Surg Today (2014) 44:732–739
DOI 10.1007/s00595-013-0640-3

ORIGINAL ARTICLE

Comparison of the Heller–Toupet procedure with the Heller–Dor procedure in patients who underwent laparoscopic surgery for achalasia

Natsuya Katada · Shinichi Sakuramoto · Keishi Yamashita · Kei Hosoda · Tomotaka Shibata · Hiromitsu Moriya · Shiro Kikuchi · Masahiko Watanabe

Received: 20 January 2013 / Accepted: 30 April 2013 / Published online: 22 June 2013

Abstract
Purpose We compared the outcomes of Toupet fundoplication with those of Dor fundoplication in patients with achalasia who underwent laparoscopic Heller myotomy.
Methods Seventy-two patients with achalasia and dysphagia underwent laparoscopic Heller myotomy with fundoplication performed by a single surgeon. Heller–Toupet fundoplication (HT) was performed in 30 patients, and Heller–Dor fundoplication (HD) was done in 42. The symptoms and esophageal function were retrospectively assessed in both groups.
Results The dysphagia scores significantly decreased after both the HT and HD procedures, and did not differ significantly between them. The incidence of reflux symptoms was significantly higher after HT (26.7 %) than after HD (7.1 %). The lower esophageal sphincter (LES) resting pressure significantly decreased after both HT and HD. Upon endoscopic examination, the incidence of reflux esophagitis was significantly higher after HT (38.5 %) than after HD (8.8 %). During esophageal pH monitoring, the fraction time at pH <4 was similar in the patients who underwent HT and HD.
Conclusions Laparoscopic Heller myotomy provided significant improvements in the dysphagia symptoms of achalasia patients, regardless of the type of fundoplication. The incidences of reflux symptoms and reflux esophagitis were higher after HT than after HD. However, the results of pH monitoring did not differ between the procedures.

N. Katada (✉) · S. Sakuramoto · K. Yamashita · K. Hosoda · T. Shibata · H. Moriya · S. Kikuchi · M. Watanabe
Department of Surgery, Kitasato University School of Medicine, 2-1-1, Asamizodai, Minami-ku, Sagamihara, Kanagawa 252-0380, Japan
e-mail: katada@kitasato-u.ac.jp

Keywords Achalasia · Laparoscopic surgery · Fundoplication · Dor · Toupet

Introduction

Achalasia is characterized by the incomplete relaxation of the lower esophageal sphincter (LES), impairing the passage through the gastric cardia and causing dysphagia [1, 2], but the fundamental cause of the condition remains unknown. Although there is no curative treatment for achalasia, laparoscopic surgery is both minimally invasive and is currently considered to be the most effective therapy [3–8].

Successful outcomes of surgery for achalasia require a good balance between two factors: relief of dysphagia, achieved by decreasing the LES pressure by Heller myotomy, and the prevention of postoperative gastroesophageal reflux, achieved by performing an antireflux procedure. A general consensus has been reached that some types of antireflux procedure should be performed with myotomy to prevent postoperative gastroesophageal reflux [3, 9, 10]. Many studies have combined laparoscopic Heller myotomy (LHM) with anterior partial (Dor) fundoplication as an antireflux procedure [11–13]. Other antireflux procedures include posterior partial (Toupet) fundoplication and total (Nissen) fundoplication. Compared with the Dor and Toupet procedures for partial fundoplication, the Nissen fundoplication has a higher risk of postoperative dysphagia [14–16] and is thus not widely used. The outcomes of the Heller–Dor procedure (HD) have been reported more often than those of the Heller–Toupet procedure (HT) [11–13, 17–19]. To our knowledge, few studies have compared the outcomes between HD and HT. In this study, we compared the outcomes of HD with those of HT in patients with

Table 1 Demographic characteristics of patients in the HT and HD groups

	Heller–Toupet 1997–2003, $n = 30$	Heller–Dor 2004–2011, $n = 42$	p value
Mean age (range)	41.8 years (23–66)	42.7 years (11–74)	NS
Gender (male:female)	12:18	21:21	NS
Disease duration (years)	4.1 ± 6.1	7.8 ± 11.8	NS
Postoperative follow-up (median, months)	139 (102–174)	42 (7–97)	<0.001
Proportion of patients with comorbidities	7/30 (23.3 %)	7/42 (16.7 %)	NS

NS not significant

achalasia who underwent laparoscopic surgery to clarify the advantages and disadvantages of these procedures.

Methods

The study group comprised 72 patients with a diagnosis of achalasia who underwent LHM in the Department of Surgery, Kitasato University Hospital from October 1997 through October 2011. Fundoplication was performed by the Toupet procedure in 30 patients (HT group) and by the Dor procedure in 42 patients (HD group). Between October 1997 and October 2003, all patients underwent HT. From November 2003 through October 2011, all patients underwent HD. All procedures were performed by a single surgeon (N. Katada, first author). All patients had severe dysphagia before surgery. The ages of the patients at the time of surgery, the sex ratios, disease durations, postoperative follow-up periods and the proportions of patients with comorbidities are shown in Table 1.

Surgical procedures

The preoperative preparations and the surgical procedure for LHM with Toupet fundoplication have been described previously [18]. The anterior and posterior vagal trunks were preserved, and the abdominal esophagus was adequately exposed. Two or three short gastric vessels were divided to mobilize the gastric fundus for cardioplasty. Next, the lower esophagus was pulled downward, and a Heller myotomy was performed. The myotomy was extended 5–6 cm proximal to the gastroesophageal junction, and was then extended 2 cm distally (Fig. 1).

In the HT group, a Toupet fundoplication was performed as an antireflux procedure. The wraps on the left and right sides of the esophagus were sutured to the cut edge of the muscularis on the left and right sides of the esophagus with three interrupted sutures. Then, the left and right wraps were sutured to the diaphragmatic crura with one or two interrupted sutures (Fig. 2).

In the HD group, a Dor fundoplication was performed as an antireflux procedure. The proximal margins of the abdominal esophagus were sutured to the diaphragmatic crura with one or two interrupted sutures. The left margin of the myotomy site was sutured to the wrap in a caudocranial direction with three to four interrupted sutures. Subsequently, the right margin of the myotomy site was sutured to the wrap in a craniocaudal direction with three or four interrupted sutures (Fig. 3).

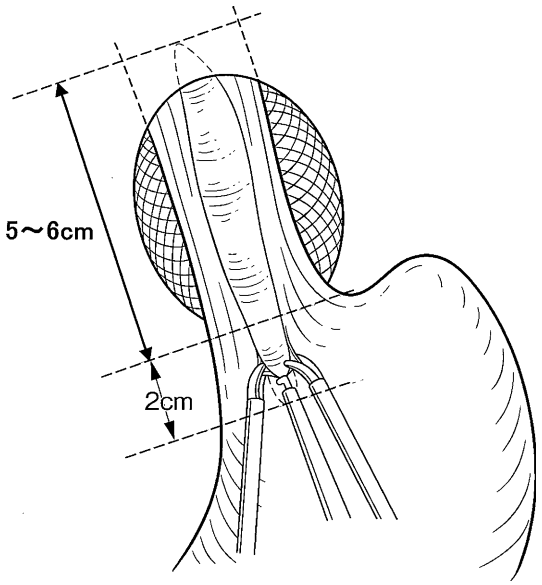

Fig. 1 A schematic diagram outlining the laparoscopic Heller myotomy (LHM). The Heller myotomy is extended 5–6 cm above the gastroesophageal junction and 2 cm below the gastroesophageal junction

We retrospectively evaluated the patients' symptoms before and after surgery, as well as the morphologic characteristics of the esophagus and the esophageal function. The following variables were also studied: intraoperative blood loss, postoperative hospital stay, number of days until the resumption of oral intake after surgery, intraoperative complications and postoperative sequelae.

Changes in symptoms after surgery

One year after surgery, the first author directly interviewed all patients in the outpatient clinic to determine the level of improvement in their dysphagia. The patients were requested to globally evaluate the postoperative dysphagia

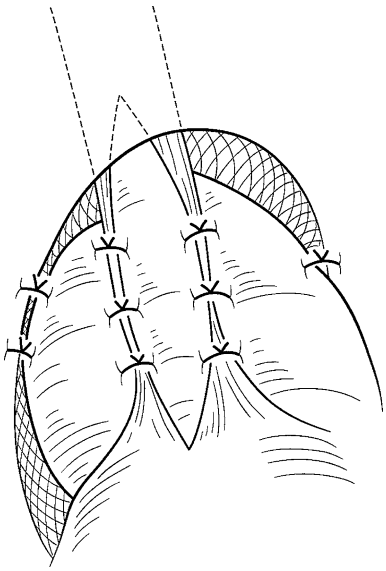

Fig. 2 A schematic diagram outlining the Heller–Toupet (HT) procedure Toupet fundoplication anchors the well-mobilized fundus to the cut edges of the myotomy. The fundoplication is then fixed to the crura

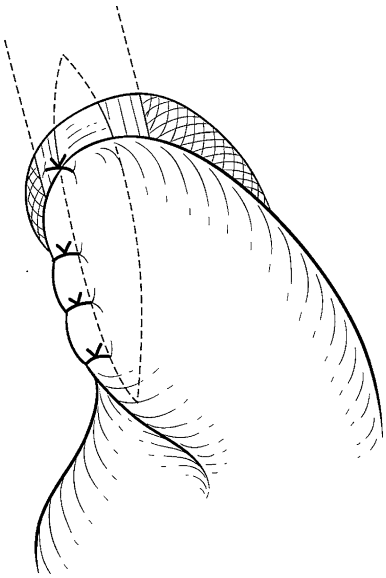

Fig. 3 A schematic diagram outlining the Heller–Dor (HD) procedure Dor fundoplication is performed as an antireflux procedure after Heller myotomy

score on the basis of the frequency of dysphagia and the severity of dysphagia according to food type (liquids and solids) after surgery, compared with a preoperative dysphagia score of 10. The presence of postoperative reflux symptoms, such as heartburn and regurgitation that required treatment with proton-pump inhibitors, was also evaluated.

Esophagography

Before and 1 year after surgery, esophagography was performed in all patients to measure the maximum transverse diameter of the esophagus. Esophagography was performed in the Department of Radiology, Kitasato University. Patients orally ingested 100 mL of 100 % barium sulfate in the standing position, and then the maximum transverse diameter of the esophagus was measured.

Esophagoscopy

One year after surgery, esophagoscopy was performed in 26 of the 30 patients in the HT group and 34 of the 42 patients in the HD group to evaluate the degree of mucosal breaks in the esophagus according to the Los Angeles classification [20]. Esophagoscopy was performed by gastroenterologists at Kitasato University. The degree of mucosal breaks in the esophagus was determined by consensus among specialists belonging to the Department of Gastroenterology. In patients who received oral proton-pump inhibitors after surgery, the drug(s) were withdrawn 8 weeks before esophagoscopy.

Esophageal manometry

Before surgery and 3 months after surgery, esophageal manometry was performed in 28 of the 30 patients in the HT group and 39 of the 42 patients in the HD group. The methods have been described previously [18]. Briefly, the resting pressure of the LES was defined as the difference (in mmHg) between the gastric baseline pressure and the mid-expiration pressure at the highest resting pressure. To calculate the LES relaxation rates, a transducer was placed in the LES, and the patient was asked to wet swallow. The percent decrease in the resting LES pressure on swallowing compared with the baseline value was determined four times. The esophageal body motility was assessed by positioning the distal transducer 3, 8, 13 and 18 cm above the upper border of the LES, after which, a series of 10 wet swallows were completed while recording the pressures at these points.

Twenty-four hour esophageal pH monitoring

Twenty-four hour esophageal pH monitoring was performed 3 months after surgery in 25 of the 30 patients in the HT group and in 26 of the 42 patients in the HD group. The method used for the monitoring has been described previously [18]. Briefly, a pH probe was placed 5 cm above the upper border of the manometrically defined LES. Gastroesophageal reflux was defined as abnormal if the percentage of time when the pH was less than 4 was greater

than 4 %. In patients who received oral proton-pump inhibitors after surgery, the drug was withdrawn 1 week before pH monitoring.

Statistical analysis

The data are expressed as the mean ± standard deviation (SD). The statistical analyses were conducted using Fisher's exact test, the Wilcoxon test, paired *t* tests and unpaired *t* tests, depending on the type and distribution of the variables being analyzed. Values of $p < 0.05$ were considered to indicate statistical significance.

Results

The preoperative demographic characteristics such as age, gender, disease duration and the proportion of patients with comorbidities did not differ significantly between the HT group and the HD group (Table 1). The major comorbidities were hypertension in four patients, a depressive state in one, myasthenia gravis in one and pneumonia in one patient in the HT group, and hypertension in three patients, a depressive state in three patients and mental retardation in one patient in the HD group. The postoperative follow-up was longer in the HT group. Intraoperatively, no patient was switched from laparoscopic surgery to open surgery in either group. There was no difference between the groups in terms of the length of the operation, the number of days until the resumption of oral intake after surgery or the length of hospital stay after surgery (Table 2). The volume of intraoperative blood lost was small, and the maximum bleeding volume was 60 mL in the HT group and 140 mL in the HD group. There was no postoperative mortality in either group.

With regard to intraoperative complications, esophageal perforation caused by injury to the esophageal mucosa at the time of Heller myotomy occurred in four patients (13.3 %) in the HT group and four (9.5 %) patients in the HD group. This difference was not significant.

Table 2 Intraoperative and postoperative findings in the HT and HD groups

	Heller–Toupet	Heller–Dor	
Length of operation (minutes)	213.8 ± 30.6	214.6 ± 38.1	NS
Number of days until the start of oral intake after surgery (median)	2 (1–49)	1 (1–4)	NS
Postoperative hospital stay (median, days)	8.5 (5–73)	6.0 (4–11)	NS
Intraoperative esophageal perforation	4 (13.3 %)	4 (9.5 %)	NS
Esophageal diverticulum after surgery	2 (6.7 %)	0 (0 %)	NS

Compared with a preoperative dysphagia score of 10, the dysphagia score 1 year after surgery decreased significantly in both groups, and did not differ significantly between the HT group and the HD group. The maximum esophageal transverse diameter on esophagography had significantly decreased 1 year after surgery in both groups. Esophageal manometry showed that the LES resting pressure was high before surgery in both groups, but significantly decreased 3 months after surgery in both groups compared with the respective preoperative values ($p < 0.001$). The postoperative LES resting pressure was significantly higher in the HD group than in the HT group ($p < 0.01$). The LES relaxation rate was low before surgery, but had significantly increased 3 months after surgery in both groups ($p < 0.001$). The esophageal body peristaltic pressure before surgery was consistently decreased from the upper to the lower portions of the esophageal body, and esophageal body contractions were simultaneous in all patients. Compared with the preoperative values, the postoperative peristaltic pressure did not differ significantly, except for the site 13 cm proximal to the gastroesophageal junction in the HT group and the site 18 cm proximal to the gastroesophageal junction in the HD group. The postoperative contractions were simultaneous and unchanged (Table 3).

Esophageal diverticula occurred in two patients (6.7 %) in the HT group, but did not develop in the HD group. However, the difference between the groups was not significant. Both diverticula developed above the diaphragm slightly to the right of the anterior aspect of the esophagus, in the area where the myotomy was performed. The diameter of the diverticulum was 6.7 cm in one patient followed for 3 years after surgery and 6.5 cm in the other, who was followed for 5 years. The diverticula did not exacerbate the dysphagia in either patient during the follow-up.

One year after surgery, the incidence of gastroesophageal reflux requiring treatment with proton-pump inhibitors because of symptoms such as heartburn and regurgitation was significantly higher in the HT group [26.7 % (8/30)] than in the HD group [7.1 % (3/42), $p < 0.05$]. Reflux symptoms were satisfactorily controlled by treatment with proton-pump inhibitors in all patients with gastroesophageal reflux. On endoscopic examination 1 year after surgery, mucosal breaks due to reflux esophagitis were detected significantly more often in the HT group [38.5 % (10/26)] than in the HD group [8.8 % (3/34), $p < 0.01$]. Among the patients with reflux esophagitis, the grade according to the Los Angeles classification was A in six patients, B in two and C in two patients in the HT group, compared with A in two patients, B in no patients and C in one patient in the HD group. None of the patients in either

Table 3 Postoperative dysphagia scores and findings on esophgography and esophageal manometry

	Heller–Toupet			Heller–Dor		
	Before	After	*p* value	Before	After	*p* value
Dysphagia score (median, 95 % confidence interval)	10	1.5 (1.23–2.17)	<0.001	10	1.5 (1.34–2.28)	<0.001
Esophagography						
Maximum diameter of the esophagus, cm	5.4 ± 1.0	3.8 ± 1.1	<0.001	4.2 ± 1.1	2.9 ± 1.0	<0.001
Esophageal manometry						
LES resting pressure, mmHg	35.2 ± 12.6	15.0 ± 6.7	<0.001	44.5 ± 17.1	20.1 ± 7.1*	<0.001
LES relaxation rate, %	62.4 ± 16.2	81.5 ± 9.7	<0.001	63.0 ± 16.4	79.5 ± 14.7	<0.001
Esophageal body peristaltic pressure, mmHg						
18 cm above the LES	18.5 ± 6.2	15.3 ± 9.8	NS	30.8 ± 12.2	22.2 ± 9.2	<0.001
13 cm above the LES	18.7 ± 6.9	13.9 ± 7.6	<0.01	32.6 ± 13.6	27.1 ± 16.4	NS
8 cm above the LES	19.4 ± 8.5	16.9 ± 9.5	NS	32.9 ± 12.2	26.7 ± 16.3	NS
3 cm above the LES	19.1 ± 8.3	19.5 ± 11.3	NS	32.5 ± 13.4	26.9 ± 21.7	NS

* $p < 0.01$, postoperative LES resting pressure HT vs. HD

group had lower esophageal strictures caused by worsening of the mucosal breaks.

During esophageal pH monitoring, the fraction time at pH <4 was 1.2 ± 3.0 % in the HT group and 3.3 ± 7.0 % in the HD group, with no significant difference between the groups. The proportion of patients in whom the fraction time at pH <4 was 4 % or higher was 12.0 % (3/25) in the HT group and 11.5 % (3/26) in the HD group. This difference was not significant (Table 4). In the HD group, two patients (4.8 %) with a dilated sigmoid esophagus before surgery had severe residual dysphagia that required postoperative dilation. In the HT group, none of the patients had dysphagia requiring dilation, but the difference between the groups was not significant.

Discussion

Although there is no curative treatment for achalasia, laparoscopic surgery is currently considered to be the least invasive and most effective therapy [3–7]. In our study, HT and HD were both safe, minimally invasive procedures for the management of achalasia, consistent with the results of previous studies [4, 7, 11, 13, 19].

Mattioli et al. [21] reported that Heller myotomy with a 5- to 6-cm proximal incision, followed by a 2-cm distal incision, most effectively decreased the LES pressure. However, Heller myotomy alone is associated with a high postoperative risk of gastroesophageal reflux. A general consensus has, therefore, been reached that some types of antireflux procedure should be performed with myotomy to prevent postoperative gastroesophageal reflux [3, 9, 10]. Compared with the Dor and Toupet procedures, Nissen fundoplication is rarely used as an antireflux procedure in patients who undergo Heller myotomy because it is associated with a higher risk of postoperative dysphagia [14–16].

Whether Toupet fundoplication or Dor fundoplication is the better procedure for partial fundoplication after LHM remains a matter of debate. Although experience with HT is relatively limited, Raiser et al. [19] compared HD with HT in patients with achalasia who underwent laparoscopic surgery. Their results showed that HT is associated with a lower risk of postoperative dysphagia. On the other hand, Arain et al. [17] compared these procedures for partial fundoplication after LHM and reported no significant differences between the groups in the physicians' assessment of postoperative symptom scores or the resolution of dysphagia, the patients' assessment of outcomes or the postoperative use of proton-pump inhibitors. Recently, Rawlings et al. [22] conducted a multicenter, prospective, randomized-controlled trial comparing HD with HT in patients who underwent laparoscopic surgery for achalasia, and found that the improvement in dysphagia did not differ significantly between the groups. Although a higher percentage of patients in the HD group had abnormal pH results compared with those in the HT group, the differences were not significant.

In our study, the LES resting pressure significantly decreased in both the HT and HD groups. In addition, the LES relaxation rates significantly increased in both groups, resulting in a relative decrease in the LES residual pressure. These decreases in the LES residual pressure were accompanied by significantly reduced dysphagia scores in both groups. In both groups, the median dysphagia score decreased from a preoperative score of 10 to a postoperative score of 1.5, indicating that the severity of dysphagia after surgery was equivalent to about 15 % of the baseline level. The residual dysphagia may be related to the fact that,

Table 4 Postoperative status of gastroesophageal reflux

	Heller–Toupet	Heller–Dor	*p* value
Reflux symptoms			
Incidence of GER requiring PPI	8/30 (26.7 %)	3/42 (7.1 %)	<0.05
Esophageal pH monitoring			
Fraction time at pH <4 (%)	1.2 ± 3.0	3.3 ± 7.0	NS
Proportion of patients in whom the fraction time at pH <4 was 4 % or higher	3/25 (12.0 %)	3/26 (11.5 %)	NS
Postoperative reflux esophagitis on endoscopy			
Incidence of reflux esophagitis (%)	10/26 (38.5 %)	3/34 (8.8 %)	<0.01
Grade by the Los Angeles classification (A/B/C)	6/2/2	2/0/1	NS

GER gastroesophageal reflux, *PPI* proton-pump inhibitor

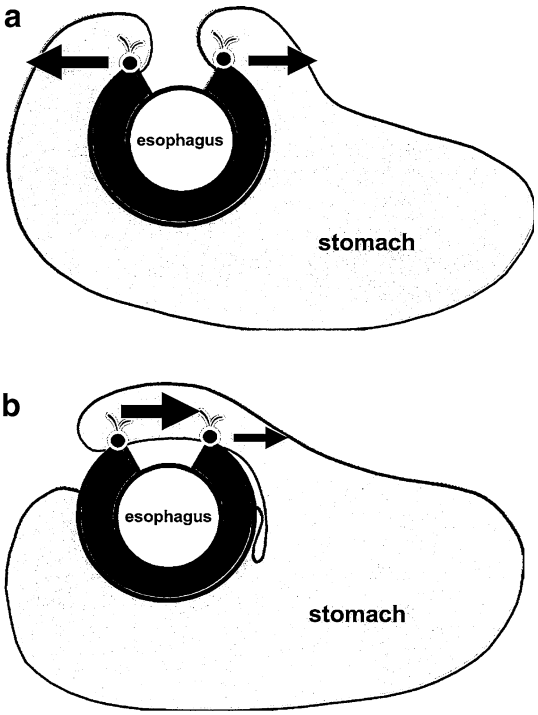

Fig. 4 **a** A cross-sectional view of the cardia upon completion of HT. During the HT procedure, the wrap around the posterior aspect of the esophagus pulls the anterior wall of the esophagus to the *left* and *right*, opening the myotomy site. **b** A cross-sectional view of the cardia upon completion of HD. During the HD procedure, the *right side* of the wrap is pulled to the *left* of the *right* margin of the cut muscularis, thereby closing the myotomy site

although the maximum transverse diameter of the esophagus had decreased significantly on postoperative esophagography in both groups, it remained larger than normal.

Currently, LHM with Dor fundoplication is the most widely performed procedure used to manage achalasia [11–13]. One advantage of HD is that it does not require dissection of the posterior aspect of the esophagus. The procedure is, therefore, straightforward. Another advantage is that leakage of esophageal contents into the peritoneal cavity can be prevented even if the mucosa is injured, because the injury is covered by the wrap. On the other hand, one advantage of the Heller–Toupet procedure is that the wrap around the posterior aspect of the esophagus pulls the anterior wall of the esophagus to the left and right, which opens the myotomy site and produces a sustained decline in the LES resting pressure (Fig. 4a).

In our study, the postoperative LES resting pressure was significantly higher in the HD group than in the HT group. Heller myotomy was performed in a similar fashion in both groups. The LES resting pressure immediately after Heller myotomy probably decreased to about zero in both groups [21]. Therefore, the postoperative decrease in the LES resting pressure after surgery likely depends primarily on the type of fundoplication. After HD, stress may be medially applied to the right border of the myotomy site (Fig. 4b). In addition, fibrosis might develop between the wrap and the mucosa, potentially increasing the postoperative risk of residual dysphagia [19]. The LES relaxation rate was low before surgery and significantly increased after surgery in both groups. A decrease in the LES resting pressure with an increase in the LES relaxation rate is expected to contribute to the improvement in dysphagia. However, the mechanism underlying the increased LES relaxation rate remains unclear.

To assess the motility of the esophageal body, we measured the peristaltic pressure before and after surgery. The preoperative peristaltic pressure of the esophageal body was low in all patients in both groups. The body motility was generally negligible and did not improve after surgery in either group. This may explain why the dysphagia was not completely resolved after surgery.

With regard to postoperative sequelae, in our previous study, esophageal diverticula occurred in two patients (6.7 %) who underwent HT [18]. In the present series, there were no flare-ups of dysphagia due to diverticula. However, diverticula can worsen after HT. We, therefore, studied patients in whom diverticula were unlikely to occur after HD, and changed the surgical procedure from HT to HD in 2003 to compare the outcomes after these procedures. In our series, no esophageal diverticula developed in patients who underwent HD. The HD procedure may be

associated with a lower risk of esophageal diverticula because the myotomy site is covered with a wrap.

Even if an antireflux procedure is combined with LHM, it is difficult to completely prevent gastroesophageal reflux after surgery. The rate of gastroesophageal reflux after LHM with an antireflux procedure has been reported to range from 0 to 44 %, with an average rate of 8.8 % [3]. In our study, symptoms of gastroesophageal reflux were significantly more common in the HT group than in the HD group. However, most symptoms were mild. In contrast, Rawlings et al. [21] reported no difference between HT and HD in terms of the severity or frequency of postoperative symptoms of gastroesophageal reflux. In our study, an endoscopic examination 1 year after surgery showed a significantly higher rate of reflux esophagitis in the HT group than in the HD group. Most mucosal breaks in our patients were mild (grade A or B) and were located within 1 cm proximal to the squamocolumnar junction. We believe that the assessment of postoperative gastroesophageal reflux by endoscopic examination provides important information that complements the results of esophageal pH monitoring. To our knowledge, however, no previous study, including the report by Rawlings et al. [21], has endoscopically evaluated gastrointestinal reflux after HT and HD. We, therefore, consider this an important feature of our study.

The esophageal pH monitoring performed 3 months after surgery showed that the reflux was within physiological limits in most patients. The fraction time of a pH <4 did not differ significantly between the HT group and the HD group. Esophageal pH monitoring is generally considered the gold standard for the quantitative assessment of gastroesophageal reflux [23]. In patients with achalasia, however, stagnant food and saliva in the lower esophagus undergo fermentation, decreasing the esophageal pH [24]. LHM cannot completely eliminate the presence of stagnant food in the lower esophagus in patients with achalasia. Therefore, the results of esophageal pH monitoring in patients with achalasia may not always reflect the presence or absence of true gastroesophageal reflux, and should be examined using other studies for confirmation. We, therefore, cannot conclude on the basis of the results of the esophageal pH monitoring that there was no difference in the incidence of postoperative gastroesophageal reflux between the HT and HD groups. Given that the sensor used for the esophageal pH monitoring was placed 5 cm proximal to the upper margin of the LES, most detected cases of gastroesophageal reflux after surgery may have been limited to reflux occurring near the proximal portion of the squamocolumnar junction. The lower postoperative LES resting pressure after HT compared with that after HD may have created an environment conducive to free gastroesophageal reflux. However, even if gastroesophageal reflux occurred, it might have been limited to near the squamocolumnar junction.

The fact that our results showed that the incidence of symptoms of gastroesophageal reflux, as well as the incidence of reflux esophagitis on endoscopic examination, was significantly higher after HT than after HD suggests that HT may be more similar to Heller myotomy alone than HD, and may be more likely to cause gastroesophageal reflux after surgery. However, there was no significant difference between the groups during the pH monitoring. Although it is difficult to conclude which procedure is better, HD may be superior to HT, because the latter may have higher risks of the development of gastroesophageal reflux and diverticula after surgery, with no difference in the postoperative improvement in dysphagia.

We are aware that our study had several important limitations. First, it was a relatively small, retrospective study. Second, the results of HT and HD performed by a single surgeon over the course of a prolonged period were compared. The influence of bias due to the learning curve of the surgeon cannot be ruled out. Further large, long-term, prospective, randomized-controlled studies are needed to confirm the advantages and drawbacks of each procedure.

In conclusion, both laparoscopic HT and HD are safe, minimally invasive procedures for the management of achalasia. Both procedures significantly reduced the postoperative LES resting pressure, and the dysphagia score 1 year after surgery decreased significantly in both groups, and did not differ significantly between the HT group and the HD group. However, the postoperative LES resting pressure was higher after HD than after HT. Esophageal diverticula were found in 6.7 % of the patients after HT, but did not occur after HD. Mild gastroesophageal reflux occasionally occurred after each procedure. The incidence of reflux symptoms and reflux esophagitis was higher after HT than after HD. However, the results of pH monitoring did not differ between the procedures. Although further studies are needed to confirm our results, we believe that both HT and HD should be considered safe and effective for the treatment of patients with achalasia.

Conflict of interest None of the authors has any conflict of interest.

References

1. Clouse RE, Staiano A. Manometric patterns using esophageal body and lower sphincter characteristics. Findings in 1013 patients. Dig Dis Sci. 1992;37:289–96.
2. Ferguson MK. Achalasia: current evaluation and therapy. Ann Thorac Surg. 1991;52:336–42.
3. Campos GM, Vittinghoff E, Rabl C, Tanaka M, Gadenstatter M, Lin F, et al. Endoscopic and surgical treatments for achalasia: a systematic review and meta-analysis. Ann Surg. 2009;249:45–57.
4. Shimi S, Nathanson LK, Cuschieri A. Laparoscopic cardiomyotomy for achalasia. J R Coll Surg Edinb. 1991;36:152–4.

5. Kilic A, Schuchert MJ, Pennathur A, Gilbert S, Landreneau RJ, Luketich JD. Long-term outcomes of laparoscopic Heller myotomy for achalasia. Surgery. 2009;146:826–31 (discussion 831–23).
6. Wright AS, Williams CW, Pellegrini CA, Oelschlager BK. Long-term outcomes confirm the superior efficacy of extended Heller myotomy with Toupet fundoplication for achalasia. Surg Endosc. 2007;21:713–8.
7. Ancona E, Anselmino M, Zaninotto G, Costantini M, Rossi M, Bonavinal L, et al. Esophageal achalasia: laparoscopic versus conventional open Heller–Dor operation. Am J Surg. 1995;170: 265–70.
8. Yano F, Omura N, Tsuboi K, Hoshino M, Yamamoto SR, Kashiwagi H, Yanaga K. Single-incision laparoscopic Heller myotomy and Dor fundoplication for achalasia: report of a case. Surg Today. 2012;42:299–302.
9. Patti MG, Herbella FA. Fundoplication after laparoscopic Heller myotomy for esophageal achalasia: what type? J Gastrointest Surg. 2011;14:1453–8.
10. Richards WO, Torquati A, Holzman MD, Khaitan L, Byrne D, Lutfi R, et al. Heller myotomy versus Heller myotomy with Dor fundoplication for achalasia: a prospective randomized double-blind clinical trial. Ann Surg. 2004;240:405–12.
11. Hunter JG, Trus TL, Branum GD, Waring JP. Laparoscopic Heller myotomy and fundoplication for achalasia. Ann Surg. 1997;225:655–64.
12. Mattioli S, Ruffato A, Lugaresi M, Pilotti V, Aramini B, D'Ovidio F. Long-term results of the Heller–Dor operation with intraoperative manometry for the treatment of esophageal achalasia. J Thorac Cardiovasc Surg. 2010;140:962–9.
13. Patti MG, Molena D, Fisichella PM, Whang K, Yamada H, Perretta S, et al. Laparoscopic Heller myotomy and Dor fundoplication for achalasia: analysis of successes and failures. Arch Surg. 2001;136:870–7.
14. Wills VL, Hunt DR. Functional outcome after Heller myotomy and fundoplication for achalasia. J Gastrointest Surg. 2001;5: 408–13.
15. Rebecchi F, Giaccone C, Farinella E, Campaci R, Morino M. Randomized controlled trial of laparoscopic Heller myotomy plus Dor fundoplication versus Nissen fundoplication for achalasia: long-term results. Ann Surg. 2008;248:1023–30.
16. Frantzides CT, Moore RE, Carlson MA, Madan AK, Zografakis JG, Keshavarzian A, et al. Minimally invasive surgery for achalasia: a 10-year experience. J Gastrointest Surg. 2004;8: 18–23.
17. Arain MA, Peters JH, Tamhankar AP, Portal G, Almogy G, DeMeester SR, et al. Preoperative lower esophageal sphincter pressure affects outcome of laparoscopic esophageal myotomy for achalasia. J Gastrointest Surg. 2004;8:328–34.
18. Katada N, Sakuramoto S, Kobayashi N, Futawatari N, Kuroyama S, Kikuchi S, et al. Laparoscopic Heller myotomy with Toupet fundoplication for achalasia straightens the esophagus and relieves dysphagia. Am J Surg. 2006;192:1–8.
19. Raiser F, Perdikis G, Hinder RA, Swanstrom LL, Filipi CJ, McBride PJ, et al. Heller myotomy via minimal-access surgery. An evaluation of antireflux procedures. Arch Surg. 1996;131: 593–7 (discussion 597–598).
20. Lundell LR, Dent J, Bennett JR, Blum AL, Armstrong D, Gamiche JP, et al. Endoscopic assessment of oesophagitis: clinical and functional correlates and further validation of the Los Angeles classification. Gut. 1999;45:172–80.
21. Mattioli S, Pilotti V, Felice V, Di Simone MP, D'Ovidio F, Gozzetti G. Intraoperative study on the relationship between the lower esophageal sphincter pressure and the muscular components of the gastro-esophageal junction in achalasic patients. Ann Surg. 1993;218:635–9.
22. Rawlings A, Soper NJ, Oelschlager B, Swanstorom L, Matthews BD, Pellegrini C, et al. Laparoscopic Dor versus Toupet fundoplication following Heller myotomy for achalasia: results of a multicenter, prospective, randomized-controlled trial. Surg Endosc. 2012;26:18–26.
23. Johnson LF, Demeester TR. Twenty-four-hour pH monitoring of the distal esophagus. A quantitative measure of gastroesophageal reflux. Am J Gastroenterol. 1974;62:325–32.
24. 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: 1257–65.