Comparison of Autologous Flap-Supported vs. Stent-Supported Preventive Ileostomy in Laparoscopic Radical Resection of Low Rectal Cancer

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AIM: This study compared the clinical efficacy of preventive ileostomy supported by autologous flaps versus stents in laparoscopic radical resection of low rectal cancer.

METHODS: Sixty-four patients diagnosed with low rectal cancer who underwent laparoscopic radical resection in Fuyang Women's and Children's Hospital between April 2020 and December 2023 were included in this study. Based on the intraoperative support method, the patients were divided into a control group (n = 30) receiving stent support and a flap support group (n = 34) undergoing autologous flap support. Surgical outcomes, perioperative indicators, and postoperative complications were analyzed and compared between the groups. Patients were followed up for six months to evaluate recovery outcomes.

RESULTS: Significant differences were observed in operative time, total duration of surgery, intraoperative blood loss, and hospitalization costs between the two groups ($p < 0.05$). Postoperative levels of inflammatory markers, including C-reactive protein (CRP), interleukin-6 (IL-6), and procalcitonin (PCT), were elevated at 2, 4, and 6 days after surgery in both groups, while erythrocyte sedimentation rate (ESR) and prealbumin (PA) levels decreased in both groups compared to preoperative levels ($p < 0.05$). Notably, the flap support group demonstrated significantly lower CRP, IL-6, PCT, and ESR levels and higher PA levels at the same time points compared to the control group at 2, 4, and 6 days after surgery ($p < 0.05$). The complication rate in the flap support group (2.94%) was significantly lower than in the control group (20.00%) ($p < 0.05$). During the follow-up period, no cases of permanent fistula were observed in the flap support group, while the control group reported a 13.33% incidence of permanent fistula, indicating a statistically significant difference between the two groups ($p < 0.05$).

CONCLUSIONS: Preventive ileostomy supported by autologous skin flaps offers advantages in laparoscopic radical resection for low rectal cancer. This approach simplifies the procedure, eliminates the need for secondary stent removal, reduces postoperative complications, and improves overall safety and recovery outcomes.

Keywords: low rectal cancer; surgical treatment; traditional stent support; autologous flap support

Introduction

In clinical practice, cancerous lesions located in the lower third segment of the rectum are collectively referred to as low rectal cancer (RC). The development of low RC is influenced by several risk factors, including chronic rectal inflammation, dietary patterns, and exposure to carcinogenic substances [1,2]. Surgery remains the cornerstone of treatment for low RC, with laparoscopic radical surgery increasingly adopted in clinical practice due to its minimally invasive nature. However, anastomotic leakage has emerged as a significant postoperative complication [3].

Anastomotic leakage, characterized by the extravasation of intestinal contents from the intestinal lumen, can lead to severe complications such as long-term intestinal obstruction, tachycardia, and systematic infections. It is recognized as an independent risk factor that adversely affects surgical outcomes and patient prognosis [4]. To reduce the risk of anastomotic fistula, preventive ileostomy has traditionally been used as a supportive measure. However, the application of this technique requires an additional surgery to close the ileostomy, which carries a higher risk of wound healing complications, including but not limited to stoma prolapse and peristomal infection, leading to poor patient recovery [5].

Autologous flaps, derived from the skin of the patient and subcutaneous fat tissue, are partially connected to the body, maintaining blood circulation in the affected area. The application of autologous flaps in reconstruction and repair surgery has the advantages of fast healing, strong anti-infection ability and good biological cleaning effect [6]. Despite these benefits, limited clinical evidence exists on the application of autologous flap support in laparoscopic radical surgery for low RC.

This study aimed to examine the efficacy of autologous flap-supported preventive ileostomy compared to tradi-

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tional stent-supported ileostomy in patients undergoing laparoscopic radical surgery for low RC. By analyzing the surgical outcomes and complications in a cohort of 64 patients, the findings from this study offer valuable insights into optimizing surgical strategies for low RC.

Materials and Methods

Research Subjects

This study included 64 patients who underwent laparoscopic radical surgery for low RC at Fuyang Women's and Children's Hospital between April 2020 and December 2023. Patients were divided into two groups based on the type of ileostomy support: the control group (n = 30) received stent-supported preventive ileostomy, and the flap support group (n = 34) underwent autologous flap-supported preventive ileostomy. Participation in the study was voluntary, with all patients and their families providing signed informed consent. The study complied with the principles outlined in the Declaration of Helsinki and was approved by the Fuyang Women's and Children's Hospital Ethics Committee (Approval number: 2024 (3)).

Inclusion and Exclusion Criteria

Inclusion criteria: (1) Patients with RC tumor located $\leq$6 cm from the anal verge, as confirmed by endoscopic examination; (2) Patients eligible for laparoscopic radical surgery for low RC and who successfully underwent the procedure; (3) Patients or their families signed informed consent obtained; (4) Patients with complete clinical data; (5) Patients aged $>$18 years. Exclusion criteria: (1) Patients with stage IV low RC with distant metastases (e.g., to the liver or lungs); (2) Patients with severe renal, cardiovascular, or cerebrovascular dysfunction; (3) Patients presenting with complications such as intestinal obstruction, perforation, or active gastrointestinal bleeding.

Methods

Preoperative preparation: Patients were instructed to take metronidazole tablets (National Drug Standard: H32026209, Jiangsu JEBEL Pharmaceutical Co., Ltd., Zhenjiang, China) orally at a dose of 0.4 g three times daily for three consecutive days. One day before the surgery, patients began a regimen of compound polyethylene glycol electrolyte powder (National Drug Standard: H20090226, Beijing Shengyong Pharmaceutical Co., Ltd., Beijing, China), taken once daily. On the morning of surgery, a cleansing enema was performed.

Surgical Method: All surgeries were performed by senior physicians with the title of associate chief physician or higher, following the principles of total mesorectal excision (TME). Laparoscopic assistance was used to facilitate the procedure. The intestinal segment was transected 3–5 cm below the tumor using a disposable linear cutting and stapling device, with a frozen pathological examination conducted when necessary to confirm negative surgical margins. The left colic artery was preserved mid-high, while mesenteric veins and arteries were ligated, and regional lymph nodes were cleared. A terminal ileum stoma was created through the abdominal wall, and two pelvic drainage tubes were routinely placed during the procedure.

In the control group (stent support): A 2.5 cm longitudinal incision was made in the right lower abdomen through the rectus abdominis. The skin, subcutaneous tissue, abdominal rectus sheath, and peritoneum were incised along the direction of the muscle fibers, exposing the end of the ileum for the stoma. The terminal ileum was externalized, and a 4–5 cm disposable suction tube was passed through the mesentery to support the intestinal segment. A stent was positioned above the incision and secured to the skin. The intestinal wall was sutured to the surrounding skin using absorbable sutures. The ileum was opened to create the stoma, and patency was verified before applying a stoma bag. Patients returned to the hospital one month postoperatively for stent removal.

In the flap support group (Autologous flap): A circular incision approximately 2.5 cm in diameter was made in the right lower abdomen through the rectus abdominis. A central "U"-shaped autologous skin flap with a preserved base was created. The fatty layer beneath the superficial fascia of the flap (approximately 3 cm $\times$ 1 cm) was preserved to prevent compression of the mesentery of the small intestine and to avoid ischemia. Blunt dissection was used to separate the subcutaneous tissue, exposing the anterior sheath of the rectus abdominis. The rectus abdominis was then incised along the direction of its muscle fibers. The rectus abdominis sheath and peritoneum were opened to externalize the terminal ileum through the stoma. At this stage, the flap was threaded through a perforation in the mesentery of the intestinal segment, creating an opening approximately 1 cm in diameter. The flap was then pulled across to the opposite side and sutured to the edge of the incision, providing support to the intestinal segment. Absorbable sutures were used to secure the intestinal wall tightly to the surrounding skin. After confirming the patency of the intestinal segment, a stoma bag was applied. Both groups received standard postoperative surgical sterilization measures.

Observation Indicators

(1) Surgical outcomes: The completion status of the surgery was recorded for each patient. (2) Perioperative conditions: Intraoperative parameters, including the duration of stoma creation, intraoperative blood loss, total surgical time, and the number of lymph nodes resected, were documented. (3) Inflammatory and nutritional biomarkers: Fasting venous blood samples (3 mL) were collected from patients before surgery and 2 days postoperatively. The samples were centrifuged at 3000 r/min for 10 minutes to isolate the serum. A flow cytometer (FACS Verse, Shanghai Zhiyan Scientific Instrument Co., Ltd., Shanghai, China) was used to measure the levels of C-reactive protein (CRP), interleukin-6

Table 1. Baseline characteristics of study groups ($\bar{x} \pm s$; n, %).

Characteristic/group	Control group (n = 30)	Flap support group (n = 34)	t/χ^2 value	p-value
Age (years)	57.49 ± 6.07	57.20 ± 6.12	0.190	0.850
Gender			0.007	0.934
Male	20 (66.67)	23 (67.65)		
Female	10 (33.33)	11 (32.35)		
Tumor diameter (cm)	2.91 ± 0.46	2.96 ± 0.59	0.374	0.709
Distance of tumor from the anal margin (cm)	4.22 ± 1.16	4.19 ± 1.13	0.105	0.917
Pathological type			0.043	0.979
Highly differentiated	9 (30.00)	11 (32.35)		
Moderately differentiated	12 (40.00)	13 (38.24)		
Poorly differentiated	9 (30.00)	10 (29.41)		

Table 2. Perioperative parameters between the two groups ($\bar{x} \pm s$).

Group	n	Stoma surgery duration (min)	Intraoperative blood loss (mL)	Total surgery duration (h)	Number of lymph nodes cleared (pieces)	Hospital stay duration (days)	Hospitalization costs (CNY)
Control group	30	37.03 ± 2.61	154.13 ± 21.40	3.10 ± 0.31	11.80 ± 2.06	26.17 ± 6.01	41,245.21 ± 2124.21
Flap support group	34	28.41 ± 3.10	138.00 ± 27.25	2.94 ± 0.24	11.62±2.11	24.36 ± 5.77	39,458.46 ± 2015.29
t-value		11.944	2.608	2.323	0.344	1.228	3.451
p-value		<0.0001	0.011	0.023	0.732	0.224	0.001

The exchange rate is 1 US Dollar (USD) equals 7.2983 Chinese Yuan (CNY).

(IL-6), procalcitonin (PCT), erythrocyte sedimentation rate (ESR), and prealbumin (PA). (4) Postoperative complications: The occurrence of postoperative complications, including stoma site infections, stoma prolapse, and parastomal hernias, were recorded. (5) Follow-up: Patients were followed for 6 months after surgery to evaluate recovery status and long-term outcomes.

Statistical Analysis

Data analysis was performed using SPSS statistical software (version 26.0; SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk was used to assess the normality of the distribution for measurement data. Measurement data following a normal distribution were expressed as mean ± standard deviation (SD) ($\bar{x} \pm s$) and analyzed using the independent sample t-test. The interaction effect between groups over time was evaluated using repeated-measures analysis of variance (ANOVA), followed by multiple comparisons performed with the least significant difference (LSD) t-test. Categorical data were expressed as frequencies and percentages (n, %). Differences in categorical variables were analyzed using the *chi*-square test. Pearson's *chi*-square test was applied for a total sample size of 40 or more, where all expected frequencies were ≥5. The *chi*-square test was adjusted using a correction formula if the total sample size was 40 or larger and one expected frequency was <5 but ≥1. Fisher's exact test was employed for a total sample size of 40 or larger, where two or more expected frequencies were <5 but ≥1. A p-value < 0.05 was considered to indicate statistically significant differences.

Results

Baseline Characteristics

The age, gender, tumor diameter, distance of the tumor from the anal margin, and pathological type showed no statistically significant differences between the control group and the flap support group ($p > 0.05$, Table 1).

Perioperative Conditions

Significant differences were observed between the control and flap support groups in stoma creation time, intraoperative blood loss, total surgical time, and hospitalization costs ($p < 0.05$, Table 2).

CRP and Prealbumin Levels

Repeated-measures ANOVA revealed significant effects of time, group, and group-time interactions on the levels of CRP, IL-6, PCT, ESR, and PA ($p < 0.05$). On postoperative days 2, 4, and 6, both groups exhibited increased CRP, IL-6, and PCT levels compared to preoperative values, while ESR and PA levels decreased ($p < 0.05$). However, the flap support group demonstrated significantly lower levels of CRP, IL-6, PCT, and ESR and higher levels of PA compared to the control group on postoperative days 2, 4, and 6 ($p < 0.05$, Table 3).

Incidence of Postoperative Complications

The incidence of postoperative complications was significantly lower in the flap support group compared to the control group (2.94% vs. 20.00%, Fisher's exact test, $p < 0.05$) (Table 4).

Table 3. Perioperative biomarker levels between the two groups ($\bar{x} \pm s$, mg/L).

Characteristic	Group	Prior to surgery	2 days post-surgery	4 days post-surgery	6 days post-surgery
CRP (mg/L)	Control group (n = 30)	35.16 ± 3.05	67.46 ± 10.12[a]	61.83 ± 9.25[a]	53.78 ± 8.60[a]
	Flap support group (n = 34)	35.90 ± 3.01	60.46 ± 10.07[ab]	53.59 ± 9.31[ab]	41.34 ± 8.63[ab]
	F value	$F_{time} = 315.438/F_{interclass} = 16.272/F_{interaction} = 15.425$			
	p-value	$p_{time} < 0.001/p_{interclass} < 0.001/p_{interaction} < 0.001$			
IL-6 (pg/L)	Control group (n = 30)	53.94 ± 10.62	95.72 ± 19.72[a]	79.06 ± 15.82[a]	68.53 ± 12.37[a]
	Flap support group (n = 34)	51.24 ± 10.64	81.36 ± 18.63[ab]	68.22 ± 14.56[ab]	58.16 ± 11.46[ab]
	F value	$F_{time} = 133.132/F_{interclass} = 4.403/F_{interaction} = 10.411$			
	p-value	$p_{time} < 0.001/p_{interclass} < 0.001/p_{interaction} = 0.007$			
PCT (ng/mL)	Control group (n = 30)	10.46 ± 0.47	28.51 ± 3.26[a]	25.86 ± 2.70[a]	21.09 ± 3.61[a]
	Flap support group (n = 34)	10.25 ± 0.85	21.27 ± 3.55[ab]	18.62 ± 2.37[ab]	12.31 ± 2.48[ab]
	F value	$F_{time} = 741.238/F_{interclass} = 65.932/F_{interaction} = 127.430$			
	p-value	$p_{time} < 0.001/p_{interclass} < 0.001/p_{interaction} < 0.001$			
ESR (mm/h)	Control group (n = 30)	40.08 ± 5.19	36.54 ± 4.77[a]	32.88 ± 4.54[a]	27.48 ± 4.35[a]
	Flap support group (n = 34)	40.65 ± 5.14	33.84 ± 4.42[ab]	28.56 ± 4.35[ab]	21.27 ± 4.03[ab]
	F value	$F_{time} = 247.592/F_{interclass} = 11.098/F_{interaction} = 12.956$			
	p-value	$p_{time} < 0.001/p_{interclass} < 0.001/p_{interaction} = 0.001$			
PA (mg/L)	Control group (n = 30)	241.29 ± 30.41	144.49 ± 15.70[a]	120.07 ± 11.86[a]	128.53 ± 9.36[a]
	Flap support group (n = 34)	242.39 ± 30.31	160.41 ± 15.61[ab]	151.21 ± 12.50[ab]	146.17 ± 11.44[ab]
	F value	$F_{time} = 358.475/F_{interclass} = 1\ 0.862/F_{interaction} = 22.028$			
	p-value	$p_{time} < 0.001/p_{interclass} < 0.001/p_{interaction} < 0.001$			

Compared to the same group before treatment, [a]$p < 0.05$; compared to the control group at the same time point, [b]$p < 0.05$; CRP, C-reactive protein; IL-6, interleukin-6; PCT, procalcitonin; ESR, erythrocyte sedimentation rate; PA, prealbumin.

Table 4. Postoperative complications between the two groups (n, %).

Group	Peristomal infection	Stoma prolapse	Parastomal hernia	Incidence
Control group (n = 30)	2 (6.67)	2 (6.67)	2 (6.67)	6 (20.00)
Flap support group (n = 34)	0 (0.00)	1 (2.94)	0 (0.00)	1 (2.94)
p-value (Fisher's exact test)				0.044

Table 5. Occurrence of anastomotic leak and permanent fistula (n, %).

Group	Anastomotic leak (n, %)	Permanent fistula (n, %)
Control group (n = 30)	5 (16.67)	4 (13.33)
Flap support group (n = 34)	2 (5.88)	0 (0.00)
p-value (Fisher's exact test)	0.238	0.043

Follow-up Results

During the 6-month follow-up period post-discharge, 2 patients in the flap support group experienced anastomotic leaks, but no permanent stomas occurred. In contrast, 5 patients in the control group developed anastomotic leaks, and 4 patients developed permanent fistula. The incidence of permanent fistulas was 0% in the flap support group, which was significantly lower compared to 13.33% in the control group (Fisher's exact test, $p < 0.05$, Table 5).

Discussion

RC remains a significant public health threat, with approximately 75% of cases occurring in the lower rectum, referred to as low RC. Surgery is currently the primary effective treatment for low RC. However, it is frequently associated with severe complications, such as anastomotic leaks [7]. Previous studies have reported that the incidence of anastomotic leaks following radical surgery for low RC ranges from 10% to 20% [8,9]. These leaks represent a significant risk factor for acute peritonitis and pelvic infections while also contributing to an increased risk of reoperation, prolonged hospital stays, and poor long-term outcomes. The findings of this study align with previous research, revealing an anastomotic leak rate of 10.94% (7/64) among 64 patients with low RC [8,9]. These findings highlight the significance of strategies to reduce anastomotic leak rates in clinical practice.

Data suggest [10,11] that prophylactic ileostomy effectively establishes a stoma at the proximal end of the anastomosis, diverting fecal content and preventing intestinal contents from reaching the newly constructed anastomosis. This di-

version reduces mechanical pressure and contamination by pathogens, thereby protecting the anastomosis and reducing the risk of anastomotic leaks. Prophylactic ileostomy relies on structural support, and traditional stents are commonly made of materials such as rubber, plastic, or suction tubes. However, these stents require secondary surgical removal, which is associated with an elevated risk of stoma leakage, parastomal infections, and other complications. Therefore, enhancing support methods is critical for improving the clinical outcome of prophylactic ileostomies in patients undergoing radical surgery for low RC [12]. The autologous flap support technique, involving a U-shaped incision in the right lower abdomen, offers an innovative alternative. This approach creates a central, tongue-shaped skin flap without the need for an external support framework. The method is simple and quick, minimizing the risk of stoma infections associated with the secondary removal of traditional support frameworks [13,14].

In this study, the application of autologous flap support was compared to traditional support methods for prophylactic ileostomy during laparoscopic low anterior resection. The findings demonstrated that the flap support group had significantly shorter surgery and total operation times and reduced intraoperative blood loss and hospitalization costs compared to the control group. These findings indicate that autologous flap support offers superior clinical efficacy. The observed advantages of autologous flap support can be attributed to its unique design and application. The autologous flap is threaded through the mesenteric perforation of the intestinal tube to the contralateral side and secured with absorbable sutures. This design offers a softer, more elastic support structure compared to conventional frameworks, ensuring minimal impact on the blood circulation of the protruding ileum [15]. Additionally, the use of absorbable sutures eliminates the risk of foreign body-related complications, such as peristomal infections, as the sutures dissolve naturally over time [16]. This process further contributes to a reduced risk of stoma-related complications, facilitates faster recovery, and offers economic benefits.

Peristomal infection, prolapse, and parastomal hernia are among the most common complications associated with preventive ileostomy. These complications often result from stoma retraction and irregularities of the peristomal skin [17]. When stoma complications occur, they increase the risk of abdominal incision infections and peristomal dermatitis, emphasizing the need for strategies to minimize these stoma complications in preventive ileostomy [18].

C-reactive protein (CRP) activates the complement system and enhances the phagocytic activity of phagocytic activity of immune cells, while PA is essential in physiological processes such as the body's stress response, tissue repair, and clearance of necrotic materials [19]. In this study, the application of autologous flap support in preventive ileostomy demonstrated a lower incidence of complications and reduced levels of CRP, IL-6, PCT, and ESR on postoperative days 2, 4, and 6 compared to the control group. Conversely, PA levels were significantly higher in the flap support group on postoperative days 2, 4, and 6. These findings suggest that autologous flap support offers a safer alternative to traditional support frameworks. By mitigating inflammatory response and promoting the recovery of intestinal function, autologous flap support contributes to improved outcomes. The enhanced skin compatibility of the autologous flap, compared to the traditional support frameworks, is likely a key factor in preventing healing difficulties in the peristomal skin. Furthermore, the risk of creating an excessively large stoma base, which can arise when the support framework exceeds the required dimensions of the stoma, is minimized with autologous flap support. This feature reduces stoma leakage and lowers the risk of complications such as peristomal infection and prolapse.

Conclusions

In conclusion, preventive ileostomy supported by autologous skin flaps offers significant advantages, including reduced operative time and a lower incidence of stoma-related complications, demonstrating excellent safety and efficacy. Furthermore, this approach reduces healthcare costs and saves healthcare resources by eliminating the need for patients to subsequently go to the hospital to remove the support frame, thereby helping to improve patient outcomes. However, this study has several limitations. The patient cohort was restricted to individuals undergoing low RC radical surgery under laparoscopy. Additionally, the sample size was relatively small, and the follow-up period was short. Future studies should aim to expand the clinical scope by including a broader range of patient populations, extending the follow-up period, and conducting rigorous validation studies to further elucidate the clinical value and broader applicability of autologous flap support.

Availability of Data and Materials

The data analyzed was available on the request for the corresponding author.

Author Contributions

XL and WLW designed the research study. ML and LG performed the research and analyzed the data. XL drafted this manuscript. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study complied with the principles outlined in the Declaration of Helsinki and was approved by the Fuyang Women's and Children's Hospital Ethics Committee (Approval number: 2024 (3)).

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Conflict of Interest

The authors declare no conflict of interest.

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