Hernia
https://doi.org/10.1007/s10029-024-03152-3

ORIGINAL ARTICLE

Early outcomes of robotic modified retromuscular Sugarbaker technique for end colostomy parastomal hernia repair

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Received: 4 July 2024 / Accepted: 20 August 2024

Abstract

Aim The modified retromuscular Sugarbaker or Pauli technique is a technique for parastomal hernia repair, which requires the dissection of the retromuscular space and a transversus abdominis release for stoma lateralization and placement of a retromuscular mesh. Given the limited evidence regarding the robotic approach to this technique, this study aims to evaluate the outcomes of this newly introduced procedure, focusing on the rate of 30-day complications and recurrence rates.

Methods Retrospective case series report. Patients included underwent an elective robotic modified retromuscular Sugarbaker technique for the repair of a parastomal hernia associated with an end colostomy. All surgeries were performed at a tertiary referral center from September 2020 to December 2023.

Results A total of 21 patients underwent a robotic modified retromuscular Sugarbaker in our study. The parastomal hernias operated on were classified according to the European Hernia Society as 9.5% (2/21) type I, 52.4% (11/21) type II, 23.8% (5/21) type III, 14.3% (3/21) type IV. Early complications observed included 14.3% (3/21) seroma, 9.5% (2/21) surgical site infection, 19% (4/21) postoperative ileus, and one case of large bowel obstruction due to colitis (4.8%), which was managed conservatively. No Clavien-Dindo grade III complications were reported. The overall recurrence rate was 9.5% (2/21) with a median follow-up of 12.5 months (IQR: 3.9–21.3). Both recurrences occurred during the early phases of the learning curve and were possibly attributed to insufficient lateralization of the stoma.

Conclusion Robotic modified retromuscular Sugarbaker for parastomal hernia repair is a challenging procedure with promising early outcomes.

Keywords Hernia, ventral · Incisional hernia · Colostomy, adverse effects · Surgical mesh · Postoperative complications · Recurrence

Introduction

Background

Parastomal hernias frequently arise following the creation of a stoma, with reported incidences reaching up to 48.1% with long-term follow-up [1]. These hernias can manifest as symptoms ranging from difficulties in stoma appliance management to discomfort, ultimately impacting the patient's quality of life [2]. In severe cases, they may lead to acute bowel obstruction, requiring urgent surgical intervention [3]. Surgical repair is indicated for chronic symptoms that significantly impair the patient's quality of life or for managing acute complications [4].

Suture repair and stoma relocation are discouraged for parastomal hernia treatment due to their high recurrence rates [5, 6]. There is insufficient data to determine the optimal mesh material for parastomal hernia repair or the preferred surgical technique for the open approach [6]. In laparoscopic repair, a flat mesh is preferred over a keyhole mesh [6], given the notably high recurrence rate of 24.1% (CI 95%: 17.1–31.1) with the laparoscopic keyhole mesh,

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Published online: 30 August 2024

compared to the lower 9% (CI 95%: 5.5–12.5) observed with the Sugarbaker technique [7]. However, in both techniques, placing the mesh intraperitoneally may lead to the development of significant bowel adhesions, complications during abdominal access in subsequent surgeries, or bowel erosion [8].

To overcome these issues, Pauli et al. [9] introduced a modification of the Sugarbaker technique in 2016. This technique involves a retrorectus dissection, followed by a posterior component separation via transversus abdominis release, and lateralization of the stoma using a flat mesh within the retromuscular space. This minimizes the contact between the mesh and the bowel, allows for a wide mesh overlap and includes the possibility of repairing other concomitant defects [9], with low recurrence rates observed in some series [9–13]. Since then, various articles have been published regarding the minimally invasive approach to this technique, either laparoscopic [10, 12] or robotically [12–14]. Nevertheless, the evidence is still limited and to our knowledge, only three articles [12–14] have assessed the outcomes of robotic modified retromuscular Sugarbaker for parastomal hernia repair. Therefore, there is a need for a larger number of patients and centers to evaluate its outcomes comprehensively.

Objective

The aim of the study was to analyze the outcomes of the modified retromuscular Sugarbaker technique for the repair of a parastomal hernia associated with an end colostomy, focusing on the rate of 30-day complications and recurrence rates.

Methods

This article was written according to the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Series [15].

Study design

Retrospective case series report.

Setting and participants

All consecutive patients who underwent a robotic modified retromuscular Sugarbaker procedure for the repair of a parastomal hernia associated with an end colostomy were included. All patients were operated on by a subspecialised abdominal wall surgeon at a tertiary referral centre from 1st September 2020 to 31st December 2023.

Included patients had either primary or recurrent parastomal hernia, with or without a concomitant midline incisional hernia. The parastomal hernia was classified according to the EHS classification [16]. All patients were older than 18 years. Excluded patients were those with a parastomal hernia associated with a loop colostomy, ileostomy or an ileal conduit, those operated on with an open approach, or those who underwent other surgical procedures for primary or recurrent parastomal hernia repair, such as the modified Sugarbaker or sandwich techniques.

The study was approved by the Institutional Research Ethics Committee (CEIC-3046). All patients signed the informed consent for the surgical intervention. Permission was obtained to waive the informed consent for the study.

Intervention

The robotic modified retromuscular Sugarbaker technique was the most frequently used procedure for parastomal hernia repair in our institution during the study period, primarily due to the advantages of the retromuscular mesh placement. Contraindications for this procedure included the anticipation of severe adhesions resulting from previous surgeries or complications, or medical comorbidities that hindered the robotic approach.

For the intervention, the patient was placed in a supine position, with the arms tucked to the side, and the surgical bed was flexed at the umbilicus to increase the distance between the xiphoid process and the pubic bone. All patients received preoperative antibiotic prophylaxis; the colostomy bag was removed, and the stoma was covered with sterile dressings. All interventions were performed using either a DaVinci Xi or a DaVinci X robotic system (Intuitive Surgical, Sunnyvale, California, USA). The modified retromuscular Sugarbaker technique was performed via a transabdominal or extraperitoneal approach.

A transabdominal approach was mainly used at the beginning of the series, and for the management of type I and III parastomal hernias where the midline is healthy and can be preserved. It was also more suitable for releasing adhesions and addressing previous mesh-based parastomal repairs. Conversely, an extraperitoneal approach may be more appropriate for type II and IV parastomal hernias, which require concurrent repair of midline defects, although previous experience with totally extraperitoneal ventral hernia repair is required.

For a transabdominal approach, pneumoperitoneum is created using a Veress needle at Palmer's point with a pressure of 12 mmHg. Then, the lateral border of the rectus sheath is localized. This anatomical landmark is defined as the EIT Ambivium [17], and should not be confused with the linea semilunaris, which is the transition from muscle

to aponeurosis in the transversus abdominis muscle. Lateral to the EIT Ambivium [17], three 8 mm robotic trocars are inserted on the right flank. The bowel adhesions are then dissected, and the hernia content is reduced. Subsequently, the posterior rectus sheath is incised to access the retrorectus space. This incision could be made on the right posterior rectus sheath to address a concomitant midline incisional hernia or on the left posterior rectus sheath to address a pure parastomal hernia. Following retrorectus dissection, an additional 5–12 mm trocar is placed in the left upper quadrant by the assistant to aid in the mobilization of the end colostomy and to introduce the mesh. Then, a left transversus abdominis release is performed. Afterwards, the posterior rectus sheath is incised from medial to lateral and then sutured with slowly absorbable self-fixating suture 2/0 or 3/0 for lateralization of the stoma. Then, the parastomal defect and other midline defects in the anterior rectus sheath are closed with absorbable STRATAFIX™ Symmetric 2/0 (Ethicon, Bridgewater, New Jersey, USA). Throughout the study period, the meshes used were standard polypropylene (PP), the polyvinylidene fluoride (PVDF) mesh DynaMesh®-CICAT (FEG Textiltechnik, Aachen, Germany), and the dual 12% PP and 88% PVDF mesh DynaMesh®-IPOM (FEG Textiltechnik, Aachen, Germany). After the first cases, the mesh was consistently fixed with a transfascial suture cranial and caudal to the stoma on the lateral wall. Finally, the posterior rectus sheath is closed with absorbable self-fixating suture 2/0. Key steps of the procedure are shown in Fig. 1.

For an extraperitoneal approach, a comprehensive video of this approach has been previously published by our group [18]. First, an incision is made is the right upper quadrant; the anterior rectus sheath is opened medial to the EIT Ambivium [17] and the retrorectus space is accessed using a dissecting balloon. Then, a 12 mm trocar is placed, CO_2 is insufflated, and two additional 8 mm trocars are positioned. In this approach, bowel adhesions can be addressed while dissecting the midline or parastomal defects. The remaining steps are consistent with those of the transabdominal approach. Finally, a drainage can be left in the retromuscular space at the surgeon's discretion. In all cases, incisions of trocars larger than 10 mm are closed with absorbable sutures.

Follow-up

All patients had scheduled outpatient visits at 1 month, 6 months, 1 year, and 2 years after surgery. Additionally, routine visits were conducted with the stoma nurse to prevent and address possible stoma complications. Abdominal computed tomography (CT) scans performed for oncological or hernia follow-up were carefully evaluated to detect possible recurrences.

Variables

Data were extracted from the electronic medical records. Demographic variables included age (years), sex, body mass index (BMI), smoking habit, medical comorbidities, previous surgeries, and years past since stoma surgery. The characteristics of the parastomal hernia were determined by the type of hernia (pure parastomal or associated midline hernia), status of recurrent hernia, hernia defect measurements from preoperative CT scans and classification according to the European Hernia Society (EHS) [16].

Surgical outcomes included the type of approach (transabdominal vs. extraperitoneal), mesh used, mesh surface area (cm^2), intraoperative events and operative time. Early postoperative outcomes consisted of length of hospital stay, time to first stool after surgery, overall 30-day morbidity, specific complications, and grading of the complication according to the Clavien-Dindo classification [19]. Postoperative outcomes were based on the duration of the follow-up, availability of follow-up CT scans, rates of chronic pain and recurrence.

Statistical analysis

Categorical variables were presented as numbers and percentages. Quantitative variables were described using the mean and standard deviation (SD) if they followed a normal distribution, and the median and interquartile range (IQR) if they followed a non-normal distribution. The distribution of the variables was assessed using the Shapiro-Wilk test. The analysis was conducted using SPSS Statistics 26® (IBM, Chicago, IL).

Results

Participants, baseline, and hernia characteristics

A total of 21 patients underwent an elective robotic modified retromuscular Sugarbaker procedure for parastomal hernia repair from 1st September 2020 to 31st December 2023.

The sample consisted of a higher number of male patients (12/21; 57.1%), with a mean age of 73.8 years (SD: 7.4) and a mean BMI of 27.4 kg/m^2 (SD: 4.7). Only two cases had an active smoking habit (2/21; 9.5%). All but three end colostomies (3/21; 14.3%) were a result of cancer surgery, while the most common operation was a previous abdominoperineal resection (12/21; 57.1%). The median time from the

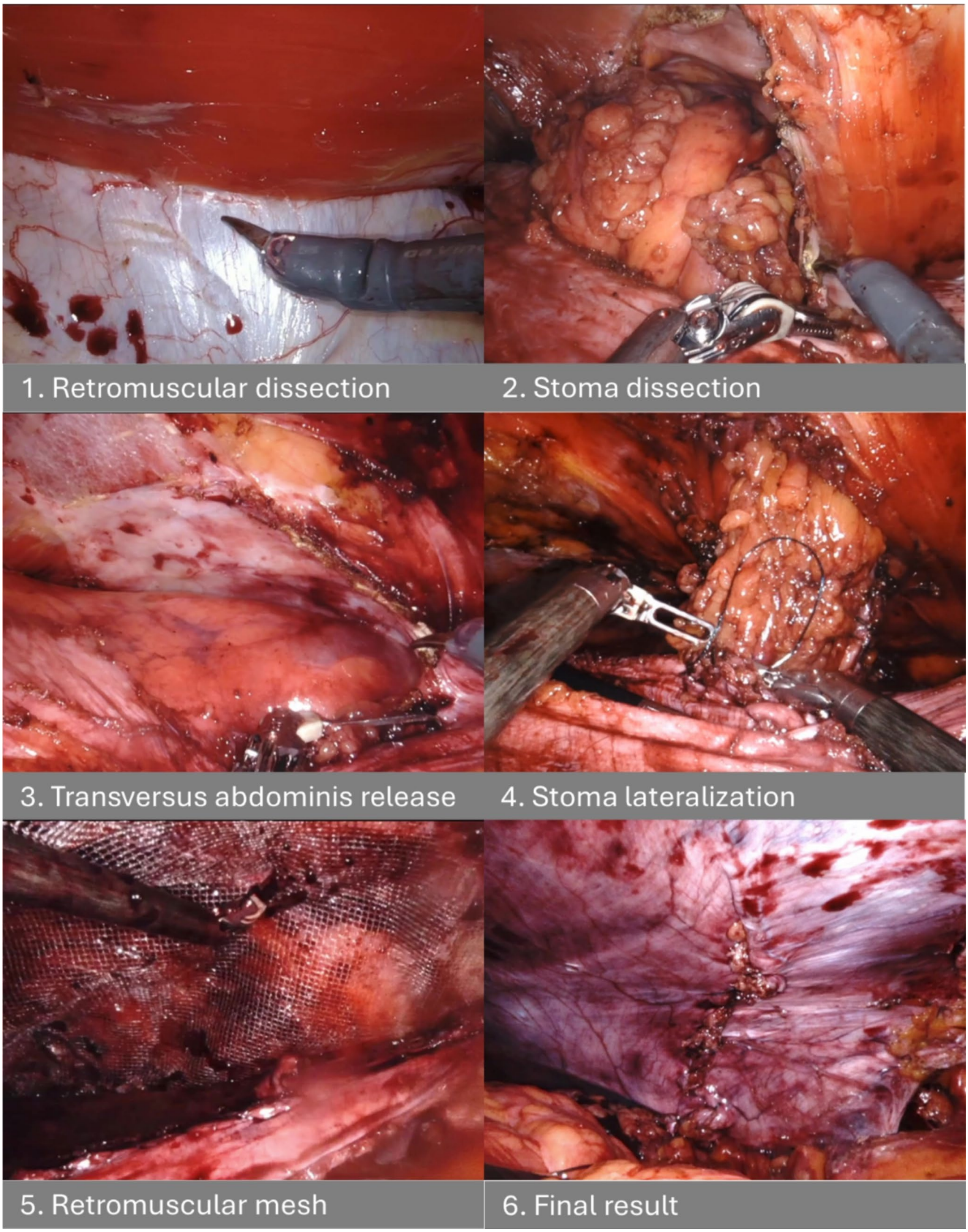

Fig. 1 Surgical steps for the transabdominal modified retromuscular Sugarbaker technique

Table 1 Baseline and hernia characteristics

	Pauli technique n: 21
	n (%) Median (IQR)
Age	73.8 (7.4)
Sex	
Male	12 (57.1)
Female	9 (42.9)
IMC (kg/m2)*	27.4 (4.7)
Smoking habit	
No	10 (47.6)
Active	2 (9.5)
Previous	9 (42.9)
Comorbidities	
Diabetes mellitus	5 (23.8)
COPD	1 (4.8)
CKD	2 (9.5)
Liver disease	1 (4.8)
Immune suppressants	2 (9.5)
Previous surgery	
Derivative stoma	3 (14.3)
Sigmoidectomy	3 (14.3)
Low anterior resection	3 (14.3)
Abdominoperineal resection	12 (57.1)
Time from stoma surgery (years)	3.7 (2.4–5.7)
Type of hernia	
Midline and parastomal	14 (66.7)
Pure parastomal	7 (33.3)
Recurrent	5 (23.8)
Transverse defect (cm)	
Midline (14/21)	3.8 (2.6–7.3)
Parastomal (21/21)	4.3 (3.5–5.1)
Hernia surface (cm^2)	
Midline	33 (16.1–94.2)
Parastomal	22.5 (18.2–29.7)
EHS classification	
I	2 (9.5)
II	11 (52.4)
III	5 (23.8)
IV	3 (14.3)

*Mean (SD)

BMI Body mass index, *COPD* Chronic obstructive pulmonary disease, *CKD* Chronic kidney disease, *EHS* European Hernia Society

index surgery to the parastomal hernia repair was 3.7 years (IQR: 2.4–5.7).

Two-thirds of the sample had a concomitant midline incisional hernia associated with the parastomal defect (14/21; 66.7%), while the remaining one-third had a pure parastomal hernia (7/21; 33.3%). The parastomal hernia defect of the sample had a median diameter of 4.3 cm (IQR: 3.5–5.1), while the midline defect of those patients with a concomitant incisional hernia was 3.8 cm (2.6–7.3). Thus, according to the European Hernia Society classification, there were 9.5% (2/21) type I hernias, 52.4% (11/21) type II, 23.8% (5/21) type III, 14.3% (3/21) type IV. A 23.8% (5/21) of the sample had a recurrent parastomal hernia: three cases after an elective herniorrhaphy, one case after an elective retromuscular keyhole, and one case after an urgent onlay keyhole. These results are summarized in Table 1.

Table 2 Surgical outcomes

	Pauli technique n: 21
	n (%) Median (IQR)
Approach	
Transabdominal	11 (52.4)
Extraperitoneal	10 (47.6)
Mesh used	
Polypropylene	7 (33.3)
DynaMesh®-IPOM	3 (14.3)
DynaMesh®-CICAT	11 (52.4)
Mesh surface area (cm^2)	750 (600–900)
Intraoperative events	
Adhesions	7 (33.3)
Bowel reinforcement	1 (4.8)
Bowel injury	3 (14.3)
Subcutaneous emphysema	1 (4.8)
Operative time (min)*	261 (73)

*Mean (SD)

Surgical outcomes

All cases were operated on robotically, with 52.4% (11/21) utilizing a transabdominal approach and 47.6% (10/21) utilizing an extraperitoneal approach. Following closure of all defects with absorbable barbed suture as previously mentioned, the most frequently used retromuscular mesh was DynaMesh®-CICAT (11/21; 52.4%). Other meshes employed included standard polypropylene in 33.3% (7/21) of cases and DynaMesh®-IPOM in 14.3% (3/21). The median surface area of the mesh used was 750 cm^2 (IQR: 600–900).

Concerning intraoperative events, one-third of the cases (7/21; 33.3%) presented relevant bowel adhesions requiring dissection, with three of those cases demanding suturing of an enterotomy due to bowel injury. The mean operative time was 261 min (SD: 73). These outcomes are presented in Table 2.

Postoperative outcomes

The median length of hospital stay after the operation was 3 days (IQR: 3–5). The overall time to first stool was 3 days (IQR: 2–3.5), although four cases experienced a postoperative ileus (19%). The overall 30-day morbidity rate was 47.6% (10/21). There were two cases of surgical site

infection (9.5%), one involving a trocar, and one involving a parastomal abscess that required bedside drainage and antibiotics. One case required readmission due to large bowel obstruction caused by colitis, which was managed with digestive rest, intravenous fluids, enemas, and a progressive diet. Concerning medical complications, there was a case of hypertensive crisis and a case of hearth failure. Both cases responded well to medical treatment. All complications were classified as Clavien-Dindo grade I (6/21; 28.6%) or grade II (4/21; 19%), while there were no grade III or IV complications.

The median follow-up was 12.5 months (IQR: 3.9–21.3). During this period, 71.4% of patients underwent a CT scan. The overall recurrence rate was 9.5% (2/21). These results are displayed in Table 3. Both recurrences occurred during the early phases of the learning curve. We hypothesized that the likely cause of recurrence was an insufficient lateralization of the stoma, as shown in Fig. 2.

Table 3 Postoperative outcomes

	Pauli technique n: 21
	n (%) Median (IQR)
Length of stay (days)	3 (3–5)
Time to first stool (days)	3 (2–3.5)
Overall 30-day morbidity	10 (47.6)
30-day specific complications	
Seroma	3 (14.3)
Hematoma	1 (4.8)
Surgical site infection	2 (9.5)
Postoperative ileus	4 (19)
Obstruction due to colitis	1 (4.8)
Medical complications	2 (9.5)
Complications according to the Clavien-Dindo classification	
Grade I	6 (28.6)
Grade II	4 (19)
Grade III or IV	0
Follow-up (months)	12.5 (3.9–21.3)
CT scan during follow-up	15 (71.4)
Chronic pain	0
Recurrence	2 (9.5)

Discussion

The Pauli technique for parastomal hernia repair is a modification of the Sugarbaker technique, facilitating proper lateralization of the stoma through the placement of a retromuscular mesh [9]. In their original description, Pauli et al. [9] operated on three patients using an open approach, two with end colostomies and one with an end ileostomy. They reported no significant postoperative complications, and no recurrences were detected during a median follow-up period of 5.3 months.

However, repairing parastomal hernias presents a challenge for surgeons, as evidenced by our overall 30-day morbidity rate of 47.6% (10/21). Despite this, these cases were resolved without reoperation. The modified retromuscular Sugarbaker technique carries the risk of severe postoperative complications, as demonstrated in the open series reported by Tastaldi et al. [20]. In their study, the authors encountered mesh-related severe complications in 8% of

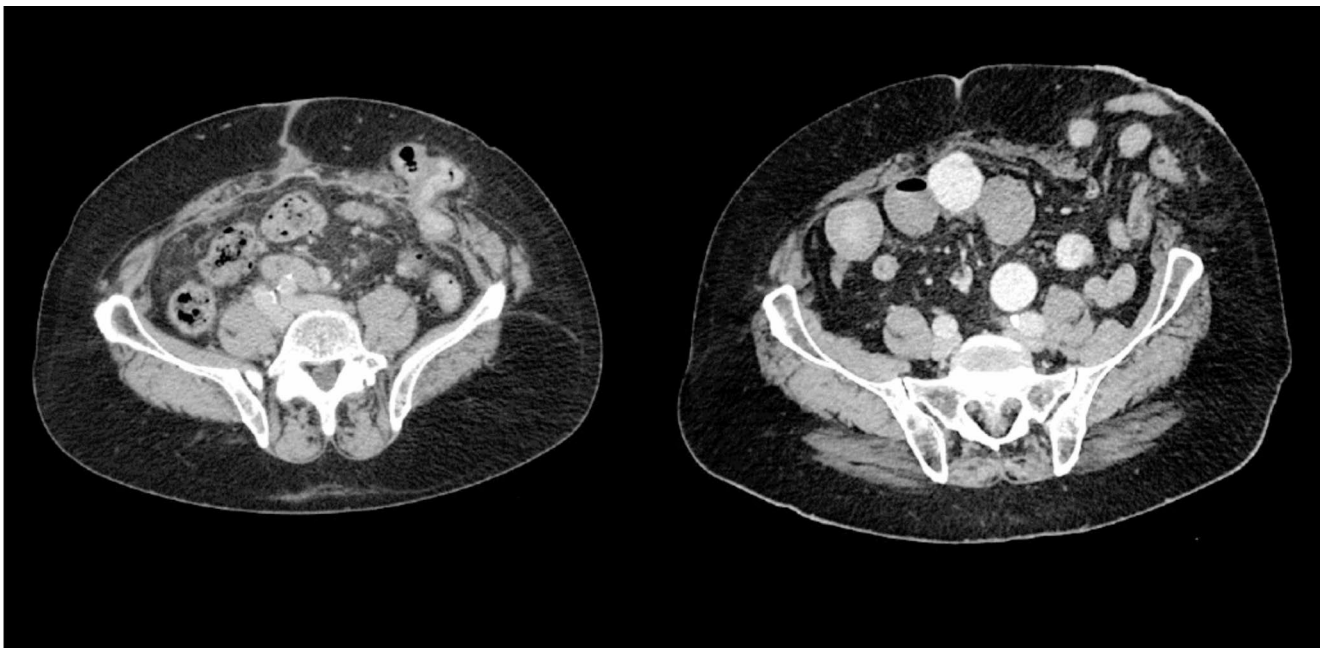

Fig. 2 CT scan image showed insufficient lateralization at the 4th postoperative month, which later resulted in a recurrence at 1-year follow-up

patients (3/38), including two cases of early postoperative bowel obstruction caused by mesh erosion in the stoma bowel, and a case of stoma necrosis due to mesh erosion in the mesentery. Stoma necrosis has also been documented in other open [21] and robotic series [13], the latter associated with extensive devascularization of the stoma. Fortunately, none of these complications have been reported in our series.

To reduce these complications, meticulous dissection during the initial phase of the surgery is essential, and immunofluorescence can be employed to assess bowel perfusion [13]. It is also advisable to achieve a secure defect closure without excessive bowel strangulation, both in the closure of the internal [13] and external stoma rings [10]. Concerning mesh selection, some authors advocate for the use of a protective biosynthetic absorbable mesh cushion between the non-absorbable mesh and the bowel [12, 13] while Bloemendaal utilized the Ovitex 1S (TelaBio, Malvern, Pennsylvania, USA), a biologic ovine matrix reinforced with polypropylene [14]. Nonetheless, the safe use of synthetic non-absorbable meshes has also been demonstrated in this technique, utilizing materials such as polypropylene [9, 10, 21] or polyester [11]. Regarding our series, we consider that the use of polypropylene or PVDF is safe, provided that mesh edge is positioned against the lateral aspect of the bowel with minimal tension [21] and loosely in contact with the colostomy.

A crucial aspect of the technique is assessing the recurrence rate, especially considering that in parastomal hernia repairs, up to 27.5% can experience recurrence during follow-up [22]. To date, published open series have reported recurrence rates between 0% [9] and 11% [20], while laparoscopic series have shown a 0% recurrence rate [10, 11], and robotic series have ranged from 3.8% [13] and 18.1% [14]. Furthermore, Gröger et al. reported a recurrence rate of 25% in their mixed publication combining open and laparoscopic approaches [23], and the minimally invasive laparoscopic and robotic approach of Lambrecht had a rate of 6.6% [12]. Therefore, our recurrence rate of 9.5% (2/21) aligns with those previously reported.

According to the literature, the lateral part of the colostomy on the posterior wall possesses the highest risk for recurrence [12, 14, 20]. To avoid this complication, it is recommended to suture the bowel to the abdominal wall [10, 13, 14]. In our series, we identified insufficient lateralization of the stoma as the most likely cause of recurrence. Therefore, maximizing bowel mobilization to facilitate optimal lateralization while minimizing mesh tension over the bowel should be a critical technical consideration [21]. Additionally, we chose to maintain the transfacial sutures placed lateral to the stoma to create a loose mesh sling that accommodates the bowel, as initially described by Pauli et al. [9].

The advantage of this technique lies in its ability to achieve comparable recurrence rates to the original Sugarbaker technique [24] while placing the mesh in the retromuscular plane. Unlike intraperitoneal techniques, operating in the retromuscular plane reduces the need for mesh fixation [10] while enhancing the mesh-tissue interface for tissue ingrowth [9]. The modified retromuscular Sugarbaker technique has probably better long-term results compared to the technically easier retromuscular keyhole [20], with recurrence rates ranging from 21.7% [25] to 45% [26]. The publication of the results from the randomized controlled trial by Maskal et al. [21] may provide further clarification on this matter.

Finally, the decision between the transabdominal and the extraperitoneal approach should be based on various factors. One is the surgeon's familiarity with transabdominal vs. extraperitoneal approaches. Transabdominal approaches are typically the initial technique practiced for ventral hernia repair [27], whereas the totally extraperitoneal (eTEP) technique can be more complex, but is associated with a shorter operative time, and increased overlap size with integrity of the posterior layer [28]. Other factors must also be contemplated in parastomal hernias, such as the increased difficulty that can arise with previous repair attempts and mesh placement in intraperitoneal or retromuscular positions. In our group, these cases were mainly managed with a transabdominal approach. Nevertheless, these cases can be complex even with small defects and expose the patient to severe postoperative complications. Considering that usual parastomal hernia repair volumes are low among general surgeons [29] the modified retromuscular Sugarbaker technique should likely be reserved for surgeons with specific expertise and experience in complex abdominal wall reconstruction and parastomal hernia repair.

A strength of our study was the homogeneous cohort of patients with terminal colostomies, as we excluded all patients with ileostomies or ileal conduits. End colostomies carry a higher risk of hernia compared to ileostomies or urostomies [6, 30], and we hypothesize that their characteristics and risk of future hernia recurrence differ. Additionally, ileal conduits are typically shorter, and lateralization can pose challenges, making them more susceptible to keyhole repairs [13].

A limitation of the study was the reduced sample size and the case series design, lacking a comparison group. The absence of randomization with other techniques increased the risk for a selection bias. However, recruiting a large sample for comparing different techniques presents a challenge for a single center given the limited number of patients undergoing parastomal hernia repair. Besides, currently

published studies of robotic modified retromuscular Sugarbaker also have a limited sample, ranging from 11 to 26 patients [13, 14]. Another limitation was the reduced follow-up time, with a median of 12.5 months (IQR: 3.9–21.3). This duration falls short of the recommended 2-year follow-up period necessary for accurately diagnosing recurrence, potentially leading to an underestimation of its impact [31], which could cause a detection bias. However, it is important to acknowledge that the median follow-up periods in the aforementioned studies range from 5.3 months [9] to 14 months [13], with the notable exception of Bellido-Luque et al. [10], who reported a follow-up duration of 29 months in their laparoscopic series. Hereafter, a prospective evaluation of the results at our institution would minimize the risk of bias in the evaluation of this technique. Finally, future comparisons between the Pauli and Sugarbaker techniques, assessing recurrence and quality of life, would be valuable in defining the role of the modified retromuscular Sugarbaker technique in parastomal hernia repair.

Conclusion

The robotic modified retromuscular Sugarbaker technique for parastomal hernia repair is a challenging procedure with promising early outcomes in terms of 30-day complications and 1-year recurrence rates.

Funding Authors received no financial support for the research, authorship, and/or publication of this article.

Declarations

Ethics approval The study was approved by the Institutional Research Ethics Committee (CEIC-3046).

Patient consent statement All patients signed the informed consent for the surgical intervention. Permission was obtained to waive the informed consent for the study.

Conflict of interest Drs. Alberto G Barranquero, Yolanda Maestre González, Cristina Gas Ruiz, Marta Sadurni Gracia, Jorge Juan Olsina Kissler and Rafael Villalobos Mori have no conflicts of interest or financial ties to disclose.

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