Original Article

Comparing the Short-term Outcomes of Two-stage Turnbull-Cutait Pull-through Coloanal Anastomosis with Double-stapled Coloanal Anastomosis: A Community Hospital Experience

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Purpose. Two-stage Turnbull-Cutait pull-through hand-sewn coloanal anastomosis (TCA) is an old technique with new applications for rectal lesions. Compared to coloanal anastomosis (CAA) with diverting ileostomy after total mesorectal excision (TME), TCA offers the advantage of preventing complications associated with diverting ileostomy creation and reversal. However, this technique has yet to be compared with the coloanal anastomosis double-stapled technique (CAA-DST). The purpose of this study was to compare the short-term surgical outcomes of TCA and CAA-DST.

Methods. Between October 2020 and June 2023, patients from our institute who underwent TME with CAA-DST, and those who underwent TME with TCA were selected. A comparison of 30-day and 1-year postoperative morbidity and mortality and long-term anastomosis complications was conducted. Propensity score-matching was used for patient selection. After matching, generalized estimating equations and stratified Cox regression were used for analysis.

Results. Twenty CAA-DST patients and 11 TCA patients were enrolled in this study. No 30-day postoperative mortality was observed. The 30-day postoperative morbidity and major morbidity rates were not significantly different between groups ($p = 0.356$, $p = 0.150$). Both groups had one pelvic infection without frank anastomotic leakage. Leakage was observed in one patient from the CAA-DST group. One patient with anal stenosis in the TCA group required dilation under general anesthesia, 20 months later. No significant difference in anastomosis-associated complications was observed after 35.6 (IQR 17.9-33.3) months of follow up ($p = 0.091$). Subdividing TCA on day 4 and after day 5 for the secondary operation, there was no significant difference in surgical complications between the two groups ($p = 0.658$).

Conclusion. TCA does not increase the postoperative morbidity rate compared with standard CAA-DST followed by ileostomy closure. The closure timing may be shortened to 4 days after the first TCA operation.

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In 1952, Turnbull et al. described a surgical technique called transanal colonic pull-through with a two-stage coloanal hand-sewn anastomosis (TCA) for intestinal transit reconstruction in adults with rectal cancer and children with Hirschsprung disease.[1] During the same period, Cutait et al. described an identical technique in adult patients with acquired megacolon secondary to Chagas disease in Brazil.[2] The TCA procedure is executed in two stages. In the first stage, the rectal lesion is resected, and the proximal colon is exteriorized through the anus. In the second stage, conducted several days later, a hand-sewn coloanal anastomosis (CAA) is performed. The formation of adhesions and scarring between the lower pelvic walls and colon during this interval is believed to reduce the risk of CAA dehiscence. Accordingly, diverting the stoma was unnecessary. Over the years, the TCA technique has gradually been superseded in favor of mechanical stapled anastomosis[3] or standard hand-sewn CAA in association with a diverting temporary stoma.[4] The TCA is now used as a salvage procedure after anastomotic failure or in cases of a hostile pelvis.[5]

In 1986, Heald et al. introduced total mesorectal excision (TME) using CAA for rectal cancer, which is now considered the gold standard treatment.[6] In 2013, Rullier et al. established specific criteria that encouraged surgeons to consider expanding the application of intersphincter resection (ISR) with reconstruction to all patients without pelvic floor muscle invasion.[7] However, one significant challenge associated with TME or ISR with CAA is the risk of anastomotic leakage (AL) and pelvic sepsis, reported in 4%-20% of cases.[8] AL often necessitates the creation of a definitive colostomy,[9] and is the third leading cause of postoperative mortality in rectal surgery, following myocardial infarction and bronchopneumonia.[10] Additionally, it is associated with a higher risk of local recurrence.[11,12]

Prophylactic diverting stomas are frequently used to mitigate the risk of AL. The creation of a diverting stoma can effectively reduce the impact of AL on the clinical course; however, it does not reduce its incidence. In the immediate CAA approach after TME, the CAA normally retracts approximately 2-3 cm further toward the pelvis after Parks' coloanal pull-through anastomosis.[13,14] Without synergistic coloanal peristalsis, the anal sphincter contraction stretches the colonic stump and its mesentery, resulting in AL. Pelvis sepsis brought about by AL can lead to further detrimental outcomes.

Nevertheless, some patients are reluctant to undergo diverting ostomy owing to the inconvenience of stomas. Stomas can lead to alterations in self-image, which may trigger feelings of anxiety and depression, ultimately affecting patients' overall quality of life and self-esteem.[15] Furthermore, it is essential to recognize that the presence of a diverting stoma does not guarantee the complete prevention of postoperative AL. Complications associated with stomas include prolonged ileus, dehydration due to diarrhea, wound sepsis, incisional hernias at the stoma site, and small bowel rotation, resulting in obstruction, fistula formation, bleeding, and intra-abdominal abscess.[16] Temporary stoma closure can bring about complications such as ileus, leakage, enterocutaneous fistula, wound infection, and wound hernia. It causes morbidity (17.3%-31%), mortality (0.3%-0.4%), re-laparotomy (3.7%), and re-stoma (5.5%).[17,18]

To prevent the need for diverting stomas, the TCA procedure has been reintroduced as an alternative treatment for rectal cancer.[19-23] A meta-analysis comparing TCA and CAA with diverting stomas showed that both procedures had similar morbidity and permanent stoma rates. However, TCA was associated with a lower incidence of pelvic sepsis.[22] In 2020, Binodo et al. published the interim results of their trial[24] that evaluated the efficacy of the TCA procedure as a new indication for low rectal cancer. The study compared short-term surgical outcomes between TCA and CAA with diverting stomas. The 30-day overall composite postoperative complication rates were similar between the groups (34.8% in TCA vs. 45.7% in CAA, $p = 0.4$), suggesting that TCA is a viable alternative for treating lower rectal cancer without requiring temporary stoma construction, thereby preventing stoma-related complications.[25-30]

The aforementioned reports focused on TCA with hand-sewn CAA. Owing to technological advancements, colorectal anastomosis utilizing the double-stapled technique (CAA-DST) is now possible through

laparoscopic or robotic surgery in modern operation rooms.[31,32] Precise dissection of the TME at the end point of the distal rectum, the so-called Morson's waist, and further advancement into the intersphincteric space is now possible.[31,33] Thus, the double-stapled technique is applicable even for juxta-anal rectal cancer. This renders transanal minimally invasive surgery (TAMIS) unnecessary in selected cases, thereby simplifying surgical procedures and saving surgical time. Considering that CAA patients would benefit from the preservation of a slightly longer segment of mucosa in the upper anal canal,[24] CAA-DST is now frequently employed in the modern operating theater.

This study aimed to retrospectively compare the short-term outcomes of CAA-DST with diverting stoma and TCA with an emphasis on surgical complications. Matching methods were used to correct for patient bias.

Patients and Methods

We screened patients with middle- or lower-third rectal lesions who underwent surgery at our institute (China Medical University Hospital) between October 2020 and June 2023. We retrospectively reviewed and analyzed baseline characteristics, laboratory data, as well as preoperative, operative, and postoperative treatment and outcome information.

The patients who underwent TME with coloanal anastomosis and diverting loop ileostomy were classified into the CAA-DST group. Patients who underwent TME with Turnbull-Cutait pull-through and two-stage coloanal anastomosis were included in the TCA group. The decision to conduct a TCA or CAA-DST was determined on an individual basis, according to the patient's clinical status, preferences, and the surgeon's judgment. Discussions with a multidisciplinary team (MDT) and the patient were held before each operation.

Statistical analysis

Propensity score matching (PSM) with nearest neighbor matching method was used to include patients. Initially, the following variables were compared: sex, age, body mass index (BMI), American Association of Anesthesiologists (ASA) grade, Charlson Comorbidity Index (CCI), preoperative serum hemoglobin, albumin, carcinoembryonic antigen (CEA), carbohydrate antigen 19-9 (CA19-9), preoperative radiotherapy, tumor size, distance of the tumor from the anal verge, pathological and clinical TNM stage, intersphincter resection, and combined mastectomy. Fisher's exact test was used for categorical data, and the Mann-Whitney *U* test was used for continuous data (Table 1).

Of the aforementioned variables, only the serum albumin level showed a significant difference ($p = 0.024$), which was then used as a PSM covariate. This model was subsequently used to obtain a one-to-two match using an optimal matching method. The matching algorithm was based on logistic regression without replacement until all possible matches were obtained. Patients who could not be matched based on propensity scores were excluded from further analysis. After matching, categorical and continuous outcome data were compared using generalized estimating equations (GEE). Stoma free rate analysis was performed using a stratified Cox regression.

The primary outcome was the composite 30-day surgical morbidity between the CAA-DST and TCA groups. In the CAA-DST group, composite morbidity included 30-day postoperative complications of ileostomy closure. Postoperative complications were classified using the Clavien-Dindo classification of surgical complications. Any pelvic abscess was considered as anastomotic leakage. The secondary outcomes were surgical time, reoperation, length of hospital stay, and readmission rate.

Quantitative data are presented as medians and percentiles (25th-75th). Qualitative data are presented as absolute numbers and percentages. All statistical analyses were performed using SPSS for Windows (version 26.0; IBM Corp., Armonk, NY, USA), and significance was set at a two-sided p value less than 0.05.

Univariable linear or logistic regression analysis were performed for each outcome on the unmatching primary patient population, and listed in Table 3.

Table 1. Propensity score matching, one-to-two

	Unmatched			Matched		
	CAA_DST (n = 72)	TCA (n = 17)	*p*	CAA_DST (n = 20)	TCA (n = 11)	*p*
Age	61 (52-67.3)	60 (45-68)	0.798	60.5 (53-68)	63 (57-74)	0.807
Gender			0.756			0.426
Female	24 (33.3%)	5 (29.4%)		4 (20%)	1 (9.1%)	
Male	48 (66.7%)	12 (70.6%)		16 (80%)	9 (90.9%)	
BMI	24.2 (21-26)	24.4 (21.1-25.7)	0.892	25.4 (22.6-26.7)	24.4 (23-25.6)	0.148
ASA			0.880			0.811
1	1 (1.4%)	0		0	0	
2	27 (37.5%)	8 (47.1%)		7 (35%)	5 (45.5%)	
3	44 (61.1%)	9 (52.9%)		13 (65%)	6 (54.5%)	
CCI	4 (3-6)	4 (3-5)	0.450	4 (3-5.3)	4 (3-5)	0.924
Hemoglobin	13 (12.1-14.4)	13.7 (12.5-14.2)	0.541	14 (13-14.8)	13.9 (13.7-14.7)	0.758
Albumin	4 (3.7-4.3)	4.4 (4.2-4.5)	0.024	4.3 (4.2-4.5)	4.4 (4.2-4.5)	0.144
CEA			0.562			0.940
Normal	52 (72.7%)	11 (64.7%)		13 (65%)	7 (63.6%)	
Abnormal	20 (27.8%)	6 (35.3%)		7 (35%)	4 (36.4%)	
CA19-9			1.000			0.636
Normal	68 (94.4%)	10 (94.1%)		17 (85%)	10 (90.9%)	
Abnormal	4 (5.6%)	1 (5.9%)		3 (15%)	1 (9.1%)	
Pathology T			0.435			0.650
0	10 (13.9%)	2 (11.8%)		1 (5%)	1 (9.1%)	
1	4 (5.6%)	0		1 (5%)	0	
2	19 (26.4%)	3 (17.6%)		8 (40%)	2 (18.2%)	
3	38 (52.8%)	9 (52.9%)		10 (50%)	7 (63.6%)	
4	0	2 (11.8%)		0	1 (9.1%)	
Pathology N			0.788			0.723
0	41 (56.9%)	7 (41.2%)		9 (45%)	5 (45.5%)	
1	21 (29.2%)	7 (41.2%)		8 (40%)	5 (45.5%)	
2	9 (12.5%)	2 (11.8%)		3 (15%)	1 (9%)	
Tumor size	2.8 (0-7)	2.7 (0-8)	0.477	2.5 (1.5-3.5)	2.5 (2-2.8)	0.644
Radiotherapy	35 (48.6%)	11 (64.7%)	0.232	7 (35%)	7 (63.6%)	0.097
Tumor height	6 (4.9-7)	4.4 (4.2-4.7)	0.113	5.3 (4.6-6)	4.4 (4.3-4.8)	0.153
ISR	6 (8.3%)	3 (17.6%)	0.252	2 (10%)	2 (18.2%)	0.542
Clinical M			0.286			0.971
0	57 (79.2%)	16 (94.1%)		18 (90%)	10 (90.9%)	
1	14 (19.4%)	1 (5.9%)		2 (10%)	1 (9.1%)	
Metastasis excision	9 (12.5%)	0	0.124	1 (5%)	0	-

Values are presented as quartiles Q2 (Q1-Q3), or patient numbers (percentages).
Abbreviations: CAA_DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; BMI, body mass index; ASA, American Society of Anesthesiology; CCI, Charlson Comorbidity Index; CEA, carcinoembryonic antigen; CA19-9, carbohydrate antigen 19-9; ISR, intersphincter resection.

Surgical technique

Mechanical bowel preparation was performed the day before surgery. Both CAA-DST and TCA were performed under general anesthesia, with skin preparation and draping for surgery in the lithotomy position. Parenteral prophylactic antibiotics were prescribed.

The first 12 mm trocar was inserted periumbilically using an open method. The insufflation pressure was set at 12 mmHg. After examining the entire abdomen using a three-dimensional laparoscopic camera

(Endoeye Flex 3D; Olympus, Tokyo, Japan), we set up a further trocar. For laparoscopic surgery, we preferred two trocars in the lower right and two in the left lower quadrant, including three 5 mm trocars and one 12 mm trocar in the right lower quadrant (RLQ). Another 5 mm trocar in the right upper quadrant (RUQ) may have been necessary for traction during takedown of the splenic flexure. The surgeon stood on the right side of the patient.

For robotic surgery, a line was drawn from the left subcostal margin crossing the umbilicus to the right femoral head. Two 5 mm trocars were set 6-8 cm away from the umbilical trocar in the RLQ of the abdomen. Another assistant trocar was set at the triangular vertex of the two lower-right trocars.

An energy device, such as LigaSure™ (Medtronic, Minneapolis, MN, USA), Harmonic® scalpel (Stryker, Athens, MI, USA), or da Vinci® Vessel Sealer (Intuitive Surgical, Sunnyvale, CA, USA) was used depending on the surgical method and surgical facility.

We preferred a median-to-lateral approach through the paraduodenal mesentery window. After high ligation of the inferior mesenteric vein (IMV) near the pancreatic border, we dissected above the pancreatic plane to perform splenic flexure takedown. After high ligation of the inferior mesenteric artery (IMA) was controlled, dissection continued to the pelvis following the total mesorectal excision (TME) principle. Distal transection of the rectum was performed to achieve a free distal margin of at least 1 cm. An intraoperative indocyanine green (ICG) test was used to assess colonic blood perfusion.

For the CAA-DST group, we performed rectum stump resection on the pelvic floor, above the surgical anal channel using ECHELON FLEX™ ENDOPATH® Staplers and ECHELON FLEX™ ENDOPATH® Powered Plus Staplers (Ethicon, Sommerville, NJ, USA), or da Vinci® SureForm (Intuitive Surgical). Side-to-end anastomosis was accomplished using a double-stapled technique, with an ECHELON CIRCULAR™ Stapler and ECHELON CIRCULAR™ Powered Stapler (Ethicon). If the mesocolon was bulky, and a side-to-end anastomosis was difficult to achieve, an end-to-end anastomosis was performed. Specimens were removed using a Pfannenstiel incision. A diverting loop ileostomy was then performed. This protective ileostomy was typically closed three months later, depending on the patient's physical tolerance and status. Postoperative care was guided by the Enhanced Recovery After Surgery (ERAS®) protocol.

In the TCA group, rectal stump resection and specimen extraction were conducted from the anus. After a Lone Star retractor (Cooper Surgical, Trumbull, CT, USA) and GelPort (Applied Medical, Rancho Santa Margarita, CA, USA) were deployed for TAMIS, the distal rectal stump was closed with purse-string sutures and divided from the anal canal. The specimen was then removed from the anus. Exteriorization of the short segment of the left colon through the anal canal (pull-through) was performed as described by Turnbull and Cutait in 1961. A 7-8 cm length of colon was left outside the anal canal and fixed with 3-0 Vicryl sutures (Ethicon) in eight directions. After the operation, the exteriorized colon was covered with gauze containing 50% dextrose water, which was changed every 8 hours. Total parenteral nutrition (TPN) and partial parenteral nutrition (PPN) were administered during the surgical interval depending on the patient's nutritional status. However, the use of clear oral liquids was not limited. If the tumor was located at the juxta-anal level, the internal sphincter was partially removed. The second stage of the TCA technique was typically performed 4-7 days later. The exteriorized colon was cut at the level of the anal canal and a coloanal anastomosis was hand-sewn using 8 to 123-0 Vicryl sutures.

Results

From October 2020 to June 2023, 72 patients underwent TME and coloanal anastomosis with a diverting loop ileostomy, while 17 patients underwent TME with TCA in our hospital. After PSM, 20 patients with CAA-DST and 11 with TCA were enrolled in the study (Fig. 1, Table 1).

The baseline characteristics of the patients, including preoperative characteristics, surgical method used, and postoperative treatment, are listed in Tables 1 and 2. The current study included only laparoscopic

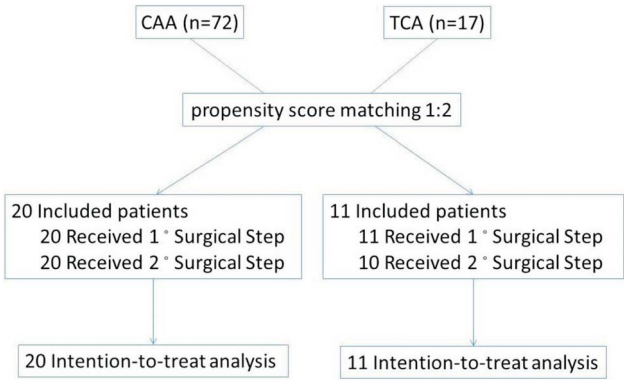

Fig. 1. Flowchart of the study population. CAA-DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, 2-stage Turnbull-Cutait pull-through anastomosis.

or robotic surgeries, and no open surgeries were performed. The surgical interval between the two stages of the TCA technique was 5 (interquartile range [IQR] 4-5) days. For CAA-DST, the surgical interval between diverting ileostomy creation and closure was 3.2 (IQR 2.3-5.9) months. During the secondary surgery, it was observed that one patient in the TCA group had poor perfusion. Diagnostic laparoscopy was performed, and the cause of poor perfusion to the small segment of the distal colon was identified. Coloanal anastomosis was repeated, and the case was excluded as a per-protocol case. For the two ISR cases in the CAA-DST group, direct robotic dissection along the TME plane to the ISR space was performed. The double-stapled technique was used for anastomosis.

Three patients (one patient from the TCA group and two from the CAA-DST group) with stage IV rectal cancer underwent radical curative surgery. One patient in the CAA-DST group had a hepatic hilar mass that underwent concurrent excision during surgery, confirming lymph node metastasis. Another patient in the CAA-DST group had a rectal adenocarcinoma with bilateral lung metastases. The patient received preoperative short-course radiation therapy, followed by bevacizumab combined with a folfoxiri regimen. The bilateral lung metastases shrank, and the patient underwent surgery.

Preoperative radiotherapy (RT) was received by 14 patients. One patient had long-course RT. Seven patients received total neoadjuvant therapy (TNT), and six received concurrent chemotherapy (CRT). There were nine long-course and five short-course RTs. For

Table 2. Characteristics of preoperative and postoperative data

	CAA_DST (n = 20)	TCA (n = 11)
Clinical TNM		
T		
1	4 (20%)	1 (9.1%)
2	3 (15%)	0
3	13 (65%)	9 (81.8%)
4	0	1 (9.1%)
N		
0	6 (30%)	3 (27.3%)
1	5 (25%)	5 (45.4%)
2	9 (45%)	3 (27.3%)
M		
0	18 (90%)	10 (90.9%)
1	2 (10%)	1 (9.1%)
Preoperative treatment		
No treatment	13 (65%)	4 (36.4%)
CRT	2 (10%)	4 (36.4%)
RT only	1 (5%)	0
TNT	4 (20%)	3 (27.6%)
Surgical technique		
Laparoscopy	5 (25%)	9 (81.8%)
Robotic	15 (75%)	2 (18.2%)
Surgical pathology (TNM)		
T		
0	1 (5%)	1 (9.1%)
1	1 (5%)	0
2	8 (40%)	2 (18.2%)
3	10 (50%)	7 (63.6%)
4	0	1 (9.1%)
N		
0	9 (45%)	5 (45.5%)
1	8 (40%)	5 (45.5%)
2	3 (15%)	1 (9%)
Postoperative treatment		
No treatment	9 (45%)	7 (63.3%)
CRT	1 (5%)	0
Adjuvant CH only	8 (40%)	4 (36.4%)
RT only	1 (5%)	0
Target + CH	1 (5%)	0

Values are presented as quartiles Q2 (Q1-Q3), or patient numbers (percentages).
Abbreviations: CAA_DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; CRT, chemoradiation therapy; RT, radiotherapy; TNT, total neoadjuvant therapy; CH, chemotherapy; Target, targeted therapies.

cases involving TNT and CRT, our institute prioritized radiation as the initial treatment approach. After surgery, additional radiation was recommended for lymph node-positive patients if no preoperative radiation was administered. Overall, seven cases underwent additional radiation, including one patient with a large-cell neuroendocrine carcinoma, three patients will, and three elderly patients with poor health status.

Surgical morbidity was not significantly different between the two groups (Table 3). In the TCA group, the Clavien-Dindo IIIb case that was previously described underwent a redo coloanal anastomosis. Other surgical complications are listed in Table 4. There was one case of pelvic abscess in the TCA cohort, while the CAA-DST group had one pelvic infection and leakage. Antibiotics were administered for 25, 9, and 26 day, respectively. Both groups had one patient who experienced ileus and received TPN for 26 days in the TCA cohort, and 25 days in the CAA-DST cohort. No 30-day postoperative mortality was observed in either group.

There was no statistically significant difference in length of hospital stay between the two groups (Table 3). Furthermore, results of the statistical comparison did not show any significant difference in blood loss between the two groups ($p = 0.969$). The total blood loss in the two operations was 15 (IQR 10-31.3) cc in the CAA-DST group and 25 (IQR 12.5-25) milli-Liter (mL) in the TCA group. However, there was a statistically significant difference in the operation time between the two groups. The composite surgical time was 436 (IQR 380.5-511.8) minutes for CAA-DST

Table 3. Primary and secondary outcomes

Outcomes	PSM and GEE model			Regression model		
	CAA_DST (n = 20)	TCA (n = 11)	p^a	CAA_DST (ITT = 72, PP = 59)	TCA (ITT = 17, PP = 16)	p^b
Overall 30-d Postoperative morbidity						
1 step (event)	2	4	0.356	25	5	0.677
2 step (event)	0	N/A	N/A	2	N/A	N/A
Composite (ITT) (person)	2	3	0.132	17	4	0.994
1 step (PP) (event)				14	3	0.696
Composite (PP) (person)				12	3	0.911
30-d Postoperative morbidity ≥ Dindo IIIb						
Composite (person)	0	1	0.150	8	0	0.998
ITT (event)	0	1	0.150	11	1	0.327
PP (event)				5	0	0.999
Surgical time, median (IQR), min						
1 step	367.5 (319.5-417)	345 (278.5-362)	0.390	359 (300.5-429.8)	345 (266-375)	0.302
2 step	58 (43.5-88.5)	39 (31-49.5)	0.019	55.5 (49-82.5)	38 (30-44)	0.002[a]
Composite (ITT)	436 (380.5-511.8)	381 (315.5-429.5)	0.047	408 (355.3-493.3)	381 (307-435)	0.154
Composite (PP)				419.5 (367-513.5)	363.5 (304.3-426.8)	0.093
Hospital stay, median (IQR), d						
1 step	6 (6-7.3)	11 (10-14.5)	0.001	8 (6-9.3)	11 (10-13)	0.009
2 step	5 (4-5)	N/A	N/A	4 (4-5)	N/A	N/A
Composite (ITT)	11 (10-12.3)	11 (10-14.5)	0.285	11 (10-14)	11 (10-13)	0.762
Composite (PP)				11 (10-14)	11 (10-13)	0.553
1-y postoperative morbidity	1	4	0.150			

Values are presented as quartiles Q2 (Q1-Q3), or patient numbers.

Abbreviations: PSM, propensity score matching; CAA_DST, handsewn coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; ITT, intention-to-treat population; PP, per protocol population; IQR, interquartile range; [a], generalized estimating equations (GEE); [b], logistic/linear regression.

Table 4. Surgical complications according to the Clavien-Dindo Grading System

Grade	CAA_DST (n = 20)		TCA (n = 11)	
	Type (No.)	Treatment(s)	Type (No.)	Treatment(s)
I	Pelvic infection without frank anastomotic dehiscence	Re-admission, Antibiotics	Pelvis abscess without frank anastomotic dehiscence	Antibiotics
II			Ileus	TPN
			Ileus after redo coloanal anastomosis	TPN
	Leakage	Antibiotics		
III-b			Partial ischemic colostomy	Laparoscopic redo coloanal anastomosis

Abbreviations: CAA_DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; TPN, total parenteral nutrition.

and 381 (IQR 315.5-429.5) minutes for TCA. The interval between the first and secondary operations was 5 (IQR 4-5) days in the TCA group, and 3.2 (IQR 2.3-5.9) months in the CAA-DST group.

We also performed the regression analysis on the primary unmatching patient population (Fig. 2) for primary and secondary end point outcomes (Table 3). It comes to the same conclusion. There were no statistical significant of surgical morbidity, total surgical time, total hospital stay between two groups, whether for intention treatment or complete takedown enterostomy status

The 1-year morbidity rate, excluding the 30-day postoperative complications, was similar between the two groups (Table 5) ($p = 0.227$). Both groups had one incontinence case that required anti-diarrheal drugs for more than one year. One patient with a large-cell neuroendocrine carcinoma in the TCA group suffered from diarrhea-induced dehydration and required two admissions due to disease progression. Another patient in the TCA group developed anastomotic stenosis and required dilation under general anesthesia, 20 months post-surgery. The long-term anastomosis-specific complications are listed in Table 6.

Two patients in the TCA group required a redo permanent loop T-colostomy. In one case, the obstruction resulted from locally advanced recurrence, 11.6 months later. The other case was due to local recurrence with peritoneal carcinomatosis, 4.1 months later. The 1-year stoma free rate was 80.8% (95% confidence interval, 0.736 to 0.88) for TCA group. The Cox regression shows no significant different ($p = 0.108$). No metastases or deaths occurred in the

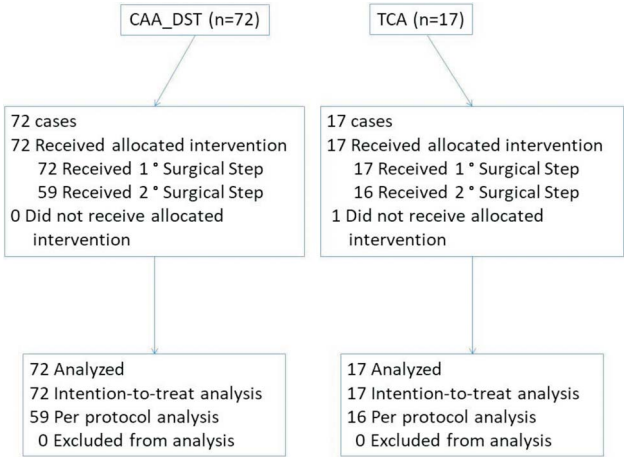

Fig.2. Flowchart of the patients primary (unmatching) population. CAA-DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, 2-stage Turnbull-Cutait pull-through anastomosis.

CAA-DST group. Two patients in the TCA group expired after 19.7 and 24.4 months due to cancer progression.

Discussion

This study aimed to investigate the safety of TCA in comparison to CAA-DST with diverting ileostomy. We observed no significant difference in the rate of short-term surgical complications between the two groups ($p = 0.356$). The interval between the initial and secondary procedures was 5 (IQR 4-5) days in the TCA group, and 3.2 (IQR 2.3-5.9) months in the CAA-DST group. The 1-year postoperative complications were comparable between groups ($p = 0.150$, Table 3).

Table 5. Long-term postoperative complications according to the Clavien-Dindo Grading System

Grade	Group	Months post-surgery	Type (No.)	Treatment(s)
I	TCA		Incontinence	Anti-diarrheal drugs
	CAA_DST		Incontinence	Anti-diarrheal drugs
II	TCA	2.2, 2.5	Large cell NEC, PD, Diarrhea induced dehydration	Hydration, PPN
III-b	TCA	20	Anastomosis stricture	Dilation

Abbreviations: CAA_DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; NEC, neuroendocrine carcinoma; PD, disease progression; PPN, partial parenteral nutrition.

Table 6. Anastomotic complications

	CAA_DST (n = 20)	TCA (n = 11)	*p*
Anastomotic stricture	0	1	0.091
Pelvis abscess/infection without frank anastomotic dehiscence	1	1	
Anastomotic leak	1	0	
Incontinence	1	1	
Return to OR within 30-d	0	0	
Return to OR long-term	0	1	
Permanent fecal diversion			
Permanent colostomy	0	2	
1-y stoma free rate %	100	80.8	0.108
Reason for permanent fecal diversion			
Rectal cancer local recurrence	0	1	
Cancer progression	0	1	

Abbreviations: CAA_DST, double-stapled coloanal anastomosis and diverting ileostomy; TCA, two-stage Turnbull-Cutait pull-through anastomosis; OR, operating room; CI, confidence interval.

The long-term anastomotic complications were also similar between groups ($p = 0.091$, Table 6).

In TCA, the postoperative care of the exteriorized colonic segment outside the anus necessitates keeping the colon moist. Initially, we used wet gauze soaked in 50% glucose water, which was changed every 2 hours, to cover the colonic segment. Patients were given total parenteral nutrition (TPN) and nothing per os (NPO). However, after gaining practical experience, we were able to prolong the frequency of changing the gauze soaked in 50% glucose water to 8-hour intervals. Similarly, patients were allowed a clear liquid diet, with partial parental nutritional (PPN) support.

Moreover, we were able to shorten the time interval between the two stages of the TCA procedure. Initially, the interval was approximately seven days, but it was reduced to approximately four days. A comparison was made between the four patients who underwent the secondary operation 4 days later, and the seven patients who had the operation over 5 days later. There were no statistically significant differences in surgical complications ($p = 0.658$). This suggests that the 8-12 suture stitches employed in the first TCA procedure for exteriorized colon fixation, and the 8-12 suture stitches in the secondary TCA procedure for coloanal anastomosis were sufficient to prevent anastomotic leakage. This finding shortens the length of hospital stay.

During the first operation, suture fixation may be another limitation of TCA. It is difficult to perform those sutures far away from the anus. We did not advise sacrificing more rectum segments of middle or upper cancer just for those sutures, as it would not align with oncological surgical principles. This indicates that TCA may be suitable for low rectal cancer only.

Following the initial TCA surgery, we did not observe any ischemia in the exteriorized colon segments. However, one patient in the TCA group had inadequate blood flow after the exteriorized colon segment was cut during the secondary procedure. Diagnostic laparoscopy and repeated ICG were performed. Slow

perfusion of ICG for more than 2 minutes was noted,[34,35] so we opted to redo the coloanal anastomosis using the hand-sewn method. This patient was not included in the complete TCA protocol. This 79 year male (BMI 25) experienced ileus during hospitalization. He developed local recurrence with obstruction and subsequently underwent a permanent loop T-colostomy, 1 year later.

In the literature, several key points are emphasized in executing the TCA. One of the most frequently mentioned points is the preservation of blood supply to the left colon, particularly the marginal artery, during splenic takedown.[36] Another important consideration is preventing the bulky mesocolon from being forced into the pelvic anal canal, which can induce the so-called "guillotine effect".[37] In this regard, the ICG test may be a practical tool for identifying areas with poor blood supply.[34,35] After this incident, the ICG test was implemented in the secondary TCA procedure.

With regard to anastomotic complications, the CAA-DST group had one case of leakage, and the TCA group had one patient with a pelvic abscess without frank anastomotic dehiscence. Both patients received antibiotics and prolonged Jackson-Prate drainage in situ without TPN therapy. Another patient presented with anal pain and was readmitted under the impression of anastomotic leakage. However, imaging failed to show any leakage, and the patient was treated with antibiotics accordingly. In the TCA cohort, one patient developed anastomotic stenosis that required dilation, 20 months later, under general anesthesia. Generally, the risk of stenosis is approximately 15%-23.5%.[5,38] Bianco et al. suggested an alternate method of early anal dilation, starting from 30 days after surgery and continuing until 6 months post-surgery.[37]

As our hospital did not have an anal function laboratory, there was no reliable anal function data.[19,38,39] Generally, literature reports a 27%-29% drop in anal function.[19,36,38] Bowel function stabilizes 2 years later.[19,38] Nevertheless, both groups in our study had one instance of stool seepage that necessitated anti-diarrheal drugs at every meal daily for 21 months in the TCA group and 24 months in the CAA-DST group.

Limitations

The major limitation of this study was the limited number of cases. However, we used PSM to correct for patient bias.

Conclusion

TCA may be a reliable option after TME based on its short-term outcomes. The surgical morbidity rates of TCA do not differ from that of CAA-DST. If the patient can overcome self-image issues and accept the physical ramifications of exteriorization, a temporary diverting stoma may be avoided. Shortening the surgical interval between exteriorization and coloanal anastomosis to 4 days may be acceptable based on surgical morbidity.

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Authors' Contributions

Dr. Jau-Jie You conceptualized and designed the study, designed the data collection instruments, collected data, carried out the initial analyses, drafted the initial manuscript, and revised the manuscript. Dr. Ming-Yin Shen conceptualized and designed the study, reviewed and revised the manuscript. Dr. William Tzu-Liang Chen reviewed and revised the manuscript. Dr. Yen-Chen Shao, Dr. Chu-Cheng Change and Dr. Yu-Hao Su collected data, reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Data Availability Statement

The datasets presented in this article are not re-

adily available because data release is not allowed by the China Medical University Hsinchu Hospital. Requests to access the datasets should be directed to Dr. Ming-Yin Shen/ mingyin.shen@gmail.com.

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Declaration of Competing Interest

All authors have no conflicts of interest to declare.

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原　著

比較兩階段式 Turnbull-Cutait 手縫結腸肛門吻合手術和雙重釘合結腸肛門吻合手術的短期結果：地區醫院經驗報告

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目的　兩階段式 Turnbull-Cutait pull-through hand-sewn coloanal anastomosis (TCA) 是一種舊技術，在直腸疾病的新應用。相較於全直腸系膜切除術 (TME) 後的結腸肛門吻合術 (CAA) 同時合併保護性迴腸造口，TCA 避免了迴腸造口相關併發症的優勢。然而，文獻上這種技術尚未與結腸肛門吻合雙重釘合技術 (CAA-DST) 進行比較。本研究的目的是比較 TCA 和 CAA-DST 的短期手術預後及結果。

方法　我們選擇在我們醫院從 2020 年 10 月到 2023 年 6 月，接受 TME 加 CAA-DST，以及接受 TME 加上 TCA 的患者。分析比較手術後 30 天和 1 年併發症和死亡率以及中長期吻合口併發症。我們在患者選擇上使用傾向性分數匹配來進行校正。匹配後，使用廣義估計方程和分層 Cox 回歸進行分析。

結果　本研究共納入 20 名 CAA-DST 患者和 11 名 TCA 患者。兩組患者均沒有手術後 30 內死亡案例。兩組患者的手術後 30 天內併發症和手術後 30 天內嚴重併發症沒有顯著差異 (p = 0.356, p = 0.150)。兩組患者各有一例沒有明顯吻合端滲漏的骨盆腔感染。但 CAA-DST 組有一名明顯吻合端滲漏患者。TCA 組則有一名肛門狹窄患者，且 20 個月後需要在全身麻醉下進行肛門狹窄擴張。在追蹤 35.6 個月後 (IQR 17.9-33.3)，吻合口相關併發症也沒有顯著差異 (p = 0.091)。再細分 TCA 於第 4 天，跟第 5 天之後關腸造口的病人，兩組患者的手術後 30 天內併發症沒有顯著差異 (p = 0.658)。

結論　相較於傳統的 CAA-DST 合併保護性迴腸造口，TCA 並不會增加術後併發症。我們另外發現 TCA 第二次關閉腸造口手術，在時間上還可以再縮短到第一次手術後 4 天執行，並不會增加併發症機率。

關鍵詞　Turnbull-Cutait 手術、大腸肛門吻合手術、雙重釘合技術、迴腸造口、腹腔鏡手術、機器手臂手術。