Achalasia cardia is a rare esophageal motility disorder. Although a primary neurological disorder, the treatment modalities of achalasia are primarily endoscopic or surgical. Pneumatic dilatation (PD) or laparoscopic Heller's myotomy (LHM) have been the mainstay of achalasia management for several decades. With the introduction of third space endoscopy, the endoscopic management of achalasia has revolutionized. Randomized studies have concluded the superiority of per-oral endoscopic myotomy (POEM) over PD. In addition, the short-term outcomes of POEM are similar to LHM. POEM is a relatively new technique and long-term data is eagerly awaited. The main concern after POEM is a high incidence of gastroesophageal reflux disease (GERD) which is found in about half of the patients undergoing this procedure. GERD is higher after POEM when compared to PD and LHM with fundoplication. The management of achalasia should be individualized and based on factors like patient characteristics (age, sex, comorbidities), subtyping on high resolution manometry, patient/doctor preference, and surgical risk of the patient.

Keywords: Dilatation; Esophageal achalasia; Heller myotomy; Per-oral endoscopic myotomy procedure
Table 1 Advantages and Disadvantages of Different Modalities of Treatment of Achalasia Cardia

| Therapy       | Advantage                                                                 | Disadvantage                                                                 |
|---------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Surgical myotomy (LHM) | • Long-term durability • Procedure time - 90 min • Excellent response rate (90%–97% with 3%–10% recurrent dysphagia) | • General anaesthesia required • Higher recovery time - hospital stay for 2–3 days • Cost • GER (2%–26%): minimized with fundoplication |
| PD            | • Most effective non-surgical option • Durability range - 2–5 yr • Short procedure • Can be done on demand | • Risk of perforation (1%–5%) • Advised only in surgically fit candidates (who can be taken for surgery if complication occurs) • Response rate poor in young male (< 40 yr), type III and I achalasia (33% and 63%, respectively) • Relapse in 33%–50% patients |
| POEM          | • Long-term durability comparable to LHM • Minimally invasive - lesser hospital stay • Longer myotomy - useful in type III achalasia and other motility disorders | • Limited availability and technically demanding • High incidence of GER (20%–54%) - can be reduced by concurrent endoscopic fundoplication |
| Medical therapy | • Can be taken as on demand therapy • Minimal risk for candidates with high surgical risk | • Least effective treatment option • Short lasting effect and continuous treatment required • High incidence of adverse effects of medications |
| Esophagectomy | • For end stage disease • For treatment resistant achalasia | • High morbidity and mortality • May develop anastomotic site strictures • Chronic vomiting observed in some patients |
| BT injection  | • Good option for high surgical risk candidates • Short procedure time | • Durability of 6–12 mo • Submucosal injection precludes future definitive therapy |

LHM, laparoscopic Heller’s myotomy; GER, gastroesophageal reflux; PD, pneumatic dilatation; POEM, per-oral endoscopic myotomy; BT, botulinum toxin.

Fig. 1. Steps of pneumatic dilatation. (A) Fluoroscopy picture showing gastroesophageal junction marked (arrow) and guidewire inserted. (B) RIGI FLEX balloon inserted over the guidewire. (C) Balloon inflated and waist appears in the middle of the balloon. (D) Balloon fully inflated and waist disappeared.
In ‘graded approach’ the smallest balloon (30 mm) is used for dilatation initially (35 kPa for 1 minute followed by 55 kPa for 1 minute). Subsequent dilatations are performed using incrementally larger balloons in those with persistent or recurrent symptoms (35 mm after 1–3 weeks, and 40 mm if Eckardt’s score > 3). In cases with late relapse (> 1 year) after completion of graded regimen, repeated dilatations have been shown to be effective in ameliorating the symptoms. In a large, retrospective study, long-term (10 years) response rates were superior with on demand dilatations as compared to single dilatation (90%-50%). However, in patients with persistent symptoms or early relapse (< 1 year) after graded PD alternative options like LHM or POEM should be considered. Some experts perform incremental dilatations on the same or consecutive days until pre-specified manometric (LES pressure < 15 mmHg) or radiographic goals are met. It is important to note that the technique of PD is not standardized making it difficult to compare the outcomes between different studies.

**Predictors of response/failure**

The predictors of good response after achalasia include type II achalasia and age > 40 years. The risk factors for non-response to PD include non-graded dilatation, age < 40 years, pre-existing daily chest pain, and pre-treatment width of the esophagus of < 4 cm. In addition, spastic esophageal motility disorders including type III achalasia, Jackhammer oesophagus, and distal esophageal spasm do not respond well to PD. The different symptoms of achalasia, chest pain responds in only about 50% of the patients.

**PD in special populations (children and prior treatment groups)**

The data on the outcomes of PD in pediatric achalasia are limited. In few studies, good response (success 87%) has been found especially in older children. Of note, the currently available pneumatic balloons have not been specifically designed for use in small children (< 8 years).

The response rate to PD is lower (~50%) in patients with symptom relapse after Heller’s myotomy. Nevertheless, PD has been shown to be a safe procedure in patients with failed myotomy. Similarly, the response to PD is poor (0%-20%) in cases with recurrent symptoms after POEM.

The data is limited regarding the outcomes of PD in pregnant patients. Few case reports have reported successful PD and BT injection in second trimester of pregnancy.

**Complications of PD**

PD dilatation is a safe procedure and major complications are uncommon. The most feared complication associated with PD is perforation which has been reported in 1%-5% of patients. Lower rates of perforation have been reported in studies from high volume centres. The risk factors for perforation after PD include use of larger (> 35 mm) balloon for initial dilatation, old age, and unstable balloon position during PD.

Tachycardia and chest pain persisting > 4 hours should alert the endoscopist about the possibility of perforation. Majority of the perforations after PD can be managed conservatively. However, larger perforations with free flow of barium into mediastinum require surgical repair. For the same reason, PD should be preferably avoided in high surgical risk patients. Other management options include endoscopic closure (over the scope clips, endoscopic suturing, and esophageal stents) and video-thoracoscopic repair.

Gastroesophageal reflux disease (GERD) is uncommon after PD and has been reported in 4%-37% cases. Overall incidence of gastroesophageal reflux is low after PD.

**LHM**

LHM is a widely performed surgical procedure for achalasia cardia. The main advantage of LHM over PD is durable response and reduced requirement of repeated interventions. The technique of Heller’s myotomy has undergone several critical modifications since its initial description by Heller in 1913. These modifications include the development of minimally invasive approach, addition of fundoplication procedure to reduce the incidence of GERD and performing an extended myotomy on gastric side to prevent future recurrences.

Minimally invasive approaches are associated with shorter postoperative pain, and hospital stay as compared to open surgical myotomy. With the availability of minimally invasive surgical options, open surgical myotomy is performed only in exceptional circumstances like in cases with multiple prior surgeries or in those who cannot tolerate a pneumoperitoneum due to severe cardiopulmonary disease. Currently, a laparoscopic approach is preferred as it is associated with a shorter operating time, lower rate of conversion to an open myotomy and shorter hospital stay as compared with thoracoscopic approach.

**Anterior (Dor) or posterior (Toupet) fundoplication**

Partial fundoplication is an essential component of LHM and can be performed anteriorly (Dor fundoplication, 180 degree) or posteriorly (Toupet fundoplication, 270 degree). Both the approaches are equivalent in terms of post-operative dysphagia and reduction in the incidence of GERD. In a randomized controlled trial (RCT), the incidence of GERD was lower in posterior fundoplication group. However, the difference was not statistically significant (21% vs 42%) (Table 2). Therefore, the choice of anterior or posterior fundoplication is largely operator dependent.

**Outcomes of LHM**

LHM has been extensively evaluated for the management of achalasia. In the European achalasia trial, the response rates to LHM at 1, 2, and 5-years are 93%, 90%, and 82%, respectively. In a more recent randomized trial, the clinical success at 2-years was 81.7%. Extended gastric myotomy (3 cm vs 1.5 cm) has been shown to improve success rates and reduce recurrences after LHM. In contrast to non-sigmoid achalasia, the outcomes of LHM in sigmoid achalasia are sub-optimal. The decision to add fundoplication in these cases should be carefully made.

**Adverse events**

The most common complication following LHM is perforation (1%-7%) due to unrecognized mucosal injury during surgery. Some surgeons prefer an anterior fundoplication in these cases as it usually buttresses the repair. GERD has been reported in 2%-26% of cases after LHM with fundoplication. In a meta-analysis, the pooled rate of post-procedure reflux symptoms, abnormal esophageal acid exposure, and esophagitis were 8.8%, 16.8%, and 7.6%, respectively after LHM. The addition of fundoplication procedure to LHM reduces rate of pathological GERD from 47.6% to 9%. Similar reduction in
esophageal acid exposure time has been reported after fundoplication (4.9% to 0.4%).

Other adverse events are rare after LHM and include inadvertent division of vagus nerve (diarrhoea, bloating, early satiety or dumping syndrome) and splenic injury (1%–5%).

**POEM**

POEM is a novel endoscopic procedure for achalasia based on the principles of submucosal endoscopy with mucosal flap safety valve technique. Since its introduction nearly a decade ago by Inoue et al., POEM is among the most widely performed procedures for achalasia.

**Technique of POEM and variations**

POEM is performed with the patient in supine position under general anaesthesia. Contraindications to POEM include coagulopathy, cirrhosis with portal hypertension, severe erosive esophagitis, esophageal submucosal fibrosis (e.g., radiation, endoscopic mucosal resection, radiofrequency ablation), and severe cardiopulmonary diseases.

We have previously described the technique of POEM procedure. In brief, the steps of POEM procedure include mucosal incision, creation of a submucosal tunnel, myotomy, and closure of mucosal incision with multiple clips. The length of esophageal myotomy is decided on the type of achalasia and manometry findings. Long esophageal myotomy is required in cases with type III achalasia. On the other hand, the length of gastric myotomy should be at least 2-cm in all the achalasia sub-types to avoid future recurrences. However, a long gastric myotomy (> 4 cm) should be avoided as it may lead to higher risk of severe erosive esophagitis.

Several variations in the POEM technique have been described in the literature. These include orientation of myotomy (anterior, posterior or greater curvature), length of myotomy (short vs long), and thickness of myotomy (full thickness vs selective circular). All the approaches have similar efficacy with no clinically relevant difference in adverse events or incidence of GERD.

### Table 2 Summary of Landmark Randomized Clinical Trials in Achalasia Cardia Treatment by PD, LHM, and POEM

| Study                  | Comparison                              | n  | Success (%) | Follow-up | Adverse events (%) | GERD (%) | Drawback                                                                 |
|------------------------|-----------------------------------------|----|-------------|-----------|--------------------|----------|--------------------------------------------------------------------------|
| Ponds et al (2019)     | POEM vs PD (30 and 35 mm)               | 67 | 92          | 2 yr      | 0                  | 41       | Only allowed PD up to 35 mm Considered re-dilatation as treatment failure |
| Werner et al (2019)    | POEM vs LHM + Dor fundoplication        | 112| 83          | 2 yr      | 2.7                | 44       | Length of myotomy was not standardized                                  |
| Boeckxstaens et al (2011) | PD vs LHM + Dor fundoplication         | 96 | 86 (2 yr)   | 43 mo     | 4                  | 15       | Follow-up short as effect may decrease over time                        |
| Moonen et al (2016)    | PD vs LHM + Dor fundoplication          | 96 | 82          | 5 yr      | 5                  | 12       | Rigorous PD protocol over 2 yr – only 3rd series of PD within 2 yr of 2nd series considered as failure |
| Khashab et al (2020)   | Anterior vs Posterior POEM              | 73 | 90          | 1 yr      | 11                 | 49       | Re-dilatation required in 25% of PD patients - considered as treatment success |
| Tan et al (2018)       | Anterior vs Posterior POEM              | 31 | 100         | 15.5 mo   | 12.9               | 26.7     | Small number                                                             |
| Ramchandani et al (2018) | Anterior vs Posterior POEM             | 30 | 100% technical success both groups | 6 mo      | 20                 | 16       | Mostly type II achalasia                                                 |
| Richards et al (2004)  | LHM vs LHM + Dor fundoplication        | 21 | Postoperative LES pressure comparable to primary outcome | 6 mo      | None               | 47.6     | Single centre                                                             |
| Rawlings et al (2012)  | LHM + Dor vs LHM + Toupet fundoplication | 36 | Similar symptoms of dysphagia relief | 6–12 mo   | 5.5                | 42       | Small number                                                             |

PD, pneumatic dilatation; LHM, laparoscopic Heller’s myotomy; POEM, per-oral endoscopic myotomy; LES, lower esophageal sphincter; GERD, gastroesophageal reflux disease; NS, not significant.
A novel cautery device (Speedboat-RS2; Creo Medical Ltd., Chepstow, Wales, UK) which uses bipolar radiofrequency energy for cutting and microwave for coagulation has been described in creation of submucosal tunnel in POEM. The use of the device has been described recently for endoscopic submucosal dissection. The advantages of the device is that there is no need to change accessories for submucosal injection (has integrated injection needle) and coagulating vessels, capability of rotation to optimize cutting and coagulation, bipolar cutting and protective hull avoiding injury to muscle and mucosa.

Outcomes of POEM

Over last decade, multiple studies with short- and medium-term follow-up have concluded the safety and efficacy of POEM for achalasia. The technical and clinical efficacy of POEM is > 90% and 80%–90%, respectively. POEM is also effective in patients with a history of prior treatment. The efficacy of POEM in patients with recurrent symptoms after LHM is 81% to 95% in different studies. Majority of the published data depicts the outcome of POEM on short-term follow-up. The efficacy of POEM in studies reporting long-term outcomes is between 80%–90%, suggesting that the response is durable after POEM. The long-term efficacy of POEM remains to be seen in large, prospective studies as these studies are mostly retrospective with only a proportion of patients completing entire follow-up.

A risk score (Zhongshan POEM score) has been proposed based on history of previous treatment, mucosal injury, and clinical reflux to predict risk of failure after POEM based on data from a large cohort (n = 1,538) from Shanghai, China. The patients in the high-risk group were 4 times more likely to encounter clinical failure on follow-up. Another study described high Eckardt score ≥ 9 as a predictive factor for POEM failure.

Adverse events

POEM is a safe procedure with relatively uncommon serious adverse events. Different severity grading systems utilized in the published literature has resulted in considerable heterogeneity in the incidence of adverse events. The incidence of major adverse events in large studies ranges from 0.5% to 3.3%. Insufflation
related events are common during POEM but usually do not translate into clinically significant adverse events. These include subcutaneous emphysema (7.5%), pneumothorax (1.2%), pneumomediastinum (1.1%), and pneumoperitoneum (6.8%).68 The use of CO2, which has a higher diffusion capacity than air has remarkably reduced the occurrence of insufflation related adverse events.69

Mucosal injuries are the second most common adverse events during POEM. Most of them can be identified and managed intraoperatively. A history of submucosal fibrosis, previous myotomy (Heller’s or POEM), mucosal edema, long tunnel (> 13 cm) are predisposing factors for mucosal injury.65 Other adverse events are rarer and include major bleeding, aspiration pneumonia, delayed mucosal barrier failure, mediastinitis, esophageal leaks, and pulmonary like pleural effusion.65 Most of them do not require major surgical intervention and can be managed intraoperatively.

**POEM and gastroesophageal reflux**

GERD is an important long-term adverse event of POEM procedure. Recent studies indicate a high incidence of GERD after POEM. In the published studies, the prevalence of symptoms, reflux esophagitis, and increased esophageal acid exposure after POEM ranges from 17% to 40%, 18% to 65%, and 13% to 58%, respectively.71 The predictors of post-POEM reflux include low integrated relaxation pressure after POEM, female sex, high body mass index (BMI), and the presence of hiatus hernia. However, these predictors need to be validated in large, prospective trials. On the contrary, the technical variations in POEM procedure have no significant impact on the incidence of GERD after POEM.71,72

**Novel techniques to prevent reflux**

Prevention of reflux is the one of the core concerns among the endoscopists performing POEM procedure. Several novel technical modifications have been proposed to reduce the incidence of post POEM GERD. These include avoidance of excess myotomy (> 4 cm) on the gastric side, preservation of sling or oblique fibers during posterior POEM (Fig. 4) and creating a fundoplication wrap

![Fig. 4. Showing technique of preservation of sling fibres by identifying two penetrating vessels (TPV). (A) The boundary between circular and oblique muscles, muscles of gastric cardia identified by TPV. (B) Preservation of sling fibres identifying TPV as the distal end of myotomy.](image)

![Fig. 5. Steps of per-oral endoscopic myotomy with fundoplication. (A) Full-thickness myotomy done along the anterior wall of the submucosal tunnel. (B) Entry into peritoneal cavity. (C) The left lobe of liver and anterior side of stomach is seen. (D) Endoloop fixed with clips to anterior wall of stomach (distal anchor) (proximal anchor at distal end of myotomy site - not shown in picture). (E) By closing endoloop and approximating proximal and distal anchors fundoplication is completed. (F) Endoscopic view shows fundoplication wrap in funds of stomach.](image)
during POEM NOTES-F (natural orifice transluminal endoscopic surgery-fundoplication) (Fig. 5). Of note, the double scope technique provides more accurate estimation of the extent of gastric myotomy and should be utilized whenever feasible. Although appealing, the utility of these novel techniques remains to be seen in randomized trials.76

**Comparison of Different Treatment Modalities (Table 2)**

**PD vs LHM**

LHM is a more durable treatment with less requirement of reinterventions as compared to PD. On the other hand, the efficacy of single session of PD is very low (50%) and re-dilatations are required in about a quarter of patients after graded dilatation. Graded and on demand PD have been found to provide similar efficacy to LHM in the landmark European achalasia trial.77 The efficacy of PD and LHM at 1 year (90% vs 93%), 2 years (86% vs 90%), and 5 years (82% vs 91%) was comparable with no difference in the objective parameters including LES pressure, quality of life, and esophageal acid exposure.10,11 The requirement for re-dilatation was higher in a subgroup of patients less than 40 years of age.10,31

**PD vs POEM**

In a large retrospective study, POEM was more effective than PD in all the sub-types of achalasia. The efficacy of POEM vs PD was 92% vs 51% in type I (P = 0.004), 92.3% vs 59.8% in type II (P = 0.007), and 91.7% vs 55.6% (P = 0.051) in type III achalasia.76 In a multi-center randomized trial comparing POEM with PD, treatment success was achieved in 92% of patients in POEM group as compared to 54% of patients in the PD group at two-years follow-up. On the other hand, reflux esophagitis was significantly more frequent after POEM as compared to PD (41% vs 7%).77 These studies suggest that POEM is more effective than PD at least in short-term follow-up. Of note, PD in the above RCT was limited to 1–2 dilatations (30-mm and 35-mm). The second dilatation was performed only if there was an inadequate symptom or physiologic response. This is in contrast to conventional graded dilatation protocol from 30 to 40 mm until symptom relief. Inclusion of 40 mm balloon may have improved the success rate from 54% to 76%. Also repeat dilatations due to recurrence of symp-toms were considered as treatment failure. This might explain the lower success rates of PD in this study (85%–90% success rate at 2 to 5-year in earlier studies).77

**POEM vs LHM**

The comparison between LHM and POEM is limited to one randomized trial and multiple small nonrandomized studies. A meta-analysis consisting of 74 cohort studies with more than 7,000 patients concluded that POEM results in higher rate of dysphagia relief (93.5% vs 91% at 1 year and 92.7% vs 90% at 2 years, both statistically significant) than LHM. However, the follow-up was longer in the LHM group (41.5 vs 16.2 months).78 In the only published randomized trial, POEM (112 patients) was compared to LHM plus Dor’s fundoplication (109 patients). Clinical success at the 2-year follow-up was similar in both the groups (83.0% vs 81.7%). Serious adverse events occurred in 2.7% of patients in the POEM group and 7.3% of patients in the LHM group. Reflux esophagitis was higher in the POEM group (44% vs 29%).79 POEM and LHM appear comparable in efficacy with higher reflux rates after POEM.

**Individualized Approach to Achalasia: One Size Does Not Fit All**

Achalasia cannot be cured with the currently available treatment options which are directed at reducing LES pressures. A finite proportion of cases do relapse on follow-up irrespective of the treatment modality used. Presently, there are three effective treatment options for achalasia cardia i.e., PD, POEM, and LHM. The choice between these three is based on patient characteristics like age and co-morbidities, type of achalasia, available expertise and patient’s preference (Fig. 6). The best candidates for PD are those older than 40 years and those with type II achalasia. Type I and III achalasia do not respond well as compared to type II achalasia. For young and type I achalasia patients, either POEM or LHM are initial choices due to suboptimal results with PD. For type II AC, either of PD or LHM or POEM can be done. For type III AC, POEM with long myotomy followed by LHM should be the initial choices. On failing therapy, re-do PD/POEM/LHM can be done. Resistant cases can be subject to esophagectomy. CT, computed tomography; EUS, endoscopic ultrasonography; POEM, per-oral endoscopic myotomy; LHM, laparoscopic Heller’s myotomy; PD, pneumatic dilatation.

![Fig. 6](https://example.com/achalasia-algorithm.png)

**Fig. 6.** Current management algorithm of achalasia cardia (AC). AC is divided into 3 types based on high resolution manometry. High surgical risk cases can be considered for botulinum toxin (BT) injection. For young and type I achalasia patients, either POEM or LHM are initial choices due to suboptimal results with PD. For type II AC, either of PD or LHM or POEM can be done. For type III AC, POEM with long myotomy followed by LHM should be the initial choices. On failing therapy, re-do PD/POEM/LHM can be done. Resistant cases can be subject to esophagectomy. CT, computed tomography; EUS, endoscopic ultrasonography; POEM, peroral endoscopic myotomy; LHM, laparoscopic Heller’s myotomy; PD, pneumatic dilatation.
Achalasia (63% vs 33% vs 90%). The possible requirement of repeated dilatations and small risk of perforation (10%–30%) should be conveyed to the patients. Graded dilatation followed by on demand dilatation is the standard of care and anything less is likely to give sub-optimal results with PD. Both LHM and POEM are effective modalities with fewer requirement for re-interventions (Table 3). LHM and POEM should be preferred over PD in young patients (< 40 years) and those with spastic esophageal motility disorders. Since there is no difference in efficacy (type I and II achalasia), the choice between these two is largely determined by the available expertise and the treating physician or surgeon’s preference. POEM may be preferred over LHM in type III or spastic achalasia and in those with spastic esophageal motility disorders. The ability to perform long esophageal myotomy is the reason for better response rates with POEM as compared to LHM in spastic esophageal motility disorders. Similarly, POEM is more efficacious than PD in patients with prior Heller’s myotomy. In patients with relapse of symptoms after POEM, re-do POEM and LHM may be superior to PD. The major drawback of POEM is limited data on outcomes during long-term follow-up and a high incidence of GERD. LHM should be preferred to POEM in patients with high risk of post-POEM reflux like those with concomitant hiatal hernia and high BMI. On the contrary, LHM has been shown to be effective in long-term and the incidence of reflux is significantly lower than POEM. The risk of GERD and possible need to stay on proton pump inhibitors for long-term should be discussed with the patient while contemplating POEM procedure. At this point, POEM may be avoided in pediatric age group as they may be exposed to acid exposure for more years of which the consequences are not well-known.

**Conflicts of Interest**

No potential conflict of interest relevant to this article was reported.

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**References**

1. Reynolds JC, Parkman HP. Achalasia. Gastroenterol Clin North Am. 1989;18:223-55.
2. Spiess AE, Kahrilas PJ. Treating achalasia: from whalebone to laparoscope. JAMA. 1998;280:638-42.
3. Boeckxstaens GE, Zaninotto G, Richter JE. Achalasia. Lancet. 2014;383:83-93.
4. Wang L, Li YM, Li L. Meta-analysis of randomized and controlled treatment trials for achalasia. Dig Dis Sci. 2009;54:2303-11.
5. Biasotti G, Anness V. Review article: pharmacological options in achalasia. Aliment Pharmacol Ther. 1999;13:1391-6.
6. Kadakia SC, Wong RK. Graded pneumatic dilation using Rigiflex achalasia dilators in patients with primary esophageal achalasia. Am J Gastroenterol. 1993;88:344-8.
7. Ghoshal UC, Kumar S, Sarawat VA, Aggarwal R, Misra A, Choudhuri G. Long-term follow-up after pneumatic dilation for achalasia cardia: factors associated with treatment failure and recurrence. Am J Gastroenterol. 2004;99:2304-40.
8. Zehrf B, Théict V, Rici F, Benajah DA, Message I, Lamouliatte H. Repeated pneumatic dilations as long-term maintenance therapy for esophageal achalasia. Am J Gastroenterol. 2006;101:892-7.
9. Eckardt VF, Göckel I, Bernhard G. Predictors of outcome for achalasia: late results of a prospective follow up investigation. Gut. 2004;53:629-33.
10. Boeckxstaens GE, Anness V, des Varannes SB, Costantini M, Cuttitta A, et al. Pneumatic dilation versus laparoscopic Heller’s myotomy for idiopathic achalasia. N Engl J Med. 2011;364:1807-16.
11. Moonen A, Anness V, Belmans A, Bredennou AJ, Bruley des Varannes S, Costantino M, et al. Long-term results of the European achalasia trial: a multicentre randomised controlled trial comparing pneumatic dilation versus laparoscopic Heller myotomy. Gut. 2016;65:732-9.
12. Karamanolis G, Sguores S, Kazantzis G, Papadopoulou E, Vassiliadis K, Stefanidis G, et al. Long-term outcome of pneumatic dilation in the treatment of achalasia. Am J Gastroenterol. 2005;100:270-4.
13. Elliott TR, Wu PI, Fuentelba S, Szczesniak M, de Carle DJ, Cook LJ. Long-term outcome following pneumatic dilation as initial therapy for idiopathic achalasia: an 18-year single-centre experience. Aliment Pharmacol Ther. 2013;37:1210-9.
14. Hulsbermans M, Vanuytsel T, Degré T, Siffrin D, Coeomsans W, Lerut T, et al. Long-term outcome of pneumatic dilation in the treatment of achalasia. Clin Gastroenterol Hepatol. 2010;8:30-5.
15. what are the benefits of following the guidelines for treating patients with achalasia? Aliment Pharmacol Ther. 2013;37:1210-9.
16. Eckardt VF, Göckel I, Bernhard G. Predictors of outcome in patients with achalasia treated by pneumatic dilation. Gastroenterology. 1992;103:1732-8.
17. Hirano N, Sasaki O, Sato M, Hida T, Miyazawa H, Yamaoka Y. Long-term outcome of pneumatic dilation in the treatment of achalasia. Gastroenterol Hepatol. 2010;8:30-5.
18. Csendes A, Braghetto I, Hernández A, Cortés C. Late results of a prospective randomised study comparing pneumatic dilation and oesophageomyotomy in patients with achalasia. Gut. 1989;30:299-304.
19. van Hoeij FR, Ponds FA, Werner V, Stormbach JM, Fockens P, Bastiaensen MA, et al. Management of recurrent symptoms after per-oral endoscopic myotomy in achalasia. Gastrointest Endosc. 2018;87:95-101.
20. Fiest TC, Foong A, Chokhavatia S. Successful balloon dilation of achalasia during pregnancy. Gastrointest Endosc. 1993;39:810-2.
21. Neubert ZS, Stickle ET. Bridging therapy for achalasia in a second trimester pregnant patient. J Fam Med Prim Care. 2019;8:289-97.
22. Lynch KL, Pandolfini JE, Howden CW, Kahrilas PJ. Major complications of pneumatic dilation and Heller myotomy for achalasia: single-center experience and systematic review of the literature. Am J Gastroenterol. 2012;107:1817-25.
23. Borotto E, Gaudric M, Danel B, Samama J, Quartier G, Chassande S, et al. Risk factors of oesophageal perforation during pneumatic dilation for achalasia. Gut. 1996;39:12-9.
24. Metman EH, Lagasse JP, d’Alteroche L, Picon L, Scotto B, Barbieux JP. Risk factors for immediate complications after progressive pneumatic dilation for achalasia. Am J Gastroenterol. 1999;94:279-85.
25. Nair LA, Reynolds JC, Parkman HP, Ouyang A, Strom BL, Rosato EF, et al. Complications during pneumatic dilation for achalasia or diffuse esophageal spasm. Analysis of risk factors, early clinical characteristics, and outcome. Dig Dis Sci. 1993;38:1893-404.
26. Lo AY, Surick B, Ghazi A. Nonoperative management of esophageal perforation secondary to balloon dilation. Surg Endosc. 1997;11:529-32; discussion 513.
27. Elhassour A, Dufman M, Sunny J, Said S, Cooper CJ, Alkhatib H, et al. Esophageal perforation post pneumatic dilation for achalasia managed by esophageal stenting. Am J Case Rep. 2013;14:512-5.
28. Sanaka MR, Raja S, Ithota PN. Esophageal perforation after pneumatic dilation for achalasia: successful closure with an over-the-scope clip. J Clin Gastroenterol. 2016;50:267-8.
29. Nathanson IK, Gortley D, Smithers M, Braniček F. Videofluoroscopic primary re-pair of early distal oesophageal perforation. Aust N Z J Surg. 1993;63:399-403.
30. Novais PA, Lemme EM. 24-h pH monitoring patterns and clinical response after achalasia treatment with pneumatic dilation or laparoscopic Heller myotomy. Aliment Pharmacol Ther. 2010;32:1475-67.
31. Vela MF, Richter JE, Khandwala F, Blackstone EH, Wachberger D, Baker ME, et al. The long-term efficacy of pneumatic dilation and Heller myotomy for the treatment of achalasia. Clin Gastroenterol Hepatol. 2006;4:580-7.
32. Heller E. Extra mucous cardiopathy in chronic cardiac uspasium with dilation of the esophagus (extramukose cardiaplastik mit dilatation des oesophagus). Mitt Grenz- Med Chir. 1913;27:141-8.
33. Oelschlager BK, Chang I, Pellegrini CA. Improved outcome after extended gastric myotomy for achalasia. Arch Surg. 2001;136:490-5; discussion 495-7.
34. Richards WO, Torquati A, Holzman MD, Khaitan L, Byrne D, Lutfi R, et al. Heller myotomy versus Dor fundoplication for achalasia: a prospective randomized double-blind clinical trial. Ann Surg. 2004;239:405-12; discussion 412-5.
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oral endoscopic myotomy as salvation technique post-Heller: international experi-
ence. Dig Endosc. 2018;30:52-6.

61. Zhang X, Modayil RJ, Friedel D, Gurram KC, Brathwaite CE, Taylor SL, et al. Per-
oral endoscopic myotomy in patients with or without prior Heller’s myotomy: comparing long-term outcomes in a large U.S. single-center cohort (with videos). J Gastrointest Endosc. 2017;15:741-9.e3.

62. Li QL, Wu QN, Zhang XC, Xu MD, Zhang W, Chen SY, et al. Outcomes of peroral endoscopic myotomy for treatment of esophageal achalasia with a median follow-
up of 49 months. Gastrointest Endosc. 2018;87:1405-12.e3.

63. Gap H, Yarot H, Zhang X, Wang L, Lv Y, Zou X, et al. Long-term outcomes of peroral endoscopic myotomy for patients with achalasia: a retrospective single-
center study. Dis Esophagus. 2017;30:1-6.

64. Tettelbaum EN, Dunst CM, Reavis KM, Sharaiha AM, Ward MA, DeMeester SR, et al. Clinical outcomes five years after POEM for treatment of primary esophageal motility disorders. Surg Endosc. 2018;32:421-7.

65. He C, Li M, Lu B, Ying X, Gao C, Wang S, et al. Long-term efficacy of peroral en-
doscopic myotomy for patients with achalasia: outcomes with a median follow-
up of 36 months. Dig Dis Sci. 2019;64:803-10.

66. Liu XY, Cheng J, Chen WF, Liu ZQ, Wang Y, Xu MD, et al. A risk-scoring system to predict clinical failure for patients with achalasia after peroral endoscopic myotomy. Gastrointest Endosc. 2020;87:972-85.

67. Ren Y, Tang X, Chen Y, Chen F, Zou Y, Deng Z, et al. Pre-treatment Eckardt score is a simple factor for predicting one-year peroral endoscopic myotomy failure in patients with achalasia. Surg Endosc. 2017;31:3234-41.

68. Nabi Z, Reddy DN, Ramchandani M. Adverse events during and after peroral end-
oscopic myotomy: prevention, diagnosis, and management. Gastrointest Endosc. 2018;87:874-17.

69. Ramchandani M, Nageshwara Reddy D, Darisetty S, Kotla R, Chavan R, Kalapala R, et al. Posterior endoscopic myotomy for achalasia cardia: treatment analysis and follow up of over 200 consecutive patients at a single center. Dig Endosc. 2016; 28:19-26.

70. Wang Y, Liu ZQ, Xu MD, Chen SY, Zhong YS, Zhang YQ, et al. Clinical and endo-
doscopic predictors for intraprocedural mucosal injury during peroral endoscopic myotomy. Gastrointest Endosc. 2019;89:769-78.

71. Nabi Z, Ramchandani M, Reddy DN. Peroral endoscopic myotomy and gastro-
esophageal reflux: what we have learned from the treatment of more than 700 pa-
tients. J Gastrointest Endosc. 2019;38:287-94.

72. Shimawaki H, Inoue H, Sasaki T, Yamashita K, Ohimia T, Takeno S, et al. A pro-
spective analysis of GERD after POEM on anterior myotomy. Surg Endosc. 2017;31:3242-9.

73. Inoue H, Ueno A, Shimawaki Y, Chiu PWY, Sato H, Ikeda H, et al. Outcomes of peroral endoscopic myotomy for treatment of esophageal achalasia: a single centre experience. Ann Surg. 2020;264:786-93.

74. Wohler A, Evans SRT. Laparoscopic esophagomyotomy with Dor fundoplication. J Thorac Cardiovasc Surg. 2004;128:1320-4.

75. Khashab MA, Sethi A, Rosch T, Repici A. How to perform a high-quality peroral endoscopic myotomy? Gastrointest Endosc. 2019;80:1044-50.

76. Shiwaku H, Inoue H, Sasaki T, Yamashita K, Ohmiya T, Takeno S, et al. A pro-
nominal single-blinded clinical trial. Gastrointest Endosc. 2020;91:288-97.e7.

77. Ponds FA, Fockens P, Lei A, Neuhaus H, Beyna T, Kandler J, et al. Effect of peroral endoscopic myotomy method preserving oblique muscle using two penetrat-
ing vessels as anatomic landmarks reduces postoperative gastroesophageal reflux. J Gastroenterol Hepatol. 2019;34:2158-63.

78. Kim GH, Jung KW, Jung HY, Kim MJ, Na HK, Ahn JY, et al. Superior clinical outcomes of peroral endoscopic myotomy compared with balloon dilation in all achalasia subtypes. J Gastroenterol Hepatol. 2019;34:659-65.

79. Scholtmann F, Luckett DJ, Fine J, Shaheen NJ, Patt M, Larg descriptive. J Neurogastroenterol Motil. 2011;17:48-53.

80. Kumbhari V, Tieu AH, Omumara M, El Zein MH, Tettelbaum EN, Ujiki MB, et al. Peroral endoscopic myotomy (POEM) vs laparoscopic Heller myotomy (LHM) for the treatment of type III achalasia in 75 patients: a multicenter comparative study. Endosc Int Open. 2015;3:E195-201.

81. Rohlf WJ, Salvador R, Annesy V, Bruyé des Varannes S, Chaussade S, Costantini M, et al. Outcomes of treatment for achalasia depend on manometric subtype. Gastroenterology. 2011;144:718-25; quiz e13-4.

82. Campos GM, Vittinghoff E, Rahil C, Takata M, Gademütteler M, Lin F, et al. En-
doscopic and surgical treatments for achalasia: a systematic review and meta-
analysis. Ann Surg. 2009;249:45-57.