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Robotic mesh explantation (RoME): a novel approach for patients with chronic pain following hernia repair

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Abstract

Background Post-herniorrhaphy pain is common with an estimated 8–10% incidence of mesh-related complications, requiring mesh explantation in up to 6% of cases, most commonly after inguinal hernia repairs. Reoperation for mesh explantation poses a surgical challenge due to adhesions, scarring and mesh incorporation to the surrounding tissues. Robotic technology provides a versatile platform for enhanced exposure to tackle these complex cases. We aim to share our experience with a novel robotic approach to address these complex cases.

Methods A descriptive, retrospective analysis of patients undergoing a robotic mesh explantation (RoME) for mesh-related chronic pain, or recurrent ventral hernia by two surgeons between the period of March 2016 and January of 2020. The patients were evaluated for resolution of mesh related abdominal pain as well as early post-operative complications. RoME was performed with concomitant hernia repair in cases of recurrences.

Results Twenty-nine patients underwent a robotic mesh explantation (RoME) for mesh-related chronic pain, or recurrent ventral hernia between March 2016 and January of 2020. Nineteen patients (65.5%) had a prior inguinal hernia repair and 10 patients (34.5%) had a prior ventral hernia repair. Indications for mesh removal included chronic pain with or without hernia recurrence. Seventeen patients (58.6%) reported improvement or resolution of pain postoperatively (63% with a prior inguinal hernia repair and 50% of patients with a prior ventral hernia repair). Five patients (17.2%) required mesh reinforcement after explantation. Nineteen patients (65.5%) underwent mesh explantation with primary fascial closure or no mesh reinforcement. The mean follow-up was 36.4 days. The most common postoperative complication was seroma formation (6.8%), with one reported recurrence (3.4%).

Conclusion Robotic mesh explantation in challenging cases due to the effect of chronic scarring, adhesions and mesh incorporation to the surrounding tissues is safe and provides an advantageous platform for concomitant hernia repair in these complex cases.

Keywords Mesh explantation · Ventral hernia · Chronic pain · Robotic surgery · Minimally invasive surgery

Abbreviations

RoME	Robotic Mesh Explantation
NSAIDs	Non-steroidal anti-inflammatory drugs
ASA	American Society of Anesthesiologist
LOA	Lysis of Adhesions
BMI	Body mass index
HTN	Hypertension
HLD	Hyperlipidemia
DM	Diabetes mellitus
CAD	Coronary artery disease
IPOM	Intraperitoneal Onlay Mesh
TAPP	Transabdominal preperitoneal
LOS	Length of stay
VAS	Visual analogue scale
PTFE	Polytetrafluoroethylene
OVHR	Open ventral repairs
NRS	Numeric pain rating scales

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More than 20 million hernias are estimated to be repaired worldwide, with approximately 700,000 inguinal hernias repaired annually in the United States alone [1].The use of mesh for hernia repair is considered the standard of care in the United States [1–3]. Though a "tension-free" reinforcement with mesh has led to better outcomes in terms of recurrence, particular attention is placed on the long-term outcomes and mesh-related complications that ensue with the increased prevalence of mesh repairs and the effect on the quality of life of these patients [4, 5].

Chronic post-herniorrhaphy pain, as well as chronic mesh infections, are the two most common mesh-related complications [5–7]. While the specific etiology for both of these occurrences is multifactorial and not well understood, mesh and foreign body removal (sutures and tackers) has been reported in the literature by multiple authors with favorable outcomes, demonstrating improvement, or complete resolution of symptoms [5, 7–9]. Despite the positive results seen with mesh removal, radical mesh removal (complete mesh removal with dissection off from the surrounding neurovascular or soft tissue structures) may prove challenging for many surgeons, given the risk of damage to vascular or adjacent structures leading to increased morbidity.

The advantages of the robotic platform include a minimally invasive approach with better visualization, enhanced dexterity, precision, lower infection rates, better cosmesis, and enhanced patient recovery in comparison to open techniques [10]. It also provides access to alternate tissue planes to perform an abdominal wall for reconstruction (i.e., preperitoneal, retro rectus) during the same operation. We aim to share our experience with Robotic Mesh Explantation (RoME), its feasibility, and short terms outcomes.

Methods

Study design

A descriptive, retrospective analysis of patients undergoing robotic mesh explantation (RoME) for mesh-related chronic pain, or recurrent ventral hernia between March 2016 and January of 2020 was performed. Two hernia specialists performed a RoME from two different centers during this period. Patients who presented with nociceptive, neuropathic, or combined symptoms after an inguinal or ventral hernia repair and who had failed non-operative therapies (NSAIDS, opioids, neuromodulators, multimodal analgesia, nerve blockage or nerve ablation) at least 2 months after their initial operation were selected for mesh removal. The patients were evaluated preoperatively by a detailed history and physical examination to determine their complaints' etiology. The patients underwent imaging studies such as Ultrasound (US), computed tomography (CT), or magnetic resonance imaging (MRI) at the discretion of the surgeon based on clinical findings to rule out non-neuropathic sources of pain (e.g., seroma, mesh infection or recurrence) when indicated.

Source of data is from electronic medical records (EMR) from two academic medical centers. This study was approved by the Institution Review Board of both institutions and hall HIPAA compliant mechanisms were followed.

Data collection

Data were retrospectively collected and divided into the following sections: patient characteristics, hernia characteristics, perioperative data, and patient outcomes. The following patient demographics and comorbidities were analyzed: age, sex, body mass index (BMI), diabetes mellitus (DM), hypertension, chronic obstructive pulmonary disease (COPD), smoking status, and American Society of Anesthesiologists (ASA) class.

Preoperative data collected information regarding history and chronicity of hernia, type of hernia, history of prior hernia repairs, indications for mesh removal, preoperative pain mapping, operative technique of prior hernia repair, operative time, adjunct operative technique during mesh removal, operative data, mesh characteristics, perioperative morbidities, length of stay (LOS), follow-up, hernia recurrence and evaluation for resolution of symptoms.

Statistical analysis

Descriptive analysis was performed. Categorical variables were expressed as counts and percentiles. Continuous variables whose distribution approximated normality were reported as mean and standard deviation, and those with skewed distributions were reported as median and range. Data were analyzed using the SPSS v.26 Chicago: SPSS Inc.

Results

Twenty-nine patients underwent a RoME procedure between March 2016 and January of 2020. Nineteen had a previous inguinal repair and ten a prior ventral repair. Patient characteristics are as listed in Table 1. Most ventral hernias were: 4 umbilical (40%) hernias and 2 (20%) epigastric and 2 (20%) incisional. Regarding inguinal hernias, 6 (32%) were right and 5 (26%) were left. Tackers were used in 8 (42%) previous inguinal repairs and in 6 (60%) ventral prior repairs. Hernia characteristics are as listed in Table 2.

Indications for mesh removal included chronic pain with or without hernia recurrence in 14 (74%) inguinal repairs and 9 (90%) ventral repairs, and isolated hernia recurrence in 5 (26%) inguinal and 1 (10%) ventral repair. (Table 3)

Table 1 Patient characteristics

	Inguinal n (%) $n=19$	Ventral n (%) $n=10$
Sex		
Male	16 (84)	5 (50)
Female	3 (16)	5 (50)
Median Age (range)*	49 (27–83)	53 (26–67)
Median BMI (Range)**	26 (22–40)	28 (22–35)
Race		
White	8 (42)	7 (70)
Latino	4 (21)	2 (20)
Black	4 (21)	1 (10)
Other	3 (16)	0
Comorbidities		
Smoker	5 (26)	3 (30)
Hypertension	4 (21)	3 (30)
Hyperlipidemia	3 (16)	4 (40)
Diabetes Mellitus	1 (5)	3 (30)
ASA		
Class I	5 (26)	1 (10)
Class II	11 (58)	8 (80)
Class III	3 (16)	1 (10)

*in years

**in kg/m^2

BMI Body Mass Index, *ASA* American Society of Anesthesiologist

Table 2 Hernia characteristics

	n (%)
Hernia location	
Ventrals	
Umbilical	4 (40)
Incisional	2 (20)
Subxiphoid	1 (10)
Epigastric	2 (20)
Infraumbilical	1 (10)
Inguinals	
Right	6 (32)
Left	5 (26)
Bilateral	4 (21)
NR	4 (21)
Operative technique prior hernia repair	
Inguinal hernia	
Plug and Patch	8 (42)
TEP	6 (32)
TAPP	5 (26)
Ventral	
IPOM	5 (50)
Open	4 (40)
Laparoscopic Spigelian	1 (10)
Use of tackers	
Inguinal	8 (42)
Ventral	6 (60)
Recurrence from prior repair	
Inguinal	7 (37)
Ventral	3 (30)

NR not reported

Preoperative pain mapping was available for 14 patients in total. Pain in the ilioinguinal nerve distribution was the most common: 7 (37%) of the prior inguinal repairs and 1 (10%) ventral repair. (Table 3). Also, in patients with chronic pain, 7 (37%) had used tackers in their inguinal repair and 9 (90%) in the ventral repairs.

Median operative time was 184 min (101–284) in the inguinal group and 202 (92–286) minutes in the ventral group. Intraoperative outcomes are as listed in Table 4. 4 (21%) patients who had a previous inguinal repair had seroma and 2 (20%) with prior ventral repair had serosal tear. 12 (63%) patients with prior inguinal repair and 5 (50%) patients with prior ventral repair had resolution of pain. (Table 5) 5 (50%) patients with prior ventral repair had persistence of pain after RoME. Patients were mostly discharged in the same day of the procedure and median follow up was 18 days (1–284) for patients with previous inguinal repair and 19 (11–186) days for patients with prior ventral repair. There was only one recurrence after inguinal repair. (Table 5).

Discussion

Pain following hernia repair can be neuropathic, nociceptive (hypothesized to be related to the presence of mesh and its ensuing local effects) or combined, and the preoperative evaluation of these patients by means of detailed history and physical examination in conjunction with imaging techniques to determine the etiology of their pain complaints is critical. [5, 11]

Pain presumed to be associated with a mesh inflammatory reaction has been described as a new onset of symptoms within the first months after hernia repair [11]. However, it may seldomly occur chronically after an asymptomatic period. Nociceptive symptoms follow a non-neuropathic distribution and include chronic pain, foreign body sensation, localized swelling, palpable meshoma, and when related to inguinal hernia repairs, can include tightness in groin, pain aggravation during car driving or crossing legs, and pain relief by hip extension or supine position. [4, 11–13]

Table 3 Clinical characteristics

	Inguinal *n* (%)	Ventral *n* (%)
Indication for mesh removal		
Chronic Pain	12 (63)	9 (90)
Hernia recurrence	5 (26)	1 (10)
Hernia recurrence and chronic pain	2 (11)	0
Preoperative pain mapping		
Ilioinguinal nerve	7 (37)	1 (10)
Ileo-hypogastric	1 (5)	1 (10)
Genitofemoral	1 (5)	1 (10)
Lateral-femoral cutaneous	1 (5)	0
No pain	3 (16)	2 (20)
No pain mapping	9 (47)	6 (60)
Chronic pain and previous repair		
Inguinal pain	14 (74)	
Plug and Patch	5 (26)	
TAPP	4 (21)	
TEP	5 (26)	
Use of tackers	7 (37)	9 (90)
IPOM		6 (60)
Open		3 (30)

TAPP transbabdominal preperitoneal, *TEP* Total extraperitoneal, *IPOM* Intraoperitoneal Onlay Mesh

Table 4 Surgical data

	Inguinal *n* (%)	Ventral *n* (%)
Perioperative antibiotics	8 (42)	9 (90)
Median Operative time (range)	184 (101–284)	202 (92–286)
Median EBL (range)	5 (5–50)	8 (5–50)
Associated procedures		
TAPP	1 (5)	0
IPOM	1 (5)	0
Primary repair of fascial defect	1 (5)	0
Removal of cord lipoma	1 (5)	0
Round ligament resection	1 (5)	0
None	13 (68)	6 (60)
Other	1 (5)	0
Rectus plication	0	4 (40)
Mesh reinforcement		
Anatomical polypropylene mesh	3 (16)	1 (10)
Self-gripping polypropylene mesh	2 (11)	1 (10)
P4HB mesh	1 (5)	2 (20)
None	3 (16)	2 (20)
NR	10 (53)	4 (40)
Mesh fixation		
Suture	4 (21)	0
Barbed suture	1 (5)	0
Absorbable tacker	0	1 (10)
Non-absorbable tacker	0	1 (10)
No fixation	14 (74)	8 (80)

TAPP Transabdominal preperitoneal, *IPOM* Intraperitoneal Onlay Mesh, *EBL* estimated blood loss, *NR* not reported

Table 5 Perioperative results

	Inguinal *n* (%)	Ventral *n* (%)
Complications		
Serosal tear	0	2 (20)
Seroma	4 (21)	0
No	15 (79)	8 (80)
Post-operative symptoms		
Resolution of pain	12 (63)	5 (50)
Persistence of symptoms	3 (16)	5 (50)
N/A	4 (21)	0
Median LOS (range)*	0 (0–1)	0 (0–4)
Median Follow up (range)*	18 (1–284)	19 (11–186)
Recurrence	1 (5)	0

*in days

LOS length of stay

Not every patient who develops chronic post herniorrhaphy pain will require mesh explantation. However, meshectomy to treat chronic herniorrhaphy pain after the failure of non-surgical management has demonstrated favorable outcomes with a resolution or improvement of pain in several studies [5, 7, 14–17] Despite this, technical difficulties enhanced by altered anatomical planes with chronic inflammatory changes and the potential morbidities related to the procedure (testicular atrophy, seroma, hematomas, wound infection, damage to vascular structures, adjacent viscera, recurrent hernias and worsening or persistent pain) pose a challenge to the dedicated hernia surgeon.

Mesh explantation for chronic inguinal post herniorrhaphy pain is safe when performed by experienced hands in high-volume centers [16, 18, 19] Currently, treatment options for chronic inguinodynia after inguinal hernia repair and ventral abdominal pain after ventral hernia repair when non-operative therapies fail include triple or selective neurectomy and mesh explantation. [8, 9, 11, 15–18] Preoperative pain mapping is crucial while evaluating these patients. A detailed conversation addressing the need for neurectomies and the risk of injury to adjacent structures and their consequences is vital during the consent process. Meticulous preoperative planning is necessary in order to tackle these complex cases to minimize morbidity.

Nineteen patients in our cohort had a history of a previous inguinal hernia repair, with those presenting with chronic pain and no recurrent hernia having an ilioinguinal nerve distribution on pain mapping as the most commonly involved nerve. This trend is not surprising as 42% of patients had undergone a prior open repair.

The complication rate of mesh explantation for chronic inguinal pain is low for both MIS and open approaches. [11, 16, 19] The postoperative complications in our cohort were limited to seroma formation with no intraoperative complications. However, the risk for vascular and visceral injuries remains one of the most dreaded complications. Recently, Lu et al. performed a retrospective consecutive case series study of patients with chronic post herniorrhaphy inguinal pain who underwent minimally invasive groin exploration and mesh removal, reporting an overall incidence of intraoperative vascular injury of (22%). [19] In these series, the most commonly injured vascular structure were the inferior epigastric vessels, and all procedures were performed with an MIS approach. While most laparoscopic procedures were planned in a hybrid fashion and vascular control was achieved through a groin incision, there was no need for conversion to achieve vascular control in the robotic cases. [19] This speaks of the advantages of the robotic platform in regards to improved visualization, dexterity, availability of up to four arms by the surgeon, monopolar and bipolar energy devices, stability of exposure with tremor reducing software, enhanced suturing capacities, and stable camera.

Truong et al. described a step-wise approach to remove preperitoneal inguinal meshes, which can be implemented laparoscopically or robotically. [20] It is interesting to note the transition in practice towards using the robotic platform for these cases based on their lower incidence of complications compared to their laparoscopic cases. [20] In our practice, we also advocate initiating the dissection at known/more accessible areas (well-defined tissue planes and anatomical landmarks), utilizing virgin planes that facilitate access to previously operated areas where inflammatory changes and mesh incorporation is present. Dissection is then transitioned to unknown/more complex planes (proximity to vascular structures, adhesions to the anterior abdominal wall, inflammatory tissues, and scarring from mesh incorporation that require a more careful approach). Changing targeted areas of dissection continuously as the dissection gets difficult is encouraged; target a different area/zone following the basic principles for safe dissection. Perhaps the most crucial concept is to "stay at the mesh", aiming to remove the foreign body safely or even performing a partial mesh removal when dense adhesions prevent a safe dissection.

Slitted meshes are quite challenging as the mesh wraps the elements of the cord. Preparedness to address vascular injuries or bleeding is crucial. We introduce a 4–0 prolene suture inside the cavity and anchor it against the anterior abdominal wall to be readily available; this may facilitate a prompt intervention if a vascular injury ensues. Vascular instrumentation should also be available in the operating room and select cases should be discussed with the vascular surgery team in advance. Another essential detail to consider is the possibility of orchiectomy, which should be part of the informed consent.

Twelve patients (63%) with post herniorrhaphy inguinal pain reported improvement or resolution of pain; these results are comparable to those reported in other series where an open approach was performed [11]. We did not collect data on neurectomies as the focus of our series was to determine the feasibility of mesh explantation with the robotic platform. However, our standard practice is to perform a neurectomy in patients with a positive preoperative pain mapping with intraoperative evidence of nerve involvement (e.g., from scarring, nerve entrapment, mesh irritation, inability to preserve the nerve during mesh explantation), attempting a nerve-sparing procedure when feasible. Our small sample size and selective nerve-sparing approach may reflect our lower outcomes regarding pain resolution compared to those encountered via an open approach with selective neurectomies demonstrated by Campanelli et al. [16].

Four (21%) of our patients did not have post-operative follow-ups; therefore, we could not determine whether or not these patients had improvement, persistent, or worsening symptoms. In clinical practice, a failure to follow up in the post-operative period may represent a satisfactory recovery in the absence of adverse outcomes. Alternatively, some patients may opt to defer additional treatments or may elect to consider an evaluation by a different surgeon if symptoms are persistent following their interventions. It is important to note that despite the proposed advantages with the robotic approach, other authors have noted no difference in outcomes with mesh explantation alone vs. mesh explantation with selective neurectomy in terms of resolution of pain [7].

The evaluation of chronic pain after ventral hernia repairs can be challenging as often their pain complaints follow a combined neuropathic and nociceptive pattern. Data on long-term pain after ventral hernia repair is a poorly studied subject; however, several factors have been identified as predictors for the occurrence of chronic pain and mesh explantation [6, 21]

In 2014, Liang et al. evaluated 407 patients who underwent open ventral repairs (OVHR) to identify the incidence, etiologies, and independent predictors of abdominal reoperation and mesh explantation following OVHR with mesh [17]. In their cohort, 6.9% of patients underwent mesh explantation predominantly for SSI and hernia recurrence. They identified prior hernia repairs (> 5) as risk factors for needing a reoperation for any reason. [17] Furthermore, the rate of chronic pain following ventral hernia repair in their cohort was as high as 20–30%, depending on the technique (open vs. laparoscopic) and the mesh fixation method or device utilized. [17] In our cohort, the indications for mesh explantation were chronic pain with or without associated recurrence. We had no mesh infections as an indication for

mesh explantation, and only one patient presented with an associated recurrent hernia.

In 2109, Sikar et al. evaluated 112 patients who underwent laparoscopic ventral hernia repair due to recurrence of midline hernias, comparing the outcomes of patients regarding the removal of the previous mesh during a laparoscopic repair [14]. In their cohort, they evaluated patients who underwent complete mesh explantation vs. partial mesh explantation. Among their outcomes, they evaluated postoperative numeric pain rating scales (NRS) in both complete and partial excision of mesh against a control group who had undergone ventral hernia repair with mesh as an index operation, demonstrating lower NRS scores with complete mesh removal compared to partial mesh removal [14].

Our approach for mesh explantation for ventral hernias follows the same principles for inguinal mesh explantations. In ventral locations of meshes, careful lysis of adhesion (LOA) is vital with avoidance of enterotomies at all costs. Partial resection of mesh leaving small pieces of mesh with the bowel to avoid enterotomies is acceptable. In our experience, most pain complaints are related to previous fixation techniques, so removal of transfascial sutures, tacks, and prior permanent sutures is key. Ventral mesh explantations tend to be less challenging than pelvic mesh explantations since there are fewer critical structures to dissect the mesh off.

Our complication rate (20%) was similar to that seen for inguinal mesh explantations; however, the most common occurrence in this group was serosal tears. This is logical as our patients had either a prior open repair or IPOM repair, which led to the development of intrabdominal adhesions that had to be managed intraoperatively to explant the mesh. None of our patients required a small bowel resection or conversion to an open procedure, and the serosal tears were managed with suture reinforcement. We did not encounter any post-operative SSOs in this cohort.

In our experience, we reported an improvement or resolution of pain in only half of our patients compared to 63% for inguinal mesh explantations. We cannot explain these inferior outcomes and whether a higher nociceptive component in this population is prevalent is unknown. Interestingly, 90% of the patients who presented with pain had undergone mesh fixation with tackers. While we noticed an association of chronic pain with the use of tackers in our cohort, we cannot determine causality with this study. Another limiting factor is the lack of information regarding the tackers or securing methods utilized during the initial operation, as many of these patients were operated on by a different surgeon and referred in the setting of chronic post herniorrhaphy pain.

In common practice, high-risk features for reoperation are frequently encountered in these patient populations. The management of mesh-related pain requiring explantation often relies almost exclusively on expert hands, given the difficulties associated with these cases [5]. With the advances in surgical technology, the robotic platform's adoption opens a new window for mesh explantation techniques with safe concomitant abdominal wall reconstruction. This is facilitated by articulated instruments that allow primary fascial closure and mesh reinforcement with suture fixation, avoiding tackers or transfascial sutures. However, the robotic systems have disadvantages such as the lack of haptic feedback, high direct and capital costs, and the learning curve associated with these cases.

The undertaking of these challenging operations requires profound anatomical knowledge and the expertise of a dedicated hernia surgeon. We could not find robust literature addressing the utilization of the Robotic Platform for mesh explantation. The data available from the urogynecological literature is not reflective of hernia surgery. However, we believe that the robotic platform's advantages provide a valuable tool to tackle these complex cases.

In 2018, Sharma et al. described their experience on mesh removal with 105 cases over 4.5 years noticing a downtrend of open and laparoscopic procedures with an increase in robotic technique from 0–70% reinforcing the utility and applied benefits of the robotic platform for these conditions with the growing applications of robotic surgery [5]. Another interesting finding in their study is that neurectomy was more commonly performed during open mesh removal for pelvic meshes than robotic removal, which coincides with our experience with the robotic platform seen with the enhanced exposure and ease of dissection that facilitates the preservation of neurovascular bundles.

The scarcity of literature addressing mesh removal and the concerns for recurrence deems mesh removal a controversial first approach for therapy. Despite this, ample literature demonstrates favorable outcomes in improving or resolving pain after mesh removal in this select group of patients [5, 8, 14, 17]. Our experience demonstrates the feasibility of the robotic approach for these cases.

Limitations

This study has several limitations. First, it is a descriptive, retrospective study with a small cohort and a statistical analysis is not possible as this is a descriptive manuscript addressing our initial experience with a novel approach There was no control group to compare with other MIS approaches and we cannot generalize our results.

Conclusions

Robotic mesh explantation in challenging cases due to chronic scarring, adhesions, and mesh incorporation to the surrounding tissues provides a new approach to tackle

these complex cases. Further studies with larger cohorts and comparatives studies against laparoscopic and open approaches are necessary to determine its safety and long-term outcomes.

Declarations

Disclosures Drs. Cosman Camilo Mandujano, Loic Tchokouani, Diego Lima, and Brian Jacob have no conflicts of interest or financial ties to disclose.

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