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Robotic-assisted reoperative benign foregut surgery

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Abstract

Foregut disorders including gastroesophageal reflux disease (GERD), hiatal hernia (HH), and achalasia are often treated operatively including anti-reflux surgery (ARS), fundoplication, and Heller myotomy (HM). Minimally invasive surgery has become the preferred technique to treat these disorders. These operations have an inherent risk of failure requiring reoperation. These redo operations are more difficult because adhesions and destruction of tissue planes impair visualization during dissection of the hiatus and the gastroesophageal junction (GEJ). Conventional laparoscopic techniques have been described for redo foregut surgery with good results. Surgical robotic systems provide an alternative minimally invasive approach that improves visualization, dexterity, and surgeon ergonomics in many operations. The robot can be used safely and effectively for redo foregut surgery. In this review, we discuss the robotic surgical technique for reoperative foregut surgery and discuss the approach to individual foregut diseases.

Keywords: Foregut, GERD, hiatal hernia, achalasia, robotic surgery, reoperative, anti-reflux surgery, Heller myotomy

INTRODUCTION

Foregut disorders include a significant portion of the general thoracic surgeon's practice. Typically, these disorders include gastroesophageal reflux disease (GERD), hiatal hernia (HH), and achalasia. The incidence of GERD in the US is about 28%[1]. Over 50% of people over 50 years of age have a HH with about 10% of these being symptomatic and needing intervention[2]. Incidence of paraesophageal hernias (PEH) is in the range of 20%-50%[3]. Laparoscopic repair is often performed for symptomatic cases for prevention of serious

complications such as obstruction, volvulus, strangulation, and perforation. The incidence of achalasia is 0.05%[4,5]. In 2011, over 5,000 Heller myotomies were performed for achalasia compared to about 1,000 in 1992[6]. Presumably, this number is much higher now.

Better understanding of these disease processes has led to more advances in surgery including the widespread adoption of minimally invasive surgery. More operations are being performed for foregut disorders with good success rates[7-10]. However, given the natural history of these benign diseases, their operations come with a certain recurrence rate. Although some of these recurrent symptoms can be managed medically, a reasonable proportion of them need re-intervention. Most studies report a 2%-30% reoperation rate for foregut procedures[8,11-19]. Surgical re-interventions in the foregut create particular technical challenges due to factors such as dense adhesions, scarring, obliteration of tissue planes, and altered anatomy[11,16,20-22]. Reoperative foregut operations have increased morbidity to the patient with higher incidences of esophageal perforation, delayed gastric emptying, and vagal nerve injury[11,19,23]. Hiatal mesh repairs further complicate re-intervention with higher rates of major resection requiring complex reconstruction[24,25]. Of note, complications and patient-reported outcomes worsen with each reoperative anti-reflux surgery (ARS)[21].

There are several studies describing the role and advantages of laparoscopic re-operative foregut surgery[11,16,20,21,26]. With the introduction of the robotic platform in the 1990s, several conventional laparoscopic procedures have been replaced by the robot. Intuitively, the improved visualization and dexterity should have some added advantages in complex foregut procedures, but it is unclear if this translates into clinically better outcomes. There is some evidence that robotic-assisted laparoscopic foregut surgery offers shorter postoperative length-of-stay and fewer complications compared to the respective laparoscopic techniques[27,28]. Other studies suggest no benefit in regards to quality of life or functional outcome with short-term follow-up between conventional laparoscopic *vs.* robotic-assisted techniques[29,30]. In this review article, we discuss the indications for re-operative benign foregut surgery and critically evaluate the technique and outcomes of using the robotic platform for these operations.

PART 1: ROBOTIC ASSISTANCE IN REDO FOREGUT SURGERY

Understanding that there will be more reoperations in the coming decades, there is an imminent need to improve skills and identify technology and techniques that can offer better outcomes for these patients. There are well-known limitations to conventional laparoscopic surgery (CLS), including limited range of motion, unsteady camera visualization, and poor ergonomics. Especially in a reoperative field, this is inferior compared to the jointed arms and controlled camera with the robot[31].

Since the introduction of robotic surgical systems in the 1990s, robotic-assisted surgery has become increasingly popular in foregut surgery due to improved visualization and dexterity within the small mediastinal and subdiaphragmatic operative spaces. Known limitations to robotic surgery are the high cost of the platforms and the learning curve while training[28,32]. These limitations are applicable to reoperative foregut surgery as well. Earlier studies found significantly longer operative times for several robotic procedures including ARS. It appears that this is a learning curve issue and recent data with experienced surgeons and experienced teams has shown shorter operating times for robotic foregut surgery[28,33-35]. This does highlight the fact, however, that some outcomes rely on external variables with the robotic platform. Cost is another concern. It is well documented that robotic foregut procedures are more expensive as there is an initial capital investment together with disposables that add to the cost[28,32]. There is some discussion regarding the downstream cost savings with better outcomes and shorter lengths of stay with robotic procedures. This is not universally applicable but should be examined further in the reoperative foregut

scenario given the potential benefits.

The most widely used robotic surgical system is Intuitive Surgical's da Vinci Surgical System, although competitors have produced newer platforms that offer more accessibility and additional features such as haptic feedback[32,36]. There are several recent descriptions of newer robotic systems in foregut surgery. Quijano *et al.* and Menke *et al.* described techniques for robotic-assisted fundoplication using the Hugo™ Robotic assisted system and Senhance® Surgical System, respectively[37,38]. Salem *et al.* reported the first robotic Heller myotomy (HM) using the Hugo RAS™ in 2023[39]. There is limited description of redo foregut surgery using these newer systems.

Robotic-assisted laparoscopy in reoperative foregut surgery has its own added value. Areas of extensive adhesions and anatomical abnormalities at the gastroesophageal junction (GEJ) in redo surgery demand the best possible visualization with precise and refined dissection in a confined space, which the robot offers. Techniques for robotic-assisted laparoscopic ARS, HH repair, and HM have been well described[28]. Further review of these techniques and their outcomes in regard to redo-foregut surgery will be discussed in this paper.

PART 2: ARS AND PEH REPAIR

GERD and ARS

A systematic review by El Serag estimated the prevalence of GERD to be close to 30%, although the true incidence is suspected to be higher[1,40]. The surgical treatment of choice for reflux disease is ARS involving some form of fundoplication[10,40-42]. Multiple systematic reviews have supported ARS to be superior to medical management of GERD in patient-related outcomes[41-43]. The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) 2021 guidelines for surgical treatment of GERD reported benefits of ARS for patients in both short-term quality of life measures and long-term dysphagia[41]. Factors associated with successful ARS include response to anti-reflux medications, body mass index (BMI) < 35 kg/m^2, and typical symptoms[44].

ARS offers a durable repair that reliably cures GERD[17]. Essential components of an effective fundoplication include repair of the HH and a tension-free infradiaphragmatic fundoplication around the distal esophagus. Use of mesh in HH repair is controversial. Primary repair of HH is well supported and complications associated with mesh have been reported in the literature[24,45]. Several studies have shown that patient satisfaction at five years is about 90%[17,46]. Up to 10% of patients end up needing a reoperation[17-19,46].

With the advent of laparoscopic surgery, the rates of ARS soared. Finlayson *et al.* reported that the population-based rate of ARS more than doubled between 1993 (4.8 per 100,000) and 1998 (11.7 per 100,000)[10]. Laparoscopic anti-reflux procedures increased more than 6-fold between 1993 and 1998, from 1.2 to 8.9 procedures per 100,000 adults, with improved outcomes[10]. Owen *et al.* analyzed data across the University Health System Consortium, an alliance of medical centers, numbering over 115 academic institutions and their 271 affiliated hospitals and found that 12,079 patients received fundoplication procedures from October 2008 to June 2012[30]. Of those, 2,168 were open fundoplications, 9,572 were conventional laparoscopic fundoplications, and 339 were robot-assisted laparoscopic fundoplications (RLF)[30].

Current data suggests that RLF procedures have similar patient outcomes to conventional laparoscopic procedures when assessing both short- and long-term outcomes[29,33,47,48]. Similar findings have been reported in meta-analyses comparing robotic vs. conventional laparoscopy for abdominal surgery[47,49]. There is not a

widespread body of literature comparing these two techniques in reoperative ARS; however, there are factors that suggest the robotic technique may be helpful specifically in reoperative settings.

Notably, there exists a newer surgical treatment option for GERD in which a magnetic device is implanted laparoscopically around the lower esophageal sphincter (LES) to augment its function[50]. Insertion of this device is described to be less technically challenging than fundoplication[50,51]. Magnetic sphincter augmentation (MSA) has been demonstrated to be a safe and effective option for treatment of GERD comparable to fundoplication surgery[52-54]. Some of these studies report fewer side effects with MSA than with fundoplication; however, long-term follow-up studies are needed to solidify these claims. There have been reports of MSA device removals as well, although rare, ranging from 1%-7%[55-57]. Indications for removal are most commonly dysphagia, persistent GERD symptoms, and device erosion[58]. As our institution does not perform these operations, our review on reoperative technique will not focus on magnetic devices.

Reoperation in ARS

With the escalating number of ARS performed and long-term follow-up data available, the number of patients who report subjective dissatisfaction, symptom recurrence, or both has also continuously increased. Recurrent and/or new symptoms may be reported by 2%-30% of patients after primary ARS; 3%-10% of these patients may require redo surgery[11,21,46,58]. Mechanisms of failure that are reported include slipped fundoplication, too-tight or too-loose wrap, and recurrent hiatal herniation[11,12,20,21,59]. Patients usually present with recurrence of reflux, dysphagia, bleeding, pain, or chest or abdominal discomfort[18,20]. A systematic review by Furnée *et al.* confirmed that morbidity and mortality after redo surgery is higher than after primary surgery and symptomatic and objective outcomes are less satisfactory[20]. Other studies have supported this finding that success rates and patient satisfaction decline with each reoperation[21]. Patient satisfaction is lower after redo surgery than after a primary procedure[21,58]. Increased incidence of hollow viscus perforation, delayed gastric emptying, vagal nerve injury due to scarring, and altered physiology make reoperative ARS more challenging and less attractive than primary ARS.

Minimally invasive redo ARS can be performed safely by experienced surgeons with results comparable to open redo anti-reflux operations[11,12]. The laparoscopic approach for redo operations has become more common compared to the open approach due to advantages discussed previously in this paper. Unsurprisingly, laparoscopic reoperative ARS has significantly higher complication rates compared to primary ARS. In some of the largest reports studying conventional laparoscopic reoperative ARS, the conversion to open rate is between 8% and 12% and the rate of operative complications is between 20% and 30%, with gastrointestinal perforation accounting for over 70% of intraoperative complications[16,20,21,60]. Complications are comparable between open and laparoscopic redo ARS. In the study by Furnée *et al.*, intraoperative complications were higher in the laparoscopic redo ARS (19.5% *vs.* 5.4%); however, postoperative complications and 30-day mortality were higher in open redo operations (17.4% *vs.* 15.3% and 1.3% *vs.* 0%, respectively)[20]. The 13-year prospective analysis by Smith *et al.* of 307 patients undergoing redo foregut surgery reported higher overall rate of complications in patients who underwent open redo ARS compared to laparoscopic redo ARS (32.5% *vs.* 10%)[12].

A study by Elmously *et al.* comparing robotic primary ARS to reoperative ARS demonstrated that robotic reoperative ARS had comparable outcomes to primary ARS[61]. Of the 200 patients, 38 underwent robotic reoperative ARS. There were no conversions to the open technique and only one patient in the reoperative group (2.6%) had an intraoperative perforation. There was no significant difference between the two groups in regard to length of stay, readmission rates (6%) and postoperative complication rates (3%). They did

report longer operative times for reoperative surgery (226 *vs.* 180 min, $P < 0.001$)[62]. Although this study was not a direct comparison between the laparoscopic and robotic approaches to reoperative ARS, it does suggest that the robotic approach has better outcomes compared to historical data on laparoscopic reoperative ARS.

The only study directly comparing robotic reoperative ARS to conventional laparoscopic reoperative ARS was conducted by Tolboom *et al.* in 2016[31]. Over a five-year period, 75 patients underwent a total of 83 redo procedures: 30 laparoscopic and 45 robotic. The number of conversions was lower in the robot-assisted group compared to conventional laparoscopy (1/45 *vs.* 5/30, $P = 0.035$) despite a higher proportion of patients with previous surgery by laparotomy (9/45 *vs.* 1/30, $P = 0.038$). Length of stay was shorter in the robotic group by one day (3 *vs.* 4, $P = 0.042$). There was no significant difference between groups with regard to postoperative symptoms with over 50% of patients in both groups reporting minimal to no complaints after the procedure. Four patients in each group required another reoperation; seven for recurrent GERD symptoms and one in the robotic group for dysphagia. Timing of redo operations was not reported, as patients followed up six weeks after surgery then as needed. The reported follow up time was increased in patients in the conventional group (309 days) *vs.* robotic group (87 days)[31].

PEH repair

Although most of the above discussion is applicable to PEH repairs as well, giant PEH repairs have some unique features. About 50% of people over the age of 50 have a HH[2]. Paraesophageal (type II-IV) HHs constitute about 5% of all HHs. Although there is debate on repairing asymptomatic PEH[61,63], for symptomatic PEH, minimally invasive repair has shown to have good quality-of-life outcomes and symptom relief[64-66]. Studies quote high recurrence rates of 20%-50%[64,67] and about 5%-10% need a reoperation for hernia recurrence[68,69]. Reoperative PEH shares the same complexities as reoperative ARS in particular and any reoperative foregut surgery in general. They are technically extremely challenging and are associated with increased operating times, complications and additional procedures such as Collis gastroplasty and gastropexy[26,65].

As Gerull *et al.* rightly indicate in their study, high mediastinal dissection is a critical step to obtain adequate esophageal mobilization and length[66]. Adequate mobilization of the GEJ below the hiatus by at least 2-3 cm is necessary to ensure tension-free HH repair and prevent recurrence[70,71]. Esophageal lengthening procedures, such as Collis gastroplasty, can be performed in laparoscopic ARS when a shortened esophagus is identified[72-76]. Robotic techniques for Collis gastroplasty have also been described[77]. Conventional laparoscopic techniques limit ability to perform adequate mediastinal dissection and may result in unnecessary lengthening procedures and increased rate of clinical failure[66,78,79]. Zahiri *et al.* reported 30% of initial and 87% of redo laparoscopic PEH repairs underwent esophageal lengthening procedures[26]. On the contrary, Gerull *et al.* reported just 1/233 patients required a lengthening procedure during robotic PEH repair[66].

Principles and technique

Principles of surgery

The general principles of reoperative ARS and PEH repair are similar, and these core principles remain the same whether open, laparoscopic, or robotic. These tenets include a thorough preoperative evaluation, proper closure of the hiatus, and appropriate intra-abdominal esophageal length above the GEJ[18,44,80]. For best outcomes, reoperation should be considered only when there is evidence of radiographic or anatomic recurrence and new or recurrent symptoms are present[12,81]. Standard imaging workup includes upper endoscopy, pH study, barium esophagram, and esophageal manometry[44,82-84] [Table 1].

Table 1. Required preoperative tests for redo foregut surgery

Testing modality	Reason to perform test	Findings suggestive of GERD	Other findings
Testing for structural abnormalities			
Upper endoscopy	Visual examination of mucosa, biopsies	Esophagitis, BE	HH, EE, normal mucosa
Barium esophagram	Evaluate dynamic function of esophagus (swallowing, peristalsis, *etc.*)	Gastric reflux of contrast with provocation	Esophageal shortening, HH, diverticulum, stricture
Testing for physiologic abnormalities			
Ambulatory pH study	Evaluate esophageal acid exposure and episodes of reflux	Increased AET	Reflux-symptom association, impedance
Esophageal manometry	Assess LES function, evaluate esophageal motility	Defective LES, impaired peristalsis	Achalasia

GERD: Gastroesophageal reflux disease; BE: Barrett esophagus; HH: hiatal hernia; EE: eosinophilic esophagitis; AET: acid exposure time; LES: lower esophageal sphincter.

Surgical technique; how we do it

We have developed a robotic-assisted technique of reoperative hernia repair and ARS adapted from standard laparoscopic approaches, maintaining the same principles of the procedure. We have previously described this technique in a step-by-step approach in another publication[85] and will review the major considerations here:

Set up and instruments:
- Robotic ports (8 mm × 4)
- Assistant port (12 mm × 1)
- 5 mm port × 1 for liver retractor
- Tip-Up fenestrated grasper
- Cadiere forceps
- Mega SutureCut™ needle driver
- Large needle driver
- SynchroSeal
- Round tip scissors
- Mediflex Monolithic FlexArm™ Plus
- Mediflex Lapro-Flex® Articulating Retractors

Anesthesia:
- Single lumen endotracheal tube
- Rapid sequence induction

Positioning:
- Supine with arms out

Port placement and docking [Figure 1]:
- Open Hasson technique to enter the peritoneal cavity in the left supra-umbilical space - camera
- 2 more 8 mm ports in the left upper quadrant and one 8 mm port in the right upper quadrant. We place the ports about 10 cm above the umbilicus and have about a handbreadth space between the ports
- Assistant port in the right infraumbilical area
- The liver retractor is inserted through a 5 mm port placed in the extreme lateral portion of the right upper quadrant

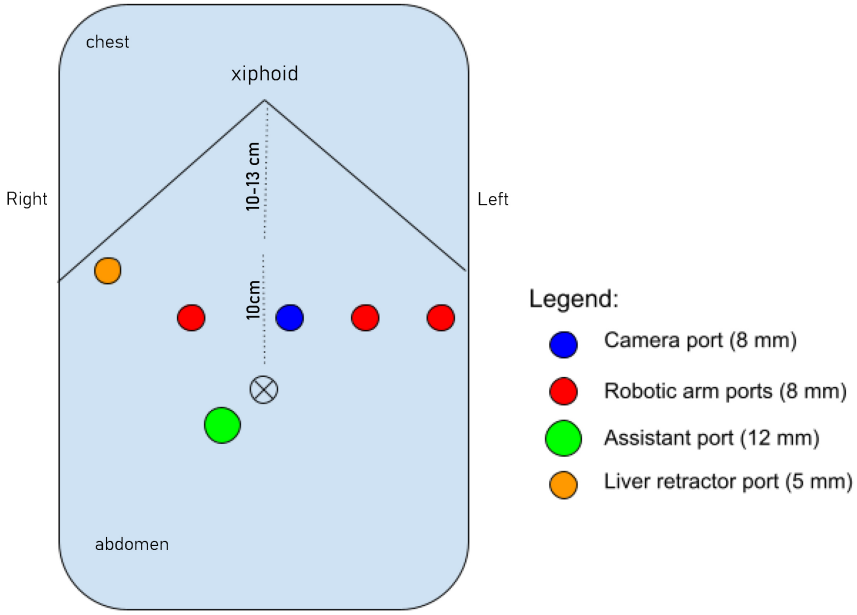

Figure 1. Port placement for robotic ARS. ARS: Anti-reflux surgery.

- We then dock the robot

Critical steps of the operation:
- Reduce the HH
- Take-down of previous fundoplication
○ Mostly with sharp dissection using robotic scissors
- Esophageal mobilization
- Leak test
○ Recommended in the reoperative setting
- Hiatal repair
- Fundoplication
○ Partial or complete if and as indicated
- Gastropexy and Gastrostomy tube
○ We typically insert a gastrostomy tube for giant PEH

PART 3: ESOPHAGEAL MYOTOMY (HM) FOR ACHALASIA AND OTHER MOTILITY DISORDERS

Achalasia

Achalasia is a rarer foregut disorder compared to GERD and HH with a prevalence of 0.05%[5]. It is a disorder of the LES and is divided into subtypes I-III based on differences in high-resolution manometry findings[86]. Treatment options for achalasia include medical management with calcium channel blockers and nitrates, endoscopic therapy with botulinum toxin injection into the LES, pneumatic dilation under fluoroscopic or endoscopic guidance, and myotomy (surgical *vs.* peroral endoscopic myotomy)[87,88]. The standard surgery for achalasia is the HM where LES muscle fibers are surgically divided[89]. In 2017, Haisley *et al.* showed a trend of increasing utilization of laparoscopic HM (LHM) (1,576 cases in 1992 to 5,046 cases in 2011) at teaching institutions with decreased in-hospital mortality and shorter length-of-stay[6]. Studies in the past have indicated that LHM was the procedure of choice for achalasia[87,90-93].

Per-oral endoscopic myotomy (POEM) is the newest treatment option for achalasia[89]. More recent literature since the advent of POEM demonstrates that both minimally invasive HM and POEM have comparable results[89,90,94-96]. According to the American College of Gastroenterology (ACG) 2020 guidelines, patients who are symptomatic with type I or II achalasia are candidates for definitive therapy with Parkinson's disease (PD), LHM, or POEM, while patients with type III achalasia should undergo tailored myotomy via LHM or POEM[87]. LHM remains the surgical procedure of choice after the failure of other non-surgical/endoscopic treatments.

As with other benign foregut operations, the reintervention rates for LHM are high and can be as high as 20%[97-100]. In 2022, the study by Ieong *et al.* identified 1,817 patients who underwent HM as a primary intervention for various indications and 320 (17.6%) of these required subsequent intervention[99]. Although most of them were managed with endoscopic intervention as the initial reintervention (234 patients, 73.1%), 40 (16.8%) of these 234 patients required a subsequent surgical procedure. About 25% needed a reoperation as the first reintervention; 54 patients (16.9%) underwent minimally invasive procedures and 32 patients (10%) underwent resectional procedures. Reintervention rates after ten years following HM for achalasia, diverticulum, and other indications were 24.4%, 12.6%, and 37%, respectively[99]. In the study by Raja *et al.*, out of 218 patients, 169 (9%) experienced at least one symptom after myotomy[98]. Fifty patients underwent 85 re-interventions, 41 endoscopic only, four surgical only, and five both[98]. Choice of intervention (POEM *vs.* HM) for reoperation in achalasia should be based on patient factors. Adequate education regarding possibility of additional future operations should be provided to the patient.

Reoperation in achalasia

Although it appears that recurrent symptoms can often be managed by endoscopic interventions, there is certainly a relatively high proportion of patients who require a reoperation[101-104]. It is reported that frequently, an incomplete myotomy is found during the reoperation[105]. Other reasons for failure included failure of fundoplication, fibrosis of the esophagus, mucosal stricture, or disease progression[101,104]. The goal of reoperation is improvement of quality of life and providing ability for oral diet rather than complete resolution of symptoms[102,104]. The ultimate goal is to avoid esophagectomy, which is the procedure of choice for "end stage" achalasia that has failed other management options[87-89].

With the pathology of achalasia, it is important to consider that a significant number of patients will have undergone one or more endoscopic interventions prior to surgery. This can result in significant scarring and inflammation in the operative field even for a first operation. There is differing data on whether preoperative non-surgical interventions have a negative impact on LHM outcomes[103,106-110]. Some studies suggest increased risk of mucosal perforation during LHM with prior pneumatic balloon dilation[103,107,108,111]. Others report no increased risk of negative postoperative outcomes with prior dilations[107,109,110]. Increased fibrosis of LES and worse surgical outcomes have been reported with prior botulinum toxin injection[109,110].

Technical challenges with redo HM include lysis of adhesions around the GEJ, localization and protection of the vagus nerve, and finding the correct submucosal plane for dissection[101,102,105]. The previous fundoplication must be taken down and a new one constructed following proper dissection while avoiding perforation of the distal esophagus[102]. Often more extensive dissection of the esophagus is required due to adhesions altering "normal" anatomy. Extension of previous or creation of a new myotomy is then performed.

There is sufficient evidence at this point favoring the robotic platform for HM over conventional laparoscopy[113-117]. Maeso *et al.* conducted a meta analysis comparing the efficacy of the da Vinci surgical

system with that of CLS for various abdominal operations[113]. They included three studies for HM that showed that the rate of perforation was lower with the Da Vinci system (0/102) compared with 11% (17/150) in the laparoscopic group[113]. In a recent review and meta analysis by Xie *et al.*, the robotic-assisted HM had significantly lower intraoperative esophageal perforation rate (1/233) compared to conventional laparoscopic approach (27/211)[119]. Similarly, Engwall-Gill *et al.* reported perforation in LHM more than four times the frequency of perforation in robotic technique[120]. Several studies have established that there is no difference between length of surgery, blood loss, conversion to open, or length of hospital stay when comparing robotic and laparoscopic approaches for HM[113,118-120]. Although there are no specific studies comparing reoperative HM using classic vs. robotic laparoscopic techniques, presumably, these results can be extrapolated to reoperative situations. A serious risk in redo myotomy operations is esophageal perforation, and decreased risk of perforation with the robotic approach would be a great benefit for redo surgery[119,120].

Principles and technique

Principles of surgery

Preoperative workup for redo HM is similar to that of reoperative ARS [Table 1]. The gold standard for diagnosis of achalasia is esophageal manometry[121]. However, data may not be accurate in a patient who has already had surgery. Newer diagnostic modalities such as the endoluminal functional lumen imaging probe (EndoFLIP) may be more helpful in these reoperative situations. It is important to review the operative history and details including the length of myotomy and type of fundoplication prior to a reoperation.

Operative technique

- The set-up, positioning, anesthesia and port placement are similar to reoperative ARS
- Identify anatomy
- Take-down of fundoplication
- Dissect gastric fat pad to visualize GE junction
- Endoscopy and identify GEJ
- Myotomy:
  - Assess previous myotomy
  - Posterior mobilization of esophagus is not needed if an anterior myotomy and extension is planned. May require a 270-degree mobilization for full access if lateral or posterior myotomy is planned
  - Identify the vagus
  - Extend myotomy on the stomach at least 3 cm. Long myotomy on esophagus
  - Recommend sharp dissection and blunt stretching; avoid using energy devices
  - If mucosal injury occurs, repair immediately
- Leak test
- Consider partial fundoplication *vs.* no fundoplication

CONCLUSION

Foregut disorders treated by thoracic surgeons include GERD, HH, and achalasia. Operations for these diseases include ARS, HH repair, and HM, respectively. Laparoscopic surgery has become standard in these operations given its lower morbidity and similar to better outcomes compared to open operations. Since the introduction of the surgical robot systems, robotic-assisted laparoscopic foregut surgery has increased in popularity due to improved visualization, dexterity, and ergonomics.

All foregut procedures have a significant failure rate requiring reoperation. Redo foregut surgery brings further challenges with distortion of anatomy from previous dissection and dense adhesions. The robot

plays a role in reoperative foregut surgery to improve visualization and mobility of the surgeon in a more fragile operative field. The indication for use of the robot in reoperative foregut surgery is dependent on patient choice, available resources, and surgeon skill and preference. When a patient presents after failed foregut surgery, it is important to complete a thorough workup to determine the most appropriate operation and technique. Robotic-assisted laparoscopy is a safe option for redo foregut surgery; however, each operation must be individualized to a patient's medical and surgical history.

The robotic approach holds the promise of evolving into the preferred approach for reoperative foregut surgery. It will be critical to collect and analyze the outcomes in order to make evidence-based recommendations.

DECLARATIONS

Authors' contributions

Study conception and design: Rao M
Data acquisition: Rao M, Schaffer E
Draft manuscript preparation and revision: Rao M, Schaffer E
All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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