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SURGICAL SYMPOSIUM CONTRIBUTION

Heller Myotomy for Achalasia. From the Open to the Laparoscopic Approach

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Abstract The last three decades have witnessed a progressive evolution in the surgical treatment of esophageal achalasia, with a shift from open to a minimally invasive Heller myotomy. The laparoscopic approach is currently the standard of care with better short-term outcomes and similar long-term functional results when compared to open surgery. More recently, the laparoscopic single-site approach and the use of the robot have been proposed to further improve the surgical outcome in achalasia patients.

Introduction

The development and wide diffusion of minimally invasive surgical techniques in the last 30 years have led to radical changes in the treatment algorithm of esophageal achalasia. While in the "open" era pneumatic dilatation (PD) was the recommended treatment modality for this disease and open (trans-abdominal or trans-thoracic) Heller myotomy was mostly performed in patients with persistent dysphagia after PD, in the "minimally invasive" era Heller myotomy has become the treatment modality of choice in most Centers [1].

The "minimally invasive" era started in 1991 when the first Heller myotomy through a left thoracoscopic approach was performed aiming to couple the benefits of myotomy and reduced postoperative discomfort of a minimally invasive approach [2]. However, the identification of several technical limitations of thoracoscopic Heller myotomy soon became clear. Specifically, because an antireflux procedure was not added to the myotomy, about 60 % of patients experienced postoperative pathological gastro-esophageal reflux. The ability of extending the myotomy easily onto the gastric wall and the ability of adding a partial fundoplication brought a progressive switch to laparoscopic Heller myotomy (LHM).

LHM is considered today in most Centers the standard of care for the management of esophageal achalasia, with minimal perioperative morbidity and excellent long-term functional outcomes [3]. Recently, the use of the robotic technology [4–7] and the laparoscopic single-site (LESS) access have been developed to further reduce the morbidity and the invasiveness of LHM [8].

The aim of this article is to critically review the evolution of the surgical treatment of achalasia over the last 30 years, focusing on the technical aspects that have made LHM the approach of choice to achalasia.

Heller myotomy: the "open" era

Heller described the first myotomy as surgical treatment of achalasia in 1914 [9]. The procedure consisted of two

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simultaneous trans-abdominal extra-mucosal myotomies on both the anterior and the posterior wall of the esophagus. This approach was then modified in 1923 by Zaaijer who described excellent results in 8 achalasia patients using only a myotomy on the anterior wall of the esophagus [10].

During the 1960 and 1970s, esophageal myotomy was performed by an open approach, either left transthoracic or trans-abdominal. Main controversies were the relief of dysphagia and the incidence of postoperative pathologic gastroesophageal reflux. For instance, Ellis [11] reported in 1993 his 22-year personal experience with transthoracic short myotomy (only 5 mm onto the gastric wall) without an antireflux procedure in 179 achalasia patients. The rationale of this approach was to provide relief of dysphagia and avoid gastroesophageal reflux. He observed an overall improvement rate of 89 % over a mean postoperative interval of 9 years, with no significant deterioration over time. Poor results with marked gastroesophageal reflux symptoms were reported in 9 (5 %) patients only, showing that a short transthoracic myotomy without an antireflux procedure provided excellent long-term results in terms of relief of dysphagia with very low incidence of symptomatic gastroesophageal reflux. Similar results were reported by others [12, 13].

The open trans-abdominal approach to achalasia without an antireflux procedure was mostly used in Europe and South America [14–16]. Excellent to good results in terms of relief of dysphagia were reported in 80–95 % of patients, while the incidence of postoperative reflux symptoms varied between 8.5 and 22 %. When compared to the transthoracic myotomy, the trans-abdominal approach apparently resulted in a significantly higher incidence of postoperative gastroesophageal reflux. Several mechanisms have been proposed to explain this finding, including a longer myotomy onto the gastric wall, division of the phreno-esophageal ligament, and the greater mobilization of the esophagus. However, the assessment of reflux in in these studies was based on symptoms only, therefore underestimating the real incidence of reflux [17]. In fact, when an objective evaluation by 24-h pH monitoring was performed, the incidence of postoperative reflux was significantly higher. For instance, Streitz et al. assessed the functional outcomes by esophageal manometry and 24-h pH monitoring in 14 patients with esophageal achalasia who had undergone a short myotomy without an antireflux procedure [18]. The lower esophageal sphincter (LES) pressure decreased from a preoperative mean of 26.7 mmHg to a postoperative mean of 14.6 mmHg; the esophageal acid exposure was pathologic in 4 patients (28.6 %). By multivariate analysis, esophageal acid exposure correlated only with the level of residual LES pressure.

In 1962, Dor proposed to add a partial anterior fundoplication to a long trans-abdominal myotomy aiming to provide relief of dysphagia minimizing the risk of postoperative pathologic gastroesophageal reflux [19]. Since then several studies assessing the outcome of open trans-abdominal myotomy and anterior fundoplication have been published [20–26]. For instance, Csendes analyzed the outcomes in 100 achalasia patients who had undergone an anterior 6-cm myotomy (extending onto the gastric wall no more than 5–10 mm) with anterior fundoplication [22]. With a mean follow-up of 6.8 years in 92 of the 94 patients, postoperative dysphagia was reported occasionally in only 8 % of patients. Squamous carcinoma developed in three patients, 5–9 years postoperatively. Postoperative 24-h pH monitoring showed pathologic gastroesophageal reflux in 19 % of patients.

Bonavina et al. evaluated 206 patients who had undergone trans-abdominal Heller myotomy (8-cm long on the esophagus and 2-cm long on the stomach) and Dor fundoplication as primary treatment modality of achalasia [23]. A total of 193 patients were followed up for a median period of time of 64.5 months (range, 12–144 months). Good to excellent results were achieved in 93.8 % of patients. Recurrent dysphagia was reported in 3.6 % of patients. Abnormal acid exposure at 24-h pH monitoring was present in only 8.6 % of patients tested.

In conclusion, transthoracic and trans-abdominal approaches for myotomy are both effective in the relief of dysphagia; however, the addition of a partial anterior fundoplication to a trans-abdominal myotomy significantly reduces the rate of postoperative pathologic gastroesophageal reflux.

Heller myotomy: the "minimally invasive" era

The early 1990s have witnessed the advent of minimally invasive techniques for the treatment of several abdominal diseases including achalasia [27]. The first minimally invasive myotomy in the United States was performed with a left thoracoscopic approach in 1991. Pellegrini et al. published in 1992 the results of their initial experience with the first 17 achalasia patients treated by either thoracoscopic ($n = 15$) or laparoscopic ($n = 2$) myotomy [2]. For the thoracoscopic myotomy, the patient was placed in the right lateral decubitus position after insertion of a double-lumen endotracheal tube to selectively intubate the right main stem bronchus. Two 5-mm trocars and two 10-mm trocars were inserted. Under guidance of a gastroscope, the myotomy was started on the esophageal wall at a point midway between the inferior pulmonary vein and the diaphragmatic hiatus. Distally, the myotomy was extended for about 5 mm onto the gastric wall (reproducing the Ellis'

procedure) until endoscopy showed wide patency of the lumen at the level of the gastroesophageal junction. Lastly, the edges of the muscular layers were separated by blunt dissection. At the end of the procedure, a chest tube was placed.

The authors reported a small intraoperative mucosal laceration in two patients, which was treated by conversion to open surgery and suture of the defect in both cases. All patients who had undergone minimally invasive surgery resumed soft diet on postoperative day 2 and were discharged on postoperative day 3. There was no postoperative morbidity or mortality. The chest tube was the only cause of postoperative discomfort and was removed after 24–48 h. Dysphagia did not improve in the first three patients who were treated by thoracoscopic myotomy as the myotomy was not carried far enough distally onto the stomach. A second myotomy was performed in these three patients, one by open trans-abdominal approach and two by laparoscopy, with complete relief of dysphagia in two patients. Excellent to good results in terms of swallowing were obtained in 82 % of patients. A 24-h pH monitoring was performed in 4 patients 1–13 months postoperatively, and showed pathologic acid exposure in 50 % of them.

Since an antireflux procedure was considered not necessary when the myotomy was performed through the chest without disrupting the antireflux barrier [28], the left thoracoscopic myotomy became quickly the minimally invasive approach of choice for the surgical treatment of achalasia, while the laparoscopic approach was reserved for patients with a previous myotomy or for those who had undergone a previous left thoracotomy [2]. However, several case series and comparative studies published in the late 1990s showed that LHM plus partial anterior fundoplication was safe, feasible, and associated with significantly better early and late outcomes than left thoracoscopic approach [29–41]. In particular, LHM and partial fundoplication were associated with reduced postoperative pain and discomfort, shorter hospital stay, better relief of dysphagia, and lower incidence of postoperative gastroesophageal reflux than thoracoscopic myotomy. For instance, Patti et al. retrospectively reviewed the outcomes in 60 achalasia patients who had undergone thoracoscopic myotomy (30 patients) or LHM plus anterior fundoplication (30 patients) [33]. They found that median hospital stay was 42 h in the laparoscopic group (60 % of patients were discharged within 23 h) and 84 h in the thoracoscopic group; good to excellent results in terms of resolution of dysphagia were achieved in 87 % of thoracoscopic group patients and 90 % of laparoscopic group patients. In addition, ten patients in each group underwent 24-h pH monitoring postoperatively: abnormal reflux was present in 60 % of patients in the thoracoscopic group and in 10 % only of patients in the laparoscopic group. Stewart et al. [42] retrospectively compared intraoperative results and postoperative symptoms in 24 achalasia patients undergoing thoracoscopic myotomy and 63 patients treated by LHM and partial fundoplication. Mean operating room time was significantly shorter and there were fewer conversions to open surgery (2 vs. 21 %) in the laparoscopic group than the thoracoscopic group. No postoperative leaks occurred in either group. Mean postoperative length of stay was significantly shorter after LHM. Higher rates of persistent dysphagia and heartburn were reported in the thoracoscopic group. Similar results were reported by others [43]. An incomplete myotomy on the gastric wall was the main cause of persistent dysphagia in patients undergoing thoracoscopic myotomy, while the construction of a fundoplication by laparoscopy was key in preventing reflux [32, 44].

In the second half of the 1990s, several studies were conducted aiming to compare laparoscopic and open transabdominal myotomy with Dor fundoplication [45–49]. For instance, Ancona et al. retrospectively reviewed the short-term outcomes of 17 patients who had LHM and 17 patients who had undergone open myotomy [44]. Both groups were well matched for age, sex, duration of symptoms, maximum esophageal diameter, and length of follow-up. The operative time of LHM was significantly longer than open myotomy. There was no mortality, and morbidity rates were similar in both groups. Patients in the laparoscopic group required significantly less pain medications, and had a quicker resumption of gastrointestinal function. As a consequence, hospital stay was shorter, the return to daily activities quicker, and total costs lower. With a median follow-up of 6 months in both groups, recurrent dysphagia was observed in one patient (5.8 %) in the laparoscopic group, while pathologic acid exposure at 24-h pH monitoring was found in one (5.8 %) patient after open surgery.

Douard et al. designed a prospective non-randomized study to compare functional outcome after laparoscopic and open myotomy with Dor fundoplication [49]. A total of 82 patients were included: 52 were treated by laparoscopy and 30 by an open approach. Median follow-up was 51 months (range, 12–111). Dysphagia, chest pain, regurgitation, and gastroesophageal reflux were recorded prospectively and evaluated using a clinical score at 3, 6, and 12 months after surgery, then every year. Excellent to satisfactory results in terms of relief of dysphagia were achieved in 92 % of patients after LHM and 93 % after open myotomy. Median dysphagia score dropped at 3 months after surgery in both groups, and did not change significantly over time during the follow-up. Typical symptoms of reflux were reported by 10% of patients in the laparoscopic group and 7 % of patients in the open group. The 24-h pH monitoring confirmed a pathological

esophageal acid exposure in all symptomatic patients and in 2 asymptomatic patients.

In conclusion, the benefits of the minimally invasive approach in terms of early postoperative outcomes and the similar long-term functional results when compared to the open approach have led to a progressive switch in clinical practice from open to thoracoscopic and to laparoscopic Heller myotomy. These advantages have had a major impact on (a) the number of achalasia patients referred for surgery rather than PD; (b) the number of patients referred for surgery without previous endoscopic treatment; and (c) the surgical outcome of the procedure [1]. The transabdominal approach to achalasia is superior to the transthoracic approach as it determines better symptom control and lower incidence of postoperative gastroesophageal reflux. LHM with partial fundoplication is the recommended surgical procedure for the treatment of achalasia [3].

Heller myotomy: what is new?

The LESS approach and the use of the robotic technology have been recently proposed to further improve the surgical outcome in achalasia patients.

Barry et al. [8] compared 66 achalasia patients treated by trans-umbilical LESS Heller myotomy and anterior fundoplication with 66 patients undergoing conventional LHM and anterior fundoplication. The LESS procedure took significantly longer than conventional LHM; additional ports were inserted in 11 (16 %) patients of the LESS group. There was no conversion to open surgery in either group. No significant differences were reported in intraoperative and early postoperative complications. Excellent to good results in symptom resolution were achieved in 88 % of patients after LESS and 82 % of patients treated by conventional LHM.

Further large controlled randomized trials with long follow-up are needed to confirm these preliminary promising results and to assess the real benefits of the LESS approach in terms of symptom relief, incidence of de novo gastroesophageal reflux and cosmesis.

Few studies have focused on the impact of the robotic technology on intraoperative complications and the long-term functional outcome of Heller myotomy [4–6, 49]. For instance, Horgan et al. [4] conducted a multi-institutional retrospective review of 121 achalasia patients: 59 underwent a robotic myotomy and 62 patients had a conventional LHM. Mean follow-up of the robotic group and the laparoscopic group was 18 and 22 months, respectively. The mean operative time was significantly longer in the robotic group, even though no significant differences were detected in the last 30 cases. Esophageal perforations occurred more frequently in the laparoscopic group (16 vs. 0 %). Excellent to good results in terms of relief of dysphagia were achieved in 92 % of patients after robotic surgery and 90 % of patients after LHM.

Similar findings were reported by others. Huffmanm et al. [5] compared 37 laparoscopic myotomies and 24 robotic myotomies. They found a lower rate of esophageal perforations in the robotic group (0 vs. 8 %) and higher postoperative quality of life indices. Melvin et al. [5] published the results of a multicenter prospective study including 104 patients undergoing robotic myotomy for achalasia. They reported no esophageal intraoperative perforations. Conversion to open surgery occurred in 1 patient. With a mean follow-up period of 16 months, no patient required reoperation. The authors concluded that robotic Heller myotomy is safer than conventional LHM since the three-dimensional visualization, the lack of tremor, and increased surgeon dexterity significantly reduce the risk of intraoperative esophageal perforation.

On the contrary, a multicenter, retrospective analysis of a large administrative database including 2,116 laparoscopic myotomies and 149 robotic myotomies did not find any difference in intraoperative complications and postoperative course, but increased costs in the robotic group [6].

In conclusion, the overall quality of the studies published in the literature is poor and the follow-up too short to draw any definitive conclusion. The evidence currently available does not support the use of the robot as the approach of choice in the management of achalasia.

Conflict of interest The authors have no conflicts of interest to declare.

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