BMC Surgery

RESEARCH

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A comparison study of two fecal diversion methods based on novel intestinal stents for preventing anastomotic leakage after middle and lower rectal cancer surgery

Dayong Wei[1], Xiong Zhou[1], Lian Bai[1] and Jia Liu[2*]

Abstract

Background This study aims to evaluate the feasibility and safety of two intestinal fecal diversion methods using novel stents to prevent anastomotic leakage after surgery for middle and lower rectal cancer, and to compare their advantages and disadvantages for clinical application.

Methods A retrospective analysis was conducted on 101 patients who underwent laparoscopic radical resection(LAR) for rectal cancer at Yongchuan Hospital from June 2021 to March 2024. Patients were divided into three groups: 26 in the ileum group (using terminal ileal stents) ,54 in the in situ group (using rectal in situ covered stents) and 21 in the control group. Preoperative, surgical, and postoperative data were compared among the three groups.

Results No significant differences were found in baseline characteristics, surgical data, or the occurrence of postoperative anastomotic leakage or other complications. The in situ group showed no statistically significant differences from the control group in the postoperative hospital stay(12.6 ± 3.7 vs. 11.4 ± 2.9days, $p > 0.05$), total cost of hospitalization (48903.58 ± 7094.14 vs. 82205.77 ± 12222.41yuan, $p > 0.05$). Moreover, the ileum group in these comparisons performed worse than the control group. After incorporating data related to stoma closure surgery, the in situ group and ileum group showed significant advantages in overall hospitalization costs(59085.88 ± 7460.79 vs. 48903.58 ± 7094.14 vs. 81418.32 ± 11186.78yuan, $p < 0.05$), and the in-situ group also had shorter overall hospital stay(17.6 ± 5.0 vs. 22.2 ± 4.0days, $p < 0.05$).

Conclusions Both fecal diversion methods showed acceptable rates of postoperative anastomotic leakage and can avoid a second stoma closure surgery. The in situ covered stent method seemed better as it not only saved hospitalization time and costs but also made postoperative management simpler and more efficient.

Keywords Rectal malignant tumors, Low rectal cancer, Anastomotic leakage, Novel intestinal stent

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Background

Rectal cancers, particularly low and middle rectal cancers, account for 70–75% of cases and have a rising incidence [1]– [2]. Early-stage low rectal cancer often requires abdominoperineal resection, leading to permanent stomas that significantly impact quality of life. Patients increasingly prefer anus-preserving surgeries, raising the risk of anastomotic leakage, the most common complication of laparoscopic radical resection [3], which can cause severe infections and higher hospitalization costs. While creating a preventive stoma of the terminal ileum can prevent infections after leakage [4]– [5], it necessitates stoma closure, further diminishing quality of life and increasing medical burdens.

By using a novel intestinal stent, our department innovatively implemented two different surgical methods to replace preventive ostomy: intestinal fecal diversion via a terminal ileal stent and intestinal fecal diversion via a rectal in situ covered stent. This study aimed to compare the safety and feasibility of two novel and distinct surgical methods preventing anastomotic leakage in patients with low rectal cancer.

Methods

Research objects

The data of patients with low rectal cancer who underwent laparoscopic radical resection (low anterior resection, LAR) at Yongchuan Hospital Affiliated with Chongqing Medical University between June 2021 and march 2024 were retrospectively analyzed. After applying the inclusion and exclusion criteria outlined below, a total of 101 patients were included. Among them, 26 patients who underwent intestinal fecal diversion with terminal ileal stents composed the ileum group, 54 patients who underwent intestinal fecal diversion with rectal in situ covered stents composed the in situ group, 21patients who underwent without stents composed the control group. Ethical approval was obtained from the ethics committee of the Yongchuan Affiliated Hospital of Chongqing Medical University (202260). All patients signed the informed consents.

Inclusion and exclusion criteria

Inclusion criteria: a diagnosis of a malignant rectal tumor, laparoscopic radical resection for rectal cancer (LAR), a distance between the distal end of the tumor and the anus of at most 8 cm, preventive ostomy or implantation with one of the novel intestinal stents for intestinal diversion.

Exclusion criteria: the presence of liver, lung or distant metastasis; acute intestinal obstruction; emergency surgery; previous laparoscopic surgery; liver cirrhosis or severe malnutrition; and long-term use of glucocorticoids.

Surgical methods

Ileum group

The terminal ileal stent method was used to replace preventive ostomy, and laparoscopic radical resection for rectal cancer was performed via the standard LAR approach. The stent installation method was as follows: (1) Stent placement: After radical tumor resection, the ileal segment 15–20 cm from the ileocecal region was selected as the bowel segment for diversion. A 2-cm transverse incision was made along the small bowel wall. Then, a novel bio-disintegrable stent (Waken, Zhe Jiang, China) with a diameter corresponding to the intestinal wall was placed through the incision(closed type, model: BIS-HB, Fig. 1 A), the bowel incision was closed with interrupted sutures, and the intestinal stent is fixed to the intestinal wall with a double knot of 2 – 0 absorbable suture. (Johnson & Johnson VICRYL30). Completely block the flow of small intestine contents towards the distal end, through the anastomosis. (2) Drain placement: A 5-mm longitudinal incision was made along the intestinal wall approximately 5 cm from the proximal end of the stent. Then, an F28 latex drain(mushroom-shaped tube) was placed through the incision, divert the intestinal contents outside the body. The latex drain was fixed with a semipurse-string suture. (3) Drain fixation: An incision of approximately 1 cm was made at the lateral edge of the right upper rectus abdominis. The latex drain was pulled out of the abdominal cavity, the bowel wall around the drain was sutured to the peritoneum, and the latex drain was sutured and fixed in the dermis. After about 20 days, the intestinal stent degrades, and intestinal patency is restored; the small intestine wall adheres tightly to the abdominal wall, forming a fistula, and removing the drainage tube allows the skin to heal. For more information on the novel stent and surgical methods, please refer to previous articles published by our team [6].

In situ group

A rectal in situ covered stent was used for intestinal diversion, and laparoscopic radical resection of rectal cancer was also performed via standard LAR approach. The stent installation method was as follows: (1) Assembly: the cover (balloon with the closed end cut off) was fixed to the outer surface of the novel bio-disintegrable stent (hollow type, model: BIS-H, Fig. 1B) with non-absorbable No. 10 suture, and the end of the cover was tied tightly with the suture for later use. (2) Placement: the disintegrable covered stent was placed completely in the proximal colonic lumen, approximately 5 cm from the stumped end of the colon. (3) Fixation: outside the intestinal tube, 2 – 0 absorbable sutures (Johnson & Johnson VICRYL30) were used to fix the stent onto the intestinal tube. (4) Anastomosis: the proximal colon stump was sutured with a purse-string suture, and the sigmoid

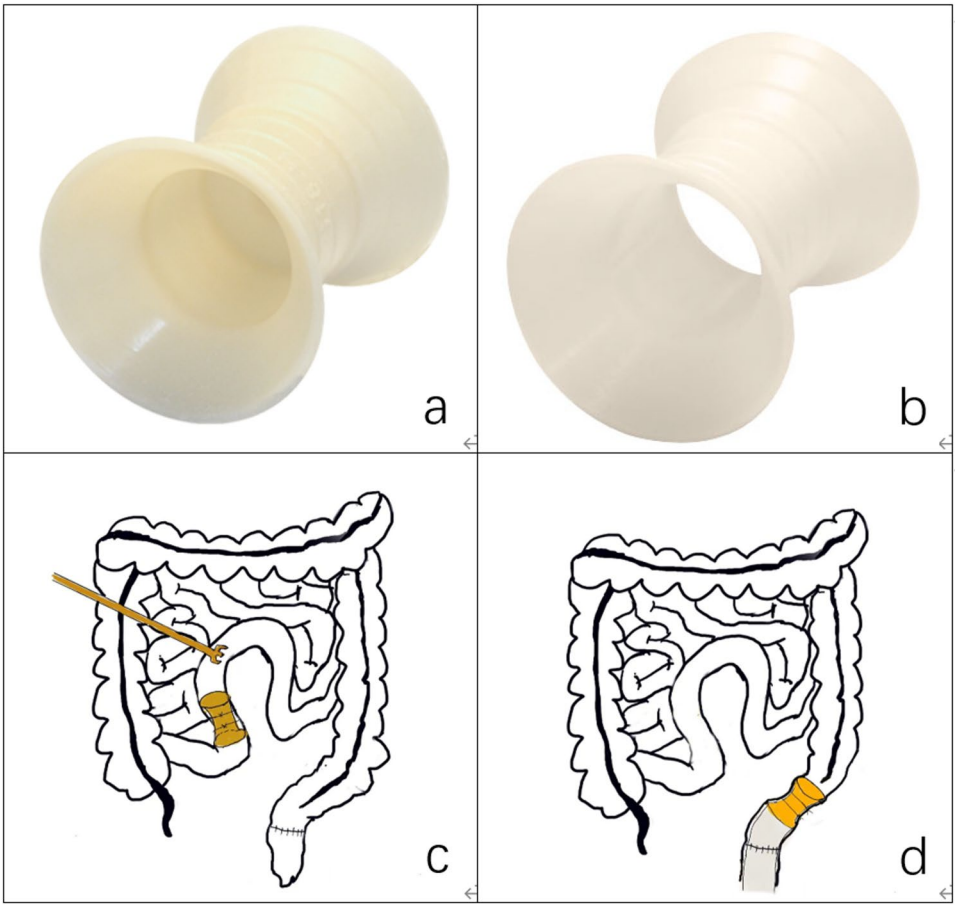


Fig. 1 Novel biocompatible stents **a**: Closed type. **b**: Hollow type. **c**: Surgical rendering of the Ileum group. **d**: Surgical rendering of the In situ group

colon and the distal rectum were anastomosed with a disposable tubular stapler. An inflation test was performed through the anus after formation of the anastomosis to ensure that the anastomosis was well crafted. During the operation, the suture at the end of the cover was tied to the mushroom head of the tubular stapler to facilitate the subsequent operation. (5) Adjustment: the cover was pulled out from the anus through the suture at the end of the cover and placed outside the anus, and the terminal sutures were cut. For details on the surgical methods, please refer to the published articles by our team [7].

Control group

Laparoscopic radical resection for rectal cancer was performed via the standard LAR approach. Prophylactic ileostomy to prevent anastomotic leakage of the rectum.

Postoperative management

Patients in the ileum group were required to keep the ileostomy tube unobstructed after the surgery. The daily drainage volume was recorded, and if the volume was significantly reduced, the patient was asked to carefully monitor for obstructions of the ostomy tube. Angiography was performed 7 days after surgery, before discharge, and before removing the ostomy tube to confirm the patency of the tube and completeness of the diversion. In the in situ group, the angiographic examination was performed 7 days and 20 + days after surgery (covering the area between the rectal wall and the cover through the anus) to confirm complete diversion and that the stent had been expelled from the body. Figure. 2 parts A - B - C - D shows postoperative angiographic images from patients in the ileum group, and Figure. 3 parts A - B - C - D shows postoperative angiographic images from patients in the in situ group and colonoscopy images 3 months after surgery.

Data collection

For all groups, general data, including sex, age, history of hypertension, diabetes, history of heart disease, history of emphysema, Nutritional Risk Screening 2002 (NRS-2002) score, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and preoperative hemoglobin (Hb) and albumin (ALB) levels, were collected.

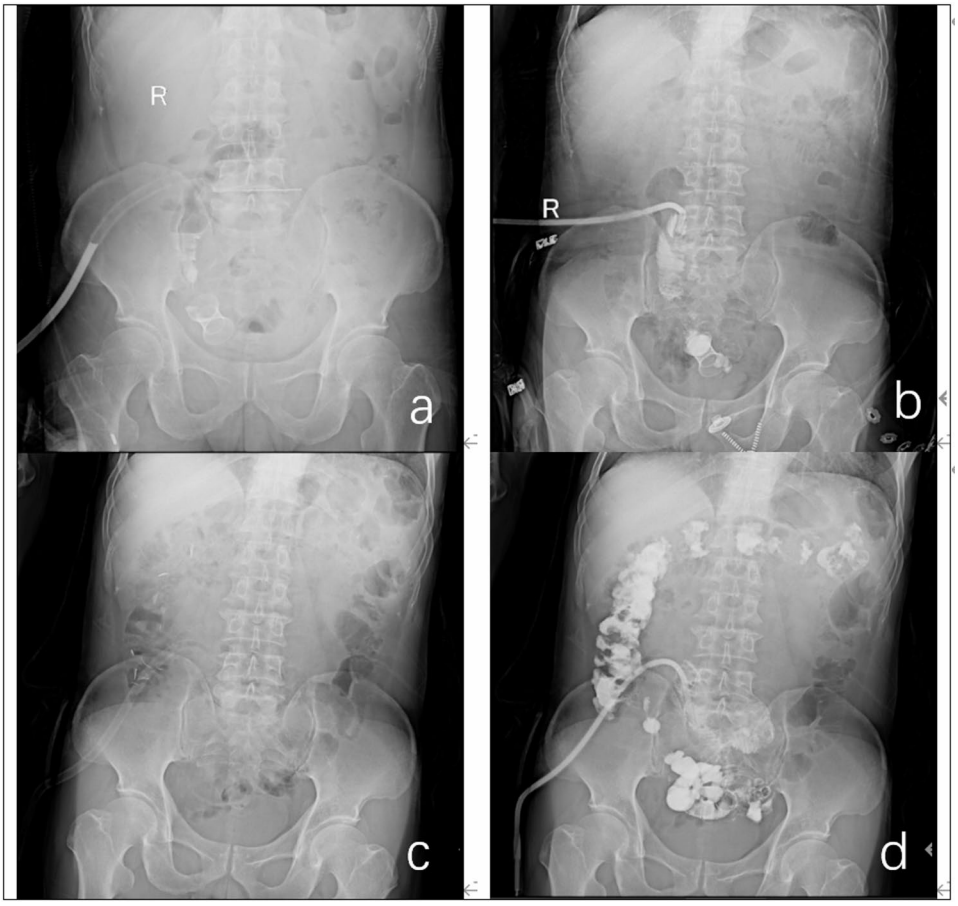


Fig. 2 **a**: Angiographic images from patients in the ileum group, showing the ileostomy tube 7 days after surgery; no contrast agent has passed between the stent and the bowel wall. **b**: Angiographic images from patients in the ileum group, showing the ileostomy tube 14 days after surgery; no contrast agent has passed through the bowel wall. **c**, **d**: Angiographic images from the patients in the ileum group, showing the ileostomy tube 27 days after surgery. Ruptured stent fragments are observed in the ascending colon, and the contrast agent has passed through the small intestine.

Surgical data included the duration of surgery, the amount of surgical blood loss, the location of the tumor, the distance from the anastomotic stoma to the anus, the number of reinforced reloads, the tumor diameter, the pathological tumor-node-metastasis (pTNM) stage, and the number of lymph nodes dissected.

Postoperative data included whether there was anastomotic leakage, assessed through an abdominal CT scan before discharge (Defined by International Study Group of Rectal Cancer, ISREC), the total length of hospitalization stay, overall hospital stay(LAR and stoma closure surgery), the length of postoperative hospital stay, the presence of other related complications (such as lung infection, urinary tract infection, tube detachment, chyle leakage, and wound infection), the time to removing the drainage tube (the in situ group and control group refer to the removal of the abdominal drainage tube, while the ileum group refers to the removal of the ileostomy tube), the time to the first postoperative chemotherapy, the total hospitalization costs and overall hospitalization cost(LAR and stoma closure surgery).

Statistical methods

SPSS 25.0 was used to analyze the data. Metric data that follows a normal distribution is expressed as $\widetilde{x}\pm s$, with multiple group comparisons performed using ANOVA and pairwise comparisons using T-tests. For metric data that does not follow a normal distribution, intergroup comparisons are made using median values and non-parametric tests (Mann-Whitney U test). Count data is presented as n(%), and intergroup comparisons are done using chi-square tests. A P-value of less than 0.05 indicates statistically significant differences.

Results

Preoperative general information

There were no significant differences in the male-to-female ratio, age, BMI, preoperative NRS 2002 score, ASA classification, preoperative HB or ALB levels, or number of patients with comorbidities (heart disease, chronic obstructive pulmonary disease (COPD), diabetes, rcTx(Preoperative primary tumor staging), or hypertension among the three group ($p > 0.05$). (Table 1)

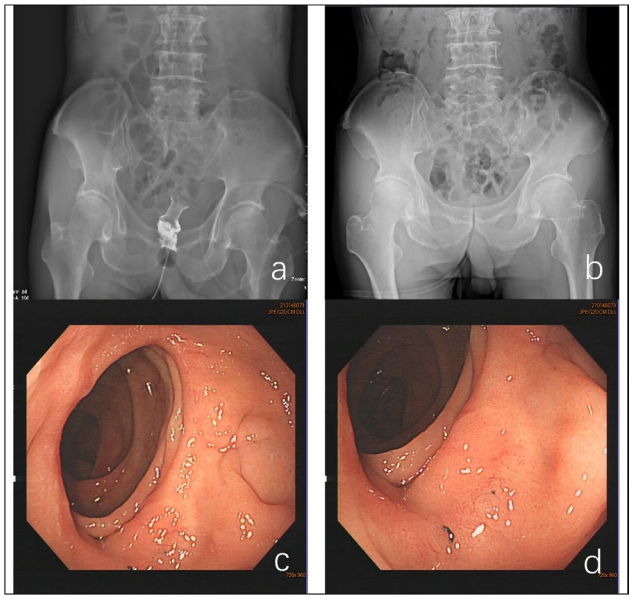


Fig. 3 **a**: Angiographic images from patients in the in situ group 7 days after surgery, covering the area between the rectal wall and the cover through the anus; no contrast is shown to have leaked into the proximal colon. **b**: The novel intestinal stent has been completely extruded from the body in a patient from the in situ group 23 days after surgery. **c**, **d**: Three months after surgery, the anastomosis is smooth, and the intestinal segment with the stent fixed to the proximal end of anastomotic stoma has not stenosed

Surgery and tumor staging

None of the surgery-related conditions or tumor characteristics, including the surgical duration, the number of reinforced reloads, the volume of intraoperative blood loss, the length of the tumor(The distance from the lower edge of the tumor to the anus), the distance between the anastomosis and the anus, the tumor diameter, the total number of dissected lymph nodes, or the proportions of patients with different TNM stages, were significantly different among the three group ($p > 0.05$), as shown in Table 2.

Safety indicators (e.g., postoperative complications)

No significant differences were found in the occurrence of postoperative anastomotic leakage (3.8% vs. 0% vs. 4.6%, $p = 0.313$) or other complications (23.1% vs. 20.4% vs. 22.7%, $p = 0.952$). The total length of hospital stay、the length of postoperative hospital stay、the total hospitalization costs、the time to removing the drainage tube and the time to the first chemotherapy session after surgery in the ileum group was significantly different from the other two group ($p < 0.05$). The ileum group had significantly lower overall hospitalization cost compared to the control group(60336.38 ± 7377.77 vs. 81418.32 ± 11186.78, $p < 0.05$). The in situ group showed no statistically significant differences from the control group in the postoperative hospital stay(12.6 ± 3.7

Table 1 The preoperative general data of the three groups of patients[M(P25,P75),n%, x±s]

$\tilde{x}$				
Item Group	Ileum group ($n = 26$)	In situ group ($n = 54$)	Control group($n = 22$)	p
Sex				0.539
Male	16(61.5)	32(59.3)	16(72.7)	
Women	10(38.5)	22(40.7)	6(27.3)	
Age (years)	61.2 ± 11.5	65.7 ± 10.8	62.6 ± 11.7	0.204
BMI (kg/m^2)	23.6 ± 3.1	22.8 ± 2.8	22.7 ± 2.4	0.410
NRS2002				0.402
≥ 3	6(23.1)	16(29.6)	9(40.9)	
< 3	20(76.9)	38(70.4)	13(59.1)	
ASA				0.461
≥III	14(53.8)	24(44.4)	13(59.1)	
< III	12(46.2)	30(55.6)	9(40.9)	
Preoperative HB (g/L)	127.7 ± 21.0	124.6 ± 21.6	128.4 ± 17.2	0.709
Preoperative ALB (g/L)	40.5 ± 3.2	40.4 ± 3.6	40.5 ± 2.5	0.989
Heart disease	0(0)	1(1.9)	2(9.1)	0.140
COPD	1(3.8)	7(13.0)	4(18.2)	0.284
Diabetes	4(15.4)	11(20.4)	5(22.7)	0.799
Hypertension	6(23.1)	20(37.0)	6(27.3)	0.405
rcTx				0.998
T2	6(23.1)	13(24.1)	4(22.5)	
T3	19(73.1)	39(72.2)	17(77.3)	
T4	1(3.8)	2(3.7)	1(4.5)	

Table 2 The surgical and tumor staging situations of the three groups of patients[M (P25, P75), n%, x±s]

$\tilde{x}$				
Item Group	Ileum group ($n = 26$)	In situ group ($n = 54$)	Control group($n = 22$)	p
Surgery time (min)	222.2 ± 32.0	237.9 ± 59.0	239.8 ± 27.1	0.329
Number of reinforced reloads (pieces)	2(1,2)	2(1,2)	2(1,2)	0.806
Intraoperative blood loss (ml)	49.6 ± 23.0	57.6 ± 47.9	40.0 ± 24.1	0.192
Tumor length (cm)	7.0(6.0,8.25)	8.0(6.0,10.0)	7.0(6.1,7.6)	0.196
Distance from anastomosis to anus (cm)	5.0(4.0,6.0)	5.5(4.0,7.0)	4.8(3.5,6.0)	0.068
Tumor diameter (cm)	3.3(3.0,4.0)	4.0(3.0,5.0)	3.0(2.8,4.0)	0.079
Number of dissected lymph nodes	15(13,20)	13(10,18)	13(10,15)	0.076
TNM stage				0.610
Stage I	4(15.4)	9(16.7)	3(13.6)	
Stage II	12(46.2)	21(38.9)	13(59.1)	
Stage III	10(38.4)	24(44.4)	6(27.3)	

Table 3 The postoperative safety indicators and complication situations of the three groups of patients [M (P25, P75), n%, ±s]

Item Group	Ileum group ($n=26$)	In situ group ($n=54$)	Control group($n=22$)	p
Anastomotic fistulae	1(3.8)	0(0)	1(4.6)	0.313
Total length of hospital stay (days)	21.5 ± 6.2[a]	17.6 ± 5.0[b]	14.5 ± 3.4	< 0.001
Overall stay(LAR and stoma closure surgery)	21.5 ± 6.2	17.6 ± 5.0[b]	22.2 ± 4.0	< 0.001
Length of postoperative hospital stay (days)	14.5 ± 3.3[a]	12.6 ± 3.7	11.4 ± 2.9	0.008
Total cost of hospitalization (yuan)	60336.38 ± 7377.77[a]	48903.58 ± 7094.14	50614.86 ± 4818.02	< 0.001
Overall cost(LAR and stoma closure surgery)	60336.38 ± 7377.77[a]	48903.58 ± 7094.14[b]	81418.32 ± 11186.78	< 0.001
Time to removing the drainage tube (days)	26.0(25.0,28.0)[a]	9.0(8.0,9.5)	8.0(7.0,9.0)	< 0.001
Time to first chemotherapy session after surgery (days)	43.0(38.0,48.5)[a]	27.0(24.5,30.0)	26.0(25.0,27.0)	< 0.001
Other postoperative complications	6(23.1)	11(20.4)	5(22.7)	0.952
Lung infection	1	4	3	
Urinary tract infection	2	3	1	
Ostomy tube detachment/stent protective cover detachment	2	2	0	
Chyle leakage	1	1	0	
Wound infection	0	1	1	

[a]The ileum group had a $p<0.05$ compared to the control group

[b]The in situ group had a $p<0.05$ compared to the control group

vs. 11.4 ± 2.9days, $p>0.05$), total cost of hospitalization (48903.58 ± 7094.14 vs. 50614.86 ± 4818.02yuan, $p>0.05$), the time to removing the drainage tube (9.0(8.0,9.5) vs. 8.0(7.0,9.0)days, $p>0.05$), and time to first chemotherapy session after surgery(27.0(24.5,30.0) vs. 26.0(25.0,27.0)days, $p>0.05$). The in situ group had an advantage over the control group in terms of overall hospital stay (17.6 ± 5.0 vs. 22.2 ± 4.0days, $p<0.05$) and overall hospitalization costs(48903.58 ± 7094.14 vs. 81418.32 ± 11186.78yuan, $p<0.05$). (Table 3)

Discussion

To ensure a safe surgery and avoid severe abdominal infection caused by anastomotic leakage, surgeons often employ preventive stomata in anus-preserving surgery for low rectal cancer, which is currently the most mature and effective solution [8]; however, complications such as stoma prolapse, parastomal hernia, and peristomal infection are possible, requiring stoma closure further reducing the quality of life of the patient while they have the stoma and increasing their economic burden [9–11]. W. Bugiantella et al. used the ALPPI (Anastomotic Leak Prevention by Probe Ileostomy) approach for fecal diversion, which can avoid a second stoma surgery [12]– [13]. Using a novel intestinal stent, our department innovatively implemented two different surgical methods to replace the preventive stoma, i.e., the terminal ileal stent method and the rectal in situ cover stent method for intestinal diversion. Both surgical methods achieved good results in actual clinical application. The significant advantage of these new surgical methods is that the preventive stoma is replaced, preventing anastomotic leakage, avoiding the need for stoma closure, and reducing the costs of a second surgery and the length of hospitalization, thus reducing the financial burden and surgical pain for the patient.

The probability of anastomotic leakage after low rectal cancer surgery is approximately 7–10%, and the risk of Grade C leakage is 5% [14–16]. In this study, one patient experienced Grade C leakage in the ileum group. This patient was admitted to the hospital due to rectal cancer combined with obstruction. The obstruction was relieved after conservative treatment such as fasting, gastrointestinal decompression, and enema, the patient underwent laparoscopic surgery two weeks later. Owing to edema of the bowel wall and poor preparation of the bowel wall, the patient experienced anastomotic leakage developed peritonitis; after undergoing transverse colostomy, the patient was discharged from the hospital. No patient in the in situ group experienced anastomotic leakage. One patient experienced Grade A leakage in the control group, the patient recovered after antibiotic treatment. In this study, the total incidence of anastomotic leakage in the two groups was 1.25%, similar to our control group and the findings of previous studies that used preventive stoma, indicating that intestinal diversion via the stent method can effectively divert the fecal stream and reduce the risk of severe abdominal infection caused by anastomotic leakage; moreover, the procedure is safe, effective, and easily translated to for clinical application. Patients with low rectal cancer who receive AR after neoadjuvant therapy are at significantly elevated risk of anastomotic leakage [17], and thus most surgeons choose to perform preventive ostomy of the terminal ileum. In this study, 3 patients (1 in the ileum group, 2 in the in situ group) underwent preoperative neoadjuvant radiotherapy, and no anastomotic leakage occurred after surgery via the stent method, indicating that intestinal diversion via the stent method may have more extensive application prospects. However, large-sample data are needed to validate the effectiveness of the procedures.

Other postoperative complications occurred in 6 patients in the ileum group, with an incidence of 23.1%, including 2 patients with stoma tube detachment, 1 with lung infection, 2 with urinary tract infection, and 1 with chyle leakage. Eleven patients in the in situ group developed postoperative complications, with an incidence of 20.4%, including 4 patients with lung infection, 3 with urinary tract infection, 1 with chyle leakage, 1 with wound infection, and 2 with stent protective cover detachment. 5 patients in the control group developed postoperative complications, with an incidence of 22.7%, including 3 patients with lung infection, 1 with urinary tract infection, 1 with wound infection. There were no significant difference in the incidence of other complications among the three groups, and the observed incidences were all within the clinically acceptable range and are similar to those reported in previous studies [18]– [19]. Stoma tube detachment is a serious complication that can lead to intestinal obstruction. In clinical practice, the drainage tube is replaced through angiography to avoid further aggravation and prevent injury to the patient; tube fixation with multiple sutures and intensive postoperative education may reduce the incidence of stoma tube detachment. The stent protective cover fell off in 2 patients in the in situ group on the 3rd and 5th days after surgery. Although no complications, such as anastomotic leakage, occurred after this detachment, the protective cover needs to be in place to properly divert the feces; diversion failure can increase the risk of anastomotic leakage and reduce the trust between the doctor and the patient. When the procedure was initially performed, a latex condom was used as a protective cover in our department. Because the latex condom is relatively weak, however, the protective cover would detach or break if the patient pulled it accidentally. During later implementations of the surgery, a vaginal ultrasound probe cover was used as the protective cover, and no detachment occurred.

The length postoperative hospital stay of the ileum group was significantly greater than that of the control group (14.5 ± 3.3 vs. 11.4 ± 2.9, $p < 0.05$), as were the total hospitalization costs (60336.38 ± 7377.77 vs. 50614.86 ± 4818.02, $p < 0.05$). However, when considering the costs associated with stoma closure, the ileum group was clearly more cost-effective(60336.38 ± 7377.77 vs. 81418.32 ± 11186.78, $p < 0.05$). In the ileum group, the average stent dissolution time was 3–4 weeks, during which time the patient needed to use a stoma tube to drain the intestinal fluid. The length of stoma tube usage was up to 27.0 ± 3.0 days. During the indwelling tube period, tube detachment and tube obstruction are possible. After surgery, the drainage volume should be closely monitored, and the tube should be irrigated to maintain patency if necessary. These factors increase the difficulty of postoperative management, reduce the confidence of doctors and patients at discharge, and prolong the length of hospitalization. The patients in the in situ group had an abdominal drainage tube for 9.0(8.0,9.5) days after surgery, and the patients were discharged from the hospital after they could tolerate a liquid diet. In the postoperative management of the ileum group, to reduce the risk of stoma tube obstruction, a parenteral nutrition support program was often implemented, typically for a longer duration than normal, and 3–5 somatostatin was administered postoperatively to inhibit gastrointestinal tract secretions to reduce the intestinal contents, thus avoiding abdominal infections caused by anastomotic leakage; therefore, the patients started eating solid foods late after surgery. The hospitalization costs of the patients in the ileum group were greater due to the prolonged hospital stays and duration of parenteral nutrition support. However, the in situ group showed no statistically significant differences from the control group in the postoperative hospital stay(12.6 ± 3.7 vs. 11.4 ± 2.9, $p > 0.05$) and the total cost of hospitalization (48903.58 ± 7094.14 vs. 50614.86 ± 4818.02, $p > 0.05$). This means that both the hospital stay time and costs for subsequent secondary stoma closure surgery were completely saved. As our data shows, when the hospitalization costs and duration for stoma closure surgery were included, the in situ group had a clear advantage.

In the ileum group, after the stent dissolved and ruptured, the patients were required to undergo digestive tract angiography to confirm that the intestinal tract was unobstructed so that the stoma tube could be removed. After removing the stoma tube, the opening of the fistula was closed with Vaseline-soaked gauze and was usually healed within 7 to 10 days. Owing to the formation of adhesions between the small intestine wall and the peritoneum, the arrangement and structure of the small intestine in the abdominal cavity is altered, which may increase the incidence of postoperative bowel obstruction and the difficulty of second abdominal surgery. Patients in the ileum group did not develop adhesive bowel obstruction in the short term after surgery, but follow-up is still needed to observe long-term complications. After the stent has dissolved and ruptured, patients treated with the in situ method can pass it out of the body without a second surgical operation, dressing changes or other treatments, and they do not require long-term oral nutrition preparations after surgery, resulting in reduced examination costs. In addition, for patients treated with the rectal in situ covered stent approach, the feces are excreted through normal physiological structures; thus, the postoperative absorption of nutrients, water and electrolytes are not affected, and so the patients tolerated the approach well. Moreover, the intestinal arrangement is not altered during rectal in situ covered stent

surgery, which reduces the risk of complications such as long-term intestinal obstruction. Notably, due to the presence of the stent, a subset of patients in the in situ group reported a notably pronounced sensation of anal heaviness, while others exhibited incomplete defecation control accompanied by increased bowel movement frequency.

According to the National Comprehensive Cancer Network (NCCN) guidelines for rectal cancer and previous clinical studies, patients are recommended to undergo their first adjuvant chemotherapy session 3–4 weeks after surgery for rectal cancer [20]– [21]. In this study the time to the first chemotherapy session in the ileum group was significantly later than that of the in situ group and the control group ((43.0 (38.0, 48.5) vs. 27.0 (24.5, 30.0) vs. 26.0(25.0,27.0), $p < 0.05$). In the ileum group, the patients needed to wait for the stent to dissolve and the intestinal patency to be restored, allowing them to eat and drink normally for approximately 3–4 weeks. After removing the stoma tube, the intestinal fistula wound healed completely approximately 1 week. Since premature chemotherapy would affect the healing of the intestinal fistula wound, the time until for the first cycle of chemotherapy could be started in the ileum group was significantly longer than that of the control group. Such a delay for the first round of chemotherapy after surgery may affect the long-term outcomes of rectal cancer patients, increase the risk of local recurrence and distant metastasis, and reduce overall and progression-free survival. There was no such concern in the in-situ group due to the time to the first chemotherapy session done not significantly differ from the control group. In the future, we plan to carry out further relevant studies to more thoroughly assess the impact of chemotherapy session delay on these patients [22]– [23].

Conclusions

Both methods have acceptable leakage rates comparable to protective ileostomy as there is no statistically significant difference between the three groups. But these novel stent fecal diversion methods provide alternatives to stoma creation, avoiding the need for stoma closure and alleviating patient burdens. The rectal in situ covered stent method did not fare worse than the control group in terms of postoperative hospital stay, total cost of hospitalization, the time to removing the drainage tube, and time to first chemotherapy session after surgery. Moreover, considering the hospitalization costs and duration associated with stoma closure, it actually offered advantages, making it preferable for clinical use. However, there are still some issues with using terminal ileum stents that require enhanced clinical management and improvement. This study is a single-center retrospective study with a small sample size, and both the data and conclusions have limitations. This study also lacks relevant data reflecting changes in postoperative defecation sensation for the in situ group, as well as the condition of the rectum after the dissolution of the stent. Future multicenter, prospective studies are needed to confirm these findings and assess long-term outcomes.

Abbreviations

LAR	Laparoscopic Radical Resection
NRS2002	Nutritional Risk Screening 2002 Score
BMI	Body Mass Index
ASA	American Society of Anesthesiologists classification
Hb	Preoperative hemoglobin
ALB	Albumin Levels
pTNM	Pathological Tumor-node-metastasis Stage
COPD	Chronic Obstructive Pulmonary Disease
NCCN	National Comprehensive Cancer Network
ALPPI	Anastomotic Leak Prevention by Probe Ileostomy
ISREC	International Study Group of Rectal Cancer

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-025-03201-3.

Supplementary Material 1.

Acknowledgements

We thank AJE for language editing services, family support, and departmental colleagues for their support.

Authors' contributions

Wei Dayong: Have drafted the work or substantively revised it Liu Jia: The acquisition, analysis, interpretation of dataZhou Xiong: Design of the work Bai Lian: Guided the whole research process and conducted quality control.

Funding

There was no financial support for this study.

Data availability

The datasets analysed during the current study are available from the corresponding author on reasonable request. We have also provided the data to the journal.

Declarations

Ethics approval and consent to participate

was obtained from the ethics committee of the Yongchuan Affiliated Hospital of Chongqing Medical University (202260). All patients signed the informed consents.

Consent for publication

We have obtained the consent of all relevant research subjects to publish our study.

Competing interests

The authors declare no competing interests.

Received: 6 February 2025 / Accepted: 2 September 2025
Published online: 06 October 2025

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality

worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229–63. https://doi.org/10.3322/caac.21834.
2. Lang D, Ciombor KK. Diagnosis and management of rectal cancer in patients younger than 50 years: rising global incidence and unique challenges. J Natl Compr Canc Netw. 2022;20(10):1169–75. https://doi.org/10.6004/jnccn.2022.7056.
3. Kverneng Hultberg D, Svensson J, Jutesten H, Rutegård J, Matthiessen P, Lydrup ML, et al. The impact of anastomotic leakage on long-term function after anterior resection for rectal cancer. Dis Colon Rectum. 2020;63(5):619–28. https://doi.org/10.1097/DCR.0000000000001613.
4. Wu S-W, Ma C-C, Yang Y. Role of protective stoma in low anterior resection for rectal cancer: a meta-analysis. World J Gastroenterol. 2014;20(47):18031–7. https://doi.org/10.3748/wjg.v20.i47.18031.
5. Garg PK, Goel A, Sharma S, Chishi N, Gaur MK. Protective diversion stoma in low anterior resection for rectal cancer: a meta-analysis of randomized controlled trials. Visc Med. 2019;35(3):156–60. https://doi.org/10.1159/000497168. (**Epub 2019 Mar 27. PMID: 31367612; PMCID: PMC6616072**).
6. Wen ZL, Bai L, Zhou X. Novel stent-assisted ileal bypass is applied to avoid protective stoma and prevent anastomotic leakage for rectal cancer. ANZ J Surg. 2024;94(3):418–23. https://doi.org/10.1111/ans.18781.
7. Zhou X, Bai L, Li QG, Xie J, Liu CA, Wen ZL. Clinical application of a novel stent-assisted in situ intestinal bypass in preventing postoperative anastomotic leakage for low-mid rectal cancer: a retrospective study. Medicine. 2023;102(44):e35756. https://doi.org/10.1097/MD.0000000000035756.
8. Coco C, Tondolo V, Amodio LE, Pafundi DP, Marzi F, Rizzo G. Role and morbidity of protective ileostomy after anterior resection for rectal cancer: one centre experience and review of literature. J Clin Med. 2023;12(23):7229. https://doi.org/10.3390/jcm12237229.
9. Back E, Häggström J, Holmgren K, Haapamäki MM, Matthiessen P, Rutegård J, et al. Permanent stoma rates after anterior resection for rectal cancer: risk prediction scoring using preoperative variables. Br J Surg. 2021;108(11):1388–95. https://doi.org/10.1093/bjs/znab260.
10. Liu F, Wang LL, Liu XR, Li ZW, Peng D. Risk factors for radical rectal cancer surgery with a temporary stoma becoming a permanent stoma: A pooling up analysis. J Laparoendosc Adv Surg Tech A. 2023;33(8):743–9. Epub 2023 Apr 26. PMID: 37099806.
11. Zhou L, Qin Z, Wang L. Risk factors and incidence of non-closure stoma in patients with anterior resection of rectal cancer with temporary stoma: A systematic review and meta-analysis. Eur J Surg Oncol. 2023;49(12):107120. Epub 2023 Oct 25. PMID: 37907017.
12. Bugiantella W, Rondelli F, Mariani L, Boni M, Tassi A, Stella P, et al. Traditional lateral ileostomy versus percutaneous ileostomy by exclusion probe for the protection of extraperitoneal colo-rectal anastomosis: the ALPPI (anastomotic leak prevention by probe ileostomy) trial. A randomized controlled trial. Eur J Surg Oncol. 2014;40(4):476–83. https://doi.org/10.1016/j.ejso.2013.12.025.
13. Bugiantella W, Rondelli F, Mariani L, Polistena A, Sanguinetti A, Avenia N, et al. Cost-effectiveness analysis of the temporary percutaneous ileostomy for faecal diversion after colorectal resection in elderly. Aging Clin Exp Res. 2017;29(Suppl 1):47–53. https://doi.org/10.1007/s40520-016-0658-7.
14. Rahbari NN, Weitz J, Hohenberger W, Heald RJ, Moran B, Ulrich A, et al. Definition and grading of anastomotic leakage following anterior resection of the rectum: a proposal by the International Study Group of Rectal Cancer. Surgery. 2010;147(3):339–51. https://doi.org/10.1016/j.surg.2009.10.012.
15. Degiuli M, Elmore U, De Luca R, collaborators from the Italian Society of Surgical Oncology Colorectal Cancer Network Collaborative Group. Risk factors for anastomotic leakage after anterior resection for rectal cancer (RALAR study): a nationwide retrospective study of the Italian society of surgical oncology colorectal cancer network collaborative group. Colorectal Dis. 2022;24(3):264–76. https://doi.org/10.1111/codi.15997.
16. Yu XN, Xu LM, Bin YW, Yuan Y, Tian SB, Cai B, et al. Risk factors of anastomotic leakage after anterior resection for rectal cancer patients. Curr Med Sci. 2022;42(6):1256–66. https://doi.org/10.1007/s11596-022-2616-2.
17. Deng K, Zhang J, Jiang X, Feng S. [Factors associated with anastomotic leakage after anterior resection in rectal cancer]. Zhonghua Wei Chang Wai Ke Za Zhi 2018 Apirl. 2018;25(4):425–30 Chinese. PMID: 29682714.
18. Feng Q, Yuan W, Li T, Tang B, Jia B, Zhou Y, et al. Robotic versus laparoscopic surgery for middle and low rectal cancer (REAL): short-term outcomes of a multicentre randomised controlled trial. Lancet Gastroenterol Hepatol. 2022;7(11):991–1004. https://doi.org/10.1016/S2468-1253(22)00248-5.
19. Yamanashi T, Miura H, Tanaka T, Watanabe A, Goto T, Yokoi K, et al. Comparison of short-term outcomes of robotic-assisted and conventional laparoscopic surgery for rectal cancer: a propensity score-matched analysis. Asian J Endosc Surg. 2022;15(4):753–64. https://doi.org/10.1111/ases.13075.
20. Benson AB, Venook AP, Al-Hawary MM, Azad N, Chen YJ, Ciombor KK, Cohen S, Cooper HS, Deming D, Garrido-Laguna I, Grem JL, Gunn A, Hecht JR, Hoffe S, Hubbard J, Hunt S, Jeck W, Johung KL, Kirilcuk N, Krishnamurthi S, Maratt JK, Messersmith WA, Meyerhardt J, Miller ED, Mulcahy MF, Nurkin S, Overman MJ, Parikh A, Patel H, Pedersen K, Saltz L, Schneider C, Shibata D, Skibber JM, Sofocleous CT, Stotsky-Himelfarb E, Tavakkoli A, Willett CG, Gregory K, Gurski L. Rectal Cancer, Version 2.2022, NCCN Clinical Practice Guidelines in Oncology. J Natl Compr Canc Netw. 2022;20(10):1139–1167. PMID: 36240850. https://doi.org/10.6004/jnccn.2022.0051.
21. Biagi JJ, Raphael MJ, Mackillop WJ, Kong W, King WD, Booth CM. Association between time to initiation of adjuvant chemotherapy and survival in colorectal cancer: a systematic review and meta-analysis. JAMA. 2011;305(22):2335–42. https://doi.org/10.1001/jama.2011.749.
22. Yang Y, Lu Y, Tan H, Bai M, Wang X, Ge S, Ning T, Zhang L, Duan J, Sun Y, Liu R, Li H, Ba Y, Deng T. The optimal time of starting adjuvant chemotherapy after curative surgery in patients with colorectal cancer. BMC Cancer. 2023;23(1):422. https://doi.org/10.1186/s12885-023-10863-w. PMID: 37161562; PMCID: PMC10170689.
23. Gögenur M, Rosen AW, Iveson T, Kerr RS, Saunders MP, Cassidy J, Tabernero J, Haydon A, Glimelius B, Harkin A, Allan K, Pearson S, Boyd KA, Briggs AH, Waterston A, Medley L, Ellis R, Dhadda AS, Harrison M, Falk S, Rees C, Olesen RK, Propper D, Bridgewater J, Azzabi A, Cunningham D, Hickish T, Gollins S, Wasan HS, Kelly C, Gögenur I, Holländer NH. Time from colorectal cancer surgery to adjuvant chemotherapy: post hoc analysis of the SCOT randomized clinical trial. JAMA Surg. 2024;159(8):865–71. https://doi.org/10.1001/jamasurg.2024.1555. PMID: 38865139; PMCID: PMC11170448.

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