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Application of Hand-Sewn Anastomosis in Totally Laparoscopic Radical Resection of Colorectal Cancer with Transanal Specimen Extraction

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Abstract: *Objective:* To explore the value of hand-sewn anastomosis in totally laparoscopic radical resection of colorectal cancr with transanal specimen extraction. *Methods:* A retrospective descriptive study was conducted. Clinical data of 54 patients with colorectal cancer who underwent totally laparoscopic transrectal specimen extraction surgery between January 2019 and December 2023 at the Department of Gastrointestinal Surgery, Bayannur City Hospital, were collected. All patients underwent digestive tract reconstruction using hand-sewn end-to-end colonic or rectal anastomosis. Intraoperative and postoperative general conditions, pathological results, complications, and follow-up data were analyzed. *Results:* Among the 54 cases, 37 were male, and 17 were female. The cases included 26 sigmoid colon cancers, 27 high rectal cancers, and 1 descending colon cancer. All patients underwent totally laparoscopic radical resection of colorectal cancer with transrectal specimen extraction. The average surgical duration was 187.87 ± 61.36 minutes, with 16 (14–19) minutes required for hand-sewn anastomosis. Intraoperative blood loss was 16 (10–200) mL, with no conversions to open surgery or blood transfusions. Postoperative outcomes included first flatus time of 1 (1–3) day, liquid diet resumption on 2 (2–3) days, postoperative Visual Analog Scale (VAS) pain score of 2 (2–3), and hospital stay duration of 8 (7–9) days. The total hospitalization cost was 41,011 (25,655–148,589) Chinese yuan, with an average cost of 42,558.81 ± 8,599.30 Chinese yuan after excluding three cases with complications. Pathological examination revealed all cases to be adenocarcinomas: 20 well-differentiated, 32 moderately differentiated, and 2 poorly differentiated. All resection margins were negative. An average of 16.85 ± 7.97 lymph nodes were dissected. Pathological staging included 18 stage I, 17 stage II, and 19 stage III cases. Postoperative complications included 2 cases of anastomotic leakage (3.7%), 1 case of anastomotic stricture (1.8%), and 1 case of pulmonary infection (1.8%). No unplanned readmissions or postoperative deaths occurred during the 30-day follow-up period. *Conclusion:* Hand-sewn anastomosis in totally laparoscopic radical resection of colorectal cancer with transanal specimen extraction is safe and feasible.

Keywords: Hand-sewn anastomosis; Colorectal cancer; Natural orifice specimen extraction surgery, Totally laparoscopic

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1. Introduction

Colorectal cancer is one of the most common malignant tumors in China, with a steadily increasing incidence that poses significant health risks [1]. The primary treatment approach is comprehensive therapy centered on surgical intervention. Laparoscopic radical resection of colorectal cancer has gained widespread acceptance among colorectal surgeons. Among these, natural orifice specimen extraction surgery (NOSES) has made significant advancements in colorectal surgery in China [2,3]. Compared with laparoscopic-assisted colorectal cancer surgery, totally laparoscopic radical resection with NOSES avoids abdominal wall incisions, reduces postoperative pain, improves abdominal wall aesthetics, lowers postoperative complications, and shortens hospital stay [4,5]. However, this approach is technically demanding, particularly in terms of specimen extraction via natural orifices and totally laparoscopic digestive tract reconstruction. NOSES for colorectal cancer can involve either transvaginal or transanal specimen extraction. This study retrospectively analyzed data from 54 patients who underwent totally laparoscopic radical resection of colorectal cancer with transanal specimen extraction at Bayannur City Hospital between January 2019 and December 2023, focusing on the application value of hand-sewn end-to-end colonic and rectal anastomosis.

2. Materials and methods

2.1. General information

A retrospective descriptive study was conducted, collecting clinical, pathological, and follow-up data of 54 patients who underwent laparoscopic transrectal specimen extraction surgery for colorectal cancer at Bayannur City Hospital from January 2019 to December 2023. General patient data are presented in **Table 1**. The study complied with the requirements of the Declaration of Helsinki and was approved by the Ethics Committee of Bayannur City Hospital, with all participants signing informed consent forms.

Table 1. General patient data

Results	Mean ± SD / median (range)
Gender	
Male (%)	37 (68.5%)
Female (%)	17 (31.5%)
Age (years)	67.00 ± 8.77
BMI (kg/m²)	23.44 ± 3.08
KPS score	90 (80–90)
NRS2002 score	2 (1–2)
Maximum tumor width measured by CT (cm)	3 (1–4)
Tumor location	
Sigmoid colon (%)	26 (48.1%)
High rectum (%)	27 (50.0%)
Descending colon (%)	1 (1.9%)

Table 1 (Continued)

Results	Mean ± SD / median (range)
Pathological staging (pT)	
T1	11 (20.4%)
T2	19 (35.2%)
T3	22 (40.7%)
T4a	2 (3.7%)
Pathological staging (pN)	
N0	32 (59.2%)
N1	17 (31.5%)
N2	5 (9.3%)

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Preoperative colonoscopy and pathology confirmed sigmoid or upper rectal cancer; (2) Preoperative enhanced chest, abdominal, and pelvic CT ruled out distant metastasis; (3) Preoperative high-resolution pelvic MRI, transrectal ultrasound, or proctoscopy indicated clinical T stage < T4 and maximum tumor diameter ≤ 5 cm; (4) BMI range of 18–30 kg/m²; (5) MDT consultation deemed surgery suitable, with complete clinical data.

Exclusion criteria: (1) Patients undergoing neoadjuvant therapy before surgery; (2) Emergency surgeries due to complications or other factors; (3) Combined organ resection cases; (4) Cases involving terminal ileostomy or transverse colostomy; (5) Preventive intraperitoneal hyperthermic chemotherapy during surgery.

2.3. Treatment methods

All surgeries were performed by the same team using a 2D high-definition laparoscopic system.

2.3.1. Radical resection

(1) Performed under general anesthesia with tracheal intubation. Patients were positioned in a modified lithotomy position and switched to lithotomy for specimen extraction.

(2) A 10 mm trocar was placed at the upper edge of the umbilicus as the observation port, 5 mm trocars in the left abdomen and lower left abdomen as auxiliary operation ports, a 5 mm trocar in the right abdomen as an assistant port, and a 12 mm trocar in the lower right abdomen as the main operation port.

(3) CO_2 was insufflated, maintaining pressure at 14 mmHg.

(4) A thorough exploration of auxiliary injuries, bleeding, liver metastasis, peritoneal dissemination, or pelvic fluid was conducted.

(5) Tumor location was identified while ensuring oncological principles were maintained. In cases of small tumors, intraoperative colonoscopy was used for precise localization.

(6) Lymphadenectomy was performed at the root of the inferior mesenteric artery (lymph node no. 253), with ligation of the sigmoid and superior rectal arteries (**Figure 1a–b**). Preservation of autonomic nerves was emphasized.

(7) The colon was mobilized proximally and distally, ensuring tension-free anastomosis. The proximal colon was mobilized 10 cm from the tumor, and the mesentery was fan-shaped and dissected for resection and anastomosis preparation.

2.3.2. Transrectal specimen extraction and digestive tract reconstruction

(1) For low sigmoid and high rectal tumors, the intestine was mobilized 5 cm distal to the tumor; for mid-rectal tumors, the margin was 3 cm to avoid hand-sewn anastomosis difficulty.

(2) The distal colon was transected using a laparoscopic 60-mm articulating linear stapler (**Figure 1c**).

(3) The anus was dilated, and the distal rectal stump was rinsed with povidone-iodine saline.

(4) The distal closure was excised using an ultrasonic scalpel (**Figure 1d**). A 30-cm thin membrane protective sleeve was inserted via the main operation port, with one end pulled through the distal rectum and anus (**Figure 1e**). The specimen was extracted along with the sleeve.

(5) The colon was transected proximally, and the specimen with the protective sleeve was removed (**Figure 1f**).

(6) A 3-0 absorbable barbed suture was used for laparoscopic end-to-end anastomosis, starting at the 10 o'clock position and proceeding counterclockwise in one layer for full-thickness suturing, ensuring alignment and tightness (**Figure 1g–h**).

(7) A second layer of muscular-serosal sutures reinforced the anastomosis, covering defects and preventing narrowing.

(8) Warm saline was injected into the pelvis to submerge the anastomosis for air leakage tests or endoscopic evaluation (**Figure 1i**).

(9) A drainage tube was placed under laparoscopic guidance, with a rectal tube secured near the anastomosis.

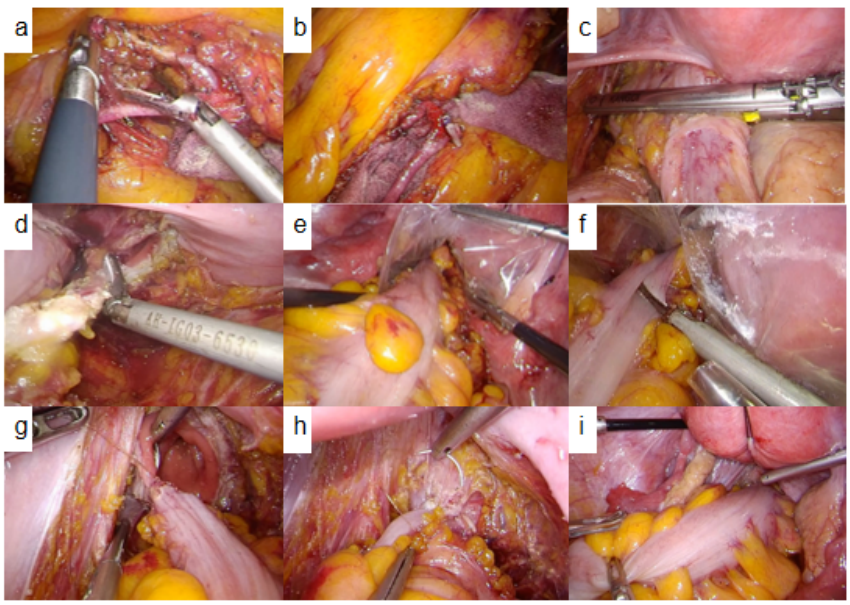

Figure 1. Radical resection, transrectal specimen extraction, and digestive tract reconstruction. **(a)** Dissection of No. 253 lymph nodes; **(b)** Preservation of the left colic artery; **(c)** Transection of the distal bowel at the tumor site; **(d)** Transection of the distal intestinal stump; **(e)** Insertion of the specimen into the protective sleeve; **(f)** Transection of the proximal bowel at the tumor site; **(g)** Full-thickness suturing at the 10 o'clock position, proceeding counterclockwise; **(h)** Continuous seromuscular suturing for reinforcement; **(i)** Air leakage testing of the anastomosis using intestinal inflation

2.4. Observational indicators and evaluation criteria

Observational indicators:

(1) Intraoperative data: surgery duration (min), hand-sewn anastomosis time (min), intraoperative blood loss (mL).

(2) Postoperative data: time to first flatus (days), time to oral intake (days), postoperative VAS pain score, hospital stay duration (days).

(3) Pathological data: type of pathology, differentiation grade, staging, resection margin status, number of lymph nodes dissected, number of positive lymph nodes.

(4) Perioperative complications: anastomotic leakage, stricture, wound infection, incisional hernia, pelvic or abdominal infection, bowel obstruction, pulmonary infection, pulmonary embolism, and deep vein thrombosis.

(5) Follow-up data at 1 month post-discharge.

Evaluation criteria: Perioperative complications were graded using the Clavien-Dindo classification system.

2.5. Statistical analysis

Statistical analysis was performed using SPSS 25.0 software. Continuous variables were tested for normality. Data with normal distribution were expressed as mean ± standard deviation (SD), while non-normally distributed data were presented as median (range). Categorical data were expressed as absolute numbers or percentages. A *P*-value of < 0.05 is considered a statistically significant difference.

3. Results

3.1. Intraoperative data

All 54 patients successfully underwent surgery. The operative time was 187.87 ± 61.36 minutes, with the time for hand-sewn anastomosis being 16 (14–19) minutes. Intraoperative blood loss was 16 (10–200) mL, and no patients required conversion to open surgery or blood transfusion.

3.2. Postoperative data

The median time to the first postoperative passage of flatus was 1 (1–3) days, and the median time to initiation of a liquid diet was 2 (2–3) days. The postoperative Visual Analog Scale (VAS) pain score was 2 (2–3), and the length of hospital stay was 8 (7–9) days. Total hospital expenses were 41,011 (25,655–148,589) Chinese yuan. Excluding three cases with complications, the remaining 51 patients had a mean hospital expense of 42,558.81 ± 8,599.30 Chinese yuan. See **Table 2**.

Table 2. Intraoperative and postoperative data of patients

Results	Mean ± SD / median (range)
Intraoperative	
Operative time (min)	187.87 ± 61.36
Hand-sewn anastomosis time (min)	16 (14–19)
Intraoperative blood loss (mL)	16 (10–200)

Table 2 (Continued)

Results	Mean ± SD / median (range)
Postoperative	
Time to first flatus (days)	1 (1–3)
Time to liquid diet (days)	2 (2–3)
VAS pain score	2 (2–4)
Length of hospital stay (days)	8 (4–28)
Total hospital expenses (Chinese yuan)	41,011 (25,655–148,589)
Hospital expenses (excluding cases with complications, Chinese yuan)	42,558.81 ± 8,599.30

3.3. Postoperative pathological data

All 54 patients were pathologically diagnosed with adenocarcinoma. Among them, 20 cases (37.0%) were highly differentiated, 32 cases (59.3%) were moderately differentiated, and 2 cases (3.7%) were poorly differentiated. All resection margins were negative. The number of lymph nodes dissected was 16.85 ± 7.97. The pathological stages included 18 cases (33.3%) in stage I, 17 cases (31.5%) in stage II, and 19 cases (35.2%) in stage III. See **Table 3**.

Table 3. Postoperative pathological findings

Results	Mean ± SD / [*n* (%)]
Pathological type	
Adenocarcinoma	54 (100%)
Differentiation grade	
High	20 (37.0%)
Moderate	32 (59.3%)
Low	2 (3.7%)
Margins	
Negative	54 (100%)
Lymph nodes dissected (*n*)	16.85 ± 7.97
Pathological stage	
Stage Ia/Ib	18 (33.3%)
Stage IIa/IIb/IIc	17 (31.5%)
Stage IIIa/IIIb/IIIc	19 (35.2%)

3.4. Postoperative complications

Postoperative anastomotic leakage occurred in 2 cases (3.7%). One case required ileostomy, drainage, anti-infection treatment, and nutritional support, resulting in recovery and discharge. This patient later developed anastomotic stricture (1.8% incidence). Another case of occult anastomotic leakage was confirmed by imaging and treated with fasting, intravenous nutritional support, and recovery without surgical intervention. The

Clavien-Dindo grades were IIIb and II, respectively. Additionally, 1 case (1.8%) of postoperative pulmonary infection was treated in the respiratory department, with recovery and discharge. No cases of wound infection, incisional hernia, abdominopelvic infection, bowel obstruction, pulmonary embolism, or deep vein thrombosis were observed. See **Table 4**.

Table 4. Postoperative complications

Complications	[*n* (%)]
Anastomotic leakage	2 (3.7%)
Anastomotic stricture	1 (1.8%)
Pulmonary infection	1 (1.8%)

3.5. Postoperative follow-up

Within 30 days after discharge, no patients required unplanned readmission, and no deaths were reported.

4. Discussion and study limitations

4.1. Discussion

The application of NOSES in colorectal surgery involves two approaches for specimen extraction: transrectal and transvaginal. However, transvaginal extraction is limited to women without childbearing requirements. The transrectal approach is more frequently reported in the literature, and digestive tract reconstruction is typically performed using stapled anastomosis [6-9]. Professor Xi-Shan Wang classified colorectal NOSES procedures into types I to X, all of which use stapled anastomosis for digestive tract reconstruction. The technique in this study was developed by learning and modifying the NOSES IV method introduced by Professor Wang [10].

Using a circular stapler anvil inserted via the distal rectum or anus increases the risk of pelvic contamination. Additionally, embedding the stapler anvil laparoscopically is relatively complex. Closing the distal rectum with a laparoscopic linear stapler and performing end-to-end anastomosis with a circular stapler increases the number of instruments used and costs. Therefore, this study utilized hand-sewn end-to-end colorectal anastomosis for digestive tract reconstruction during transrectal specimen extraction. A barbed absorbable suture (3-0) was used for the laparoscopic hand-sewn anastomosis. Starting at the 10 o'clock position, the suture was advanced counterclockwise for a single-layer, full-thickness anastomosis, similar to reports by Liu *et al.* [11]. The suture entry distance from the edge equals the needle spacing and the intestinal wall thickness. This technique ensures alignment and tightness of the anastomosis. Without cutting the suture, the same suture was used for a continuous seromuscular layer reinforcement in the same direction. This layer strengthens the primary anastomosis by covering any defects, improving the anastomotic quality while avoiding stenosis. A similar seromuscular reinforcement technique was reported by Yang *et al.* [12], but the current study used a single barbed absorbable suture for the seromuscular layer.

The technique, termed the First Stitch at Ten o'clock Position Suture Method (FTOS) and Three-Equidistant Hybrid Suture (TEHS) by Professor Tengqi Wang, has shown promise in laparoscopic distal gastrectomy with jejunal interposition [13]. This study also employed these methods to further investigate their applicability in laparoscopic colorectal cancer NOSES procedures.

Laparoscopic NOSES is highly regarded in colorectal surgery for its minimally invasive nature, good

short-term outcomes [3], safety, and oncological results [6]. Recent studies have frequently reported successful applications. However, the indications for NOSES must be strictly controlled, especially for transrectal specimen extraction, as the distal rectum and anus have limited width and extensibility. Tumors are typically hard and brittle, making deformation difficult. Forcing the specimen through these areas can cause tumor fragmentation or injuries to the rectum or anus, leading to complications. Therefore, tumor size is critical for the success of transrectal specimen extraction. Additionally, mesenteric thickness, anal sphincter function, and the presence of anal stenosis should be carefully evaluated preoperatively. A study by Pei *et al.* showed that a tumor diameter of ≥ 4 cm was a risk factor for complications in transrectal specimen extraction [14]. Since a tumor has three dimensions—length, width, and thickness (length > width > thickness)—the width is the determining factor for passage through a narrow channel. In this study, the maximum tumor width was 3 cm (range: 1–4 cm), which falls within the safe range (< 4 cm).

All cases in this study preserved the left colic artery (LCA), enhancing blood supply and reducing the incidence of anastomotic leakage. The key to this technique lies in complete lymph node dissection at the root while preserving the LCA. Preserving the vessel without adequate lymph node dissection is not recommended [15-17]. Hand-sewn anastomosis was performed in all cases, with full-thickness suturing followed by seromuscular reinforcement. This approach allowed real-time assessment of anastomotic blood supply [12], enabling immediate intervention if abnormalities were detected. However, hand-sewn techniques require advanced laparoscopic skills, flexible instruments, and adequate space, making them technically demanding. Thus, these procedures should be performed by teams with solid laparoscopic expertise, starting with higher anastomoses and gradually progressing to lower ones.

From a health economics perspective, hand-sewn anastomosis reduces medical costs and conserves resources. However, it carries a higher risk of postoperative intra-abdominal infections. Preoperative bowel preparation, intraoperative antibiotic use, aseptic techniques, and thorough irrigation should be optimized to mitigate these risks [11]. This study also used intraoperative rectal air-leak testing and indwelling anal tubes to reduce anastomotic leakage, similar to the PST technique proposed by Chang *et al.* [18]. Reducing anastomotic leakage is a critical goal for gastrointestinal surgeons. To eliminate potential bias, patients with protective stomas were excluded, as stomas may lower leakage incidence [19]. In this study, anastomotic leakage occurred in 2 cases (3.7%), with 1 case (1.8%) developing stenosis. One leakage case had a distal margin of < 1 cm intraoperatively, requiring an additional 2 cm resection. Potential damage to distal bowel tissue and blood supply during the operation may have affected healing, emphasizing the need for protective stomas when adverse factors are present. Local inflammation and infection during leakage healing can cause scarring, increasing the risk of stenosis [20].

Avoiding abdominal wall specimen extraction incisions reduces postoperative pain and improves abdominal wall aesthetics. The anastomotic leakage rate (3.7%) and stenosis rate (1.8%) in this study are consistent with the literature [2,6,7,13,21]. Other complications, such as wound infections, hernias, pelvic infections, bowel obstruction, pulmonary embolism, and deep vein thrombosis, were not observed. This may be attributable to the implementation of enhanced recovery after surgery (ERAS) protocols, although further validation with larger sample sizes is needed.

The mean operative time was 187.87 ± 61.36 minutes, including 16 (14–19) minutes for hand-sewn anastomosis, comparable to domestic reports on stapled anastomosis [2,3] and similar to other hand-sewn techniques [11,22]. The insertion and embedding of a stapler anvil, distal closure, and stapled anastomosis may

prolong operative time. Observations such as intraoperative blood loss, lymph node yield, time to first flatus, time to liquid diet, length of hospital stay, and postoperative pain align with mainstream studies on colorectal NOSES surgery [23-25], indicating that this study achieved the expected outcomes.

4.2. Study limitations

This single-center, retrospective, single-arm study included a small number of cases and had a short follow-up duration. Long-term oncological outcomes require further investigation.

5. Conclusion

Performing laparoscopic radical resection of colorectal cancer with transrectal specimen extraction requires strict adherence to indications and effective measures to reduce postoperative complications. Due to its complexity and steep learning curve [26], this approach is suitable for experienced laparoscopic teams. It reduces medical costs, shortens operative time, and does not increase complication rates. Therefore, hand-sewn end-to-end colorectal anastomosis for digestive tract reconstruction in laparoscopic transrectal specimen extraction surgery is safe and feasible for colorectal cancer.

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Disclosure statement

The authors declare no conflict of interest.

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