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Da Vinci robot-assisted pull-through in secondary megarectum resection after anorectal malformation surgery

Boyuan Tao
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Min Ye
Guangzhou First People's Hospital
Xiaogang Xu
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Fei Liu
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Menglong Lan
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Yuanyuan Luo
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Zhihua Ye
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Hong Zhang
Guangzhou Women andChildren's Medical Center, Guangzhou Medical University
Jixiao Zeng
zengjixiao@163.com

Guangzhou Women andChildren's Medical Center, Guangzhou Medical University

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Abstract

Purpose Some children with anorectal malformations (ARMs) acquire secondary megarectum (SMR) following anorectoplasty, leading to intractable constipation and overflow fecal incontinence. Currently, there is no established treatment for this condition. This study aims to characterize the clinical features of SMR following anorectoplasty for ARMs and to evaluate the outcomes of the da Vinci robot-assisted pull-through procedure.

Methods Between October 2022 and June 2023, a total of 14 children with recurrent constipation following anorectal malformation surgery presented to our department, of whom 8 were included in this clinical analysis based on the established criteria.

Results This cohort included 5 males and 3 females, comprising 3 cases of intermediate-type and 5 cases of low-type ARMs. All patients underwent the da Vinci robot-assisted pull-through procedure to resect the megarectum (MR) due to recurrent constipation following anorectoplasty. The age at the time of surgery ranged from 30.4 to 50.6 months, with a median age of 38.8 months. According to the Krickenbeck classification (2005), postoperative constipation improved significantly in 7 patients, with 5 cases achieving complete resolution from grade 3 and 2 improving from grade 3 to grade 1; one patient, however, remained at grade 3. Preoperatively, 6 patients presented with soiling; postoperatively, this symptom improved in 5 cases, while 1 case remained unchanged at grade 1. Postoperative pathology revealed thickened nerve plexuses, disordered and thickened muscle fibers with degeneration, thickened submucosa in the distal intestinal wall, and increased collagen deposition. No obvious abnormalities were observed in the number or distribution of ganglion cells.

Conclusion Resecting MR following anorectal malformation repair significantly alleviates constipation in pediatric patients. The da Vinci robot-assisted pull-through procedure facilitates precise dissection of the abdominal and pelvic anatomy, which minimizes tissue trauma.

1. Introduction

ARMs are sometimes associated with MR, with a reported incidence of 10% to 50%. MR is classified into primary and secondary types. The potential causes of primary MR include underlying sacral neuropathy leading to the loss of afferent sensation and innervation, as well as fetal hindgut obstruction. [1]. SMR is primarily attributed to denervation resulting from anorectoplasty, chronic constipation, and anal stenosis [2, 3]. In some cases, impaired peristalsis of the dilated rectum or sigmoid colon can lead to intractable constipation. When constipation persists despite rigorous conservative management, surgical resection of the dilated bowel segment becomes necessary [1, 4]. Robotic laparoscopy, characterized by high-definition magnification, stability, and enhanced dexterity, has been increasingly utilized in pediatric gastrointestinal surgery [5, 6]. This study aims to elucidate the clinical characteristics of SMR following anorectoplasty and to evaluate the efficacy of the robot-assisted pull-through procedure for MR resection.

2. Methods and materials

2.1. Patients Between October 2022 and June 2023, a total of 14 pediatric patients with recurrent constipation following anorectoplasty for ARMs presented to the Department of Gastrointestinal Surgery at Guangzhou Women and Children's Medical Center, Guangzhou Medical University.

The inclusion criteria were as follows: (1) diagnosis of constipation based on the Rome IV criteria, with failure to improve after conservative treatments such as oral medications, anal dilatation, and transanal irrigation (TAI); (2) imaging findings indicating a rectopelvic ratio (RPR)> 0.61 [7] (Fig. 1); and (3) performance of robot-assisted pull-through surgery by the same lead surgeon.The exclusion criteria included: (1) concurrent neurological disorders, such as syringomyelia or myelomeningocele; (2) Currarino syndrome or Hirschsprung's disease; and (3) post-anorectoplasty complications, such as anastomotic leakage or rectal retraction.

Ultimately, 8 patients meeting these criteria were included in the study. All 8 patients had undergone their initial anorectoplasty at outside institutions. Data regarding demographic characteristics, clinical manifestations, surgical outcomes, and complications were collected. Bowel function was evaluated using the Krickenbeck classification (2005) [8] both preoperatively and at the last follow-up. This study was approved by the Ethics Committee of Guangzhou Women and Children's Medical Center, Guangzhou Medical University (Approval No. 2026-318A01), and informed consent was obtained from the families of all patients.

2.2. Surgical procedures

Using the 4th generation da Vinci Xi surgical system, trocars were placed at the umbilicus and 5 cm lateral to the umbilicus on both sides. Pneumoperitoneum was then established with an intra-abdominal pressure of 8–10 mmHg (1 mmHg = 0.133 kPa). The sigmoid colon and rectum were explored to preliminarily determine the resection margins. Subsequently, a tissue sample was excised approximately 2 cm distal to the planned margin and sent for intraoperative frozen section analysis (Fig. 2).

Important anatomical structures, including the bilateral ureters, gonadal vessels, and vasa deferentia, were carefully identified to ensure their protection during bowel mobilization. When mobilizing the rectum, circumferential dissection was performed closely along the surface of the rectal muscularis down to the level of the levator ani muscle. During the dissection, clamping or electrocauterizing of the perirectal mesenteric tissue was avoided to prevent injury to the neurovascular plexuses contained within. The splenocolic ligament were completely divided, and the descending colon was mobilized along Toldt's fascia plane. This was done to ensure that the bowel segment intended for resection could be smoothly pulled through the anus and to achieve a tension-free anastomosis. If the intraoperative rapid frozen section pathology report showed no significant abnormalities, the robotic surgical system was undocked. Subsequently, the pediatric patient was repositioned into the lithotomy position, and a Lone-Star retractor was used to retract the anus while carefully protecting the dentate line.

A circumferential incision of the rectal mucosa was made using electrocautery 1.0 cm above the anorectal line. In patients with severe anal scarring, the incision was placed at the mucocutaneous junction. After dissecting upwards for 0.5 cm, the rectal muscular layer was transected. A slight dissection adjacent to the rectal wall was performed to allow the planes to meet with the one previously created under robotic assistance. Subsequently, the mobilized bowel segment was pulled through the anus. It was crucial to ensure that the colon 2 to 3 cm proximal to the intended anastomotic plane was exposed outside the anus without tension, as this was the key to achieving a tension-free anastomosis (Fig. 3). Pneumoperitoneum was re-established, and under the da Vinci Xi laparoscopic view, it was confirmed that the pulled-through bowel was free of torsion and was not compressing the small intestine. The dilated bowel segment was resected, and an interrupted, full-thickness anastomosis was performed with the rectal stump or the anal skin.

2.3 Postoperative Management

The nasogastric tube and urinary catheter were removed within 24 hours postoperatively. Intravenous second-generation cephalosporins were administered for infection prophylaxis for 48 hours. Infection markers, including complete blood count (CBC) and C-reactive protein (CRP), were rechecked to determine the necessity of continuing antibiotic therapy. The discharge criteria included a return to the preoperative diet, normal body temperature, satisfactory wound healing, return of bowel function, and the absence of elevated white blood cell count or CRP.

3. Results

A total of 8 pediatric patients with complete data were included (5 males and 3 females). The age at initial anoplasty ranged from 2 days to 4.8 months. Preoperative diagnoses included rectoperineal fistula in 3 cases, rectobulbar fistula in 2 cases, anterior anus in 2 cases, and rectovestibular fistula in 1 case. A review of preoperative imaging studies from local hospitals, including abdominal X-rays and gastrointestinal contrast examinations, showed no significant rectal dilation in any of the patients. Among the 5 patients with low ARMs, 2 underwent posterior sagittal anoplasty (PSA), and 3 underwent posterior sagittal anorectoplasty (PSARP). The 3 patients with intermediate ARMs underwent laparoscopic-assisted anorectoplasty (LAARP). Of these, 2 also underwent terminal ileostomy, and the stomas were closed 3 months postoperatively. Constipation occurred within 3 months postoperatively in 3 patients, while the other 5 developed it after 3 months. The median duration of conservative treatment was 31.5 months (range: 23.0–49.0 months), including a median duration of TAI of 19.5 months (range: 16.0–37.0 months) (Table 1).

All 8 patients successfully underwent da Vinci robotic-assisted resection of the MR, with no new cases requiring enterostomy. The median age at surgery was 38.8 months (range: 30.4–50.6 months), the median operative time was 248 minutes (range: 175–470 minutes), and the median blood loss was 10 ml (range: 2–20 ml). Pelvic adhesions were observed in the 3 patients with a history of LAARP. There were no intraoperative complications, although 1 patient required an intraoperative transfusion of 1 unit of packed red blood cells. Postoperatively, 2 patients developed incomplete intestinal obstruction, which resolved with conservative treatment. No patients experienced pelvic infection, anastomotic leakage, or other postoperative complications. The median follow-up time was 35.2 months (range: 25.1–42.0 months). All 8 patients achieved voluntary bowel movement. Constipation improved in 7 cases, while 1 patient remained at Grade 3, requiring occasional glycerin enemas but no TAI. Of the improved cases, 2 downgraded from Grade 3 to Grade 1 with dietary management alone. Six patients presented with preoperative soiling. Postoperatively, soiling severity improved from Grade 2 to Grade 1 in 2 cases, and resolved completely in 3 cases, while 1 patient remained at Grade 1 (Table 2).

Pathological results of the 8 pediatric patients showed that ganglion cells were present in both the proximal and distal margins of the resected bowel, with Calretinin immunohistochemical staining being positive in all cases. The dilated bowel segments exhibited muscular hypertrophy, myofiber degeneration, and disorganized muscle layer arrangement. The myenteric and submucosal nerve plexuses were thickened. In the distal bowel wall near the anus, the submucosa was thickened with increased collagen deposition and disorganized smooth muscle architecture.

Table 1. Clinical features of the 8 pediatric patients with MR

No.	sex	Type of ARM	Wingspread classification	History of surgery	Conservative treatment / TAI duration*（m）	RPR	RAIR	IAS
1	m	Rectoperineal	Low	PSARP	31/16	0.74	+	good
2	f	anterior anus	Low	PSA	30/20	0.79	+	good
3	m	Rectoperineal	Low	PSARP	38/28	0.84	+	good
4	f	Rectoperineal	Low	PSARP	49/37	0.87	+	good
5	f	anterior anus	Low	PSA	36/18	0.75	+	good
6	m	Rectobulbar	Intermediate	LAARP+ DBI+Ileostomy closure	32/19	0.85	+	good
7	f	Rectovestibular	Intermediate	LAARP+ DBI+Ileostomy closure	29/18	0.72	+	good
8	m	Rectobulbar	Intermediate	LAARP	23/21	0.70	+	poor

PSAR:Posterior sagittal anorectoplasty PSA:Posterior sagittal noplasty, LAARP: Laparoscopic-assisted anorectoplasty, DBI:Double-barrel ileostomy，TAI:Trans-anal irrigation, RPR:Rectopelvic ratio , RAIR:Rectoanal inhibitory reflex, IAS:Internal anal sphincter. *:Values are presented as Total duration of conservative treatment / Duration of TAI.

Table 2. Outcomes of MR resection in 8 pediatric patients with ARMs

No.	Age at resection of MR (m)	Operation time (min)	Bleeding (ml)	Complication	Follow-up time (m)	Voluntary bowel movement pre/post*	Soiling pre/post*	Constipation pre/post*
1	35.3	200	10	-	25.1	No/Yes	1/1	3/-
2	38.2	330	11	Incomplete Intestinal Obstruction	27.9	No/Yes	1/-	3/-
3	39.4	280	5	Incomplete Intestinal Obstruction	35.5	No/Yes	-/-	3/1
4	50.6	410	20	-	32.6	No/Yes	1/-	3/-
5	37.4	470	10	-	42	No/Yes	1/-	3/1
6	44.5	180	7	-	34.9	No/Yes	-/-	3/-
7	43.2	175	15	-	38.2	No/Yes	2/1	3/3
8	30.4	216	2	-	38.5	No/Yes	2/1	3/-

-:None; *:Using the Krickenbeck classification (2005); pre:Preoperative; post:Postoperative.

4. Discussion

Intractable constipation is a common complication following surgery for ARMs, with a particularly high incidence observed in patients with intermediate and low-type defects [9, 10]. MR is widely recognized as the primary etiology of this condition. The poor motility within these dilated bowel segments leads to fecal impaction, which further exacerbates constipation and may result in overflow fecal incontinence. Some patients may also present with concomitant sigmoid colon dilation. Regarding the definition of MR, most researchers adopt a RPR> 0.61 based on imaging findings [7], while others define it anatomically by the extension of the dilated rectum beyond the umbilicus [11]. However, the optimal management strategy for MR remains controversial. While some authors advocate for resection of the MR in cases refractory to bowel management (including diet, laxatives, and enemas), citing favorable clinical outcomes [1, 12, 13], conversely, other studies suggest that surgical resection offers no significant functional advantage over continued conservative treatment.Furthermore, the proportion of patients eventually requiring an antegrade continence enema (ACE) or intestinal stoma was significantly higher in the surgical group than in the conservative group. Despite this, these studies highlight that surgical intervention remains indicated for children with severe rectal dilation [4, 14]. Specifically, one study reported that ACE alone yielded unsatisfactory outcomes for MR patients refractory to oral laxatives, ultimately necessitating MR resection. Moreover, for patients with compromised internal sphincter function (e.g. hypoplasia or neuropathy), a combined approach of MR resection and ACE was found necessary to achieve acceptable fecal continence [11].

Currently, abdominal approaches for MR surgery include open surgery and conventional laparoscopy [12, 15]. Compared with open surgery, laparoscopy significantly reduces surgical trauma, particularly during the dissection of perirectal tissues, where it facilitates easier mobilization of the distal rectum while minimizing injury to surrounding neurovascular structures. This is crucial for preserving urinary, erectile, and ejaculatory functions. Compared with conventional laparoscopy, the da Vinci robotic system features 7 degrees of freedom and a 540-degree rotational capability of its EndoWrist instruments, offering superior flexibility. It also filters out physiological tremors to ensure enhanced stability, while its high-resolution panoramic 3D imaging system provides surgeons with a highly magnified and clear operative field. The application of robotic-assisted laparoscopy in primary and redo surgeries for pediatric Hirschsprung's disease and ARMs has been reported, with studies demonstrating favorable outcomes attributed to these technical advantages [5, 6, 16].In our cohort, three children with a history of prior laparoscopic surgery presented with varying degrees of pelvic adhesions. Notably, one female patient had the uterus and ovaries adherent to surrounding tissues. Leveraging the flexibility of the robotic system, meticulous adhesiolysis was successfully performed, effectively avoiding injury to the bladder, uterus, and ovaries.

Regarding perioperative outcomes, no intraoperative complications (such as ureteral or rectal injuries) occurred in our series. Furthermore, there were no postoperative complications, including hemorrhage, pelvic infection, anastomotic leak, or anastomotic stricture. Two patients developed incomplete intestinal obstruction, which resolved with conservative management. In contrast, a report by Mitani et al. on 5 children undergoing conventional laparoscopic surgery documented one case of anastomotic leak requiring pelvic drainage and temporary ileostomy, although no anastomotic strictures were observed in that series [15]. Similarly, Tan et al. reported relatively high morbidity in their series of 7 children undergoing MR resection, where 6 required a concomitant ACE. Of these, one patient required a permanent ileostomy due to ACE failure, and three others underwent multiple reoperations for complications such as rectovaginal fistula and stoma-related issues [14].

Currently, there are no studies specifically reporting complications of robotic-assisted surgery for ARMs complicated by MR. However, insights can be drawn from the literature on its application in Hirschsprung's disease. One report indicated that, compared with conventional laparoscopy, robotic-assisted surgery significantly reduced intraoperative blood loss. In that study, anastomotic leakage occurred in 2 of 44 patients in the laparoscopic group, whereas none were observed in the robotic group. However, due to the larger diameter of the robotic trocars, one case of incisional hernia occurred in the robotic group (1 of 31) [16]. On the other hand, other studies comparing conventional laparoscopy, single-incision laparoscopy, and robotic systems found no significant differences in intraoperative blood loss or the incidence of complications such as anastomotic leakage [17].From a technical perspective, the robotic system offers greater flexibility in mobilizing the lateral peritoneum of the descending colon and dividing the splenocolic ligament, thereby reducing tension on the pull-through bowel. Additionally, it allows for precise dissection along the bowel wall, minimizing vascular injury to the preserved segments. These advantages are particularly pronounced during the mobilization of the rectum below the peritoneal reflection, a region characterized by its deep anatomical location and confined working space.The superior stability and higher magnification of the robotic system can maximize the preservation of the mesorectum below the peritoneal reflection, thereby avoiding excessive bleeding and injury to the pelvic plexus. Compared with conventional laparoscopy, these advantages render the robotic approach particularly advantageous for older children with a deeper pelvis, as well as for those requiring reoperation in the presence of pelvic adhesions. Ultimately, these technical advantages minimize postoperative pelvic fluid collection, consequently lowering the risk of anastomotic leakage.

According to the Krickenbeck classification (2005), postoperative constipation improved significantly in 7 out of 8 patients, while 1 patient remained at grade 3. Among the 6 patients with preoperative soiling, severity improved from grade 2 to grade 1 in 2 cases, and resolved completely in 3 cases; 1 patient remained at grade 1 postoperatively. Similarly, Mitani et al. reported that among 7 ARM patients with MR who did not undergo bowel resection during their initial surgery, all subsequently developed constipation, with 5 cases progressing to intractable constipation. Of these, 3 had initially undergone PSARP and 2 had undergone LAARP. These 5 patients subsequently underwent laparoscopic-assisted MR resection, which resulted in improved postoperative bowel function [15]. In another case report, Giorgio et al. described a 19-year-old male with megasigmoid-rectum accompanied by severe constipation and fecal incontinence. This patient, who had a history of PSARP for a rectourethral fistula and multiple surgeries for rectal mucosal prolapse, underwent laparoscopic-assisted resection of the dilated bowel. At the 1-year follow-up, he reported regular bowel movements with no recurrence of fecal soiling [13].Furthermore, a study analyzing MR resection in 16 patients with overflow fecal incontinence following ARM surgery found that ideal outcomes were achieved in patients with an intact internal sphincter, a demonstrable rectoanal inhibitory reflex (RAIR) on anorectal manometry, or a resting pressure above 30 mmHg, provided they did not have concurrent neuropathy [11]. In our study, all patients underwent preoperative anorectal manometry and sacrococcygeal MRI. A RAIR was present in all 8 patients. Only one patient had an anal resting pressure lower than 30 mmHg (specifically 27 mmHg); notably, this patient experienced complete resolution of constipation postoperatively, and fecal soiling improved from grade 2 to grade 1.

Studies have found that patients with high-type ARMs and MR often have concurrent sacrococcygeal anomalies, which are frequently associated with sphincter dysplasia. Since the perianal sensory receptors are concentrated in the sphincter complex, it is inferred that sacrococcygeal anomalies are the underlying cause of MR. The author of that study also noted that patients with low-type ARMs and MR all had a history of anal dilation. Furthermore, even after undergoing corrective surgery for ARMs, the dilated rectum in these patients failed to return to a normal diameter [1]. In our current study, none of the 8 patients had concurrent sacrococcygeal anomalies, and MRI

showed no obvious developmental abnormalities of the internal sphincter. One patient was found to have a thin right external sphincter, despite this, constipation improved from preoperative Grade 3 to complete resolution, and soiling was downgraded from Grade 2 to Grade 1.

Currently, there is no consensus regarding the optimal length of the rectal stump. One study utilizing a laparoscopic-assisted Soave procedure positioned the distal rectal transection line 0.5 cm from the anus. Although the dilated bowel segment was completely resected with full preservation of the rectal muscular cuff, follow-up revealed that while all patients regained spontaneous defecation, 2 still experienced persistent grade 3 constipation requiring intermittent glycerin enemas [15]. Conversely, other scholars have positioned the resection plane at the peritoneal reflection or 3–4 cm above the dentate line, performing an end-to-end anastomosis with a stapler [15]. Some reports advocate for the preservation of the distal one-third of the rectum to maintain fecal reservoir function, with the stump sutured using absorbable sutures [11, 14]. Although Levitt et al. also proposed preserving a segment of the distal dilated rectum, they did not specify a precise length [10]. However, opposing views suggest that preserving the dilated distal rectum may not yield ideal outcomes and could instead lead to significant complications [11]. Furthermore, a systematic review found that the incidence of anastomotic bleeding, ulceration, and stricture was significantly higher with circular staplers compared to manual suturing [19]. In our own clinical practice, we have also encountered several patients who developed anastomotic ulceration, bleeding, and stricture after undergoing pull-through surgery with circular staplers at other institutions. Given that pediatric bowel diameter varies with growth and development, the use of staplers warrants greater caution. In our patients with Hirschsprung's disease, we perform a Swenson-like procedure with a colorectal anastomosis at the normal-caliber colon. The distal rectal incision is typically placed 1.0 cm above the anorectal line. This approach aims to preserve the receptors around the dentate line and retain a minimal amount of rectal muscular cuff, thereby preventing the formation of a stricture ring and subsequent recurrent constipation. The stumps are anastomosed intermittently using absorbable sutures. All 8 patients in this study underwent this procedure, and none developed anastomotic stricture or leakage.

To investigate the etiology of MR associated with ARM, a detailed histopathological examination of the resected specimens was performed, revealing that all 8 cases in our cohort exhibited muscular hyperplasia and hypertrophy, muscle fiber degeneration, and disorganized muscle layer arrangement in the dilated bowel segments. Additionally, the submucosa of the rectal wall near the anus was thickened with increased collagen deposition. Therefore, we consider that the retention of fibrotic bowel wall may be a significant contributing factor to the development of MR following anorectoplasty. Similarly, Burjonrappa et al. reported that pathological examination of all their specimens revealed muscular hypertrophy, although innervation was normal [1]. In another study, all five specimens demonstrated thickening of the circular muscle layer within the muscularis propria, with three cases also showing heterotopic ganglion cells within the circular muscle layer [15]. In contrast, Borg et al. reported that among 12 patients who underwent MR resection, histopathological results were normal in 8 rectal specimens; the remaining cases included 2 with fibrosis, 1 with muscular hypertrophy, and 1 suspected of having intestinal neuronal dysplasia [4].

Our study has several limitations. It is a retrospective case series with a small sample size of only 8 patients. The types of ARMs and the initial radical procedures were not entirely consistent across the cohort, and these variables could potentially influence bowel function following MR resection. Additionally, the postoperative follow-up period was relatively short, which precludes a comprehensive assessment of long-term complications and changes in bowel function.

In conclusion, MR following surgery for ARMs is associated with severe constipation and overflow fecal incontinence. When symptoms persist despite prolonged and aggressive bowel management, MR resection can significantly improve bowel function. Robot-assisted pull-through surgery, with its enhanced dexterity and precision, helps mitigate intraoperative complications while preserving the pelvic floor muscles and nerves. These advantages are particularly pronounced in older children or those with a history of prior pelvic surgery.

Abbreviations

ARMs	Anorectal malformations
SMR	Secondary megarectum
MR	Megarectum
TAI	Transanal irrigation
RPR	Rectopelvic ratio
CBC	Complete blood count
CRP	C-reactive protein
PSA	Posterior sagittal anoplasty
PSARP	Posterior sagittal anorectoplasty
LAARP	Laparoscopic-assisted anorectoplasty
RAIR	Rectoanal inhibitory reflex
IAS	Internal anal sphincter
ACE	Antegrade continence enema
Fig	Figure

Declarations

Ethics approval and consent to participate

This paper was approved by the ethics committee of our institution,Approval No: [2023]114A01, would be see the attached PDF.

Consent for publication

Written informed consent was obtained from the parent for the publication of this paper and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal upon request.

Availability of data and materials

All data supporting the findings of this study are provided within the article.

Competing interests

The authors declare no competing interests.

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Authors' contributions

Boyuan Tao and Min Ye are responsible for designing the paper framework and drafting the paper, they are co-first authors;

Boyuan Tao, Jixiao Zeng, Fei Liu, Xiaogang Xu, Menglong Lan, Yuanyuan Luo, Zhihua Ye and Hong Zhang all participated in the specific operation of the surgery and the patient's diagnosis and treatment process;

Boyuan Tao and Min Ye were responsible for the collection and analysis of intraoperative imaging data;

Xiaogang Xu, Boyuan Tao and Min Ye are responsible for revising the paper;

Jixiao Zeng is responsible for formulating the writing ideas, guiding the writing of the article and finalizing the draft, he is the co-corresponding authors

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Figures

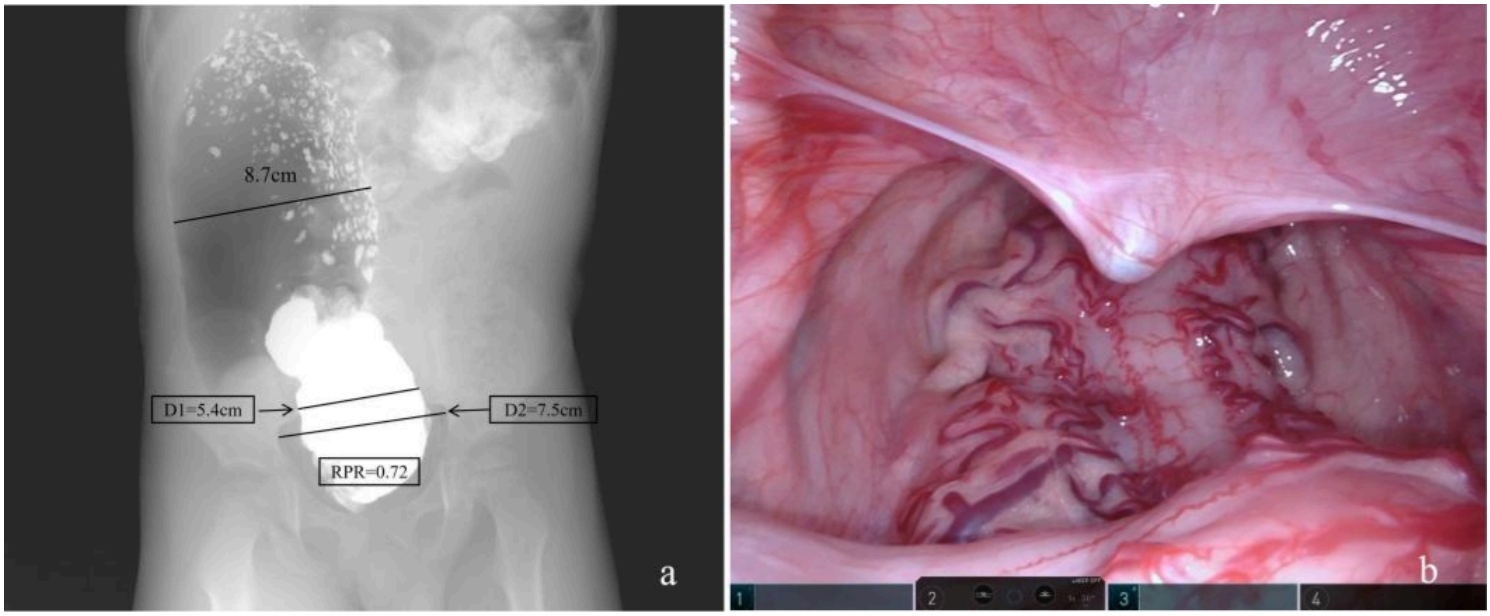


Figure 1

aPreoperative barium enema demonstrating marked dilation of the colon and rectum (maximum diameter: 8.7 cm). **b** Laparoscopic view revealing significant dilation of the rectum. D1: Diameter of the rectum, D2: Maximal pelvis diameter.

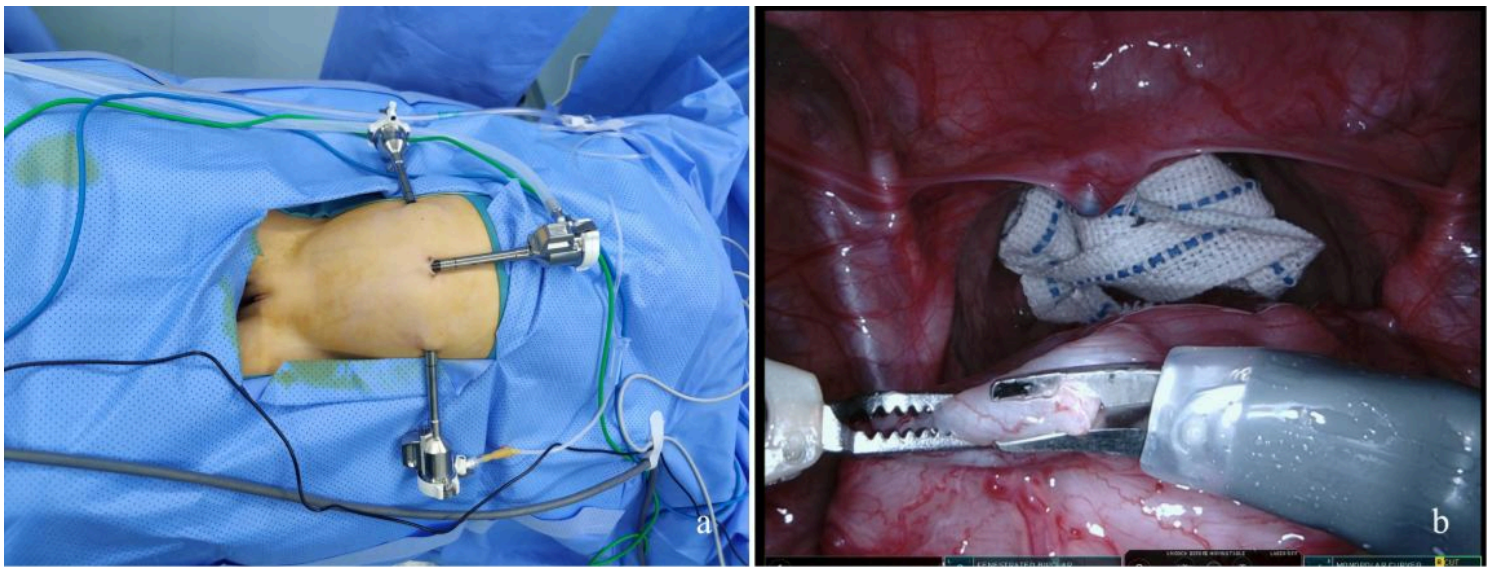


Figure 2

a Abdominal trocar placement. **b** Excision of colonic tissue for intraoperative frozen section examination.

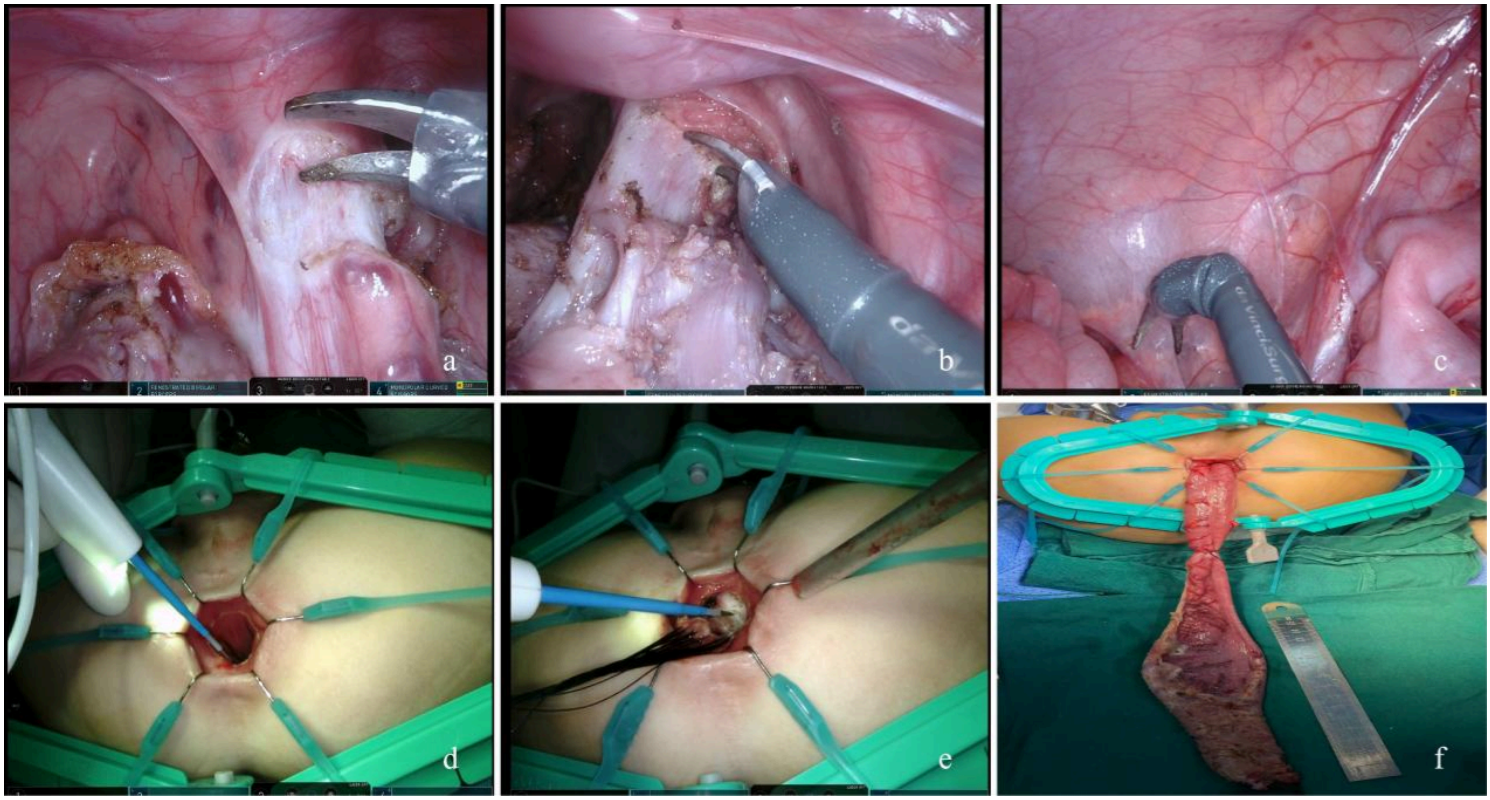


Figure 3

a Dissection of the anterior peritoneal reflection of the rectum. **b** Dissection of the mesorectum below the peritoneal reflection. **c** Mobilization of the left lateral peritoneum of the descending colon. **d, e** Marking of the distal resection margin and dissection of the distal rectum. **f** Transanal pull-through of the dilated bowel segment, with final confirmation of the proximal bowel position suitable for anastomosis.