Original Article

Robotic hiatal hernia repair without mesh

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Background: Newer minimally invasive techniques have supplanted laparotomy and thoracotomy for management of hiatal hernias. Limited data exists on outcomes after robotic hiatal hernia repair without mesh despite the increasing popularity of this approach. We report our high-volume experience with durable robotic hiatal hernia repair with gastric fundoplication without mesh.

Methods: A retrospective review was conducted on patients with type I–IV hiatal hernias who underwent an elective robotic-assisted repair from 2016 to 2019 using a novel technique of approximating the hiatus with running barbed absorbable (V-loc^{TM}) suture and securing it with interrupted silk sutures. Main outcomes included length of stay, readmission rate, and recurrence rate.

Results: A total of 144 patients were reviewed. The average age of the patient was 61 years. Most of the patients were female [95 females (66%) to 49 males], and the average body mass index (BMI) was 29.96 kg/m^2. The average operating time was 173 minutes (standard deviation 62 minutes). The average length of stay in the hospital was 2 days, and 89% of patients went home within the first 3 days. Ten patients (6.9%) were readmitted within 30 days, there were no mortalities in 30 days, and there were 6 (4.2%) recurrences on follow up requiring reoperation.

Conclusions: Elective robotic hiatal hernia repair with fundoplication and primary closure of the hiatus with V-loc^{TM} and nonabsorbable suture without mesh is safe and effective. The robotic approach has similar operative times, lengths of stay, and complications compared to nationally published data on laparoscopic hiatal hernia repairs.

Keywords: Hiatal hernia; robotic; V-loc; no mesh; primary repair

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Introduction

Background

There are many techniques to repair hiatal hernias, yet there is no consensus on the optimal approach. According to national guidelines, the laparoscopic approach is preferred to the transabdominal and transthoracic approaches. With the advent of robotic technology in surgery comes the

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comparison to laparoscopy; controversy exists on the best approach and method to repair hiatal hernias. National guidelines encourage the use of mesh for large hiatal hernias to decrease the short-term recurrence rate (1). This is based on randomized control trials with the reported 6-month recurrence rate for primary suture repair of 22–26% (2,3). The potential short-term benefit outweighing the long-term risk from mesh remains uncertain. In recent meta-analysis and systematic reviews, the benefit of mesh continues to be debated. Angeramo *et al.* investigated 7 random control trials looking at recurrence rate between primary repair and mesh reinforcement. The authors found no significant difference in recurrence or reoperation rates between the two groups and when stratifying between absorbable and nonabsorbable mesh, the only significance is the higher morbidity in nonabsorbable mesh population (4). Another meta-analysis by Sathasivam *et al.* which looked at 9 studies reported lower recurrences when comparing mesh *vs* suture repair. However, the type of mesh used, absorbable *vs* nonabsorbable, and early *vs* late recurrence was not reported (5). A main argument for using mesh is the inability to close large defects without tension, while the main fear is mesh erosion into the esophagus. Despite the statistic, many physicians do not routinely use mesh in their practice and have low recurrence rates (6). Brenkman *et al.* studied a group of 40 patients who underwent robotic hiatal hernia repair without mesh with toupet fundoplication. The recurrence rate was 2.5% but the follow up time was 6 weeks. Half of the patients had a large (>5 cm) hiatal hernia, and 30-day reoperation rate was 7.5% (7). Other studies have exhibited no difference in the long-term recurrence rate when it comes to the use of mesh (8). In another study of 50 patients who underwent robotic hiatal hernia repair without mesh, the recurrence rate requiring a redo operation was 6%, and in another series of patients, most of whom had mesh placement, 6 patients (8.5%) had recurrence and 4 of the patients went on to redo surgery (9,10).

Highlight box

Key findings

- Hiatal hernias can be safely and reliably closed robotically without mesh using a technique that approximates the hiatus with absorbable barbed suture and reinforced with interrupted nonabsorbable sutures.

What is known and what is new?

- There are many techniques to close hiatal hernia—there is no consensus on the optimal approach.
- The report demonstrates our success with employing a certain technique.

What is the implication, and what should change now?

- This may be the optimal technique to provide a durable hiatal hernia closure for elective case, further national comparisons to other techniques are needed.

Rational and knowledge gap

Similar to these studies, our data shows that the recurrence rate for primary repair is much lower than the recurrence rate the national guidelines are based upon. Furthermore, surgeons are increasingly utilizing the robotic platform for their primary method of repair for hiatal hernias. In a study of 103 patients comparing laparoscopic to robotic hiatal hernia repair, there was no difference in outcomes with regards to complications, mortality, use of proton pump inhibitors (PPIs), and reoperation. The only difference between the groups was longer operative times in the robotic group (11). Some suggest that there is no benefit to the robotic approach from small uncomplicated hernias (12). There is no definitive evidence to support one approach over the other.

Objective

Therefore, we sought to characterize the outcomes for elective robotic hiatal hernia repairs without mesh. We share our experience using the robotic platform to perform 144 elective hiatal hernia repairs with gastric fundoplication without mesh through primary repair of the hiatus using running absorbable V-loc™ (Medtronic PLC, MN, USA) suture to reduce tension and interrupted silk sutures to secure the closure. We present this article in accordance with the TREND reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-753/rc).

Methods

We performed a retrospective review on 144 patients from a large metropolitan hospital in the United States who underwent a robotic hiatal hernia repair and gastric fundoplication from July 2016 to December 2019 using the Da Vinci Xi system. Emergency cases, and patients previously admitted to the hospital who underwent the procedure, were excluded from this study; strictly elective

cases were investigated. Only patients who got V-loc™ suture were included. A total of 144 patients were included in the final analysis. Demographics, pre-operative, intra-operative, and post-operative data were collected. All patients presented to the outpatient office with significant gastro-esophageal reflux disease symptoms. They were worked up with barium swallows, computed tomography scans, endoscopy, manometry, and pH monitoring as clinically indicated. Patients assessed for surgery were symptomatic, had endoscopic or radiographic evidence of a hiatal hernia, and were medically fit to undergo the surgical procedure. Emergency cases, and patients previously admitted to the hospital who underwent the procedure, were not included in this study; strictly elective cases were investigated. The surgical technique for hiatal closure was standard amongst the six surgeons performing the robotic operation—approximation with a running V-loc and reinforcement with interrupted silk suture. Cases were excluded if approached via thoracotomy.

Technique

The patients are laid supine and administered general anesthesia. A cut-down is performed at the umbilicus and six ports are placed: a 12-mm air-seal at the umbilicus, four 8 mm robotic ports, and a 5-mm port for the liver retractor. The Da Vinci Xi system is docked at the patient's side. The dissection begins with incision of the pars flaccida and phrenoesophageal membrane to define the right crus. The hernia sac is freed from the mediastinum and completely resected. Attention is turned to the great curvature where the short gastrics are divided up to the level of the left hiatus. The esophagus is mobilized thoroughly in the chest to allow for 2–3 cm of intra-abdominal esophagus. A Penrose drain is then used for gentle retraction of the esophagus. The closure of the hiatus begins with an absorbable 12" 0 V-loc™ (Medtronic plc) suture at the base of the hiatus—secured through its own loop. The suture is placed in a running, locking fashion to relieve the tension from the hiatus. Care is taken to not narrow the hiatus—2 instruments can easily pass through the hiatus after closure. Extra suture is oversewn back towards the base, and the end is left free after the needle is cut off. The barbs hold the suture in place and does not require a knot. The closure is reinforced with a second layer of interrupted 0 silk sutures. Usually, three to four interrupted stitches are required. After the hiatal closure, a gastric fundoplication over a 54 Fr. bougie is created and the operation is concluded. The type of fundoplication is decided on a case-by-case basis and takes into consideration the patient and pre-operative testing. The patients undergo an esophagram on the first postoperative day as our standard practice to rule out reflux and prevent aspiration. They are then started on a clear-liquid diet and advanced to a soft diet as tolerated. Once they are tolerating a diet and have recovered from surgery, they are discharged home with a plan for outpatient follow-up. Patients followed up in the office at 2 weeks, 3 months, and 6 months. Patients with significant post-operative symptoms underwent repeat testing as clinically indicated.

Statistical analysis

Data analysis was done using Pearson's chi-square test of independence between categorical data. Our primary measured outcome were factors associated with return to the operating room and our secondary outcome were factors associated with surgical site infection and readmission in less than 30 days. We compared preoperative comorbidities, intraoperative conditions, and post-operative complications. In our analysis there are statistically significant associations between returning to the operating room, history of cancer (P=0.039) and readmission within 30 days (P<0.001). Surgical site infections are associated with length of operation (P=0.002) and readmission in 30 days (P=0.001). Readmission in 30 days is associated with prolonged intubation (P=0.001), surgical site infection (P=0.001), and age (P<0.001). Interestingly, the size of hernia did not affect the recurrence rate. Statistical analysis completed using RStudio [RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/].

Ethical statement

This project was approved by the Northwell Health Institutional Review Board (study No. 21-034). Informed consent was waived because of the retrospective nature of this study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Results

The average age of the patient was 61 years. Most of the patients were female (95 female to 49 male), and the average body mass index (BMI) was 29.96 kg/m^2 [standard deviation (SD) =6.09 kg/m^2], 88 (61%) patients had prior abdominal

Table 1 Demographics

Demographics	Values
Age (years), mean ± SD	61±14
Gender (female/male), n	95/49
BMI (kg/m^2), mean ± SD	29.96±2.87
Prior abdominal surgery, n (%)	88 (61.1)
Prior hiatal hernia repair, n (%)	10 (6.9)
GERD, n (%)	60 (41.7)
Barrett's, n (%)	16 (11.1)
Pre-operative PPI medication use, n (%)	85 (59.0)
Pre-operative H2 blocker medication use, n (%)	27 (18.8)
Hypertension, n (%)	72 (50.0)
Hyperlipidemia, n (%)	58 (40.3)
Diabetes mellitus, n (%)	13 (9.0)
Coronary artery disease, n (%)	9 (6.3)
Congestive heart failure, n (%)	2 (1.4)
COPD, n (%)	19 (13.2)
Cancer, n (%)	22 (15.3)
Atrial fibrillation, n (%)	8 (5.6)
Anti-coagulation medication use, n (%)	8 (5.6)
Anti-platelet medication use, n (%)	33 (22.9)
End-stage renal disease, n (%)	0
Steroid medication, n (%)	5 (3.5)
Smoking history, n (%)	62 (43.1)
Current smoker, n (%)	7 (4.9)
Alcohol abuse, n (%)	1 (0.7)

SD, standard deviation; BMI, body mass index; GERD, gastroesophageal reflux disorder; PPI, proton pump inhibitor; H2, histamine receptor; COPD, chronic obstructive pulmonary disorder.

surgery; 10 (14%) patients had a prior hiatal hernia repair. Seventy-nine (55%) patients underwent preoperative imaging with either a computed tomography (CT) scan (30, 21%), barium swallow (44, 31%), or chest X-ray (5, 3.4%). Ninety-five patients underwent preoperative endoscopy and 23 (24%) had evidence of esophagitis. Of the 23 patients with esophagitis, 10 had Los Angeles (LA) grade A, 5 had LA grade B, 7 had LA grade C, and 1 had LA grade D esophagitis. Furthermore, of the 95 patients who underwent preoperative endoscopy, 88 (93%) had no evidence of metaplasia, 5 (5%) had low grade dysplasia, and 2 (2%) had high grade dysplasia. The average pre-operative hernia size was 3.5 cm. A proportion of 45.1% (n=65) of patients underwent preoperative manometry. Of these patients, 51 (78%) had normal findings, and 14 (22%) had some degree of motility disorder. The average lower esophageal sphincter resting pressure was 22 mmHg (SD =14 mmHg). Four patients of the 65 patients (6%) had 100% failed swallows, 3 patients (5%) had 50–70% failed swallows, 7 patients (11%) had 10–30% failed swallow, and the rest (51 patients, 78%) had no failed swallows on manometry. There were 89 (62%) type I hernias, 23 (16%) type II hernias, 30 (21%) type III hernias, and 2 (1.4%) type IV hernias. Seventeen (12%) patients underwent pH testing and had an average DeMeester score of 33.8. A summary of the demographics and preoperative data is depicted in *Table 1*.

The average length of stay in the hospital was 2 days, and 89% of patients go home within the first 3 days. The average operating time was 173 minutes (SD =62 minutes), and the average operative times for each type of hernia were as follows: type I—165 minutes, type II—211 minutes, type III—177 minutes, type IV—201 minutes. The pre- and post-operative gastroesophageal junction (GEJ) was measured in 100 cases. The GEJ was at an average 34.0 cm from the mouth preoperatively and an average of 38.0 cm postoperatively. The type of fundoplication was determined on a case-by-case basis and took into account many factors including pre-operative manometry testing, the patient's comorbidity, the intraoperative findings, and the surgeon's decision. Seventy-nine (55%) Nissen, 44 (31%) Toupet, and 20 (14%) Dor fundoplications were performed. No Collis gastroplasties or esophageal lengthening procedures, and no gastroplexies were performed. One patient did not have a fundoplication due to a previous history of a gastric Roux-en-Y bypass. All patients had a 0 V-loc™ approximation to relieve tension with interrupted 0 silk reinforcement sutures, no patients had mesh placement. Three (2%) patients were noted to have a gastric volvulus at the time of operation. No patients required a conversion to open or laparoscopy. No patients required mesh placement. A summary of the operative data is depicted in *Table 2*.

One hundred and forty-one (98%) patients underwent an esophagram within the first 2 postoperative days. Ninety-one (65%) esophagrams were normal with contrast passing freely into the stomach. Twenty-four (17%) esophagrams had delayed passage of contrast into the stomach and 26 (18%) esophagrams had a minimal delay in passage of contrast. None of the esophagrams

Table 2 Operative data

Characteristics	Values
Operative time, min, mean ± SD	173±61
Nissen fundoplication, n (%)	79 (54.9)
Toupet fundoplication, n (%)	44 (30.6)
Dor fundoplication, n (%)	20 (13.9)
Pre-operative GEJ location, cm	34.0
Post-operative GEJ location, cm	38.0
Conversion to open	0

SD, standard deviation; GEJ, gastroesophageal junction.

Table 3 Post-operative data

Characteristics	Values
Length of stay, days, mean ± SD	2±1.72
Esophagrams, n (%)	141
Normal	91 (64.5)
Minimal delay	26 (18.4)
Delay	24 (17.0)
Capnothorax requiring chest tube, n (%)	16 (11.1)
Discharge disposition, n (%)	
Home	137 (95.1)
Rehabilitation center	7 (4.9)
Readmission within 30 days, n (%)	10 (6.9)
Dysphagia	4
Emesis	1
Malfunctioning J-tube	1
Surgical site infection	1
Mediastinal collection	1
Incisional hernia	1
Subcutaneous emphysema	1
Radiographic recurrences managed medically, n (%)	10 (6.9)
Reoperation for recurrence, n (%)	6 (4.2)
Median time to reoperation	1 year 3 months

SD, standard deviation.

demonstrated a leak or recurrence. The most common complication in the perioperative period was capnothorax. Sixteen patients (11%) had a capnothorax due to the dissection requiring pigtail catheter placement into the chest. All chest tubes were removed prior to discharge. One hundred and thirty-seven (95%) patients were discharged home. Seven (5%) patients were discharged to a subacute rehabilitation center. Ten (7%) patients were readmitted within 30 days. Reasons included dysphagia [4], emesis [1], malfunctioning jejunostomy tube [1], surgical site infection [1], subcutaneous emphysema [1], mediastinal collection [1], and incisional hernia [1]. All 4 patients readmitted for dysphagia had a Nissen fundoplication and underwent esophagogastroduodenoscopy upon readmission by the gastroenterology team. One of these patients was found to have a small food impaction. There were no mortalities at 30 days. Post operative data is depicted in *Table 3*.

Patients regularly followed up for a median of 8 months and 25 days (average 10 months and 16 days). Three (2%) patients were lost to follow up. Sixty-eight (47%) patients did not have any PPI or H2-blocker medication use, and 17 (12%) patients were liberated from their PPI/H2-blocker use following surgery. Forty (28%) patients underwent a follow up barium swallow for symptoms, and the average time to follow up barium swallow was 11 months. Recurrences were based on any radiographic evidence of post-operative hernia on barium swallow, computed tomography scan, or endoscopy. One hundred (69%) patients were completely asymptomatic. Twenty-six (18%) patients were experiencing mild symptoms on follow up; 15 (10%) of these patients were experiencing mild symptoms and had no abnormalities on imaging; 11 (8%) patients had mild symptoms and did not undergo further imaging. Of the remaining 15 patients (3 patients lost to follow up), 10 (6.9%) patients had small symptomatic recurrences and 5 (3.5%) patients had small asymptomatic recurrences. Of the 10 symptomatic recurrences, there were 6 (4.2%) recurrences requiring reoperation. The breakdown of initial hernia type for the patients who had operative recurrences is: 4 type I's, 1 type III, and 1 type IV. The breakdown of initial hernia type for patients who had radiologic recurrences is: 8 type I's, 6 type III's, and 1 type IV. One recurrence was due to broken down crural stitches leading to re-herniation. Three recurrences were due to anterior dilation of the hiatus—the posterior crus repair was intact. One recurrence was due to re-herniation medially along the left crus. Lastly, one recurrence was a re-herniation through the crus with an accompanying volvulus. All V-loc^{TM} with silk suture primary repairs were intact except 1. The average age of the recurrence patients was 65 years old, and the average BMI was 31.6 kg/m^2. A

Chi-square analysis was performed to identify risk factors associated with recurrence requiring reoperation. A history of cancer was associated with operative recurrence (P=0.0004). There were no early (<30 days) symptomatic or asymptomatic recurrences, and the median time to re-operation was 1 year and 3 months. There were two incisional hernia repairs 90 and 459 days after the initial operation. There was one surgical site infection requiring an operation 24 days after the initial operation. There was one patient who required an operation for a mediastinal collection 25 days after the operation. A summary of the recurrence and reoperation data is depicted in *Table 3*.

Discussion

The robotic approach to repairing hiatal hernias has gained popularity over the past decade, yet there is no clear evidence it is superior to the laparoscopic approach. Furthermore, there is not a clear consensus on the optimal technique for closing the hiatus. In our practice, we have witnessed the negative consequences of hiatal mesh, namely mesh erosion into the esophagus. While the low recurrence rates for mesh are heavily cited, the incidence for erosion is around 5% (13). One article looking at 50 patients with complication from different studies found that mesh erosion can occur anywhere from 7 days to 20 years after the operation, though 79% of erosions occurred within 2 years. Erosion can have devastating consequences including organ resection and lifelong feeding tubes (14). There are various methods of primary repair, the most common being interrupted nonabsorbable, braided sutures with or without PTFE pledgets. The use of nonabsorbable interrupted sutures without pledgets have been associated with high recurrence rates of 22–59% (15). Another study of 217 laparoscopic primary repairs with braided, nonabsorbable, interrupted sutures had an operative recurrence rate of 9.9% (16). Several recent studies detail the improved recurrence rates around 6.7–6.8% with the use of pledgets (17,18). While the pledgets seem to improve operative recurrence rates, they introduce nonabsorbable foreign material to the hiatus that is prone to erosion and migration. Dally and Falk identified 11 patients from a database that suffered from symptomatic pledget erosion causing symptoms including strictures, chest pain, and melena. Ten of these patients went on to receive surgery for pledget removal (19). We have found that closing the hiatus with a combination of barbed absorbable suture and nonabsorbable suture has provided patients with low recurrence rates and avoided complications associated with mesh. Even large hiatal hernias, that are typically difficult to tie closed with nonabsorbable suture, can be repaired in this fashion. The V-loc™ suture helps reduce the tension on the crus while the permanent suture secures the closure over the absorbable V-loc™ without a need for mesh reinforcement. We chose absorbable V-loc™ to decrease the nonabsorbable material burden at the hiatus, and kept the method consistent to track the outcomes. In our practice, we found the robotic approach to have similar operative times and complications to that of the laparoscopic approach especially in the elective setting. The robot adds a high level of acuity and dimension particularly when mobilizing the esophagus in the chest, laying the stitches on the hiatus, and performing the fundoplication. The mobilization aids with the meshless closure. Based on these results, we found that the robotic approach is safe and feasible, which is concordant with previously published data. Elective patients undergoing robotic surgery have similar operative time, lengths of stay, and post-operative course compared to data published on patients who underwent laparoscopic surgery. We felt that patients presenting to the hospital on an emergent or urgent basis, for volvulus for example, had a different work-up, pre-operative set of symptoms, and post-operative results which would skew the results of the group of patients we primarily set out to study. The heterogeneous nature of emergencies prevented us from deriving meaningful conclusions.

There were several limitations to the study, primarily the average follow-up is 10 months, thus the long-term durability of the repair is unclear. So far, the results of this method are promising. Another limitation was the small number of larger hernias (30 type III's, and 2 type IV's) which narrows the applicability of the results. Post-operative symptomatology was not clear for many patients. There was not a standardized questionnaire that homogenized the post-operative satisfaction of the patient due to the retrospective nature of the study. Post-operative symptoms were described differently by different surgeons, and the reasoning to pursue, or not pursue, a follow-up barium swallow was not consistently documented. Along this same line, PPI liberation rate was low because either patients were not asked if they continued taking a PPI or were trialed on a period of medication cessation. Lastly, the quantity of operations was not even distributed amongst all the surgeons, which may have introduced an unrecognized source of bias.

The most common complication we encountered was

capnothorax requiring a pigtail catheter. The complication arises from the high dissection in the chest that is feasible with the robotic platform. While the high dissection allows for esophagus lengthening, it increases the chance of capnothorax. There were no complications from chest tube placement, and all tubes were removed prior to discharge. There were six recurrences that required reoperation. In general, the reasons for reoperation were symptomatic re-herniation. Only one patient had a case of broken stitches. The other reasons were mainly due to enlargement of the existing hiatus. A history of cancer was associated with operative recurrence; there were no other readily identifiable risk factors for operative recurrence except for a non-statistically significant increase in age, BMI, and smoking history. There were no mortalities at 30 days and all patients were discharged in a timely manner.

Conclusions

We have found that robotic hiatal hernia repairs without mesh provides excellent results for elective cases. Although operative time is higher, the robotic approach has similar lengths of stay and complications compared to nationally published data on laparoscopic hiatal hernia repairs. Using a combination of V-loc™ absorbable suture to reduce tension on the hiatus and nonabsorbable suture to secure the hiatus has a low recurrence rate and does not introduce the risks associated with a foreign body.

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Footnote

Reporting Checklist: The authors have completed the TREND reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-753/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-753/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-753/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This project was approved by the Northwell Health Institutional Review Board (study No. 21-034). Informed consent was waived because the retrospective nature of this study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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