Esophageal Achalasia: From Laparoscopic to Robotic Heller Myotomy and Dor Fundoplication

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ABSTRACT

Objective: Laparoscopic Heller myotomy and Dor fundoplication has become the gold standard in treating esophageal achalasia and robotic surgical platform represents its natural evolution. The objective of our study was to assess durable long-term clinical outcomes in our cohort.

Methods and Procedures: Between June 1, 1999 and June 30, 2019, 111 patients underwent minimally invasive treatment for achalasia (96 laparoscopically and 15 robotically). Fifty-two were males. Mean age was 49 years (20 – 96). Esophageal manometry confirmed the diagnosis. Fifty patients underwent pH monitoring study, with pathologic reflux in 18. Preoperative esophageal dilation was performed in 76 patients and 21 patients received botulin injection. Dysphagia was universally present, and mean duration was 96 months (5 – 480).

Results: Median operative time was 144 minutes (90 – 200). One patient required conversion to open approach. Four mucosal perforations occurred in the laparoscopic group and were repaired intraoperatively. Seven patients underwent completion esophageal myotomy and added Dor fundoplication. Upper gastrointestinal series was performed before discharge. Median hospital stay was 39 hours (24 – 312). Median follow up was 157 months (6 – 240), and dysphagia was resolved in 94% of patients. Seven patients required postoperative esophageal dilation.

Conclusions: Minimally invasive Heller myotomy and Dor fundoplication are feasible. The operation is challenging, but excellent results hinge on the operative techniques and experience. The high dexterity, three-dimensional view, and the ergonomic movements of robotic surgery allow application of all the technical elements, achieving the best durable outcome for the patient. Robotic surgery is the natural evolution of minimally invasive treatment of esophageal achalasia.

Key Words: Esophageal achalasia, Dor fundoplication, Heller myotomy, Laparoscopic surgery, Robotic surgery, Eckardt Score.

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INTRODUCTION

Esophageal achalasia represents a very rare primary esophageal motility disorder secondary to loss of inhibitory nitrergic neurons at the esophageal myenteric plexus level.[1] It is characterized by lack of esophageal peristalsis and absence or partial relaxation of the lower esophageal sphincter in response to swallowing during esophageal manometry.[2] Its incidence is estimated at 1 per 100,000 people, while the prevalence is quantified around 10 per 100,000.[3] A cascade of events ranging from a possible viral infection or environmental factors lead to an esophageal myenteric plexus inflammation, which builds an autoimmune response in genetically susceptible people and chronic inflammation with destruction of the myenteric plexus.[4] In clinical practice the combined use of esophagogastroduodenoscopy (EGD) and upper gastrointestinal series (UGI) helps the provider to assess the patient presenting with dysphagia and/or regurgitation, which are the most common clinical findings in this patient population. High resolution esophageal manometry (HREM) became in the last decade a paramount tool in categorizing the types of esophageal achalasia with associated lack of lower esophageal sphincter relaxation.[5] HREM helps to diagnose three types of motility patterns in esophageal achalasia. Type I is characterized by simultaneous premature contractions which failed to elicit effective peristalsis at all; type II is categorized by panesophageal pressurization pattern, and type III is defined as vigorous achalasia due to high amplitude simultaneous contractions. We speculate that those patterns might be evolving from one type to another, making a different diagnosis of esophageal achalasia at the time of HREM. Looking after many etiologies of esophageal achalasia and at least 30 years of publications on this topic, it is clear that this disease is incurable and that any treatment methodology needs to be considered symptomatically palliative at best.

Current pharmacologic, endoscopic, and surgical treatment options are aimed at reducing the hypertonicity of the lower esophageal sphincter, but unfortunately, the absence of esophageal peristalsis does not restore it to normal propulsive waves. Pharmacologic treatments including calcium channels blockers or sequential botulinum toxin injection are usually limited to patients not amenable to surgical treatment and have limited effects.[6] Endoscopic pneumatic dilatation, Heller myotomy, and Dor fundoplication or, more recently, the peroral endoscopic myotomy (POEM) are the most frequently used modalities in treating this rare disorder. Surgery compared with medical or endoscopic pneumatic dilation is proven to provide the best long-term clinical outcome.[7–8] Based on the recent SAGES guidelines, minimally invasive surgical treatment, such as Heller myotomy and fundoplication, is considered to be the gold standard treatment for esophageal achalasia.[9] Whereas there have been significant improvements in laparoscopic instruments over the years, they are still limited in their ability to perform surgery in tight spaces or challenging angles, including esophageal myotomy. The recent introduction of robotic surgery reduces those limitations by granting the user increased dexterity of movements with the advent of wristed instruments. This retrospective review represents an evolution of a private surgical practice.[10]

MATERIAL AND METHODS

Between June 1, 1999 and June 30, 2019, 111 patients (52 males and 59 females) underwent minimally invasive surgical treatment for primary esophageal achalasia. Ninety-six patients were treated laparoscopically and 15 patients with robotic Heller myotomy and Dor fundoplication. Mean age was 49 years old (22 – 96). Preoperatively, all patients were evaluated with EGD, UGI series, and traditional esophageal manometry (until 2011) and then high-resolution esophageal manometry (HREM), thereafter (Manoscan Eso High Resolution Manometry, Medtronics, Minneapolis MN). Esophageal manometry confirmed the diagnosis. Based on the HREM, 21 patients were categorized as type I, 5 patients as type II, and 5 patients as type III esophageal achalasia. All patients had severe dysphagia for solids and liquid with median duration 96 months (5 – 480 months). Ninety-two patients presented with regurgitation, 52 patients had intermittent chest pain with normal cardiac workup, 67 patients had heartburn, and 44 patients had respiratory symptoms (**Figure 1**). EGD and UGI series were performed in all patients to rule out the presence of secondary achalasia. Preoperatively, pneumatic dilatation was performed in 86 patients (mean 2.3 dilatations), botulinum injection was used, as adjuvant therapy with pneumatic dilatation, in 21 patients (19 in the laparoscopic group and 2 in the robotic group). We categorized the patient population in three grades base on UGI series criteria: 54 patients (grade 1 < 4 cm esophageal diameter), 24 patients (grade 2 4 cm – 6 cm esophageal diameter), 33 patients (grade 3 > 6 cm esophageal diameter). **Figure 2** shows esophageal achalasia divided by three grades. Twenty four-hour pH monitoring study was performed in 50 patients and was abnormal in 18

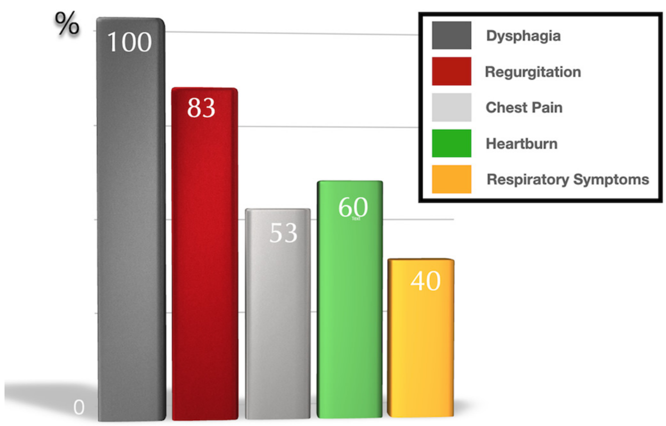

Figure 1. Distribution of preoperative symptomatology in our patient population.

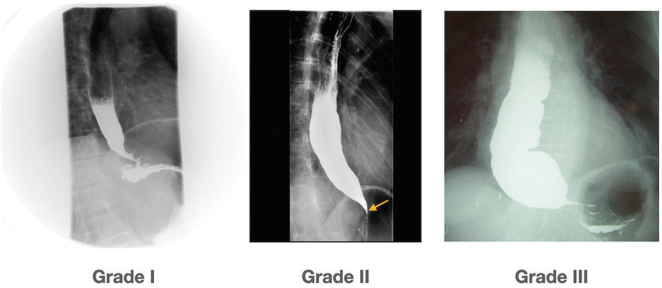

Figure 2. Upper gastrointestinal series showing the grade classification: Grade I (54 patients), Grade II (24 patients), Grade III (33 patients).

patients. Eckardt score was used in all patients to assess the clinical response before and after surgical treatment.[11] **Table 1** shows the parameters of Eckardt score and their interpretation. In addition, a pre-operative and postoperative clinical symptomatic score between 0 and 4 was utilized to measure dysphagia, heartburn, regurgitation, chest pain, and respiratory symptoms, with 0 as no symptoms and 4 as severe symptomatology.

OPERATIVE TECHNIQUE

Patient Preparation

After induction of general endotracheal anesthesia, the patient is placed in steep reverse Trendelenburg. A foley is inserted. A nasogastric tube is placed to help to decompress the esophagus in preparation for surgery. Compression stockings are placed during the procedure.

Laparoscopic Approach

Initially, with the patient on stirrups in lithotomy position, a 5 mm Optiview trocar (Applied Medical Inc., Rancho Santa Margarita, CA) is placed in the right upper quadrant with a 0-degree scope. Pneumoperitoneum is set at 14 mm Hg. Then, camera is switched to a 30 degree scope. Under direct visualization, a second 5 mm trocar is inserted at 13 cm from the xiphoid process along the midline above the umbilicus. A third 5 mm trocar is placed in the left upper quadrant and a 12 mm balloon trocar is placed in the left lower quadrant for laparoscopic assistance. The surgeon is placed in between the patient's legs while in lithotomy position in reverse Trendelenburg. A laparoscopic Nathanson retractor (Mediflex Surgical Products, Islandia, NY) is introduced in the epigastrium to lift the left lateral segment of the liver to provide excellent exposure to the hiatus. The Nathanson is anchored to a flexible laparoscopic holder (Thompson Surgical Instruments, Traverse, MI) and to a post along the patient's right side. **Figure 3**-A shows our ideal port placement for laparoscopic access.

Table 1.
Eckardt Score

Score	Weight Loss	Retrosternal Pain	Regurgitation	Dysphagia
0	None	None	None	None
1	<5 kg	Occasional	Occasional	Occasional
2	5 – 10 kg	Daily	Daily	Daily
3	>10 kg	Each meal	Each meal	Each meal

Robotic Approach

The patient is placed in supine position without the need for lithotomy position, avoiding any possible injury to the perineal nerves. The setting of the trocar position is similar to the laparoscopic approach. The trocars are all 8 mm in the robotic da Vinci Xi platform, while the camera port needs to use a 12 mm trocar in the robotic da Vinci® Si platform (Intuitive Surgical, Inc. Sunnyvale, CA). The patient needs to be in steep reverse Trendelenburg to start the operation and a base is placed below the feet to avoid the patient sliding while in this position. All patients are strapped at the operating room table as well. **Figure 3**-B shows our ideal port placement for robotic access.

Robotic Instrumentation

As part of the robotic platform, we use a Vessel seal or Harmonic scalpel as energy devices, a monopolar hook, and a bipolar grasper.

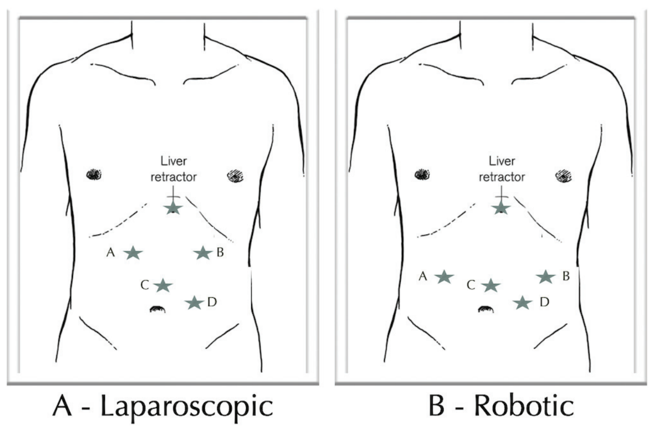

Figure 3. (**A**) Laparoscopic And (**B**) Robotic trocar position for Heller myotomy and Dor fundoplication: Liver retractor, A/B Working instruments ports, C Camera port, D Assistant port.

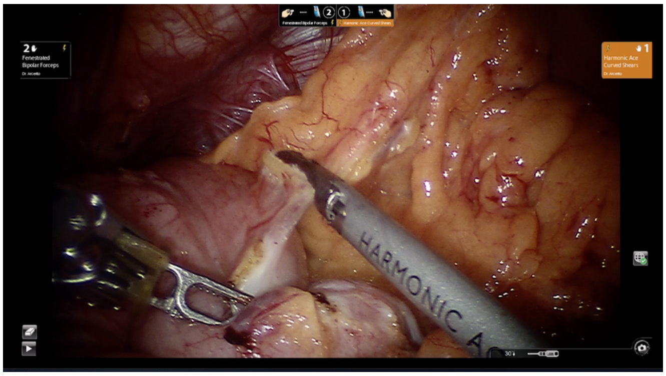

Figure 4. Division of the short gastric vessels.

Steps of the Operation (Similar Laparoscopic and Robotic Approach)

Step 1. The Phreno-Esophageal Ligament Division and Diaphragmatic Crus Dissection

The operation starts dividing the gastrohepatic ligament preserving any replaced left gastric artery when present. We use an ultrasonic dissector to expose the right diaphragmatic crus and dissect the right sight of the esophagus from it. The phreno-esophageal ligament is divided and the upper portion of the esophagus is exposed with a mandatory identification of the anterior vagus nerve.

Step 2. Short Gastric Vessels Division

The left crus is dissected from the left side of the esophagus and the greater curvature of the stomach is mobilized, dividing all the short gastric vessels (**Figure 4**). This maneuver helps to prepare the stomach for the creation of the anterior fundoplication (Dor 180 degree fundoplication) after the completion of the myotomy. Once the left crus is completely identified, a further dissection is performed in the posterior mediastinum working anteriorly and laterally around the esophagus. This step allows the surgeon to achieve enough esophageal length for the coming myotomy. In the presence of sigmoid esophagus (grade III), it is advised to dissect the entire circumference of the distal esophagus creating the retro-esophageal window. The closure of the hiatus is recommended to avoid any possible herniation of the stomach secondary to the absence of the anchoring phreno-esophageal membranes, already dissected (**Figure 5**).

Step 3. In the Presence of Hiatal hernia - Creation of the Retro-Esophageal Window and Completion of the Resection of the Hernia Sac

The reduction of the posterior gastric wall from the chest to the abdomen allows us to create a wide retro-esophageal window. A Penrose drain is placed to retract the distal esophagus. The anterior and posterior vagus nerves are always identified and protected. It is advisable, after retracting the distal esophagus, to remove the fat pad at the gastroesophageal junction using the Harmonic scalpel. In addition, this maneuver helps resect the final adhesions at the distal third of the esophagus, lengthening it enough to create the fundoplication in the abdomen without tension. The final attachments between the esophagus and the right and left crus are divided.

Step 4. Esophageal Myotomy

A nasogastric tube is used in preparation for the esophageal myotomy. The distal esophagus is prepared by dividing the fat pad at the level of the gastroesophageal junction. The assistant port in the left lower quadrant is used to straighten the distal esophagus using an atraumatic grasper at the gastric level. The length of the myotomy has been subject of multiple debates in the last few decades. We perform a 7 cm – 8 cm myotomy in length with 2 cm – 2.5 cm involving the gastric oblique fibers below the gastroesophageal junction. The myotomy is started usually 3 cm to 4 cm above the gastroesophageal junction on the right side of the identified anterior vagus, using monopolar energy device instrument to divide the longitudinal muscle, and subsequently the underlying circular fibers, one at the time!

This is the moment, in our experience, where the robotic platform provides an incredible advantage to complete the esophageal myotomy safely. The dexterity property and the wristed instruments grant the user to achieve extremely precise movement in preventing any injury to the underlying esophageal mucosa. The use of the wristed robotic hook is paramount in conducting the distal esophageal myotomy towards the stomach when the oblique

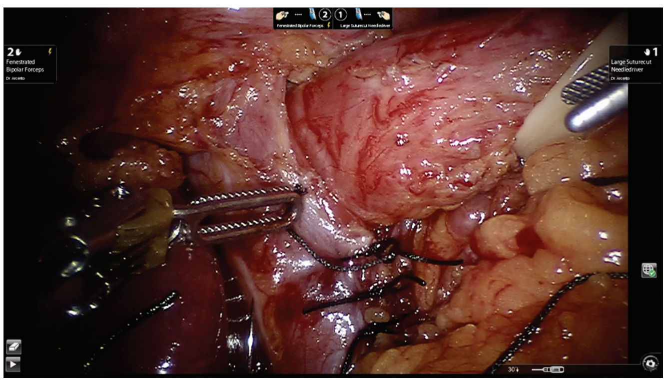

Figure 5. Completed closure of the diaphragmatic crura.

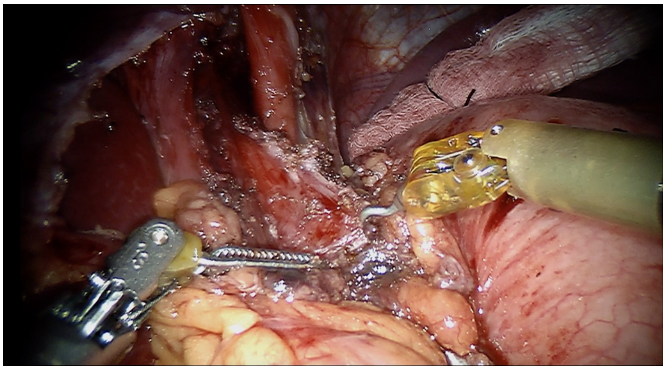

Figure 6. Robotic hook dissecting the circular and oblique muscle fibers to complete the esophageal myotomy.

fibers are encountered (**Figure 6**). This wristed capability allows the surgeon to prolong the esophageal myotomy to a length (8 cm) that should be able to control the durability of absence of dysphagia after surgery is completed. Once all the longitudinal and circular fibers are divided, the nasogastric tube is used to inject methylene blue to rule out any presence of unidentified esophageal microperforations. If present, any small esophageal perforation is repaired using absorbable interrupted 5-0 sutures. The use of the robotic technique is absolutely superior to the laparoscopic approach in repairing mucosal lesions with extreme precision and avoiding enlarging them while attempting the intracorporeal suture laparoscopically. The patients with complex previous pharmacological and medical treatment (multiple dilations and/or botulin injections) are prone to experience esophageal perforation during the completion of Heller myotomy.[30] **Figure 7** shows the completed 8 cm esophageal myotomy.

***Step 5*. Creation of Dor (180 degree) anterior fundoplication** A fundoplication should be always added to a completed Heller myotomy to minimize esophageal acid exposure in an atonic esophagus.[9] We believe a Dor fundoplication should be the treatment of choice. First described by Dr Dor, it is an anterior 180 degree fundoplication. The division of all short gastric vessels allow the creation of the Dor fundoplication without any tension. The first row of sutures anchor the fundus to the left side of the esophageal myotomy using three stitches with 2-0 silk (**Figure 8**). The upper of the three stitches involves the left diaphragmatic crus. Then the stomach is wrapped anteriorly over the completed esophageal myotomy with additional four suture of 2-0 silk with the most proximal suture incorporating the right side of the crus, the fundus of the stomach, and the right side of the myotomy. The remaining stitches are placed between the fundus and the right side of the esophageal myotomy. An additional two to three stitches are placed between the arch of the crura and the gastric fundus. This maneuver reduces the possibility of a wrap herniation due to the positive abdominal pressure towards the chest negative pressure. **Figure 9** shows the completed anterior Dor fundoplication using robotic platform. **Figure 10** shows the technical elements of laparoscopic or robotic Heller myotomy and Dor fundoplication.

RESULTS

Ninety-six patients underwent laparoscopic procedures while 15 patients were treated with robotic platform for Heller myotomy and anterior Dor fundoplication. All patients were, but one, were completed using minimally invasive techniques. One patient with hepatomegaly and hepatic steatosis was converted due to left liver segmental

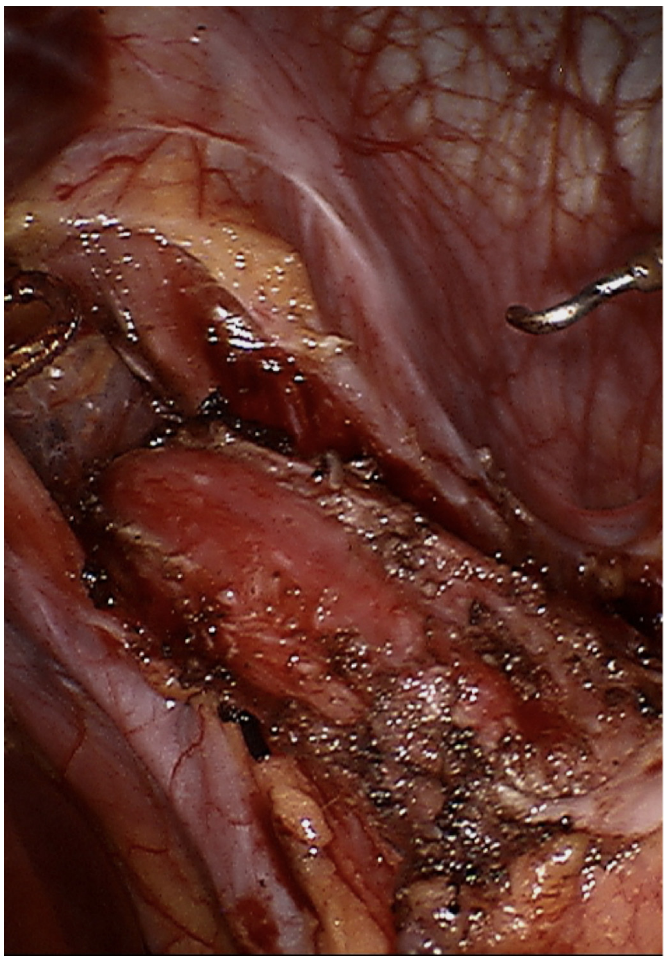

Figure 7. Robotic completed Heller myotomy.

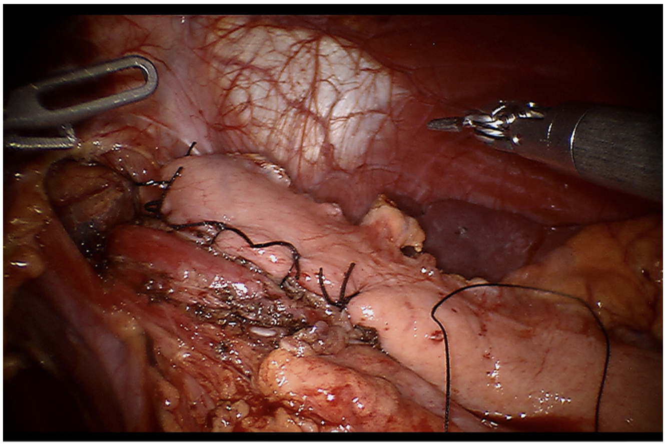

Figure 8. Robotic Dor anterior fundoplication, first row of sutures between the fundus and the left side of the myotomy.

injury during the Nathanson retractor placement. The injury was successfully repaired and the operation was completed as an open procedure. The length of the operation in the laparoscopic group was longer compared with the robotic group (158 minutes vs 105 minutes, p value 0.03). The techniques were similar among both groups. The robotic time was calculated from docking the robot platform to the patient to undocking it from the patient. We experienced four esophageal perforations in the laparoscopic group, which were repaired intraoperatively. Reviewing the time of

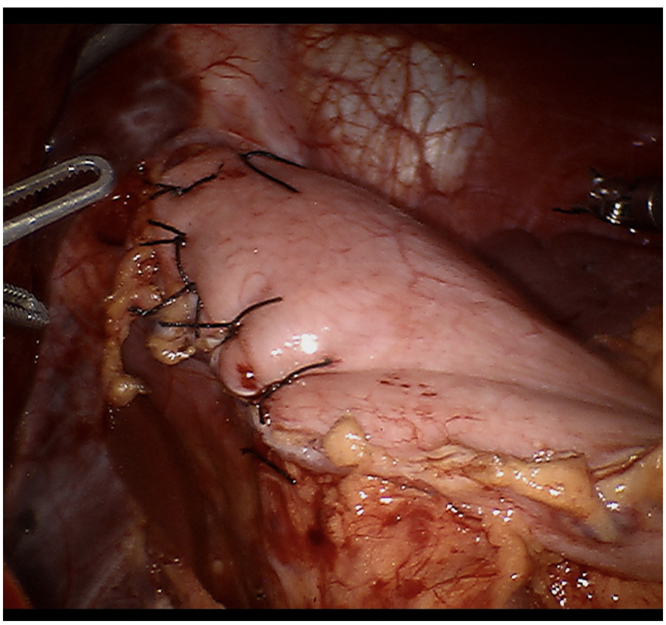

Figure 9. Completed robotic Dor anterior fundoplication.

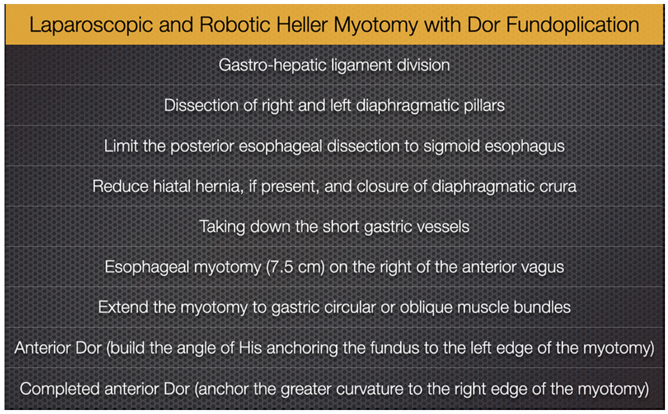

Figure 10. Technical elements in performing either laparoscopic or robotic Heller myotomy and Dor fundoplication.

the esophageal perforation, the first patient received two pneumatic esophageal dilatations, while the remaining three patients were referred for surgical treatment after undergoing three pneumatic dilations associated with an average of 4.7 botulin toxin injections (2, 5, and 7, respectively). No intraoperative blood transfusions were required and no anesthesia complications were experienced. In addition, no intraoperative or perioperative mortality were recorded. No patient experienced any late clinical sequelae following the esophageal perforation repair. By protocol, all patients were admitted for at least one overnight stay and underwent an UGI series on the first postoperative day. Seven patients were diagnosed with delayed contrast emptying into the stomach. Repeating the same radiographic test 2 days later, 5 patients had normal transit into the stomach, showing the probability of edematous postsurgical changes as a cause of the initial abnormal test. A clear liquid diet was resumed after a postoperative normal UGI series and the patient was kept on full liquid diet for the following two weeks before advancing to regular diet with several small meals per day.

The average hospital stay was 39 hours (24 – 312). About 90% of patients were discharged after 24 hours, most of the remaining patients left the hospital after 48 to 96 hours. One patient developed severe basal right pneumonia after resuming clear liquid diet, probably secondary to a subclinical aspiration pneumonitis. Her saturation was always low and chest x-ray confirmed the diagnosis. She eventually resolved her clinical status with a combination of antibiotics and respiratory therapy. She represents the 312 hours hospital stay patient in our surgical series. In addition, 8 male patients experienced urinary retention requiring Foley catheter insertion. Five patients with preoperative atrial fibrillation developed rapid atrial fibrillation requiring medical treatment. Patients were asked to follow-up clinically at 14 days, 30 days, three months, six months, and yearly post-surgery. UGI series were ordered at 3 months and 1 year postoperatively. Esophageal manometry and combined 24 hours Bravo pH monitoring were performed in 23 patients postoperatively. Most of the patients could not be studied based on denial insurance authorization. The functional study showed persistent absence of esophageal peristalsis, but decreased pressure on the lower esophageal sphincter compared with the pre-operative evaluation. In addition, only two patients showed the lower esophageal sphincter capability to relax in response to swallowing. Four patients were found to have pathologic gastroesophageal reflux among the 23 patients able to be studied postoperatively. Those patients are currently treated with proton pump inhibitors with no need for further surgical treatment. Dr. Arcerito's experience spans both Italy and the United States of America, and for patients overseas, under their authorization, he utilized videoconferencing to continue to follow their clinical outcome at a long distance. Among the study team's surgical experience, 11 patients (7 laparoscopy and 4 robotically) were referred for persistent dysphagia after undergoing laparoscopic Heller myotomy. Dor fundoplication was added to the procedure after prolonging the short myotomy up to 7 cm – 8 cm involving the gastric sling of the oblique muscle fibers in those patients who received only an esophageal myotomy. Three patents were required to take down the Dor for persistent postoperative dysphagia after 2.3 esophageal dilations. In the robotic group, two patients were referred with severe gastroesophageal disease detected by the Bravo pH monitoring test after undergoing laparoscopic Heller myotomy in outside facilities. In both patients Dor fundoplication was added robotically with resolution of their symptomatology. Pre-operative, Eckardt score was quantified as 10.7, while the latest postoperative score was 2.8. **Figure 11**

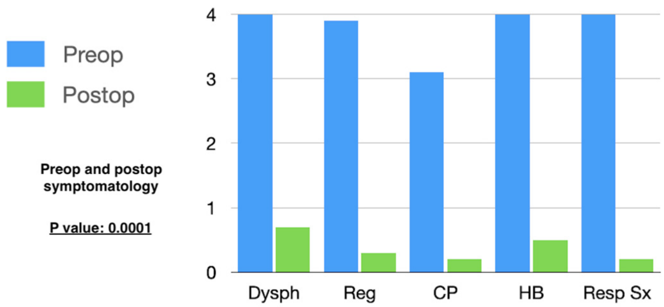

Figure 11. Clinical outcome (score 0-4, 0 as no symptoms and 4 as severe symptoms) at median follow up of 157 months (p value < 0.001 between preoperative and postoperative symptom score).

shows the clinical outcome of our patient population using the 0 – 4 score previously described at the median follow-up of 157 months (6 – 240) and was statistically significant between pre-operative and postoperative clinical presentation ($P \leq .001$). Between personal clinical evaluation and telemedicine encounters, 91 patients were successfully contacted; 20 patients were lost in follow-up, including 7 patients who died for natural causes. Those lost patients belong to the laparoscopic treatment group, while the 15 robotically treated patients were successfully contacted. Overall, a combined resolution or intermittent dysphagia was achieved in 94% of the total population. Six patients in the laparoscopic group and 1 in the robotic group required esophageal dilation with clinical response of residual persistent dysphagia.

DISCUSSION

This study represents a 20-year retrospective clinical review of minimally invasive techniques in treating this rare esophageal motility disorder. All patients undergoing minimally invasive surgical treatments had a complete preoperative workup. Symptoms like dysphagia or regurgitation can be present in multiple esophageal motility disorders. To confirm the diagnosis of esophageal achalasia, esophageal manometry associated with 24-hour pH monitoring, following upper endoscopy to rule out any esophageal malignancy are mandatory.[12] Radiography of the esophagus should be performed in every patient with esophageal achalasia. The role of esophageal manometry and pH monitoring has been previously emphasized.[13] The advent of high-resolution manometry guided to build the Chicago classification in categorizing three types of esophageal achalasia.[5] At this moment, the goal of any treatment for esophageal achalasia is not the resolution of the disease, but to reach a successful symptomatic improvement leading to improved patient quality of life. This message should be always addressed with our patients at the time of our first encounter and the postsurgical symptomatology should be the focus of clinical outcomes in all published experiences. Medical treatment with calcium channel blockers, endoscopic pneumatic dilations, and botulinum toxin injections represent the initial approaches when esophageal achalasia is clinically encountered. For many years, the first alternative treatment to release the high-pressure zone at the level of lower esophageal sphincter has been pneumatic dilatation. This methodology is not exempted by complications like esophageal hematoma and esophageal perforation anywhere between 2 to 6%.[14] Long term resolution of dysphagia is achieved in 40 to 50% of patients after pneumatic dilation.[15] Botulinum toxin injection requires multiple applications without an acceptable long-term clinical outcome.[16] Since the advent of laparoscopic cholecystectomy in the early 1990s,[17] we have observed the improvement of optics and instrumentation technology applied to surgical principles. Those achievements helped the gastrointestinal surgeons to improve the capability to work and perform maneuvers with accuracy in confined anatomical spaces.

The surgical treatment of esophageal achalasia faced a long journey with many modifications during the last century. A very elegant review article focusing on the history of surgery for esophageal achalasia was recently published.[18] First described by Heller in 1913, surgery involved a left thoracotomy and a double 8 cm myotomy in the distal esophagus.[19] This surgical approach was then modified to a single myotomy considering the excessive gastroesophageal reflux exposure.[20]

There has been a major surgical evolution in the last 100 years including the laparotomy approach,[21] thoracoscopic surgery, laparoscopic, robotically, and POEM. The thoracoscopic Heller myotomy proved to be feasible and safe, but despite initially good results in relieving dysphagia, severe postoperative gastroesophageal reflux was encountered.[22,23] First described by Ancona et al., an anterior fundoplication was added to the laparoscopic Heller myotomy with promising long-term results in controlling postoperative reflux symptomatology.[24] Their technique was mastered by many institutions throughout the world and today minimally invasive Heller myotomy with fundoplication is considered the gold standard treatment for esophageal achalasia.[9] We applied the added antireflux operation to the Heller myotomy in our surgical experience and proved its efficacy.[10] A double blind study comparing the laparoscopic Heller myotomy with or without Dor fundoplication clearly showed the presence of a Dor minimizes gastroesophageal reflux disease (GERD) exposure compared to the absence of it.[25] Debates are still ongoing in determining which type of partial fundoplication (anterior or posterior) needs to be added. The results are similar and it seems the final decision is linked to the surgeon's preference.[26] A recent clinical randomized study focused on assessing the clinical outcomes of Heller myotomy in association with anterior Dor or posterior Toupet fundoplication. The authors randomized 38 patents with Dor and 35 patients with Toupet fundoplication assessing objective measures using high-resolution esophageal manometry and 24-hour pH monitoring studies postoperatively. No difference was noted upon basal lower esophageal sphincter pressure and sphincter relaxation in either group. Despite a lower incidence of GERD after Dor fundoplication at six months compared with the Toupet patients, the groups were comparable in GERD presentation at 12 and 24 month follow-ups. In addition, no difference was detected in postoperative symptom score at 1, 6, or 24 months.[27] We believe Dor fundoplication is more protective of the exposed esophageal mucosa after completion of the myotomy. A short myotomy was a reason for referral to our surgical experience due to persistent postoperative dysphagia despite esophageal dilatations. We applied the original Heller technique in building an adequate myotomy up to 7.5 cm – 8 cm in length traveling from the distal esophagus (5 cm) to the gastric wall involving the gastric sling and the oblique fibers (2.5 cm – 3 cm).[28] The concept of a short myotomy to prevent reflux is not applicable anymore, considering the use of a partial fundoplication added to prevent postoperative GERD.

The presence of sigmoid esophagus (end stage of esophageal achalasia) is also part of scientific debates today. We encountered 33 patients with end stage esophageal achalasia detected by UGI series in our preoperative evaluations. All patients underwent successful long esophageal myotomy and Dor fundoplication (25 in the laparoscopic group and 8 in the robotic group) applying all the surgical technical elements previously described.[29] We always consider minimally invasive Heller myotomy and Dor fundoplication as standard of care in advanced esophageal achalasia, limiting esophagectomies as the final choice in those who failed all the other treatment options.

All patients received some form of treatment before being referred for surgical intervention. In addition to multiple esophageal dilatation attempts, botulinum toxin injection is considered in the gastroenterology field, a valid alternative in treating achalasia using pharmacologic effects. The multiple injection of this molecule creates a severe scar tissue formation which makes esophageal myotomy highly challenging. We experienced four esophageal perforations while performing the myotomy in patients previously treated aggressively with multiple esophageal dilations (one patient) and with multiple botulinum injections (three patients). We showed that aggressive presurgical treatment as pneumatic dilation and botulinum injection interfere with the intraoperative and postoperative clinical outcome in this delicate patient population.[30] Those forms of treatment should be limited to patients who are not suitable for surgical intervention.

The use of the robotic platform in treating esophageal achalasia represents our natural evolution following all the surgical principles applied previously to the laparoscopic approach. Our last 15 patients treated robotically are not in consecutive order, due to insurance denials for this form of treatment. In those instances, we performed the same operation using laparoscopic techniques.

Robotic surgery has advanced over the last 20 years and helps to overcome the pitfalls of laparoscopic surgery. While there are continuous improvements of laparoscopic instrumentation, there are still limitations including poor range of motion, poor surgical ergonomics, and lack of 3D view in complex cases. Those limitations make a minimally invasive Heller myotomy and Dor fundoplication challenging. The introduction of robotic techniques reduces those limitation with the dexterity of movements granted by the wristed instrumentation compared to laparoscopic tools and helps when performing higher level surgical cases. However, despite the superiority of minimally invasive techniques with their equivalent results over open traditional surgery, the robotic surgery is considered highly costly compared with laparoscopic approach.[31]

Using the robotic platform, important technical principles should be always observed while completing the Heller myotomy and Dor fundoplication. The most difficult challenge of the operation is to complete a long myotomy with 2.5 cm into the oblique muscle fiber of the stomach. The rigid laparoscopic instrumentations, the lack of dexterity, and the 2D view in a 3D field make this portion of the operation highly challenging. We believe the use of the robotic platform helps the surgeon to overcome those pitfalls using the characteristic of robotic technology, like the control of tremors during the myotomy, the 3D view, and the excellent hand-eye coordination. Authors in recent multicenter studies and meta-analyses reviewed prospectively the successful role of robotic surgery in treating esophageal achalasia.[32,33] Robotic surgery with long esophageal myotomy and Dor fundoplication will eventually become the gold standard in treating esophageal achalasia.

First described by Inoue in 2007, POEM for esophageal achalasia is performed in the United States and around the world.[34] In recent years, published articles have focused on comparing laparoscopic, robotic, and POEM approaches for esophageal achalasia.[35] The incidence of complications such as esophageal perforation, return to the operative room seems to be higher with the laparoscopic approach compared with robotic and POEM procedure combined. Despite the initial gratifying success of the POEM, there is some concern for the absence of a gastroesophageal barrier to the myotomy, increasing the risks of reflux esophagitis and possible development of esophageal malignancy in patient with no esophageal peristalsis.

Outcomes after achalasia treatment are quantified using the Eckardt score.[11] This score was created after collecting pre and post-treatment symptoms and scoring their severity. The correlation with radiographic and manometric measures has established the Eckardt score as primary assessment tool in the management of achalasia treatment. This methodology helps to identify success (Eckardt score < 3) and failure (Eckardt score > 3) in any esophageal achalasia treatment. Our experience showed 94% of patients with an Eckardt score < 3 with a median long-term follow-up of 154 months (6 – 210). The Eckardt score has several limitations including the inability to assess quality of swallowing and the severity of GERD symptomatology after treatment. This deficiency leads to incomplete data when reporting clinical outcomes in treating esophageal achalasia. Despite our excitement in the study's 94% success rate, we believe that creating a more comprehensive assessment may help provide the real number of successfully treated achalasia patients. Recently, Shemmeri et al. published a paper using a patient report card including the use of the Eckardt score. Shemmeri et al. analyzed all patients after surgical treatment of achalasia using eight outcome measures in subjective, objective, and interventional categories to create a global postoperative assessment tool. The subjective capabilities using an Eckardt score < 3, normal swallowing, and the absence of reflux symptomatology were considered successful treatment. The objective measures included the absence of esophagitis by endoscopy, a normal integrated relaxation pressure < 15 mm Hg by high resolution esophageal manometry, a normal gastroesophageal exposure by pH monitoring, and clearance of barium on esophagogram after five minutes were considered successful treatments. Finally, the absence of any reintervention was considered successful treatment. The report card ranged between 45% to 80% success in treating this esophageal motor disorder.[36] As esophageal health care providers, this type of clinical patient report card should be standardized and used consistently to obtain uniform clinical outcomes. Achieving a medical assessment of this report card will help us to review our clinical outcomes and provide realistic expectations for patients after treating this rare esophageal motor disorder.

CONCLUSIONS

We described our professional journey in treating esophageal achalasia applying all the surgical technical principles using minimally invasive techniques. We believe that application of those principles helps us to achieve durable, excellent clinical outcomes. The role of a fundoplication is mandatory in preventing pathologic gastroesophageal reflux after destroying the gastroesophageal junction barrier. The reported success rate in treating esophageal achalasia does not represent the real clinical outcome when using the Eckardt score as a tool. We believe, adding objective "patient report cards" might help to collect more consistent data when long term symptomatic results are published. The high dexterity of robotic surgery helps us to achieve the durable clinical outcomes in this very difficult and rare group of patients. We speculate the robotic platform represents a natural surgical evolution in performing Heller myotomy and Dor fundoplication for esophageal achalasia.

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