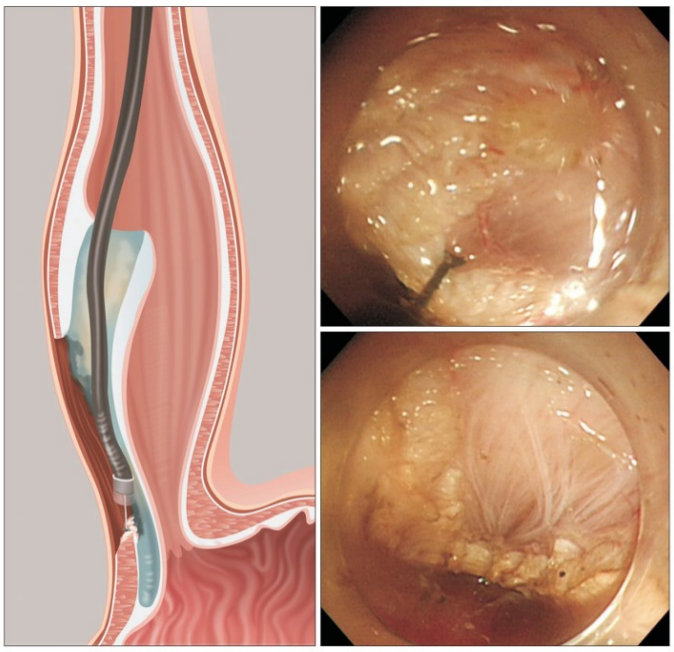


Myotomy techniques and variations

Myotomy begins 2–4 cm distal to the mucosal entry; the circular muscle bundles are cut while sparing the outer longitudinal layer in selective circular myotomy. In patients with muscular hypertrophy or previous myotomy, a full-thickness dissection may be used with similar efficacy [74].

A 2–3 cm gastric extension ensures complete division of the clasp and sling fibers [79]. Full-thickness versus circular myotomy show comparable outcomes, though the former may slightly increase subcutaneous emphysema [81,82] (**Figure 4**).

Figure 4. Reproduced from Youn YH et al (2016). Endoscopic myotomy. The circular muscle bundle is divided 2–3 cm distal to the mucosal entry and extended to 2–3 cm distal to the GEJ, using a triangle-tip knife while preserving the longitudinal layer [78].



Anterior vs posterior orientation

POEM may be performed via an anterior (11–2 o'clock) or posterior (5–6 o'clock) route. Both achieve similar clinical and manometric outcomes [70].Posterior orientation offers a more direct tunnel and may reduce post-procedure acid exposure [83]. Meta-analysis confirms no significant difference in adverse events between orientations, though posterior orientation improves scope maneuverability [84,85].

Myotomy length and subtype-specific tailoring

Myotomy length is guided by achalasia subtype.

For Type I–II, a short (3–4 cm) esophageal and 2 cm gastric myotomy provides optimal balance of efficacy and reflux risk. For Type III (spastic) achalasia, a longer (10–12 cm) myotomy extending proximally is essential [77].Functional imaging and manometry confirm superior outcomes with this tailored approach [79].

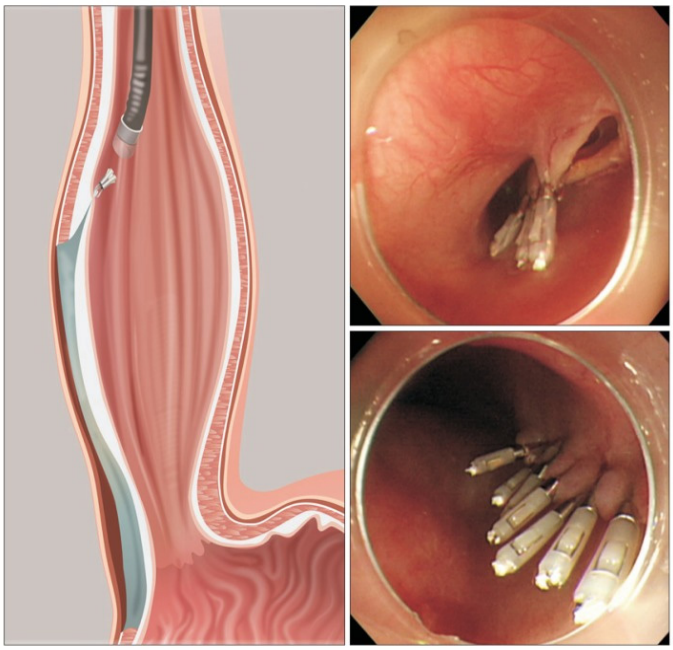
Intra-operative hemostasis and safety

Meticulous hemostasis is critical. Coagrasper forceps in soft-coagulation mode (80 W, effect 4) effectively control submucosal bleeds [79].Capnoperitoneum occurs in up to 20 % but is self-limited with CO_2 insufflation [72]. Some advocate prophylacticdecompressionduringprolongedprocedures[86].

Closure of mucosal entry

After verifying hemostasis, the mucosal entry is sealed to prevent leakage.

Figure 5. Reproduced from Youn YH et al (2016). Closure of the mucosal entry. The mucosal incision at the entry point is completely closed with hemostatic clips [78].



Sequential through-the-scope clips are most common [87]. Endoscopic suturing or over-the-scope clips secure larger openings, while barbed absorbable sutures shorten closure time [88] (**Figure 5**).

Post-operative care and imaging

Patients are monitored for pneumoperitoneum and mediastinal emphysema. A water-soluble contrast esophagram within 24 hours confirms integrity before oral intake [79]. If no leak is seen, liquids advance to soft diet; PPI therapy for 4–8 weeks mitigates reflux. Most patients are discharged in 1–3 days.

Intra-operative adjuncts: the role of EndoFLIP

The Endolumenal Functional Lumen Imaging Probe (EndoFLIP) measures EGJ distensibility in real time, quantifying the distensibility index (DI = CSA / pressure).

It is used pre- and post-myotomy to confirm LES relaxation; EndoFLIP targets are variable across studies — intraoperative post-myotomy DI values reported in the literature cluster around 6–8 mm²/mmHg (mean ≈7.2 mm²/mmHg in several series), and some authors recommend a target range of approximately 4.5–8.5 mm²/mmHg (measured at 40mL balloon volume), while others use relative increases from baseline or lower cutoffs (≈2–3 mm²/mmHg) depending on measurement protocol; therefore EndoFLIP thresholds should be interpreted with the device settings and balloon volume in mind [89,90] . Though optional, EndoFLIP is most useful in complex or revisional cases, supporting objective procedural endpoints [74].

PRIMARY OUTCOMES: EFFICACY OF POEM IN ADULTS

Clinical Success and Symptom Relief

POEM has shown exceptional efficacy in relieving symptoms of achalasia in adults, with multiple studies demonstrating >90% success rates based on the Eckardt score reduction and sustained symptomatic improvement [91,92] (Table 3). Clinical success rates exceeding 90% have been consistently replicated even in community and non-tertiary settings, demonstrating the widespread reproducibility of POEM outcomes [28]. The earliest human series reported a decline in the mean Eckardt score from 10 to 1.3, with 94% of patients achieving clinical remission within 5 months [93]. Subsequent large observational studies confirmed these outcomes, reporting 90–98% short-term clinical success [94–96]. In a North American multicenter study, more than 92% of patients experienced complete symptom relief within 12 months after POEM, highlighting the procedure's global applicability [97]. POEM remains effective even in elderly adults (>70 years), with similar rates of symptom improvement and low adverse event rates compared to younger patients [12] as shown in **Table 3**. Improvement in dysphagia and regurgitation typically occurs within days after the procedure, with marked enhancement in quality of life [98]. Long-term studies further support symptom durability, with 88–92% of patients maintaining relief beyond 3–7 years [96,99].

Manometric and Objective Outcomes

Post-procedure high-resolution manometry reveals a substantial drop in lower esophageal sphincter (LES) pressure and integrated relaxation pressure (IRP), correlating with clinical improvement [92,94]. The seminal work by Inoue et al. (2010) demonstrated a reduction in LES pressure from 52.4 mmHg to 19.9 mmHg, a finding consistently replicated across large cohorts [91,95] .

Mean LES pressure reductions range between 20–30 mmHg, confirming effective myotomy extension into the gastric cardia and adequate sphincter disruption [98,99]. Radiologic studies have also documented improved esophageal clearance and reduced barium column height, validating functional recovery after POEM [95,96].

Long-Term Durability and Recurrence

Durability of response remains one of POEM's major advantages, with sustained clinical success exceeding 85% beyond five years [99]. Recurrence of symptoms is reported in 8–12% of adults, often due to incomplete distal myotomy, disease progression, or sigmoid-shaped esophagus [96,100]. Most recurrent cases can be successfully managed with redo POEM or pneumatic dilation, maintaining long-term remission without the need for surgical conversion [95]. Predictive factors for recurrence include high baseline LES pressure and

type III (spastic) achalasia, highlighting the importance of pre-procedural manometric assessment [92,96].

Quality of Life and Functional Recovery

Beyond clinical remission, POEM markedly improves patients' quality of life, as reflected by better swallowing scores, diet tolerance, and overall functional well-being [94,98]. Postoperative assessments using the Gastrointestinal Quality of Life Index (GIQLI) have shown mean score improvements exceeding 30 points within 6 months [95] (**Table 3**).

Barium esophagram studies demonstrate near-normal transit in the majority of patients after myotomy, while manometric normalization of peristaltic coordination occurs in a significant subset [94,96]. These objective gains strongly align with subjective symptom relief, reinforcing POEM's comprehensive therapeutic efficacy [92,99] (**Table 3**).

Table 3. Summary of Primary Efficacy Outcomes of POEM in Adults.

Study	Year	N	Mean Follow-up (months)	Clinical Success (%)	Δ Eckardt Score	LES Pressure Reduction (mmHg)	Major Findings	Reference
Inoue et al.	2010	17	5	94	8.7 → 1.3	52 → 20	First human POEM study showing safety & efficacy	[93]
Talukdar et al.	2015	1,045	12	93	−7.9	−7.3	Meta-analysis showing consistent short-term efficacy	[91]
Barbieri et al.	2015	551	6	93	—	—	97% technical success, 93% clinical success	[7]
Li et al.	2019	500	12	95	−8.2	−22	Significant manometric and symptomatic improvement	[94]
Bechara et al.	2016	100	18	92	−7.5	−19	Marked radiologic and symptomatic relief	[98]
Tan et al.	2018	234	24	91	−7.4	−20	Sustained efficacy with minimal recurrence	[95]
Shiwaku et al.	2020	210	36	89	−7.1	−22	Recurrence linked to sigmoid-type esophagus	[100]
Zhang et al.	2020	502	84	88	—	−25	Durable efficacy up to 7 years	[99]
Nabi et al.	2022	337	48	92	−7.9	−27	Identified predictors of long-term success	[96]
Huang et al.	2021	>5,000	18	91.3	−7.5	−26	Pooled meta-analysis confirming efficacy	[92]

ΔEckardt Score = Change in Eckardt symptom score (pre- vs. post-procedure; lower scores indicate symptom improvement).
LES Pressure = Lower esophageal sphincter resting pressure measured by manometry.
Clinical Success = Typically defined as post-POEM Eckardt score ≤ 3.
N = Number of patients included in each study.
Mean Follow-up = Average duration of postoperative observation period.
— = Data not reported or not applicable.
POEM = Peroral endoscopic myotomy.

Summary

The accumulated evidence strongly supports POEM as a safe, effective, and durable therapy for adult achalasia. Across prospective cohorts and meta-analyses, clinical success exceeds 90%, with sustained symptom remission extending beyond 5–7 years [91,96,99]. Both Eckardt score reduction and LES pressure normalization consistently validate POEM's physiological efficacy [92,94]. These robust outcomes have established POEM as the gold-standard endoscopic therapy for adult achalasia,

with reproducible success across diverse populations and clinical settings [93,95].

SAFETY: MAJOR AND MINOR ADVERSE EVENTS FOLLOWING POEM IN ADULTS

Peroral Endoscopic Myotomy (POEM) has gained global recognition as an effective endoscopic treatment for achalasia and other spastic esophageal motility disorders. With its minimally invasive nature, attention has increasingly shifted from efficacy to the safety profile, encompassing both intraoperative and postoperative complications. Over a decade of experience has demonstrated that POEM is generally safe, but it is not devoid of adverse events (AEs), which range from mild mucosal injury to rare severe complications requiring surgical intervention [27,93,101].

Incidence of Adverse Events

Meta-analyses and large multicenter cohorts have consistently reported overall AE rates between 3% and 20%, with most being minor and managed conservatively [53,94,101,102]. Nabi et al. (2018) conducted one of the largest pooled analyses showing an overall AE rate of 7.5%, with major AEs occurring in less than 2%[101]. Similarly, Patel et al. (2021) found comparable rates across 2,000+ cases, emphasizing the safety consistency of the procedure across centers[28]. Likewise, other studies reported similar findings from multicenter studies, noting that most adverse events were endoscopically managed, with rare need for surgical conversion[21,95]. Von Renteln et al. (2013) also highlighted the procedure's learning-curve dependency, suggesting complication rates decline after approximately 20–30 cases[27]. As per **Figure 6**, incidence rate of different early and late complications are explained.

Figure 6. Reproduced from Kim and Min (2020). Early and Late Complications of POEM [103].

Early complications	Percentage (%)
Mucosal injury	4.8
Esophageal perforation	0.2
Major bleeding	0.2
Subcutaneous emphysema	7.5
Pneumothorax	1.2
Pneumomediastinum	1.1
Pneumoperitoneum	6.8
Pleural effusion	1.2
Late complications	**Percentage (%)**
Symptomatic GERD	<15
Esophagitis on EGD	28
Abnormal exposure on 24-hour pH study	55

EGD, esophagogastroduodenoscopy; GERD, gastroesophageal reflux disease.

Classification of Adverse Events

Adverse events following POEM are commonly categorized into major and minor according to the American Society for Gastrointestinal Endoscopy (ASGE) lexicon. As per **Table 4** mentioned below, Minor events typically include mucosal injury, subcutaneous emphysema, capnoperitoneum, or pneumomediastinum that do not require invasive treatment, while major events involve perforation, severe bleeding, or mediastinitis requiring additional intervention [100,101] (**Table 4**).

Table 4. Classification and Incidence of Adverse Events after POEM.

Type	Common Adverse Events	Management	Approx. Incidence	References
Minor	Mucosal injury, subcutaneous emphysema, pneumoperitoneum, pneumomediastinum, mild bleeding	Endoscopic closure, conservative management	5–15%	[28,95,101]
Major	Perforation, delayed bleeding, mediastinitis, peritonitis	Surgical or endoscopic intervention, antibiotics	<2–3%	[21,94,102]

Incidence values represent approximate pooled estimates from large series and meta-analyses.
Minor adverse events are defined as events not requiring surgical or intensive intervention and without long-term sequelae.
Mucosal injury usually managed endoscopically with clips or over-the-scope devices.
Subcutaneous emphysema, pneumoperitoneum, and pneumomediastinum typically resolve with conservative management (oxygen therapy, observation, or needle decompression if needed).

INTRAOPERATIVE COMPLICATIONS

Mucosal Injury

Intraoperative mucosal injury remains the most frequently reported complication, occurring in 5–12% of cases [94,101]. Most injuries are minor and can be promptly sealed using endoscopic clips without long-term consequences. Inoue et al. (2011) and Von Renteln et al. (2013) described the importance of careful submucosal tunneling and adequate visualization to minimize these events[27,104].

Bleeding

Bleeding is another notable intraoperative concern, with reported rates around 0.5–2% [97,100]. Endoscopic hemostasis using coagulation forceps, clips, or adrenaline injection is usually sufficient. Rarely, delayed bleeding requiring transfusion or re-intervention may occur [28].

Pneumoperitoneum and Pneumomediastinum

Gas-related events such as subcutaneous emphysema, pneumoperitoneum, and pneumomediastinum are relatively common but typically benign. Incidence varies from 10–15% depending on insufflation method, being lower with CO_2 than air [22,53,94]. Simple needle decompression or conservative observation is adequate in most cases.

POSTOPERATIVE COMPLICATIONS

Pain, Fever, and Inflammatory Changes

Post-procedure pain and transient fever occur in 10–20% of cases and usually reflect minor inflammatory responses rather than infection [95]. Prophylactic antibiotics and anti-inflammatory medications are generally sufficient [28].

Delayed Bleeding and Perforation

Delayed hemorrhage is rare, seen in less than 1% of cases, typically within 48 hours post-procedure [100]. Delayed perforation, although infrequent, can be life-threatening if not recognized early [102]. Prompt imaging and endoscopic closure remain mainstays of management.

Infectious Complications

Mediastinitis and peritonitis are uncommon, with rates <0.5%, usually secondary to unrecognized mucosal breach or leakage [94]. Most can be managed non-surgically with antibiotics and drainage, but surgical consultation is necessary for unstable patients [95].

GAS-RELATED EVENTS AND PREVENTIVE STRATEGIES

Gas insufflation complications have been substantially reduced following the adoption of carbon dioxide (CO_2) insufflation due to its rapid absorption [27,97]. Studies comparing air and CO_2 insufflation have shown markedly fewer cases of pneumoperitoneum and subcutaneous emphysema with CO_2 [53]. The use of controlled insufflators and low-flow settings further minimizes this risk [94].

Long-Term Safety Outcomes

Long-term follow-up data (>5 years) confirm the sustained safety of POEM, with negligible risk of late-onset complications [21,102]. The most discussed long-term issue is gastroesophageal reflux disease (GERD), observed in 20–50% of patients depending on diagnostic criteria [96,102]. Most cases are asymptomatic or controlled with proton pump inhibitors (PPIs). Studies comparing POEM to Heller's myotomy demonstrate similar reflux profiles, suggesting

the risk is inherent to lower esophageal sphincter disruption rather than the approach itself [22].

Predictors of Adverse Events

Experience of the endoscopist, tunnel length, procedure duration, and underlying esophageal morphology have been associated with increased AE risk [28,95]. Complex cases such as sigmoid achalasia or redo procedures carry higher risks [21]. However, high-volume centers demonstrate progressively lower AE rates, supporting centralization of POEM services [94].

Comparison with other treatment options

Several therapeutic approaches exist, including Laparoscopic Heller's Myotomy (LHM), Pneumatic Dilation (PD), and the newer Peroral Endoscopic Myotomy (POEM). Each technique varies in efficacy, safety profile, and procedural invasiveness, making careful comparison essential for optimal patient care. According to Chan et al., 2016, Patients who did LHM had longer mean operative time (P = 0.02), more blood loss (P = 0.001) than POEM. Similarly, they had higher requirement for analgesics (P = 0.009) than those treated by POEM as well [32]. Hence, Comparing to LHM, POEM is a time-efficient surgery. It has shorter operative time, reduced risk of massive blood loss , postoperative recovery time and less incidence of postoperative pain. However, POEM involves complex technical challenges that require advanced endoscopic skills [105]. As for postoperative outcomes, In a Randomized Clinical Trial by Ponds and colleagues (2019), although POEM is more invasive and requires advanced technical endoscopic skills, the risk of severe complications was not higher than with pneumatic dilation. The risk was especially minimal when it was performed by experienced endoscopists. However, in pneumatic dilation, despite the use of the smallest (30-mm) balloon for the initial pneumatic dilation ,the rate of perforations was 1.5% [21]. Comparing the esophageal acid exposure , it was found to be significantly higher in POEM as compared to LHM patients [106]. Despite treatment with proton pump inhibitors, compared to POEM, LHM was more effective in preventing the development of esophagitis. It was due to partial fundoplication [107].

The treatment success rate varied vastly. Some studies suggest that the initial clinical success rate is relatively higher in POEM than LMH [107]. Compared to 92% success rate of POEM, pneumatic dilation had only 76% success rate [108]. There is a better prognosis in treating patients with Chagas disease-affected achalasia and achalasia subtype III with POEM [107]. Among patients with achalasia who are experiencing persistent or recurrent symptoms after LHM, POEM resulted in a significantly higher success rate than PD [109]. Another meta-analysis of POEM vs HM confirmed that short-term outcomes tend to favor POEM [110]. In a randomized clinical trial that included 133 treatment-naive adult patients with achalasia, the treatment success rate which was defined as a reduction in the patient's Eckardt score to less than or equal to 3 and the absence of severe complications or need for re-treatment, conducting 2 years of follow-up was 58 of 63 patients (92%) in the POEM group and 34 of 63 (54%) in the pneumatic dilation group. This was a statistically significant difference [21] POEM, PD and LHM were all effective in improving esophageal function in achalasia at short-term [111]. In a meta-analysis done by Ma et al. (2025), where were 9 studies included with 1099 patients; 583 underwent POEM with a mean follow-up length of 34.2 months. There was no difference in treatment success between POEM and LHM .POEM and LHM have equivalent long-term efficacy [112]. 5-year follow-up data were available for 62 patients in the peroral endoscopic myotomy group and 63 patients in the pneumatic dilation group.50 (81%) patients in the peroral endoscopic myotomy group had treatment success at 5 years, compared with 25 (40%) in the pneumatic dilation group, an adjusted absolute difference of 41% [113].

While POEM demonstrates a higher success rate and fewer adverse effects compared to HM, it is also favored because insurance often covers the procedure, making it more accessible. Over time, POEM proves to be more cost-effective than LHM, thanks to shorter hospital stays, fewer required tests, and a lower risk of complications [105].

DISCUSSION

Over the past decade, POEM has transformed the therapeutic landscape for achalasia by combining endoscopic minimal invasiveness with the efficacy of surgical myotomy. The evidence synthesized in this review underscores its superior clinical outcomes, reproducibility, and durability. Clinical success consistently exceeds 90%, with significant reductions in LES pressure and Eckardt scores across multiple meta-analyses and long-term cohorts [70–75]. Inoue et al. first demonstrated a dramatic fall in LES pressure from 52 mmHg to 20 mmHg with corresponding symptom relief [72], findings later replicated by Talukdar et al. and Huang et al. in large pooled analyses involving thousands of patients [70, 71].

Manometric and objective improvements, including restoration of esophageal clearance and normalization of IRP, further support the physiological effectiveness of POEM [73, 77]. Long-term data extending up to seven years confirm durability, with over 85% of patients maintaining remission and marked improvement in quality-of-life indices [75, 78]. Notably, these benefits are not limited to tertiary centers—community-based series have demonstrated comparable outcomes, highlighting POEM's procedural reproducibility [28, 73].Safety remains one of POEM's strengths. The pooled adverse event rate of 7.5%, with major complications below

3%, reflects excellent safety when performed by experienced operators [80]. Most intraoperative events—such as mucosal injury, bleeding, or CO_2-related emphysema—are minor and managed endoscopically [73, 76, 80]. Adoption of CO_2insufflation and refinement of submucosal tunneling have further reduced procedural risks [27, 53]. International multicenter data involving 1,826 patients reaffirmed these findings, demonstrating low morbidity and no procedure-related mortality [39].

However, postoperative gastroesophageal reflux disease (GERD) remains a notable concern, reported in 20–50% of patientsdependingondiagnosticmodality[75,81].Comparative meta-analyses show that POEM carries a higher reflux incidence than LHM with fundoplication, though the majority of cases are asymptomatic or controlled with PPI therapy [81]. Long-term surveillance via endoscopy and pH monitoring remains essential to prevent reflux-related complications. Comparative effectiveness data suggest that POEM equals or surpasses traditional interventions. Randomized controlled trials and meta-analyses have shown equivalent or superior treatment success relative to LHM, with reduced blood loss, operative time, and hospital stay [1, 2, 32]. Ponds et al. demonstrated a 92% treatment success at 2 years for POEM versus 54% for pneumatic dilation, affirming its superiority in naïve achalasia patients [21]. Similarly, Ma et al. (2025) confirmed equivalent long-term outcomes between POEM and LHM [10]. The economic analyses also favor POEM, citing shorter hospitalization and lower procedural cost while maintaining equivalent efficacy [31, 42].

An additional advantage of POEM lies in its versatility. The procedure's applicability has expanded beyond idiopathic achalasia to include spastic disorders such as diffuse esophageal spasm and jackhammer esophagus, as well as patients with prior failed interventions or surgically altered anatomy [58, 59, 61]. Recent multicenter experiences and the POEM Difficulty Score framework facilitate procedural planning and risk stratification for complex cases [35, 36].

Taken together, current evidence solidifies POEM's position as the first-line therapeutic option for most adults with achalasia. Ongoing research is needed to standardize procedural parameters such as myotomy length, optimize reflux prevention strategies, and compare outcomes across global practice settings [34, 41].

CONCLUSION

Peroral Endoscopic Myotomy (POEM) represents a paradigm shift in the management of adult achalasia. Accumulated evidence confirms that POEM delivers high and durable clinical success, significant physiological improvement, and a favorable safety profile comparable to or exceeding conventional surgical and endoscopic approaches. Its minimally invasive nature, shorter recovery time, and expanding applicability to complex and spastic esophageal disorders further strengthen its clinical utility. While postoperative reflux remains a manageable limitation, the overall risk–benefit ratio strongly favors POEM as the treatment of choice for adult achalasia. Standardization of procedural technique and long-term surveillance will be crucial to maintaining safety and optimizing global outcomes.

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