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ORIGINAL ARTICLE

Optimal surgical intervention for achalasia: laparoscopic or robotic approach

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Abstract
Laparoscopic esophageal myotomy is the standard surgical intervention for achalasia. Compared to standard laparoscopic techniques, use of the robot has theoretical advantages of improved visualization and dexterity. We evaluated the University of Arizona's experience with the two alternatives to compare outcomes. Patients who underwent either laparoscopic or robot-assisted myotomy were identified from a retrospective database from 1/1/2006 to 12/31/2015. Patient demographics, prior treatment, intra-operative complications, operative time, post-operative length of stay and complications, and long-term results were compared between the two groups. We identified 35 laparoscopic and 37 robot-assisted Heller myotomies performed by multiple surgeons. Patient demographics were similar between the two groups with no statistical difference in age, gender, previous operations, pre-operative Botox or dilation treatment, or pre-op Eckardt score. In univariate analysis, the patients with the robotic procedure received a longer myotomy (5.85 cm vs. 5.56 cm for esophageal and 2.92 cm vs. 2.68 cm for gastric) and had a lower post-operative Eckardt score (0.51 vs. 1.09). A trend toward lower incidence of recurrent achalasia symptoms was found in the robotic group (0 patient vs. 4 patients) compared with those who had laparoscopic surgery ($p < 0.05$). Multivariate analysis showed that a longer gastric myotomy was associated with a lower recurrence rate ($p = 0.0002$). Both laparoscopic and robot-assisted Heller myotomy can provide definitive treatment of achalasia with good results and few complications. The mechanical advantage provided by the robotic approach may improve outcomes by providing a more complete myotomy and durable long-term result.

Keywords Heller myotomy · Achalasia, robotic · Best surgical approach

Introduction

Laparoscopic Heller myotomy has been proven to be effective and safe and is currently considered the gold standard for surgical treatment for symptomatic achalasia [1, 2]. According to American college of Gastroenterology guidelines, laparoscopic surgical myotomy with a partial fundoplication is recommended as initial therapy for the treatment of achalasia in those fit and willing to undergo surgery [3]. Although there is a proven track record for patient satisfaction and effectiveness in relief of symptoms, large case series still report up to 10% recurrence rate [2, 4]. An intra-operative esophageal perforation rate ranging from 1 to 15% has been reported in the literature as well [2, 5]. With the recent advancements in technology, consideration of robotic Heller myotomies has gained traction due to added benefits of improved three-dimensional visualization, an increased degree of instrument freedom and dexterity, and the surgeon's subjective sense of performing an esophageal and gastric myotomy. The aim of the study was to assess if the intra-operative advantage in performing the Heller myotomy translates into improved short-term and long-term outcome for recurrence of achalasia symptoms.

Materials and methods

Retrospective chart review was performed on patients who underwent surgical myotomy for symptomatic achalasia from 1/1/2006 to 12/31/2015. The institutional review board at the University of Arizona Medical Center approved the

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study. The diagnosis was made on the basis of clinical history, esophagrams, endoscopy, and manometry. All patients had disabling dysphagia and regurgitation.

The patients underwent either robotic-assisted or laparoscopic Heller myotomy based on the surgeon's preference. Intra-operative endoscopy was performed to assess for the completeness of the myotomy and possible mucosal perforation. Follow-up was obtained by in-person office visits at 2 weeks, 3 months, 6 months and 12 months, 18 months and 24 months. Patient demographics, symptoms, prior interventions, intra-operative complications, operative time, post-operative length of stay and complications, and long-term outcomes were compared between the two groups. Recurrence achalasia was defined as any patients who required any interventions to relieve symptoms after their surgical procedure.

Statistical methods

Statistical analysis was performing using Chi square (Fisher exact test) and one-way analysis of variance to evaluate differences in categorical and continuous variables across type of surgery. Exact logistic regression was used to model recurrence as a linear combination of type of surgery, gastric myotomy, and esophageal myotomy. Odds ratios (ORs) and their 95% confidence intervals (CIs) for outcome values are presented. Statistical analyses were performed using Stata/SE 14.1 for Windows (StataCorp, College Station, TX).

Results

There were 72 consecutive patients who underwent surgical Heller myotomy (36 male and 36 female). Median age at the time of the operation was 60 years. Symptoms were present in all the patients (Table 1). Dysphagia was most common (100%), followed by regurgitation (89%) and chest pain (80%). Other symptoms included weight loss (63%) and cough/aspiration (35%). Pre-operative Eckardt score for all patients was 8.55. The majority of patients (53/72) had received non-surgical interventions prior to a surgical consultation. Fifteen patients (22%) had pneumatic dilations, while 38 patients (39%) had Botox injections. Five patients had previous Heller myotomy with recurrent symptoms. 35 laparoscopic and 37 robot-assisted Heller myotomies were performed. Fifty-nine patients (82%) had a partial fundoplication following the myotomy (56 Dor fundoplication, 3 Toupet), while 13 patients did not receive any anti-reflux procedure. Patient demographics in laparoscopic and robot-assisted Heller myotomy groups were similar with no statistical difference in age, gender, previous operations, pre-operative Botox or dilation treatment, or pre-op Eckardt

Table 1 Pre-operative symptoms in 72 patients

Symptoms	None	Occasional	Every day	Every meal
Dysphagia	0	1	14	57
Regurgitation	8	41	21	2
Pain/heartburn	15	37	15	5

Table 2 Comparison between laparoscopic and robotic Heller myotomy groups

	Laparoscopic ($N=35$)	Robot ($N=37$)	p value
Age (years)	59.5	61.7	0.58
Gender			
Male	20	16	0.35
Female	15	21	
Prior abdominal surgery			
Yes	9	12	0.61
no	26	25	
Redo-op for achalasia			
Yes	0	5	0.05
No	35	32	
Dilation			
Yes	7	8	1
No	28	29	
Botox			
Yes	11	17	0.23
No	24	20	
Pre-op Eckardt score	8.49	8.65	0.44
LES mean (mmHg)	48.5	46.3	0.5
Sigmoid esophagus	1	1	0.66
Fundoplication			
Dor	27	29	0.2
Toupet	0	3	
None	8	5	
Esophageal myotomy (cm)	5.56	5.85	0.02
Gastric myotomy (cm)	2.68	2.92	0.024
Length of surgery (min)	157	158	0.95
EBL (ml)	56	41	
Perforation			
Yes	4	1	0.19
No	31	36	
Conversion to open			
Yes	3	0	0.1
No	32	37	
Length of stay (days)	2.17	2.02	0.57
Post-op Eckard*t* score	1.09	0.51	0.04
Recurrent achalasia			
Yes	5	1	0.1
No	30	36	
Median F/u length (months)	15	15	0.5

score (Table 2). In univariate analysis, the patients with the robotic procedure received a longer myotomy (5.85 cm vs. 5.56 cm for esophageal and 2.92 cm vs. 2.68 cm for gastric) and had a lower post-operative Eckardt score (0.51 vs. 1.09), $P < 0.05$.

There were a total of six patients with recurrent achalasia that required intervention (4 patients had pneumatic dilations, 2 had a redo-Heller myotomy). There was a trend toward lower incidence of recurrent achalasia (1 patient vs. 5 patients) in the robot-assisted group compared to those who had laparoscopic surgery ($p < 0.1$). Multivariate analysis showed that a longer gastric myotomy was the only factor associated with lower recurrence rate ($p = 0.0002$). There were a total of five perforations of the esophagus (4 perforations occurred during laparoscopy, 1 perforation occurred in the robot-assisted group) during the myotomy with no statistical difference between the two surgical approaches. All the perforations were recognized intra-operatively and repaired primarily; however, three out of four patients with perforation in the laparoscopic group required conversion to open laparotomy for the repair, while no patients required a conversion to open laparotomy in the robot-assisted group. There was no peri-operative mortality or major complication. Minor complications reported were atrial fibrillation (2), pneumonia (1), wound infection (1), and urinary retention (2).

Discussion

The goal of the surgical treatment for achalasia is to relieve the resistance at the level of the lower esophageal sphincter and to improve esophageal emptying. Laparoscopic Heller myotomy is the gold standard in surgical treatment, with superior long-term outcome compared to pneumatic dilations or other forms of medical therapies [6–8]. However, both early and late recurrences have been reported [9, 10]. Gockel et al. have identified that an early recurrence is related to technical failure from incomplete myotomy or a scarring process [11]. The importance of a complete myotomy extending 2–3 cm below the gastroesophageal junction in preventing post-operative dysphagia has been reported [12]. Our study supports these previous findings. Multivariate analysis demonstrated that a longer myotomy onto the stomach across the gastroesophageal junction was the only factor that was associated with lower recurrence rate. An incomplete myotomy at the GE junction is typically due to difficulty in developing the necessary submucosal plane to divide the muscle fibers as they change direction from circular on the esophagus to oblique at the stomach. Meticulous and complete myotomy is necessary, regardless of surgical approach or technique, to avoid recurrence of dysphagia.

It is interesting to note that, although there was not a statistical difference, there was a trend toward a lower incidence of recurrent achalasia in the robot-assisted group compared to those who had laparoscopic surgery (Fig. 1). Robotic Heller myotomy has potential advantages over a laparoscopic procedure with improved three-dimensional visualization, and increased degree of instrument freedom and dexterity to perform myotomy and also to peel the muscle fibers laterally enough to prevent healing together of the muscle fibers [13, 14]. Moreover, the incidence of iatrogenic perforation appeared to be less frequent with robot-assisted technique than laparoscopic myotomy. Horgan and et al. in a multicenter study showed that the robot-assisted group had less frequent intra-operative perforations compared to a laparoscopic myotomy group [15, 16]. Perforation was most frequent at the GE junction. In our experience, there were more perforations with laparoscopic than robot-assisted Heller myotomy (4 vs. 1, $p = 0.19$), but this difference did not achieve statistical significance. With superior visualization and finer motor control, it seems to be much easier and safer to perform complete myotomy with robot-assisted operation than with laparoscopic techniques.

An important advantage of robotic-assisted surgery might be in a tough re-do operation Heller myotomy for an incomplete myotomy, where the aforementioned advantages of the robotic technique could make a difference. The results of laparoscopic redo-Heller myotomy have been reported by centers, however, with success rates ranging from 50 to 73% [17]. In our series, no redo-Heller myotomies were performed in the laparoscopic groups, while five operations were performed in the robot-assisted group. Our technique of redo-myotomy involves restoring the normal anatomy by reversing the anti-reflux procedures and then performing a myotomy along the lateral aspect of the esophagus and gastric cardia to avoid the location of the previous

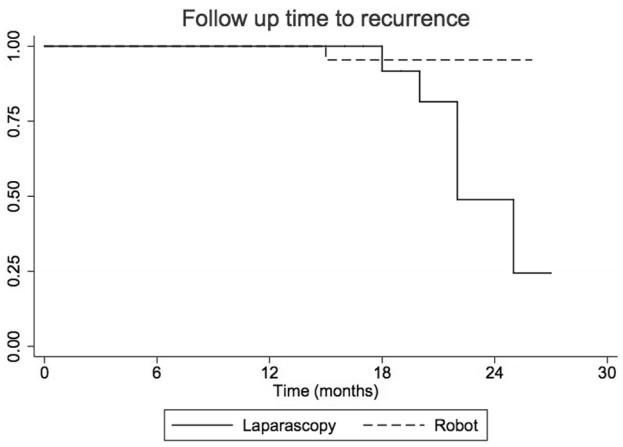

Fig. 1 Kaplan–Meier curve demonstrating the recurrence of symptoms after laparascopic vs. robotic Heller myotomy

myotomy scar. Long-term surgical result in our patients has been encouraging with no recurrence of symptoms being reported.

Our study has certain limitations. This is a nonrandomized study involving a single institution. Also, the patient numbers are relatively small, thus limiting our ability to detect small differences in our analysis. However, performing a randomized multi-institution study in comparing different surgical techniques for achalasia would be challenging, given the rarity of the disease and alternative nonsurgical treatments available such as esophageal dilation or perioral endoscopic myototmy.

Conclusion

Both laparoscopic and robot-assisted Heller myotomy can accomplish definitive treatment of achalasia with good long-term results and few complications. The longer myotomy onto the stomach across the gatroesophageal junction is the key factor associated with a lower recurrence rate. The mechanical advantage provided by the robotic approach may improve outcomes by making the operation safer and providing a more complete myotomy leading to a more durable long-term result.

Compliance with ethical standards

Conflict of interest Authors Samuel Kim, Jose Guillen-Rodriquez and Alex Little declare that they have no conflict of interest.

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