Diseases of the Esophagus (2018) **32**, 1–9
DOI: 10.1093/dote/doy105

DISEASES OF THE ESOPHAGUS

ISDE The International Society for Diseases of the Esophagus

Review

Pneumatic dilation versus laparoscopic Heller's myotomy in the treatment of achalasia: systematic review and meta-analysis based on randomized controlled trials

P. Bonifácio, D. T. H. de Moura,* W. M. Bernardo, E. T. H. de Moura, G. F. A. Farias, A. C. M. Neto, M. Lordello, N. Korkischko, R. Sallum, E. G. H. de Moura

Gastroenterology Department, Endoscopy Unit, Hospital das Clínicas, School of Medicine, University of São Paulo, São Paulo, Brazil

SUMMARY. **Achalasia is a primary esophageal motor disorder with a variety of causes. It is most common in Central and South America, where Chagas disease is endemic. In addition to the infectious etiology, achalasia can be idiopathic, autoimmune, or drug induced. It is an incurable, progressive condition that destroys the intramural nerve plexus, causing aperistalsis of the esophageal body and impaired relaxation of the lower esophageal sphincter. The literature on the treatment of achalasia comparing pneumatic dilation (PD) and laparoscopic Heller's myotomy (LHM) shows conflicting results. Therefore, a systemic review and meta-analysis are needed. A systematic review and meta-analysis of randomized controlled trials of PD and LHM, based on the preferred reporting items for systematic reviews and meta-analyses recommendations, was presented. The primary outcome was symptom remission based on the Eckardt score. Secondary outcomes were lower esophageal sphincter pressure (LESP), gastroesophageal reflux (GER), and perforation. A total of four studies were included in this analysis. The total number of patients was 404. Posttreatment symptom remission rates did not differ significantly between LHM and PD at 2 years (RD = 0.03, 95% CI [−0.05, 0.12], $P = 0.62$), or 5 years (RD = 0.13, 95% CI [−0.12, 0.39], $P = 0.32$). The posttreatment perforation rate was lower for LHM (RD = 0.04, 95% CI [−0.08, −0.01], $P = 0.03$). There was no significant difference in terms of LESP or GER. For the treatment of esophageal achalasia, LHM and PD were found to be similar in terms of their long-term efficacy, as well as in terms of the posttreatment GER rates. However, the perforation rate appears to be lower when LHM is employed.**

KEY WORDS: **esophageal achalasia, esophagus, laparoscopy, meta-analysis, systematic review.**

INTRODUCTION

Achalasia is a primary esophageal motor disorder with a variety of causes. It has an incidence of 0.03–1.63/100,000 population and a prevalence of approximately 0.01%, with no difference between genders.[1–5] It is most common in Central and South America, where Chagas disease is endemic. In addition to the infectious etiology, achalasia can be idiopathic, autoimmune, or drug induced.[6] It is an incurable, progressive condition that destroys the intramural nerve plexus, causing aperistalsis of the esophageal body and impaired relaxation of the lower esophageal sphincter (LES). The diagnosis of achalasia is based on clinical suspicion, medical history, radiography, and esophageal motility testing.[7]

*Address correspondence to: Diogo Turiani Hourneaux de Moura, MD, MSc, PhD, Division of Gastroenterology, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, Rua Ana Vieira de Carvalho, 362, casa 15, CEP: 05679-065, São Paulo/SP, Brazil. Email: dthmoura@hotmail.com

Specific author contributions: Priscila Bonifácio, Diogo Turiani Hourneaux de Moura, Wanderlei Marques Bernardo, Eduardo Turiani Hourneaux de Moura, Marina Lordello, and Nadia Korkischko conceived and designed the study, acquired, analyzed and interpreted the data, performed the statistical analysis, prepared the illustrations, and drafted the manuscript. Galileu Ferreira Ayala Farias and Antônio Coutinho Madruga Neto performed the major review. Rubens Sallum and Eduardo Guimarães Hourneaux de Moura provided administrative, technical and material support, supervised the study, and critically revised the manuscript for important intellectual content. PRISMA 2009 Checklist statement: Yes.
Conflicts of interest: The authors declare that they have no conflict of interest.

Consequently, patients with achalasia develop progressive dysphagia, as well as experiencing retrosternal pain, regurgitation, and weight loss.[8]

Due to the unknown pathogenesis and evolving characteristics of achalasia, the treatment is palliative. Current treatment modalities include pharmaceutical therapy, such as the use of calcium channel blockers; surgical interventions, such as myotomy and esophagectomy; and endoscopic procedures, such as botulinum toxin injection into the LES, pneumatic dilation (PD), and peroral endoscopic myotomy (POEM)—although there is as yet no consensus regarding the gold standard, the determinants of a good response, or the long-term results of the various modalities.[9,10]

In 1913, Heller performed the first surgical myotomy; in the 1950s, other authors (Dor, Toupet, and Pinotti) began to include the use of partial fundoplication because some patients presented postoperative gastroesophageal reflux (GER).[11] The first laparoscopic myotomy was conducted by Shimi *et al.*[12] Comparative studies of open and laparoscopic surgical access have found no significant differences between the two in terms of the occurrence of dysphagia, although hospital stays and recovery times have been shown to be shorter among patients undergoing laparoscopic surgery.[13]

The first attempts to treat achalasia through dilation of the gastric cardia involved the use of prototypes based on Hurst's pneumatic balloon (1898) or Plummer's hydrostatic model (1908), the objective being the distention and separation of the circular muscle fibers in the region of the LES. Various models of balloons were manufactured, such as the Gottstein, Sippy, Einhorn, Tucker, Brown–McHardy, Rider–Moeller, Correia Neto, and Pinotti dilators. In 1970, Witzel created the first balloon attached to the endoscope, which allowed through-the-scope balloon dilation. Notable among the physical characteristics of these balloons is their high compliance, that is, their great capacity to deform in a nonuniform manner. That increases the risk of perforation of healthy tissues because the balloon attains its greatest diameter (distension) in the areas of least resistance. With the advent of low-compliance balloons, complication rates were minimized, especially regarding perforations, given that such balloons present low deforming capacity and uniform distention throughout, although the technical success of dilation is similar to that of the more compliant balloons.[13–20]

Although PD of the gastric cardia is an effective method, the dysphagia-free duration has varied across studies and the procedure has been associated with a theoretical higher risk of GER than is open surgery.[13–20] In the last five years, a new endoscopic procedure, POEM, has come to be widely used. The POEM procedure was devised by Ortega *et al.*[21] in 1981 and standardized by Inoue *et al.*[22] in 2010. Although there was a recent systematic review about this topic,[23] it has biases in the study selection, which justifies the development of the current review.

OBJECTIVES

The objective of this review is to determine the efficacy of PD and LHM in the treatment of achalasia. The primary outcome was symptom remission. Secondary outcomes were changes in lower esophageal sphincter pressure (LESP), GER, and perforation.

METHODS

The methods of our analysis and the inclusion criteria were based on the preferred reporting items for systematic reviews and meta-analyses recommendations.[24] The protocol has been registered in the PROSPERO database (Registration no. CRD42016047796).

Searches of the literature

We attempted to identify all randomized controlled trials (RCTs) comparing PD and LHM for the treatment of achalasia, published up to June 2018 and available in at least one of the following databases: MEDLINE, Scopus, the Latin-American and Caribbean Health Sciences Literature, the Brazilian Virtual Library of Health, and the Cochrane Central Register of Controlled Trials. In all databases, we used the following search terms: *(esophageal achalasia OR megaesophagus OR achalasia OR cardiospasm) AND (endoscopic OR endoscopy)*. In addition, we conducted hand searches of the bibliographical references of the articles identified.

Study selection

The preliminary selection of articles was based on the reading of the titles and abstracts. The articles were selected on the basis of the following criteria: study design (RCT), study population (patients recently diagnosed with achalasia, confirmed by contrast-enhanced radiological study of the esophagus, stomach, and duodenum, as well as upper gastrointestinal endoscopy and esophageal manometry, who were eligible for LHM and PD), study intervention (PD), comparison group (LHM with fundoplication), and outcomes measures.

Inclusion and exclusion criteria

In our analysis, we included all prospective RCTs that compared PD and LHM, in terms of their efficacy in the treatment of achalasia. We set no limits or restrictions regarding date of publication or patient ages. Studies involving the use of PD with a high-compliance balloon were excluded.

Improvement of symptoms (dysphagia, retrosternal pain, regurgitation, weight loss, and food impaction) was defined as showing a posttreatment Eckardt score ≤3 or reporting a subjective improvement in dysphagia (one episode a week, without weight loss or food impaction). The development of GER was defined as a pH < 4 (>4.5% of the time) in 24-hour pH-metry. Among patients undergoing PD, perforation was defined as complete rupture of the muscle layers, whereas it was defined as rupture of the esophageal mucosa among the patients undergoing LHM.

Data extraction

Two independent reviewers extracted the data from the databases mentioned, confirming the studies initially selected for inclusion in the meta-analysis. Differences of opinion during the data extraction or analysis were brought before a scientific methodology discussion group in order to obtain a consensus. The following data were extracted from the selected articles: first author, year of publication, country of origin, total sample size and subgroup size (PD vs. LHM), eligibility criteria, dysphagia evaluation scale, definitions of treatment success, and outcome measures, development of GER, occurrence of adverse events, LESP, symptom improvement, methodologies of the procedures to be compared, type of allocation, blinding, randomization, follow-up, and description of losses.

Risk of bias

We assessed each potential bias individually using the Jadad scale, which evaluates the following factors: randomization, blinding, and reporting of dropouts/withdrawals.[25]

Statistical analysis

For the meta-analysis of the outcome measures, we used the Review Manager software, version 5.3.5 (RevMan 5; Cochrane Collaboration, Oxford, UK). For dichotomous outcome measures, we calculated the risk difference (RD), using the Mantel–Haenszel method, with a confidence interval of 95% (95% CI). For continuous outcome measures, we calculated the mean difference, using the fixed effects model and inverse variance weighting, also with 95% CIs. We also evaluated the heterogeneity among the studies, expressed as the I^2 statistic. If the I^2 was >50%, we attempted to adjust it by performing a sensitivity analysis if a publication bias (outlier) was identified, as evidenced by asymmetry on Egger's regression test. When the I^2 was ≤ 50% in funnel plots, we used the fixed effects model, whereas, when it was >50% in the funnel plots, we accepted the hypothesis of heterogeneity and adopted the random model. Sensitivity analysis was used only when the I^2 was >50%. Forest and funnel plots were used for the graphic analysis of the results.

RESULTS

Nine RCTs were selected, of which two (Csendes *et al.*[26] and Félix *et al.*[27]) were excluded because they involved the use of high-compliance balloons and were performed with open Heller myotomy. Of the seven remaining articles,[28-34] three articles[28,32,33] demonstrated the longer follow-up results of other three included studies[30,31,34] published with shorter follow-up and because of that were excluded from the meta-analysis. We only included the articles with longer follow-up in our study. Therefore, the final sample comprised four[28,29,32,33] studies (Fig. 1), collectively involving 404 patients. All of the selected studies used graded PD, advancing from a 30-mm balloon to a 35-mm balloon, occasionally using 40-mm balloons with slightly different criteria. The main characteristics of the selected articles are shown in Table 1, and the individual risks of bias are shown in Table 2.

Among the articles selected, publication dates ranged from 2007 to 2016. All of the studies were conducted at centers in Europe, Canada, or Brazil. Dysphagia, the primary symptom of achalasia, was evaluated using different scales. The duration of follow-up was variable and, when possible, was analyzed for each subgroup, as was symptom improvement. As for the quantitative evaluation, the Jadad score was between 2 and 3 in all of the studies. Intention-to-treat analysis was performed in all of the studies.

Improvement of symptoms

Data on remission rates following PD and LHM were reported in all selected studies. Those data were available for 2 years after treatment in two studies,[28,32] and for 5 years after treatment in two studies.[32,33]

Two studies[28,32] reported symptom improvement at 2 years after treatment (Fig. 2): 116 of the 156 participants in the LHM group were in remission, compared with 103 of the 145 participants in the PD group. The difference was not statistically significant (RD = 0.03, 95% CI [−0.05, 0.12], $P = 0.62$).

Two studies[32,33] reported symptom improvement at 5 years after treatment (Fig. 3): 111 of the 130 participants in the LHM group were in remission, compared with 97 of the 124 participants in the PD group. The difference was not statistically significant (RD = 0.13, 95% CI [−0.12, 0.39], $I^2 = 80\%$, $P = 0.32$).

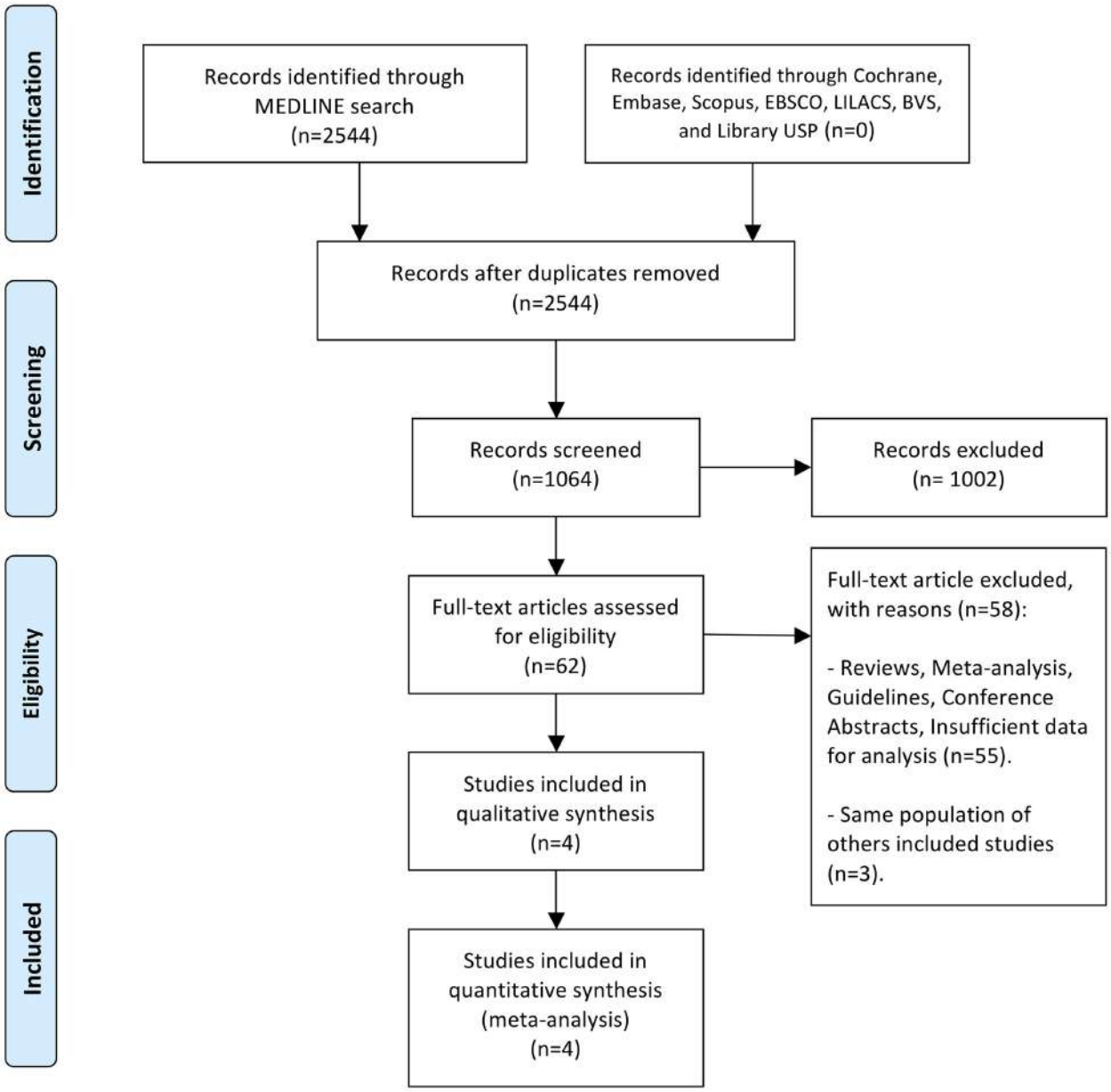

Fig. 1 Study flow diagram.

Perforation

Four studies[28,29,32,33] included data on perforation of or injury to the esophageal mucosa (Fig. 4). The perforation rate in the LHM group was 0.9% (2 of 206) and 5.1% (10 of 196) in the PD group. The perforation rate was significantly lower for LHM than for PD (RD = −0.04, 95% CI [−0.08 to -0.01], $I^2 = 0\%$, $P = 0.03$).

GER

Three studies[28,29,32] evaluated the posttreatment development of GER (Fig. 5). The reflux rate in the LHM group was 19% (33 of 173) and 21.2% (21 of 99) in the PD group. The meta-analysis showed no significant difference between PD and LHM for the development of GER (RD = −0.02, 95% CI [−0.25, 0.21], $I^2 = 82\%$, $P = 0.88$).

LESP

Three studies[28,29,32] provided complete data related to the posttreatment values for LESP (Fig. 6). The remaining studies showed LESP data only in subgroups, in absolute values, in medians, or in figures and therefore could not be included in the analysis. In the articles by Borges *et al.*,[28] Hamdy *et al.*,[29] and Moonen *et al.*,[32] there was a reduction of LESP after treatment, both in the LHM and PD group, with

Table 1 Characteristics of the randomized controlled trials included in the systematic review and meta-analysis

References	Country	PD	LHM	Age of the patients in the sample		Follow-up
		N	*N*	PD	LHM	
Moonen *et al.*[32]	Multicenter (Europe)	96	105	46.4 ± 15.6	45.7 ± 14.3	5 years
Hamdy *et al.*[29]	Egypt	25	25	30.8	32	1 years
Persson *et al.*[33]	Sweden	28	25	46 ± 18	43 ± 14	5 years
Borges *et al.*[28]	Brazil	50	50	52.8 ± 12.3	45.8 ± 14	2 years

LHM, laparoscopic Heller's myotomy; PD, pneumatic dilation.

Table 2 Evaluation of the risk of bias (Jadad scale)

Study	Jadad scale item					
	Randomization	Appropriate randomization	Blinding	Appropriate blinding	Withdrawals and dropouts reported	Total
Moonen *et al.*[32]	YES	YES	NO	NO	YES	3
Hamdy *et al.*[29]	YES	YES	NO	NO	YES	3
Persson *et al.*[33]	YES	NO	NO	NO	YES	2
Borges *et al.*[28]	YES	YES	NO	NO	YES	3

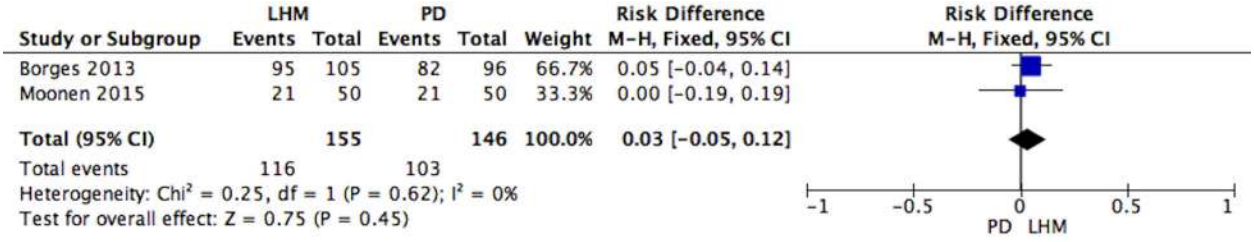

Fig. 2 Meta-analysis of symptom improvement at 2 years after treatment for achalasia: pneumatic dilation (PD) versus laparoscopic Heller's myotomy (LHM).

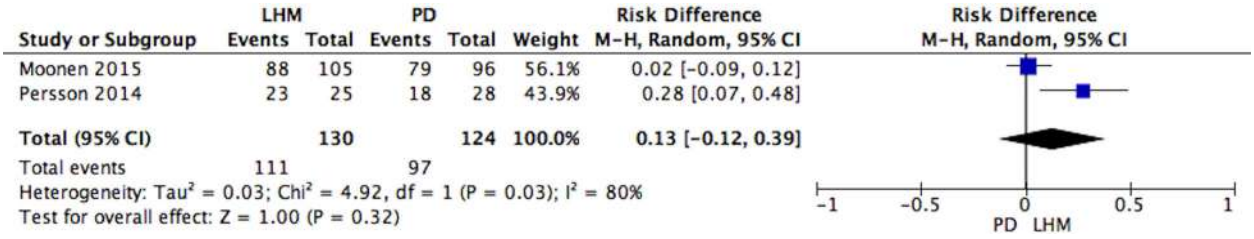

Fig. 3 Meta-analysis of symptom improvement at 5 years after treatment for achalasia: pneumatic dilation (PD) versus laparoscopic Heller's myotomy (LHM).

the following pre- and postprocedure values. In the LHM group: 27.8 to 15.2, 39.8 to 11.04 and 30.5 to 10.2, respectively. In PD group: 29.9 to 14.7, 37.4 to 16.01, and 33.4 to 14.1, respectively. The meta-analysis showed no significant difference among the three studies (mean difference = −2.99, 95% CI [−6.03 to 0.06], an $I^2 = 81\%$, $P = 0.05$).

DISCUSSION

For many years, achalasia has been treated mainly through the use of the PD technique because the technique does not require hospitalization, as well as because of its wider availability and lower cost in comparison with other methods.[31] However, LHM with fundoplication continues to be the gold standard for minimizing the posttreatment risk of GER. Because PD was initially performed with high-compliance balloons, which deformed unevenly, with greater expansion above and below the area of highest resistance, there was a high risk of perforation of healthy tissues; the pneumatic balloons were subsequently improved, and low-compliance models are currently used.[15]

Previous studies have shown that LHM is superior to PD, with higher success rates and lower recurrence rates, as well as lower reoperation rates.[10,35–42] Nevertheless, LHM can result in complications, such as incomplete myotomy, postmyotomy fibrosis, mucosal

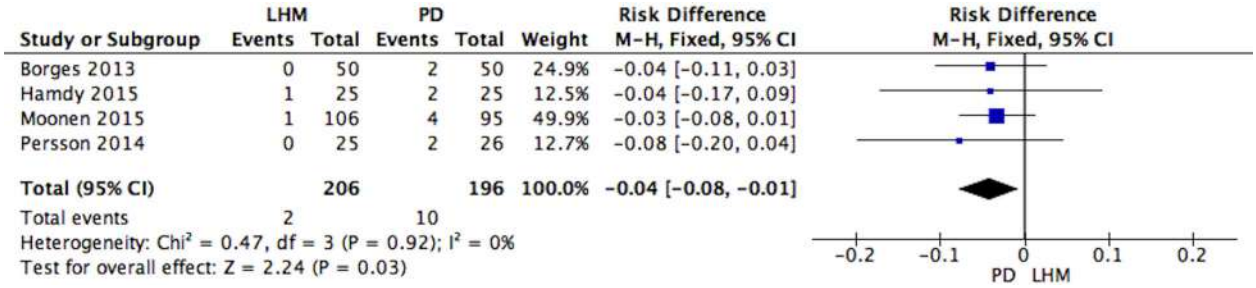

Fig. 4 Meta-analysis of perforation after treatment for achalasia: pneumatic dilation (PD) versus laparoscopic Heller's myotomy (LHM).

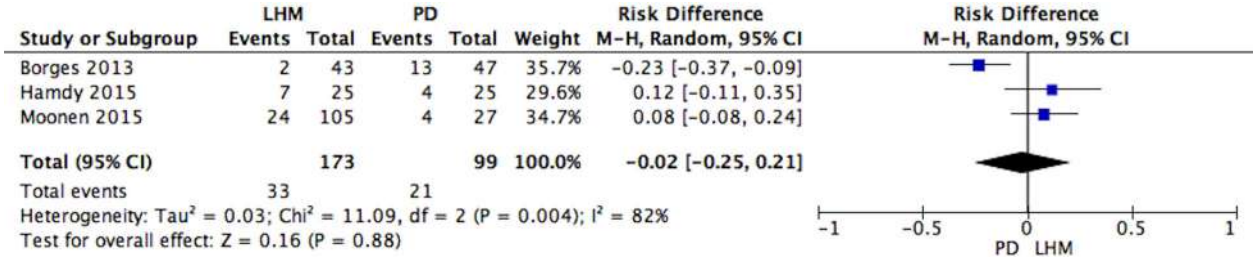

Fig. 5 Meta-analysis of gastroesophageal reflux (GER) after treatment for achalasia: pneumatic dilation (PD) versus laparoscopic Heller's myotomy (LHM).

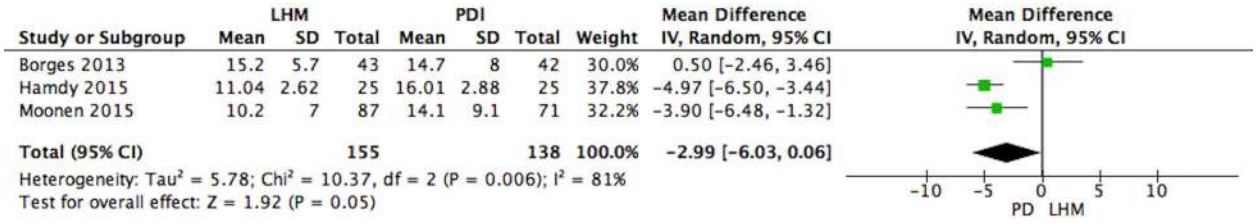

Fig. 6 Meta-analysis of lower esophageal sphincter pressure (LESP) after treatment for achalasia: pneumatic dilation (PD) versus laparoscopic Heller's myotomy (LHM).

perforation during the procedure, and late GER due to fundoplication failure.

It is difficult to prove superiority of one achalasia treatment method over another because the prevalence of the disease is low, there have been few RCTs of such treatments, and long-term results are scarce. There are many factors complicating this analysis. For LHM, such factors include the differences among the various myotomy techniques, the various types of fundoplication (partial, total, anterior, posterior, etc.), the positioning of the fundoplication, the tightness of the closure of the esophageal hiatus. For PD, the complicating factors include the type of balloon (pneumatic or hydrostatic; high- or low-compliance), the balloon diameter (30, 35, or 40 mm), the need for fluoroscopic guidance, the degree of balloon inflation (partial or total), the duration of inflation, and the standard for discontinuing the balloon distention, such as manifestation of pain or equalization of the balloon diameter (i.e. loss of balloon constriction at the LES) seen on fluoroscopy.

When a new systematic review and meta-analysis is proposed, it is aimed at addressing fundamental questions, in order to standardize reproducible methods among specialists, given that analysis errors and differences across studies in terms of the inclusion and exclusion criteria can lead to misconceptions that can affect daily clinical practice. In this context, the intention of this article was to settle such issues, minimize differences, and clearly present the existing controversies. The relevance of the topic should be highlighted. Although POEM is a new technique and has been used successfully in the treatment of achalasia, it has low reproducibility and there is a lack of long-term results regarding its efficacy.

Among the techniques available, PD and LHM are undoubtedly those most often used by specialists. The selection of the four articles analyzed in this review was in perfect harmony with the abovementioned principles, the techniques and methodology being similar among the studies. This review showed that LHM is not superior to PD regarding symptom

improvement in the long-term control of symptoms, based on the Eckardt score.[43,44]

It is noteworthy that the surgical indications for the use of the Heller technique in Latin-American countries differ slightly from those applied in the United States and Europe. In South America in particular, considerable weight is given to the morphological aspect of the esophagus, as evaluated in contrast-enhanced radiologic examinations. In addition, the advanced form of achalasia, resulting from Chagas disease, which is especially prevalent in Brazil, is not seen on other continents.

In the diagnosis of achalasia, radiologists employ the four-grade classification system proposed by Ferreira-Santos.[45] In Latin America, Ferreira-Santos grades I and II are indications for PD as well as for LHM. Endoscopic treatment is not indicated in grade III achalasia, and the recommendation for cases of grade IV achalasia is esophagectomy. It is possible that some of the patients with grade III achalasia included in this meta-analysis had received endoscopic treatment, which would represent a bias. It should be borne in mind that the abovementioned concept is not unanimously accepted.

It is noteworthy that the dilation standard used in the selected studies was maximum balloon distension, regardless of the manifestations of pain or the loss of balloon constriction at the LES. It is therefore likely that many of the patients were dilated beyond their needs and that some cases of perforation were attributable to excessive distension of the balloon. However, there are still differences of opinion regarding the balloon diameter to be used and the number of sessions required. At our facility, a PD session is typically initiated with a 30-mm balloon, under fluoroscopic guidance, with analysis of the loss of balloon constriction at the LES. If such loss is observed, the procedure is interrupted; otherwise, a 35-mm balloon is subsequently employed in the same session. A 40-mm balloon is used only rarely because of the high risk of perforation. The evaluation of the clinical result is based on resolution of the dysphagia and weight gain, as assessed with the Eckardt Score.[44] If a second dilation session is needed, it is conducted 30–45 after the first and only after esophageal manometry has been performed in order to determine whether the previous dilation session had any effect on the LESP. The studies evaluated in this review, despite not showing these criteria clearly, had the objective of achieving a marked improvement in or complete resolution of dysphagia.

None of the studies included in our review reported surgical complications that could alter the morbidity and mortality associated with LHM, as well as the early and late technical success of the procedure, such complications including incomplete myotomy, fibrosis, pronounced closure of the diaphragmatic pillars, and spleen damage, as well as migration, rotation, or detachment of the fundoplication. The gold standard for the detection of GER (24-hour pH-metry) was employed in three of the studies included in this meta-analysis.[28,29,32] The remaining studies evaluated GER with a subjective instrument (a visual analog scale), in which the patient was asked about the intensity and frequency of retrosternal pain and regurgitation. Therefore, our meta-analysis showed no difference between the methods.

In the analysis of the efficacy of the methods, esophageal manometry allows their impact on the LESP to be evaluated through comparison of the post-treatment values. Esophageal manometry was performed in three of the studies evaluated, no statistically significant difference being observed between PD and LHM in terms of the LESP.

In terms of posttreatment complications, there is little information on any complications other than perforation. Perforation after PD has been reported, as has perforation of the esophageal mucosa during LHM. The data analyzed here reveal a significant difference between the two methods, the perforation rates being significantly lower for LHM than for PD. The study published by Moonen *et al.*,[32] which included a greater number of patients than did any of the other studies evaluated and showed no significant difference between the methods, had a considerable impact.

It was not possible to perform a meta-analysis of some important outcomes, such as quality of life, cost, and re-treatment. We were unable to perform a meta-analysis to compare the results of quality of life because only two RCTs measured it and those two studies used different instruments. Cost-effectiveness analysis was not performed in the present review because cost was assessed in only two studies. However, one of those studies showed that the cost of PD (US$228) was lower than was that of LHM (US$580) and the difference was significant ($P = 0.0001$), although the authors did not report the variation or standard deviation.[29] In other study, the cost per patient during the first 60 months was $13,215 after LHM, compared with $5247 after PD ($P = 0.0001$).[33] Persson *et al.*[33] reported that 25% of patients treated with PD required retreatment after a median follow-up of >6 years.

Another systematic review of RCTs, conducted in 2017 by Cheng *et al.*,[23] demonstrated the superiority of LHM in the control of short-term symptoms and the equivalence of LHM and PD in the control of long-term symptoms, as well as a lower rate of adverse events in LHM, although the authors found no statistical difference between the two methods in terms of the occurrence of GER and LESP. The main criticism of that study was that two of the RCTs included used the same participants but had different follow-up periods: Borges *et al.*[28] published follow-up data only for the first 3 months after treatment, whereas Novais and Lemme[34] published follow-up data for 3 months,

1 year, and 2 years after treatment. Cheng *et al.*[23] used the data from the two studies to analyze the improvement of symptoms in 3 months, perforation rate, and recurrent GER.

Because of its practicality and satisfactory results, PD with a low-compliance balloon continues being an option for the treatment of achalasia.

CONCLUSIONS

For the treatment of esophageal achalasia, LHM and PD were found to be similar in terms of their long-term efficacy, as well as in terms of the posttreatment GER rates. However, the perforation rate appears to be lower when LHM is employed.

References

1 Fei L, Rossetti G, Moccia F *et al.* Definition, incidence and etiology: what's new in the 21st century? Ann Ital Chir 2013; 84: 489–94.
2 Vaezi M F, Pandolfino J E, Vela M F. ACG clinical guideline: diagnosis and management of achalasia. Am J Gastroenterol 2013; 108: 1238–49.
3 Moonen A J, Boeckxstaens G E. Management of achalasia. Gastroenterol Clin North Am 2013; 42: 45–55.
4 Moonen A, Boeckxstaens G. Finding the right treatment for achalasia treatment: risks, efficacy, complications. Curr Treat Options Gastroenterol 2016; 14: 420–8.
5 de Moura E T H, de Moura E G H. Endoscopic pneumatic dilatation and peroral endoscopic myotomy in dilated megaesophagus. Mini-invasive Surg. 2017; 1: 148–52.
6 Herbella F A, Aquino J L, Stefani-Nakano S *et al.* Treatment of achalasia: lessons learned with Chagas' disease. Dis Esophagus 2008; 21: 461–7.
7 Vaezi M F, Felix V N, Penagini R *et al.* Achalasia: from diagnosis to management. Ann NY Acad Sci 2016; 1381: 34–44.
8 Marinello F G, Targarona E M, Balagué C, Monés J, Trías M. Surgical treatment of achalasia: better than dilations? Gastroenterol Hepatolo 2009; 32: 653–61.
9 Allaix M E, Patti M G. What is the best primary therapy for achalasia: medical or surgical treatment? Who owns achalasia? J Gastrointest Surg 2013; 17: 1547–9.
10 Pandolfino J E, Gawron A J. Achalasia: a systematic review. JAMA 2015; 313: 1841–52.
11 Rezende J M. Caminhos da Medicina. História da cirurgia da acalasia do esôfago e do megaesôfago chagásico. Rev Estudos da Universidade Católica de Goiás 2006; 33: 213–50.
12 Shimi S, Nathanson L K, Cuschieri A. Laparoscopic cardiomyotomy for achalasia. J R Coll Surg Edinb 1991; 36: 152–4.
13 Ancona E, Anselmino M, Zaninotto G *et al.* Esophageal achalasia: laparoscopic versus conventional open Heller-Dor operation. Am J Surg 1995; 170: 265–70.
14 Felix V N, Sakai P, Cecconello I, Pinotti H W. Esophageal endoscopic aspects after forceful dilation of the gastric cardia in patients with achalasia of Chagas' disease. Dis Esophagus 2000; 13: 91–95.
15 Becker K, Biesenbach S, Erckenbrecht J F, Frieling T. Effect of balloon compliance on symptomatic success of pneumatic dilation in achalasia patients. Z Gastroenterol 2001; 39: 831–6.
16 Ayoubi M, Framarin L, Solerio E, Rosina F, Bonardi L. Achalasia. Minerva Gastroenterol Dietol 2003; 49: 167–72.
17 Min Y W, Lee J H, Min B H, Kim J J, Rhee P L. Association between gastroesophageal reflux disease after pneumatic balloon dilatation and clinical course in patients with achalasia. J Neurogastroenterol Motil 2014; 20: 212–8.
18 Ruiz C P, Hervás M A J, Jurado G J *et al.* Dilatación neumática en el tratamiento de pacientes con acalasia. Gastroenterol Hepatol. 2013; 36: 508–12.
19 Dağli U, Kuran S, Savaş N *et al.* Factors predicting outcome of balloon dilatation in achalasia. Dig Dis Sci 2009; 54: 1237–42.
20 Boztas G, Mungan Z, Ozdil S *et al.* Pneumatic balloon dilatation in primary achalasia: the long-term follow-up results. Hepatogastroenterology 2005; 52: 475–80.
21 Ortega J A, Madureri V, Perez L. Endoscopic myotomy in the treatment of achalasia. Gastrointest Endosc 1980; 26: 8–10.
22 Inoue H, Minami H, Kobayashi Y *et al.* Peroral endoscopic myotomy (POEM) for esophageal achalasia. Endoscopy 2010; 42: 265–71.
23 Cheng J W, Li Y, Xing W Q, Lv H W, Wang H R. Laparoscopic Heller myotomy is not superior to pneumatic dilation in the management of primary achalasia: conclusions of a systematic review and meta-analysis of randomized controlled trials. Medicine (Baltimore) 2017; 96: e5525.
24 Liberati A, Altman D G, Tetzlaff J *et al.* The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Ann Intern Med 2009; 151: W65–94.
25 Jadad A R, Moore R A, Carroll D. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 1996; 17: 1–12.
26 Csendes A, Braghetto I, Henríquez A, Cortés C. Late results of a prospective randomised study comparing forceful dilatation and oesophagomyotomy in patients with achalasia. Gut 1989; 30: 299–304.
27 Felix V N, Cecconello I, Zilberstein B, Moraes-Filho J P, Pinotti H W, Carvalho E. Achalasia: a prospective study comparing the results of dilatation and myotomy. Hepatogastroenterology 1998; 45: 97–108.
28 Borges A A, Lemme E M, Abrahao L J *et al.* Pneumatic dilation versus laparoscopic heller myotomy for the treatment of achalasia: variables related to a good response. Dis Esophagus 2014; 27: 18–23.
29 Hamdy E, El Nakeeb A, El Hanfy E *et al.* Comparative study between laparoscopic Heller myotomy versus pneumatic dilatation for treatment of early achalasia: a prospective randomized study. J Laparoendosc Adv Surg Tech A 2015; 25: 460–4.
30 Boeckxstaens G E, Annese V, des Varannes S B *et al.* Pneumatic dilation versus laparoscopic Heller's myotomy for idiopathic achalasia. N Engl J Med 2011; 364: 1807–16.
31 Kostic S, Kjellin A, Ruth M *et al.* Pneumatic dilatation or laparoscopic cardiomyotomy in the management of newly diagnosed idiopathic achalasia. Results of a randomized controlled trial. World J Surg 2007; 31: 470–8.
32 Moonen A, Annese V, Belmans A *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.
33 Persson J, Johnsson E, Kostic S, Lundell L, Smedh U. Treatment of achalasia with laparoscopic myotomy or pneumatic dilatation: long-term results of a prospective, randomized study. World J Surg 2015; 39: 713–20.
34 Novais P A, Lemme E M. 24-h pH monitoring patterns and clinical response after achalasia treatment with pneumatic dilation or laparoscopic Heller myotomy. Aliment Pharmacol Ther 2010; 32: 1257–65.
35 O'Connor J B, Singer M E, Imperiale T F, Vaezi M F, Richter J E. The cost-effectiveness of treatment strategies for achalasia. Dig Dis Sci 2002; 47: 1516–25.
36 Yaghoobi M. Treatment of patients with new diagnosis of achalasia: laparoscopic Heller's myotomy may be more effective than pneumatic dilation. Gastrointest Endosc. 2014; 80: 360.
37 Patti M G, Pellegrini C A. Esophageal achalasia 2011: pneumatic dilatation or laparoscopic myotomy? J Gastrointest Surg 2012; 16: 870–3.
38 Kolinioti A, Kayani B, Skouras C, Fovos A, Aziz O, Zacharakis E. Does laparoscopic Heller's myotomy provide superior results compared to endoscopic dilatation for oesophageal achalasia? Int J Surg 2013; 11: 238–43.

39 Wang H M, Tai W C, Chuah S K *et al.* Comparison of treatment outcomes of endoscope-guided pneumatic dilation and laparoscopic Heller myotomy. Kaohsiung J Med Sci 2015; 31: 639–43.
40 Weber C E, Davis C S, Kramer H J, Gibbs J T, Robles L, Fisichella P M. Medium and long-term outcomes after pneumatic dilation or laparoscopic Heller myotomy for achalasia: a meta-analysis. Surg Laparosc Endosc Percutaneous Tech 2012; 22: 289–96.
41 Schoenberg M B, Marx S, Kersten J F *et al.* Laparoscopic Heller myotomy versus endoscopic balloon dilatation for the treatment of achalasia: a network meta-analysis. Ann Surg 2013; 258: 943–52.
42 Chan S M, Chiu P W, Wu J C *et al.* Laparoscopic Heller's cardiomyotomy achieved lesser recurrent dysphagia with better quality of life when compared with endoscopic balloon dilatation for treatment of achalasia. Dis Esophagus 2013; 26: 231–6.
43 Tabola R, Grabowski K, Lewandowski A, Augoff K, Markocka-Maczka K. Achalasia—balloon dilation or surgery? Med Sci Monit 2013; 19: 1089–94.
44 Eckardt V F, Aignherr C, Bernhard G. Predictors of outcome in patients with achalasia treated by pneumatic dilation. Gastroenterology 1992; 103: 1732–8.
45 Ferreira-Santos R. Aperistalsis of the esophagus and colon (megaesophagus and megacolon) etiologically related to Chagas' disease. Digest Dis Sci 1961; 6: 700–26.