Retrospective Cohort Study

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Short-term and long-term outcomes of intracorporeal anastomosis in laparoscopic segmental left colectomy for splenic flexure cancer – a multicenter retrospective cohort study of 342 cases

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Introduction: While intracorporeal anastomosis (IA) has been widely used in totally laparoscopic right colectomy, its application in laparoscopic segmental left colectomy for splenic flexure cancer remains underexplored, particularly in large-scale studies with long-term outcomes. This research aims to assess the technical feasibility and oncological efficacy of IA in treating colonic splenic flexure carcinoma, drawing insights from both short-term and long-term outcomes of a retrospective cohort.

Materials and methods: A retrospective analysis was conducted on 342 patients diagnosed with colonic splenic flexure carcinoma in three Chinese medical centers. These patients underwent laparoscopic segmental left colectomy between December 2014 and December 2019 across three medical institutions. Comprehensive data encompassing demographics, disease features, pathological characteristics, operative details, and both short-term and long-term outcomes were gathered and scrutinized. Using propensity scores, each patient from the IA cohort was paired with a counterpart from the extracorporeal anastomosis (EA) cohort.

Results: IA was performed on 129 patients, while 213 underwent EA. Post-propensity score matching resulted in 129 matched pairs. After matching, many baseline characteristics were balanced. The IA cohort exhibited several advantages, including shorter incision lengths ($P < 0.001$) and more extensive proximal and distal resection margins ($P = 0.003$, $P < 0.001$). Additionally, the IA method facilitated a more rapid postoperative recovery as indicated by quicker return of bowel movements (resumption of passing flatus [2.7 (1.0–7.0) days vs. 3.3 (2.0–8.0) days, $P < 0.001$] and defecation [3.7 (1.0–9.0)] days vs. 4.5 (2.0–9.0) days, $P < 0.001$]), faster discharges [6.6 (3.0–15.0) days vs. 8.3 (5.0–20.0) days, $P < 0.001$], and decreased need for rescue analgesics ($P < 0.001$). The rate of postoperative complications, as rated by the Clavien–Dindo classification, remained consistent across both techniques ($P = 0.087$). Furthermore, the cosmetic outcome rated by Patient Scar Assessment Questionnaire and Scoring System (PSAQ) was markedly superior in the IA group ($P < 0.001$). Both approaches demonstrated equivalent 5-year overall (82.7% vs. 82.1%, $P = 0.419$) and disease-free survival (80.9% vs. 78.1%, $P = 0.476$). Subsequent stratification analysis revealed that IA achieved comparable 5-year overall (80.7% vs. 82.0%, $P = 0.647$) and disease-free survival (78.1% vs. 76.4%, $P = 0.734$) in patients with locally advanced colon cancer.

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The data derived from electronic medical record system in Cancer Hospital, Chinese Academy of Medical Sciences, Cancer Hospital and Shenzhen Hospital, Chinese Academy of Medical Sciences, and Peking University First Hospital. Due to the sensitive nature of the data in this study, information and data of the patients were assured raw data would remain confidential and would not be shared.

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Conclusion: Employing IA for laparoscopic segmental left colectomy in cases of splenic flexure carcinoma is not only safe but also offers enhanced cosmetic results and expedited postoperative recovery. Oncologically speaking, IA in left segmental colectomy for splenic flexure carcinoma can yield therapeutic outcomes comparable to those of EA, even in patients with locally advanced colon cancer.

Keywords: colonic splenic flexure carcinoma, laparoscopic segmental left colectomy, intracorporeal anastomosis

Introduction

The latest global cancer statistics from the World Health Organization (WHO) rank colorectal cancer as the third most prevalent malignancy and the second leading cause of cancer-related fatalities globally[1]. Since Jacobs' pioneering report on laparoscopic colectomy in 1991[2], the procedure has gained global acclaim, particularly for its reduced invasiveness and expedited postoperative recovery in comparison to laparotomy[3]. As surgical instruments have evolved and surgeons honed their expertise, there has been a growing inclination toward accomplishing digestive tract reconstruction intracorporeally. This approach allows for specimen extraction via a minimized abdominal incision, further reducing invasiveness. Another groundbreaking technology, robotic surgery, has overcome the kinematic limitations of laparoscopic procedures, making intracorporeal anastomosis (IA) more convenient. This has, in turn, further advanced the development of IA[4,5].

While IA for laparoscopic right colectomy has been validated by numerous retrospective and prospective studies for its superior cosmetic results (length of incision, mean difference (MD) – 1.38, 95% CI – 1.98 to – 0.78, $P < 0.00001$)[6], hastened bowel function return (MD – 0.71, 95% CI – 1.12 to – 0.31, $P = 0.0005$; MD – 0.53, 95% CI – 0.69 to – 0.37, $P < 0.00001$)[7–9], similar number of lymph nodes harvested (MD 0.40 95% CI – 1.63 to 2.43, $P = 0.70$)[7] and comparable oncological outcomes to conventional extracorporeal anastomosis (EA) (OS 66% vs. 78%, $P = 0.698$; 71% vs. 76%, $P > 0.05$)[10,11]. Most research on laparoscopic left colectomy with IA primarily focuses on short-term benefits. Studies assessing the oncological safety of this approach are scant and, when available, often have relatively brief follow-up periods. Furthermore, the safety of IA for all cases, especially those with locally advanced colon cancer (defined as T3 tumors that invade ≥ 5 mm beyond the muscularis propria, T4 tumors, or cases with extensive regional lymph node involvement, yet without distant metastases) remains undetermined. The present study aimed to evaluate short-term and long-term outcomes in patients who underwent laparoscopic segmental left colectomy with IA compared to those who underwent conventional laparoscopic segmental left colectomy with EA.

HIGHLIGHTS

- This is a retrospective study that compared short-term and long-term outcomes between laparoscopic left colectomy with intracorporeal anastomosis (IA) and conventional laparoscopic left colectomy with extracorporeal anastomosis (EA).
- Employing IA for laparoscopic left colectomy is not only safe but also offers enhanced cosmetic results and expedited postoperative recovery.
- Oncologically speaking, IA in left colectomy can yield therapeutic outcomes comparable to those of EA, even in patients with locally advanced colon cancer.

Materials and methods

Study population

Between December 2014 and December 2019, we conducted a retrospective analysis of 342 consecutive patients diagnosed with colonic splenic flexure carcinoma at three medical centers (Supplementary Table 1, Supplemental Digital Content 2, http://links.lww.com/JS9/B492). These patients had undergone laparoscopic segmental left colectomy. All operations were executed by surgeons who were proficient in both colorectal and minimally invasive surgeries, each having completed a minimum of 100 laparoscopic colectomies. All patients were presented with the choice of anastomotic modality. After a thorough discussion regarding the pros and cons of both techniques, those who opted for IA signed the informed consent, following which the surgeon proceeded with the IA procedure. Those who declined IA underwent the EA procedure. Of these, 129 patients underwent IA, while 213 received conventional EA. This study was approved by Ethics Committee and the reference number was 23/197-3939. This study has been registered at clinicaltrials.gov. The work has been reported in line with the STROCSS criteria[12], Supplemental Digital Content 1, http://links.lww.com/JS9/B491.

Inclusion criteria

(1) Carcinoma is situated in the distal third of the transverse colon, left colic angle, or the initial segment of the descending colon, within 10 cm from the anatomical flexure.
(2) Intention-to-treat was curative.
(3) Procedures were laparoscopically performed.

Exclusion criteria

(1) Patients with multiple primary colorectal cancers.
(2) Patients with complete bowel obstruction, perforation or intestinal bleeding requiring emergency surgery.
(3) Presence of distant metastases.
(4) Severe organ dysfunctions, notably severe cardiopulmonary disorders.

Data collection and analysis

Our analysis encompassed data across demographics, disease features, pathological characteristics, surgical details, and both short-term and long-term outcomes.

Demographics and disease features

This consisted of gender, age, BMI, preoperative CEA (carcinoembryonic antigen), and albumin levels, tumor location, and any prior abdominal surgeries.

Operative details

Parameters included tumor size, duration of the procedure, estimated blood loss, incision length, and the instances where laparoscopy was converted to open surgery.

Pathological characteristics

Data captured involved the TNM stage (based on AJCC's eighth edition guidelines), count of extracted lymph nodes, positive lymph node count, length of the removed colon segment, and both proximal and distal resection margins.

Short-term outcomes

These encompassed post-surgery analgesic requirements, intervals to initial flatus, first defecation, and first oral intake, as well as the duration of the postoperative hospital stay. Complications arising within a month post-surgery were categorized via the Clavien–Dindo classification. Cosmetic outcomes, particularly scar assessments, were evaluated using the Patient Scar Assessment Questionnaire and Scoring System (PSAQ)[13] – a 39-item instrument – 6 months post-surgery.

Long-term outcomes

These were defined by the occurrence of local tumor recurrence, distant metastasis, mortality, 5-year disease-free survival (DFS) rates, and 5-year overall survival (OS) rates.

Surgical procedures

Patient positioning and port placement

The patient was positioned in a modified lithotomy pose. A five-port approach was utilized.

Colonic mobilization and arterial management

All patients in this study underwent laparoscopic segmental splenic flexure resection. The left colonic artery and left branch of the middle colic artery were identified and ligated at their origins. Mobilization of the splenic flexure was achieved by dividing the gastrocolic and splenocolic ligaments. The transverse mesocolon was then separated from its attachments to the body and tail of the pancreas.

Extracorporeal anastomosis (EA) procedure

For patients in the EA group:

(1) A vertical periumbilical incision was made, and the bowel exteriorized using the laparotomy.
(2) The surgeon transected the transverse and sigmoid colons under direct visualization.
(3) Depending on the case specifics, mechanical side-to-side, end-to-side, or end-to-end anastomosis was performed.
(4) Subsequently, the bowel was repositioned into the abdominal cavity.

Intracorporeal anastomosis (IA) procedure

For patients in the IA group:

(1) The transverse and sigmoid colons were intracorporeally transected using an endoscopic linear stapler (Johnson & Johnson, models PSE60A and ECR60B).

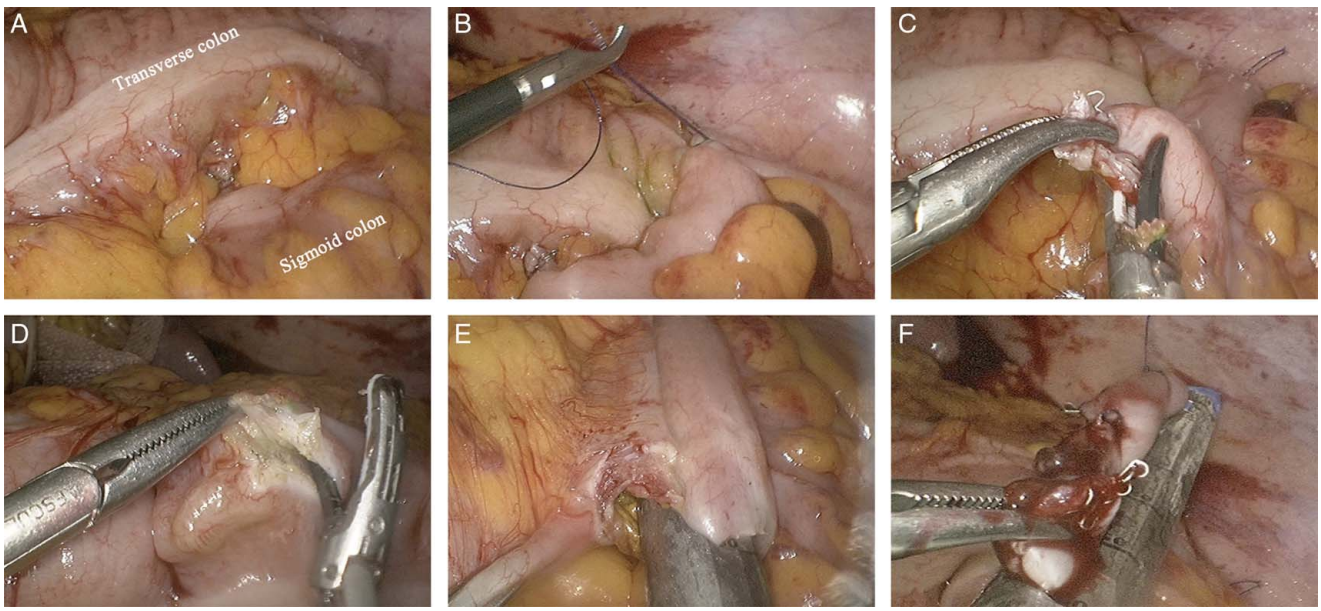

Figure 1. Procedures of intracorporeal side-to-side anastomosis. (A) The transected transverse colon and sigmoid colon were placed so that they overlapped by 7 cm in the opposite direction. (B) Fixed two ends of the colon by suturing. (C) A colotomy was made on the antimesenteric side of the sigmoid colon, at the edge of resection line. (D) Another colotomy was performed on the antimesenteric side of the transverse colon, at 7 cm proximal to the stump. (E) Two jaws of a stapler were inserted into the lumen. (F) The common enterotomy was closed.

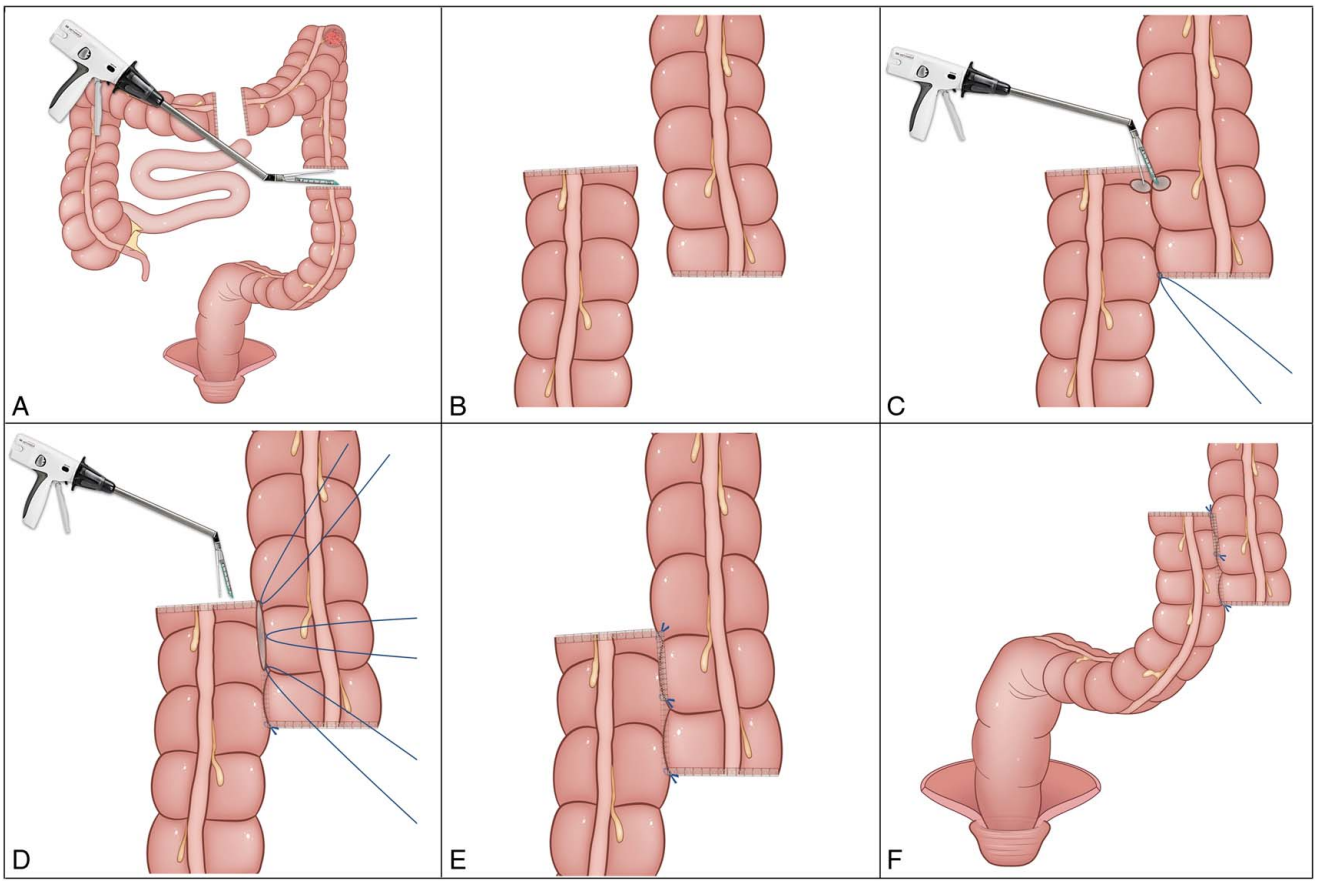

Figure 2. Schematic diagram of intracorporeal side-to-side anastomosis. (A) Transverse colon and sigmoid colon were transected by endoscopic liner staplers. (B) Two ends of the transected colon were placed so that they overlapped by 7 cm in the opposite direction. (C) Two jaws of a stapler were inserted into the lumen through colotomy. (D) The common enterotomy was closed. (E, F) Completing intracorporeal anastomosis.

(2) A sterile bag was introduced into the abdominal cavity via a trocar, with the specimen temporarily housed in the bag to prevent potential tumor dissemination.
(3) The transected sections of the transverse and sigmoid colons were overlapped by ~7 cm in opposing directions (refer to Figs 1A, 2A).
(4) For enhanced operative stability, both ends of the colon were sutured together (Figs 1B, 2B).
(5) A colotomy was executed on the antimesenteric side of both the sigmoid and transverse colons (refer to Figs 1C, 1D, respectively).
(6) Both jaws of the stapler were inserted into the colon lumens (Figs 1E, 2C). After firing and retracting the stapler, both sides of the resultant common enterotomy were sutured. With the aid of an assistant, they were elevated, and the enterotomy was sealed with an additional stapling action (Figs 1F, 2D), ensuring the back wall of the colon was not inadvertently stapled.
(7) The specimen was finally retrieved through a suprapubic transverse incision (Pfannenstiel incision).

Perioperative management

Uniform perioperative protocols were adhered to for all patients. All patients underwent mechanical bowel preparation within 24 h and received prophylactic antibiotics (intravenous moxalactam 2 g) within 2 h prior to surgery. Postoperative antibiotics were ceased within 48 h if patients exhibited no indications of infection following the surgery. Bowel recovery was gauged by the return of bowel sounds, passage of flatus, and defecation. Patients could commence oral intake within a day after the first postoperative passing of flatus. Postoperatively, on days 1 and 2, all patients were provided with patient-controlled analgesia. For breakthrough pain, non-steroidal anti-inflammatory drugs were utilized as rescue analgesics. Discharge criteria included an absence of complications, tolerance to a full diet (three meals a day), and confirmed bowel movements. At 30 days post-discharge, patients were contacted via phone to monitor their progress. Any adverse events transpiring within 30 days post-surgery were classified as surgical complications.

Postoperative surveillance

Patients underwent routine monitoring that included:
(1) Serum tumor markers level assessments.
(2) Computed tomography (CT) scans every 3 months for the initial 2 postoperative years, followed by biannual scans over the subsequent 3 years.
(3) Annual colonoscopy examinations.

Criteria for recurrence

Recurrence was determined by the detection of new tumorous growth in the surgical site, regional lymph nodes, surgical incision, or evidence of metastasis to distant organs (e.g. lungs, liver, brain) or within the peritoneal cavity.

Propensity score matching

To ensure comparable study groups, we applied propensity score matching (PSM) to select patients in a 1:1 ratio between the IA and EA groups. The propensity score for selecting IA versus EA was derived using a multivariable logistic regression model.

Given that tumor size can influence intraoperative metrics like operative time and incision length, it was equalized using PSM. Additionally, to maintain group homogeneity, four other variables – gender, age, BMI, presence of preoperative bowel obstruction and TNM stage – were incorporated into the regression model. Following this, each patient in the IA group was matched to a counterpart in the EA group using the nearest neighbor method, maintaining a match tolerance range of 0.02 for the aggregated propensity scores.

Statistical analysis

Continuous variables are presented as mean ± standard deviation and were assessed using Student's *t*-test. Categorical variables are denoted as percentages and were evaluated using Fisher's exact test or the chi-square (χ^2) test, depending on appropriateness. Survival outcomes were analyzed via the Kaplan–Meier method, and comparisons were drawn using the log-rank test. Statistical significance was determined by a *P*-value of less than 0.05. All statistical analyses were performed using SPSS software, version 25.0.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Utilizing the aforementioned algorithm, 129 patients who underwent IA were effectively paired with 129 patients who underwent EA. This ensured a balanced representation in terms of gender, age, BMI, TNM staging, and tumor size.

Table 1 presented the demographic and disease-specific data for both groups. There were no statistically significant disparities in age, gender, BMI, preoperative CEA, history of prior abdominal surgery or preoperative ileus either before or after the matching process.

The operative characteristics are detailed in Table 2. Post-PSM comparisons revealed that tumor sizes between the two groups were statistically comparable, measuring 3.8 (0.3–9.0) cm and 3.8 (0.4–9.5) cm, respectively ($P = 0.856$). After matching, the incision length was notably shorter in the IA group, averaging 5.6 (4.0–10.0) cm, compared to 6.8 (4.0–15.0) cm in the other group ($P < 0.001$). No significant difference was observed in operative duration and intraoperative blood loss between the two groups.

Table 2 delineated the pathological outcomes. In the IA group, the length of the resected colon was notably longer, measuring 21.7 (8.5–41.0) cm compared to 17.6 (7.0–35.0) cm in the other group ($P < 0.001$). Moreover, the IA approach resulted in a broader proximal resection margin, averaging 10.9 (3.0–28.0) cm versus 8.4 (3.0–28.2) cm ($P = 0.003$), and a more extended distal resection margin of 7.1 (1.5–21.0) cm in contrast to 5.6 (1.0–20.0) cm ($P < 0.001$). Nonetheless, there were no statistically significant differences between the two groups concerning the TNM stage, the number of harvested lymph nodes, or the number of positive lymph nodes.

In relation to postoperative recovery, as detailed in Table 3, patients in the IA group required fewer rescue analgesics, both before (6.9% vs. 18.8%, $P < 0.001$) and after PSM (7.1% vs. 17.8%, $P < 0.001$). Additionally, IA patients exhibited quicker resumption of passing flatus, taking 2.7 (1.0–7.0) days compared to 3.3 (2.0–8.0) days ($P < 0.001$) in the other group, and a faster return to defecation, with 3.7 (1.0–9.0) days against 4.5 (2.0–9.0) days ($P < 0.001$). Their postoperative length of stay was also shorter, averaging 6.6 (3.0–15.0) days in contrast to 8.3 (5.0–20.0) days ($P < 0.001$) in the comparator group.

Table 3 summarizes all postoperative complications classified according to the Clavien–Dindo system. Neither group recorded readmissions or deaths within 30 days post-discharge. In the EA group, two instances of anastomotic leakage necessitated reoperation. Post-surgery, two patients from the IA group and four from the EA group experienced cardiovascular events, but all showed improvement following intensive care unit (ICU) management. After PSM adjustment, the overall complication rate (20.9% vs. 30.2%, $P = 0.087$) and the rate of Grade III–V complications (3.1% vs. 4.6%, $P = 0.519$) proved statistically comparable between the two groups.

Table 1

Demographics and disease-related characteristics.

	Total cohort			Matched cohort		
	IA ($n = 129$)	EA ($n = 213$)	*P*	IA ($n = 129$)	EA ($n = 129$)	*P*
Gender			0.951			0.896
Male	84 (65.1%)	138 (64.8%)		84 (65.1%)	83 (64.3%)	
Female	45 (34.9%)	75 (35.2%)		45 (34.9%)	46 (35.7%)	
Age	56.7 (22.0–93.0)	56.4 (24.0–86.0)	0.770	56.7 (22.0–93.0)	57.4 (24.0–86.0)	0.848
BMI (kg/m²)	24.5 (16.7–38.4)	24.2 (16.6–36.1)	0.541	24.5 (16.7–38.4)	24.3 (16.6–33.6)	0.737
CEA (ng/ml)	15.4 (0.7–404.7)	9.2 (0.7–230.0)	0.234	15.4 (0.7–404.7)	8.4 (0.7–133.3)	0.131
Abdominal surgery history	23 (17.8%)	39 (18.3%)	0.911	23 (17.8%)	29 (22.5%)	0.352
Preoperative ileus	19 (15.4%)	32 (16.6%)	0.789	19 (15.4%)	20 (17.2%)	0.708

Values are presented as mean and range (min–max values) or numbers (%).

CEA, carcinoembryonic antigen; EA, extracorporeal anastomosis; IA, intracorporeal anastomosis.

Table 2

Operative and pathological characteristics.

	Total cohort			Matched cohort		
	IA ($n=129$)	EA ($n=213$)	*P*	IA ($n=129$)	EA ($n=129$)	*P*
Tumor size (cm)	3.8 (0.3–9.0)	4.4 (0.4-11.0)	0.003	3.8 (0.3–9.0)	3.8 (0.4–9.5)	0.856
Operative time (min)	182.7 (94.0–500.0)	186.0 (72.0–532.0)	0.657	182.7 (94.0–500.0)	182.6 (74.0–393.0)	0.926
Estimated blood loss (ml)	46.9 (10.0–450.0)	81.1 (5.0–2500.0)	0.002	46.9 (10.0–450.0)	59.0 (5.0–500.0)	0.129
Length of incision (cm)	5.6 (4.0–10.0)	7.0 (4.0–18.0)	< 0.001	5.6 (4.0–10.0)	6.8 (4.0–15.0)	< 0.001
TNM stage			0.160			0.863
I	22 (17.1%)	25(11.7%)		22 (17.1%)	20 (15.5%)	
II	46 (35.7%)	96 (45.1%)		46 (35.7%)	50 (38.8%)	
III	61 (47.3%)	92 (43.2%)		61 (47.3%)	59 (45.7%)	
Pathological subtype			0.455			0.554
Adenocarcinoma	122 (94.6%)	197 (92.5%)		122 (94.6%)	124 (96.1%)	
Mucinous adenocarcinoma /signet ring cell	7 (5.4%)	16 (7.5%)		7 (5.4%)	5 (3.9%)	
Differentiation			0.550			0.932
Poorly differentiated	15 (11.6%)	33 (15.5%)		15 (11.6%)	16 (12.4%)	
Moderately differentiated	109 (84.5%)	170 (79.8%)		109 (84.5%)	107 (82.9%)	
Well differentiated	5 (3.9%)	10 (2.9%)		5 (3.9%)	6 (4.7%)	
Harvested lymph nodes	22.6 (4.0–67.0)	22.4 (4.0–68.0)	0.435	22.6 (4.0–67.0)	21.2 (4.0–50.0)	0.100
Positive lymph nodes	1.8 (0.0–14.0)	1.8 (0.0–36.0)	0.307	1.8 (0.0–14.0)	2.0 (0.0–27.0)	0.809
Length of resected intestine (cm)	21.7 (8.5–41.0)	17.9 (7.0–38.0)	< 0.001	21.7 (8.5–41.0)	17.6 (7.0–35.0)	< 0.001
Proximal resection margin (cm)	10.9 (3.0–28.0)	8.2 (3.0–28.2)	< 0.001	10.9 (3.0–28.0)	8.4 (3.0–28.2)	0.003
Distal resection margin (cm)	7.1 (1.5–21.0)	5.7 (1.0–31.0)	< 0.001	7.1 (1.5–21.0)	5.6 (1.0–20.0)	< 0.001

Values are presented as mean and range (min–max values) or numbers (%).
EA, extracorporeal anastomosis; IA, intracorporeal anastomosis.

Results from the PSAQ questionnaire were presented in Table 4. In terms of both the total and global subscale scores, the median PSAQ score was significantly lower in the IA group: 39.3 (34–52) compared to 44.3 (35–98) [$P < 0.001$] and 6.9 (5–11) versus 8.2 (5–21) [$P < 0.001$], respectively. Notably, three subscales, namely appearance, symptoms, and satisfaction with

Table 3

Short-term outcomes.

		Total cohort			Matched cohort		
		IA ($n=129$)	EA ($n=213$)	*P*	IA ($n=129$)	EA ($n=129$)	*P*
Rescue analgesic usage		9 (6.9%)	40 (18.8%)	< 0.001	9 (6.9%)	23 (17.8%)	< 0.001
Reoperation		1 (0.8%)	2 (1.2%)	1.000	1 (0.8%)	1(1.2%)	1.000
Time to first flatus (d)		2.7 (1.0–7.0)	3.2 (2.0–8.0)	< 0.001	2.7 (1.0–7.0)	3.3 (2.0–8.0)	< 0.001
Time to first defecation (d)		3.7 (1.0–9.0)	4.5 (2.0–9.0)	< 0.001	3.7 (1.0–9.0)	4.5 (2.0–9.0)	< 0.001
Length of stay (d)		6.6 (3.0–15.0)	8.5 (5.0–30.0)	< 0.001	6.6 (3.0–15.0)	8.3 (5.0–20.0)	< 0.001
Readmission		0(0%)	0(0%)	1.00	0(0%)	0(0%)	1.00
Grade I		20 (15.5%)	42 (19.7%)		20 (15.5%)	29 (22.5%)	
Pain		7	18		7	13	
Fever		6	9		6	5	
Wound infection		1	7		1	6	
Nausea and vomit		6	8		6	5	
Grade II		3 (2.3%)	5 (2.3%)		3 (2.3%)	4 (3.1%)	
Blood transfusion		2	3		2	2	
Grade IIIa		2 (1.5%)	3 (1.4%)		2 (1.5%)	2 (1.5%)	
Abdominal infection		1	1		1	1	
Ileus		1	2		1	1	
Grade IIIb		0 (0%)	2 (0.9%)		0 (0%)	1 (0.8%)	
Anastomotic leakage		0	2		0	1	
Grade IV		2 (1.5%)	4 (1.9%)		2 (1.5%)	3 (2.3%)	
ICU management		2	4		2	3	
Grade V	Mortality	0 (0%)	0 (0%)		0 (0%)	0 (0%)	
Number of Grade I-II complications		23 (17.8%)	47 (22.1%)	0.347	23 (17.8%)	33 (25.6%)	0.131
Number of Grade III-IV complications		4 (3.1%)	9 (4.2%)	0.773	4 (3.1%)	6 (4.6%)	0.519
Total number of complications		27 (20.9%)	56 (26.3%)	0.262	27 (20.9%)	39 (30.2%)	0.087

Values are presented as mean and range (min–max values) or numbers (%).
EA, extracorporeal anastomosis; IA, intracorporeal anastomosis.

Table 4

Comparison of PSAQ responses of patients in IA group and EA group.

	Total subscale score			Global subscale score		
Subscale	IA group ($n=129$)	EA group ($n=129$)	*P*	IA group ($n=129$)	EA group ($n=129$)	*P*
Appearance	12.1 (9–20)	14.3 (10–27)	< 0.001	1.8 (1–4)	2.2 (1–5)	< 0.001
Symptoms	6.5 (6–11)	7.4 (6–16)	< 0.001	1.1 (1–3)	1.3 (1–4)	0.023
Scar consciousness	6.4 (5–9)	6.7 (6–14)	0.591	1.2 (1–3)	1.2 (1–4)	0.648
Satisfaction with appearance	8.7 (5–12)	9.9 (8–25)	0.025	1.4 (1–3)	2.0 (1–4)	< 0.001
Satisfaction with symptoms	5.4 (5–9)	5.9 (5–16)	0.179	1.4 (1–3)	1.5 (1–4)	0.254
Total	39.3 (34–52)	44.3 (35–98)	< 0.001	6.9 (5–11)	8.2 (5–21)	< 0.001

Values are presented as mean and range (min–max values).

EA, extracorporeal anastomosis; IA, intracorporeal anastomosis; PSAQ, Patient Scar Assessment Questionnaire and Scoring System.

appearance, were all significantly lower in the IA group. However, when evaluating scar consciousness and satisfaction with symptoms, there were no statistically significant differences between the IA and EA groups, both in the total subscale scores ($P=0.591$ and $P=0.179$) and global subscale scores ($P=0.648$ and $P=0.254$).

Table 5 detailed the long-term outcomes. The IA group had a median follow-up duration of 54.5 months, compared to 55.4 months in the EA group. Following PSM adjustment, 73 (56.5%) of the patients in the IA group and 78 (60.5%) in the EA group received adjuvant chemotherapy. The estimated 5-year DFS was 80.9% for the IA group versus 78.1% for the EA group (HR 0.82, 95% CI 0.48–1.41, $P=0.476$). Similarly, the OS rates were 82.7% and 82.1% for the IA and EA groups, respectively, demonstrating no significant difference between the two (HR 0.78, 95% CI 0.42–1.43, $P=0.419$) (Fig. 3A, B).

A total of 295 patients diagnosed with locally advanced disease were selectively chosen for further analysis. The oncological outcome-related factors, such as gender, age, TNM stage, T stage, N stage, pathological subtype, differentiation, and the rates of neoadjuvant and adjuvant chemotherapy uptake, were comparable between the IA and EA groups (Supplementary Table 2, Supplemental Digital Content 3, http://links.lww.com/JS9/B493). No significant differences in DFS (HR 0.92, 95% CI 0.56–1.51, $P=0.734$) and OS (HR 0.88, 95% CI 0.51–1.53, $P=0.647$) were observed between the two groups (Fig. 3C, D).

Discussion

With the evolution of laparoscopic techniques and the continuous drive toward minimally invasive surgery, a less traumatic surgical procedure for the treatment of colorectal cancer has gained attention: totally laparoscopic colectomy with IA. However, compared with the more straightforward EA, performed under direct vision, IA presents increased technical challenges and intricacies. With the emergence of robotics, which mitigates the kinematic limitations inherent in laparoscopic procedures and offers superior dexterity and precision through robotic instruments, intricate procedures like IA have become more accessible. This technological leap has not only made IA more practicable but has also catalyzed its progressive evolution in the medical field.

While total laparoscopic right colectomy with IA has been well documented by several centers, including ours[7,8], the focus has largely been on its technical feasibility and short-term outcomes. Advantages of IA for right colon cancer, when compared to EA, include faster bowel movement recovery and superior cosmetic results.

Interestingly, according to the SEER (Surveillance, Epidemiology, and End Results) database, left colon cancer incidence is notably lower than that of right colon cancer[14]. This difference extends to the process of anastomosis as well. The ileocolon anastomosis, usually associated with right colectomies, often has minimal tension due to the mobility of the ileum. In contrast, the transverse-sigmoid anastomosis in left colectomies

Table 5

Long-term outcomes.

	IA ($n=129$)	EA ($n=213$)	*P*	IA ($n=129$)	EA ($n=129$)	*P*
Receive adjuvant therapy	73 (56.5%)	127 (59.6%)	0.581	73 (56.5%)	78 (60.5%)	0.527
Local recurrence	4 (3.1%)	6 (2.8%)	1.000	4 (3.1%)	3 (2.3%)	1.000
Distant metastasis	20 (15.5%)	39 (18.3%)	0.506	20 (15.5%)	25 (19.4%)	0.412
Liver	12	27		12	14	
Lung	6	13		6	7	
Non-regional lymph nodes	3	7		3	4	
Peritoneal	2	8		2	5	
Bones	1	2		1	1	
Brain	1	2		1	1	
Death	18 (14.0%)	39 (18.3%)	0.673	18 (14.0%)	23 (17.8%)	0.634
5-year DFS rate	82.7%	78.7%	0.576	82.7%	78.1%	0.476
5-year OS rate	80.9%	83.6%.	0.424	80.9%	82.1%	0.419

Values are presented as numbers (%).

DFS, disease-free survival; EA, extracorporeal anastomosis; IA, intracorporeal anastomosis; OS, overall survival.

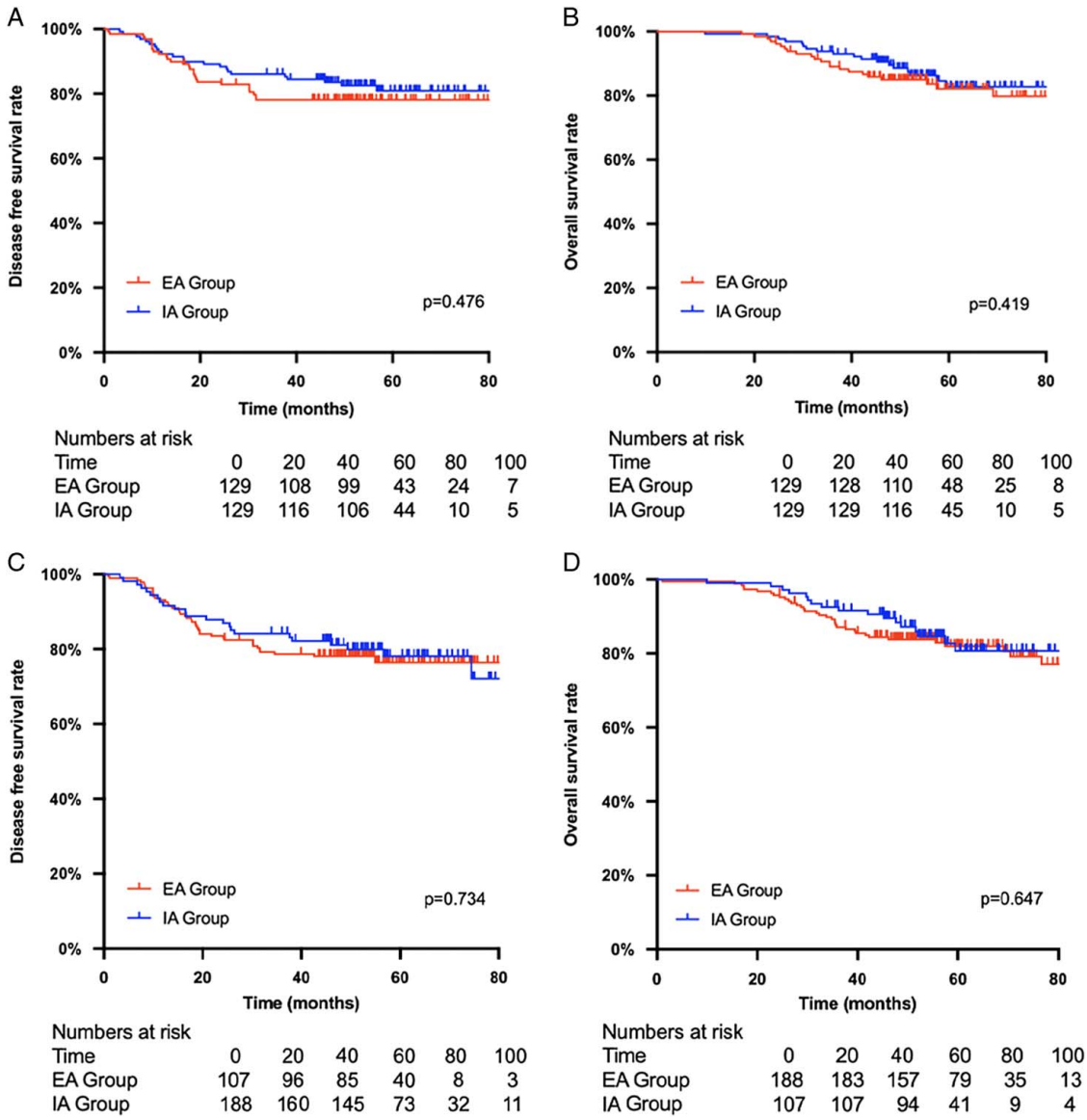

Figure 3. Kaplan–Meier survival curve for patients after propensity score matching (PSM) adjustment and patients with locally advanced colon cancer. (A) Disease-free survival for patients after PSM adjustment. (B) Overall survival for patients after PSM adjustment. (C) Disease-free survival for patients with locally advanced colon cancer. (D) Overall survival for patients with locally advanced colon cancer. EA, extracorporeal anastomosis; IA, intracorporeal anastomosis.

demands a more extensive mobilization of the colon to reduce tension. This makes IA for left hemicolectomy inherently more challenging than its right-sided counterpart.

While the technical feasibility and short-term benefits of totally laparoscopic left hemicolectomy with IA have been widely acknowledged[15–20], there remains a gap in the literature regarding its oncological outcomes. Most existing studies only provide mid-term survival data, with a maximum follow-up of 2 years[21]. Our study aims to bridge this gap by not only evaluating postoperative short-term parameters but also incorporating long-term follow-up data, offering a more comprehensive assessment of the safety and efficacy of this technique.

Regarding preoperative preparation, all patients in this study uniformly received mechanical bowel preparation and intravenous antibiotics. The efficacy of preoperative mechanical bowel preparation in reducing postoperative complications following colorectal surgeries remains a topic of debate[22,23]. Some Western countries lean toward forgoing preoperative mechanical bowel preparation and antibiotics, instead adopting the ERAS (Enhanced Recovery After Surgery) protocol to expedite postoperative gastrointestinal function recovery[23]. In contrast, in China, the majority of physicians lean toward a more cautious and conservative preoperative approach, integrating mechanical bowel preparation with intravenous/oral antibiotics[24]. Given that the digestive tract reconstruction in IA is completed intracorporeally, both IA and EA groups in our study underwent preoperative mechanical bowel preparation and received intravenous antibiotics. This not only reduced the bacterial load and stool burden within the intestine but also minimized potential biases arising from differing preoperative preparation methods.

In line with findings from Scatizzi and Hamamoto's studies[25,26], we observed that both the length of the resected

specimen and the resection margin were greater in the IA group. When performing EA, the colon must be removed from the abdominal cavity. This necessitates reserving some colon length to aid in exteriorization, which can limit the resected colon's length and resection margin. For individuals with larger tumors or a naturally shorter left colon, an intracorporeal approach might be more suitable. It has the potential to ensure a safer resection margin and diminish the risk of residual colon ischemia.

IA might offer potential advantages for obese patients. Given the anatomical positioning of the transverse mesocolon, centrally situated and not easily exteriorized, EA becomes particularly challenging for obese patients who present with thicker subcutaneous abdominal fat and relatively shorter, fat-laden mesentery. Opting for IA minimizes the potential risks associated with mesenteric tearing and hemorrhage, thereby promoting quicker bowel recovery and reducing surgical trauma.

Another benefit of the IA method is its less invasive and more discreet skin incision. This results in reduced reliance on rescue analgesics and a superior cosmetic outcome. Given the central and short position of the transverse mesocolon, incisions in the EA group often need to be near the anastomotic site. However, utilizing intracorporeal IA provides surgeons with more flexibility in choosing the specimen extraction site, such as the Pfannenstiel, rectum, or vagina[27–29]. In our study, we utilized Pfannenstiel incision for the IA group. This approach not only offers an enhanced cosmetic result, with most of the incision being concealed by the pubic hair but also demonstrates a notably low rate of incisional hernia, ranging between 0 and 2%[30–33].

Multiple studies have indicated that laparoscopic colectomy with IA can expedite postoperative bowel recovery, irrespective of tumor location[6–11,13,14]. Our findings align with these observations. The quicker recovery could be attributed to diminished direct bowel manipulation and mesenteric traction during IA[8,34]. Furthermore, the incidence of short-term complications was comparable between the two groups.

The oncological safety of a surgical technique stands as a primary concern. Achieving optimal oncological results necessitates thorough lymph node harvesting, maintaining adequate resection margins, and guaranteeing tumor-free interventions. The methodologies used for mesenteric dissection and vascular ligation in the IA group closely mirrored those of the EA group, adhering rigorously to the complete mesocolic excision (CME) principle. Importantly, the choice of digestive tract reconstruction did not impact the count of harvested lymph nodes. As our study demonstrated, lymph node retrieval was statistically similar between the groups. While we have already discussed resection margins, it is noteworthy that IA provides a more secure margin. In terms of ensuring a tumor-free procedure, IA does not heighten the risk of inadvertently touching or compressing the tumor compared to EA. To mitigate the risk of tumor dissemination, resected specimens were enclosed in a protective sleeve and then extracted through an abdominal incision along with the sleeve. The survival data from our research further attests to the oncological safety of IA in the treatment of colonic flexure carcinoma, even in locally advanced cases.

The study has some limitations. Firstly, being a retrospective analysis, patients were not grouped randomly. Even though we employed PSM to equilibrate the baseline data, some latent confounding factors might remain unaddressed. Secondly, the sample size in the IA group is relatively small, limiting its statistical power to an extent. Lastly, we did not obtain quality of life scores preoperatively and postoperatively, thus potentially missing out on a comprehensive assessment of the impact of this technique on patient recovery and overall well-being. A randomized controlled trial is essential to determine whether IA should be the benchmark approach for treating left colon cancer.

Conclusion

According to our study, laparoscopic segmental left colectomy for splenic flexure carcinoma is both technically safe and feasible. Patients undergoing this procedure can benefit from broader resection margins, enhanced cosmetic results, and expedited postoperative recovery. From an oncological perspective, laparoscopic segmental left colectomy employing IA yields long-term results comparable to those achieved with the traditional EA approach, even for locally advanced tumors.

Ethical approval

There are no potential conflicts of interest. This study involved human participants and was approved by the Ethics Committee of the National Cancer Center/Cancer Hospital, Chinese Academy of Medical Sciences, and Peking Union Medical College. This study complies with the Declaration of Helsinki. All the participating patients signed informed consent. The relevant judgment's reference number is 23/197-3939.

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Author contribution

X.W., M.Z., S.D., J.T., Y.C.: conceptualization; M.Z. and S.D.: data curation; M.Z., S.D., J.T., and X.W.: formal analysis; M.Z., Q.L., and X.W.: funding acquisition; M.Z., S.D., L.W., Z.L., and H.Z.: investigation; M.Z., S.D., and L.W.: methodology; Q.L., J.T., Y.C., and X.W.: project administration; L.W., Z.L., H.Z., Q.L., J.T., Y.C., and X.W.: resources; M.Z. and S.D.: software; J.T., Y.C., and X.W.: supervision; M.Z., S.D., J.T., Y.C., and X.W.: validation; M.Z. and S.D.: visualization; M.Z. and X.W.: writing – original draft; X.W., M.Z., S.D., J.T., and Y.C.: writing – review and editing.

Conflicts of interest disclosure

Mingguang Zhang, Shuohui Dong, Liming Wang, Zheng Liu, Haitao Zhou, Qian Liu, Yinggang Chen, Jianqiang Tang, and Xishan Wang have no conflicts of interest or financial ties to disclose.

Research registration unique identifying number (UIN)

1. Name of the registry: Clinicaltrials.
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Guarantor

Xishan Wang.

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