ORIGINAL ARTICLE

Intra-corporeal delta-shaped anastomosis in laparoscopic right hemicolectomy for right colon cancer: a safe and effective technique

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Abstract

Background and objective: Intra-corporeal delta-shaped anastomosis (IDA) is an important development in laparoscopic digestive-tract reconstruction. We applied it in laparoscopic right hemicolectomy for right colon cancer and compared the short-term outcomes between the patients treated with IDA and conventional extracorporeal anastomosis (EA).
Methods: Between 1 January 2016 and 1 October 2017, 36 and 50 patients who underwent IDA and EA, respectively, were included. Data on clinicopathological characteristics, surgical outcomes, post-operative recovery and complications were collected and compared between the two groups.
Results: Surgical outcomes and clinicopathological characteristics were similar between the two groups except the length of incision, which was significantly shorter in the IDA group than in the EA group (4.6 ± 0.6 vs 5.6 ± 0.7 cm, $P < 0.001$). The time to ground activities, fluid diet intake and post-operative hospitalization did not differ between the groups; however, the time to first flatus was significantly shorter in the IDA group than in the EA group (2.8 ± 0.5 vs 3.2 ± 0.8 days, $P = 0.004$). The post-operative visual analogue scale for pain was lower in the IDA group than in the EA group on post-operative Day 1 (4.0 ± 0.7 vs 4.5 ± 1.0, $P = 0.002$) and post-operative Day 3 (2.7 ± 0.6 vs 3.4 ± 0.6, $P < 0.001$). The surgical complication rates were 8.3 and 16.0% in the IDA and EA groups ($P = 0.470$), respectively. No complications such as anastomotic bleeding, stenosis and leakage occurred in any patient.
Conclusions: IDA is safe and feasible and shows more satisfactory short-term outcomes than EA.

Key words: Colon cancer; delta-shaped anastomosis; intra-corporeal anastomosis; digestive-tract reconstruction; laparoscopic right hemicolectomy

Introduction

Colorectal cancer (CRC) has increased rapidly and has become the fifth most commonly diagnosed cancer among men and the fourth among women in China [1]. Surgery remains the standard treatment for colorectal cancer with curative intent. The clinical application of laparoscopic surgery has been more widespread than open surgery because of its advantages such as less injury, earlier post-operative recovery, lower complication rates and comparable oncological outcomes than open surgery [2, 3]. For right colon cancer, the conventional surgical procedure is laparoscopic-assisted right hemicolectomy with extracorporeal anastomosis (EA) through assisted incision.

The performance of the totally laparoscopic treatment for right colon cancer with intra-corporeal anastomosis (IA) has been described in several studies and is less invasive than EA [4–10]. Intra-corporeal delta-shaped anastomosis (IDA) is an important development in laparoscopic digestive-tract reconstruction; it was originally named as laparoscopic distal gastrectomy by Kanaya *et al.* [11] in 2002. It is performed intra-corporeally by forming a side-to-side gastroduodenostomy using only laparoscopic linear staplers. The safety and clinical success of this specific operation have been further improved because of the increase in practical experience and better equipment [12, 13]. We applied this anastomosis procedure in the laparoscopic treatment of right colon cancer. In this study, we compared the short-term outcomes of IDA with EA in patients undergoing laparoscopic right hemicolectomy in order to explore the safety and feasibility of IDA.

Materials and methods

Patients

Consecutive patients diagnosed with right colon cancer and underwent laparoscopic right hemicolectomy by a single surgeon in Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College (Beijing, China) between 1 January 2016 and 1 October 2017 were included and their clinicopathological characteristics were analysed retrospectively in this study. Inclusion criteria included (i) 18–80 years of age at diagnosis, (ii) body mass index (BMI) between 18.5 and 30 kg/m^2, (iii) a pathological diagnosis of colon adenocarcinoma by colonoscopy and (iv) no distant metastasis shown on the chest and abdominal computer tomography (CT) images. Exclusion criteria were as follows: (i) multiple colorectal primary carcinomas; (ii) uncontrolled diabetes mellitus, immune-system diseases and hematological diseases and (iii) severe intestinal obstruction.

In the latter half of 2016, our group changed principle of operation: prefer to perform an IDA rather than an EA if possible. In the first month, two anastomoses were performed and, thereafter, the IDA was performed in all patients except five patients in which the EA was performed because a larger incision was required for extraction of the specimen. The patients were divided into two groups according to the surgical technique used to perform ileocolic anastomosis: the IDA group and the EA group. Each patient gave consent for surgery and the study was conducted in accordance to the principles of the Declaration of Helsinki. The protocol was approved by the Ethical Committee of the Cancer Hospital (Institute), Chinese Academy of Medical Science, Beijing, China (Approval Number NCC2017WJP-002).

Surgical procedures

Under general anesthesia, all patients were placed in a supine lithotomy position with a 15° tilt toward the left and with the head bent downward. The surgeon stood on the left side of the patient and the first assistant stood on the right side while the second assistant controlling the telescope stood in between the patient's legs. A five-port technique was used: a 12-mm sub-umbilical port as the observation port, a 12-mm port located in the left upper quadrant as the primary operating port and three 5-mm ports located in the left lower quadrant, the right lower quadrant and the right upper quadrant, respectively, as the secondary operating ports. The ileum, the cecum and the right colon were mobilized from their retroperitoneal attachments according to the principle of complete mesocolic excision (CME). Related vessels were isolated and double ligated using the laparoscopic blunt-tip vessel sealer or divider. D3 lymph node (LN) dissection was performed in all patients.

For the IDA group, the ileum was transected using a 60-mm endoscopic linear stapler approximately 15 cm from the ileocecal junction (Figure 1A). The colon was then transected with another 60-mm linear stapler approximately 10 cm from the tumor (Figure 1B). The resected specimen was collected and immediately stored in a specimen bag. The remaining intestines were evaluated to ensure that they were closed and not tense. Two small incisions (10 mm) were made along the curvature of the two broken ends of the intestines at the anti-mesenteric side (Figure 1C). After confirming that there was no bleeding or intestinal mesentery volvulus, the intestinal walls of the two broken ends of the intestines at the anti-mesenteric side were approximated and connected using a 60-mm linear stapler (Figure 1D). The enterocolostomy was closed using another 60-mm linear stapler (Figure 1E). If there was staple-line bleeding, the staple lines were reinforced by interrupted absorbable sutures. The digestive tract was reconstructed and then the staple line in the anastomotic stoma appeared as a curving obtuse triangle (Figure 1F). The major procedures are shown in Figure 2 as cartoon illustrations. The specimen was removed from the area of the Pfannenstiel incision, which was made 2–3 cm above the symphysis pubis at the border of the pubic hair. The peritoneal cavity was lavaged and the incision was closed.

For the EA group, a periumbilical midline incision was made around the left side of the umbilicus after proper mobilization. The colon from the terminal ileum to the mid transverse colon was exteriorized through the incision and ileocolic anastomosis was performed extra-corporeally by manual suturing or by linear-staples completion (the staple lines were routinely reinforced using continuous absorbable sutures). The anastomosis was placed back into the peritoneal cavity and then the peritoneal cavity was lavaged and the incision was closed.

Perioperative management

From 2 p.m. to 6 p.m. on the day before surgery, 70 mg of polyethylene glycol macrogol per 1 L of water was given to all patients four times (1 L each hour). Prophylactic antibiotics were administered by intravenous drip at 30 min pre-operatively and on the first day post-operatively. All patients were given non-steroid anti-inflammatory drugs intravenously using patient-controlled analgesia (PCA). Fluid diet was given to patients the next morning after first flatus.
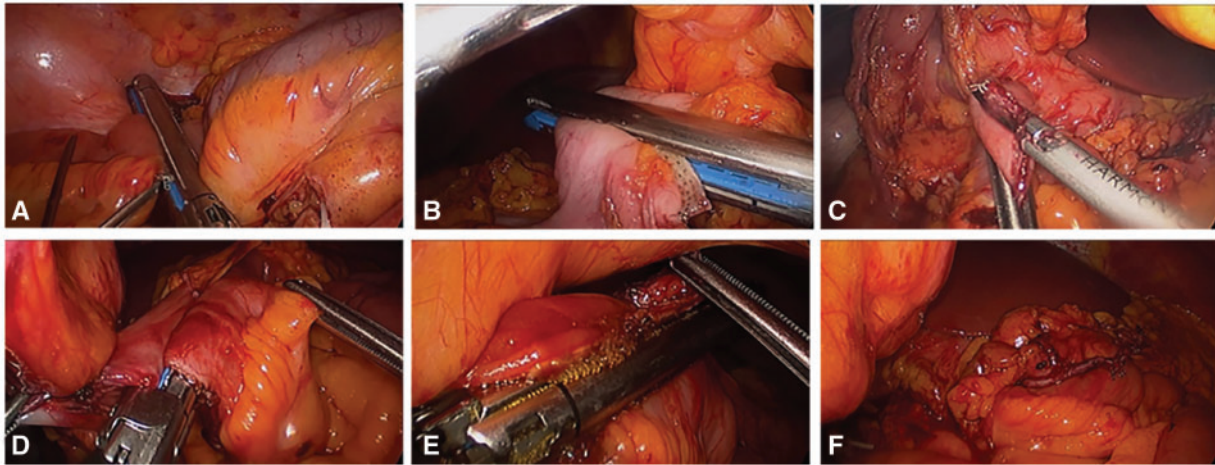
Figure 1. The surgical procedures of intra-corporeal delta-shaped anastomosis (IDA) in total laparoscopic right hemicolectomy. **(A)** The ileum is transected with one linear stapler; **(B)** the colon is transected with another linear stapler; **(C)** two small incisions are made along the curvature of the two broken ends of the intestines; **(D)** the two broken ends of the intestines are approximated and joined; **(E)** the enterocolotomy is closed with one linear stapler; and **(F)** digestive-tract reconstruction under total laparoscopy is completed.
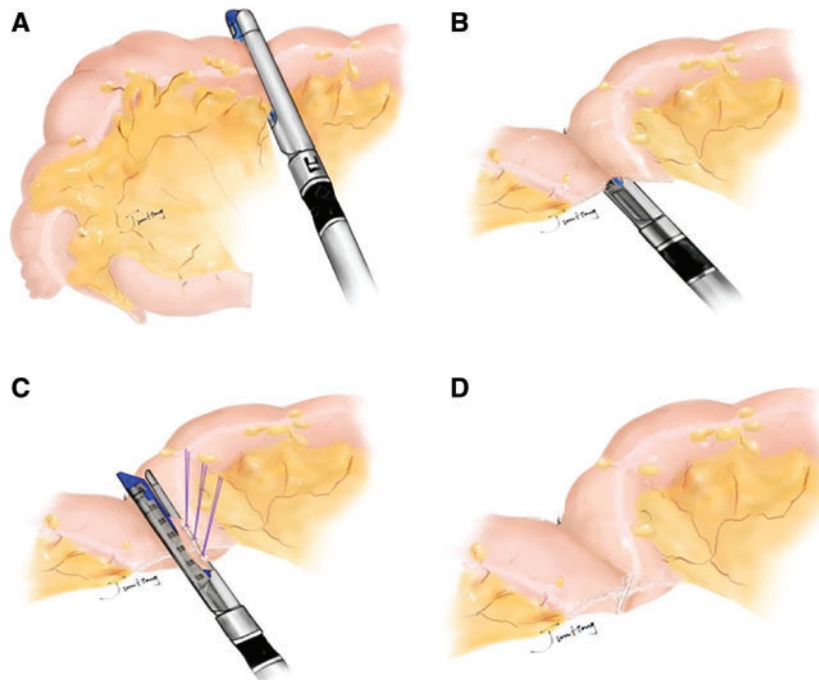

Figure 2. The major procedures of IDA in cartoon illustrations. **(A)** Transection of colon; **(B)** combining the two broken ends of the intestines; **(C)** closing of enterocolotomy; and **(D)** completion of IDA.

Evaluation

Clinical characteristics such as age, sex, BMI, the American Society of Anesthesiologists (ASA) score and previous abdominal operation history were analysed. Surgical outcomes and pathological characteristics included operative time, blood loss, anastomosis time, length of incision, proximal and distal-resection margins, number of harvested LNs, pathological TNM stage and tumor differentiation degree. Post-operative recovery and post-operative complications were also observed. Factors associated with post-operative recovery included average time to ground activities, time to flatus, time to fluid diet intake,

post-operative hospitalization and post-operative visual analogue scale (VAS). VAS was recorded on post-operative Days 1, 3 and 5 (POD1, POD3, POD5) to estimate the severity of pain after surgery. Short-term post-operative complications included anastomotic bleeding, anastomotic stenosis, anastomotic leakage, abdominal infection, pulmonary infection, incisional infection, incisional hernia and bowel obstruction.

The first day after surgery was the beginning of the follow-up period. The patients were routinely followed up at outpatient clinics 2 weeks after discharge and every 3 months after the operation. The end of the follow-up period was 20 November 2017.

Table 1. Comparison of general data between IDA and EA groups

Characteristic	IDA group (n = 36)	EA group (n = 50)	P-value
Age, mean ± SD (years)	61.1 ± 10.3	62.9 ± 11.0	0.442
Gender, n (%)			0.401
Male	22 (61.1)	26 (52.0)	
Female	14 (38.9)	24 (48.0)	
BMI, mean ± SD (kg/m²)	24.1 ± 3.3	24.2 ± 3.4	0.858
ASA score, n (%)			0.916
1	20 (55.6)	30 (60.0)	
2	11 (30.6)	14 (28.0)	
3	5 (13.8)	6 (12.0)	
Previous abdominal operation, n (%)			0.370
No	27 (75.0)	33 (66.0)	
Yes	9 (25.0)	17 (34.0)	

IDA, intra-corporeal delta-shaped anastomosis; EA, extracorporeal anastomosis; SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiology.

Statistical analysis

Statistical analysis was performed using SPSS software, version 19.0 for Windows (SPSS Inc., Chicago, IL, USA). Quantitative variables were given mean and standard deviations and were compared using Student's t-test, and qualitative variables were compared using χ^2 test. A P-value of less than 0.05 was considered statistically significant.

Results

General data

A total of 86 patients were included in the study: 36 patients in the IDA group and 50 patients in the EA group. Table 1 shows no differences in age, sex, BMI, ASA score and previous abdominal operation history between the two groups.

Surgical and pathological findings

The operative and pathological details are presented in Table 2. All patients underwent laparoscopic right hemicolectomy and there was no open conversion. There was no severe intra-operative spillage in all patients due to adequate pre-operative bowel preparation and careful patient selection. The operation time, anastomosis time and intra-operative blood loss were similar between the two groups. Routine continuous absorbable sutures reinforced all anastomotic stomas in the EA group. Interrupted absorbable sutures reinforced 18 anastomotic stomas in the IDA group because of staple-line bleeding. The length of incision was significantly shorter in the IDA group than in the EA group (4.6 ± 0.6 vs 5.6 ± 0.7 cm, $P < 0.001$).

There was no difference in the length of proximal-resection margin and distal-resection margin between the two groups. All patients underwent D3 LN dissection. The number of LNs retrieved was 21.8 ± 7.8 and 23.0 ± 9.7 per patient in the IDA group and EA group, respectively. There were no significant differences in tumor TNM staging and degree of differentiation between the two groups.

Post-operative recovery and complications

Table 3 shows that the times to ground activities, fluid diet intake and the post-operative hospitalization were similar between the two groups. The time to first flatus was significantly shorter in the IDA group than in the EA group (2.8 ± 0.5 vs 3.2 ± 0.8 days, $P = 0.004$). Moreover, the post-operative VAS was lower in the IDA group than in the EA group on post-operative day (POD) 1 (4.0 ± 0.7 vs 4.5 ± 1.0, $P = 0.002$) and POD 3 (2.7 ± 0.6 vs 3.4 ± 0.6, $P < 0.001$) but was similar to that in the EA group on POD 5 (0.7 ± 0.6 vs 0.7 ± 0.7, $P = 0.608$).

The overall rate of complications was comparable between two groups with no significant difference (Table 3). No complications related to the anastomosis, such as anastomotic bleeding, stenosis and leakage, occurred in any patient. The most common complication was incisional infection in both groups and three patients suffered pulmonary infection due to age and smoking history. There was one patient who suffered bowel obstruction in the EA group on the 14th day after surgery and was managed effectively with nasointestinal tube decompression. The mean follow-up period for the 86 enrolled patients was 8.2 ± 5.1 months. No patient was lost to follow-up and no cases experienced recurrence during the follow-up period. All complications were resolved successfully.

Discussion

We applied the IDA technique in laparoscopic right hemicolectomy and compared its short-term effect with that of EA. Some authors worry about the technical difficulty and long operation times because of the anastomosis [14]. However, IDA had a comparable operation time and anastomosis time with EA in the present study. We think IDA is not a time-consuming procedure as compared with EA and it does not affect the total operation time, especially for experienced surgeons. There was no difference in the blood loss between the IDA and EA groups, which is one of the most important evaluation parameters.

The transection and anastomosis do not need to be performed extra-corporeally for IDA, so only a small portion of the intestines is required to be freed laparoscopically. The length of incision was shorter in the IDA group than in the EA group ($P < 0.001$); however, we think the difference of 1 cm in length is not very significant clinically. Additionally, this technique of anastomosis does not limit the location of the incision; hence, we can apply the Pfannenstiel incision in patients in the IDA group, since it is less invasive, has better cosmesis and decreases the incidence of incisional hernia [15, 16]. Above all, it is associated with less post-operative pain. In our study, the post-operative VAS was lower in the IDA group than in the EA group on POD 1 ($P = 0.002$) and POD 3 ($P < 0.001$).

For post-operative recovery, the time to ground activities, time to fluid diet intake and post-operative hospitalization did not differ between the IDA and EA groups. The time to first flatus was significantly shorter in the IDA group than in the EA group ($P = 0.004$). We attributed this to less injury and post-operative pain in patients who underwent IDA. The surgical complication rates were also comparable between the two groups. The main difference between IDA and EA is the anastomotic technique; complications related to the anastomosis were the main concerns of our study. It is fortunate that no complications related to the anastomosis, such as anastomotic bleeding, stenosis and leakage, occurred in any patients. We did not routinely reinforce the anastomotic stoma in the IDA group because of operative difficulties under laparoscopy; the anastomotic stoma was only reinforced if there was staple-line bleeding. Satisfyingly, no anastomotic bleeding was observed in any patients after surgery. There were also some concerns about abdominal infection because of intra-corporeal performance in

Table 2. Comparison of operative outcomes and pathological characteristics between IDA and EA groups

Item	IDA group ($n = 36$)	EA group ($n = 50$)	P-value
Operation time, mean $\pm$ SD (min)	115.8 $\pm$ 30.8	119.3 $\pm$ 29.3	0.590
Intra-operative blood loss, mean $\pm$ SD (mL)	152.5 $\pm$ 79.6	123.7 $\pm$ 82.6	0.109
Anastomosis time, mean $\pm$ SD (min)	14.0 $\pm$ 3.4	14.5 $\pm$ 2.5	0.418
Length of incision, mean $\pm$ SD (cm)	4.6 $\pm$ 0.6	5.6 $\pm$ 0.7	<0.001
Proximal-resection margin, mean $\pm$ SD (cm)	8.8 $\pm$ 1.5	8.8 $\pm$ 2.0	0.984
Distal-resection margin, mean $\pm$ SD (cm)	7.2 $\pm$ 1.9	7.7 $\pm$ 2.7	0.310
Number of lymph nodes retrieved, mean $\pm$ SD	21.8 $\pm$ 7.8	23.0 $\pm$ 9.7	0.514
pTNM stage, *n* (%)			0.471
I	4 (11.1)	10 (20.0)	
II	14 (38.9)	15 (30.0)	
III	18 (50.0)	25 (50.0)	
Tumor differentiation degree, *n* (%)			0.468
Poor	2 (5.6)	1 (3.5)	
Moderate–poor	6 (16.7)	4 (11.6)	
Moderate	21 (58.3)	37 (67.4)	
Well–moderate	4 (11.1)	6 (11.6)	
Well	3 (8.3)	2 (5.6)	

IDA, intra-corporeal delta-shaped anastomosis; EA, extracorporeal anastomosis; SD, standard deviation; pTNM, pathological tumor node metastasis.

Table 3. Comparison of surgical recovery and complications between IDA and EA groups

Item	IDA group ($n = 36$)	EA group ($n = 50$)	P-value
First ground activities, mean $\pm$ SD (days)	1.3 $\pm$ 0.5	1.4 $\pm$ 0.6	0.585
First flatus passage, mean $\pm$ SD (days)	2.8 $\pm$ 0.5	3.2 $\pm$ 0.8	0.004
Fluid diet intake, mean $\pm$ SD (days)	3.3 $\pm$ 0.4	3.4 $\pm$ 0.6	0.124
Post-operative hospitalization, mean $\pm$ SD (days)	6.5 $\pm$ 0.7	6.5 $\pm$ 0.6	0.738
Post-operative VAS mean $\pm$ SD			
POD 1	4.0 $\pm$ 0.7	4.5 $\pm$ 1.0	0.002
POD 3	2.7 $\pm$ 0.6	3.4 $\pm$ 0.6	<0.001
POD 5	0.7 $\pm$ 0.6	0.7 $\pm$ 0.7	0.608
Post-operative complications, *n* (%)	3 (8.3)	8 (16.0)	0.470
Anastomotic bleeding	0	0	
Anastomotic stenosis	0	0	
Anastomotic leakage	0	0	
Abdominal infection	0	0	
Pulmonary infection	1 (2.8)	2 (4.0)	
Incisional infection	2 (5.6)	5 (10.0)	
Incisional hernia	0	0	
Bowel obstruction	0	1 (2.0)	

IDA, intra-corporeal delta-shaped anastomosis; EA, extracorporeal anastomosis; SD, standard deviation; VAS, visual analogue scale; POD, post-operative day.

the IDA group. This study showed that adequate mechanical bowel preparation before surgery and aseptic operation to the greatest extent resulted in no abdominal infection for both groups. One patient from the EA group suffered bowel obstruction on the 14th day after surgery and was diagnosed with early post-operative inflammatory ileus (EPII). No patients in the IDA group suffered EPII; we think that this was a benefit of the less invasive procedure. It was truly confirmed that the technique of IDA was safe and feasible.

IDA has been accepted and performed as a method of IA in laparoscopic gastroduodenostomy due to its simplicity and satisfactory results [14, 17, 18]. Many obvious advantages of IDA have been revealed as compared with conventional EA in laparoscopic gastroduodenostomy. Kinoshita *et al.* [19] found that estimated blood loss was significantly less in patients with IDA. In patients with IDA, Kim *et al.* [20] found that post-operative

pain and the amount of analgesics administered were significantly lower and post-operative scars were smaller. Kanaya *et al.* [13] found that IDA can lead to earlier, more adequate post-operative oral intake and the mean time for anastomosis was only 13 min. Moreover, some authors have applied this anastomosis technique in total laparoscopic left hemicolectomy and approved its safety and feasibility [21]. In our study, we also found that it was safe and feasible in total laparoscopic right hemicolectomy. These findings further support the satisfactory outcomes of IDA.

There are some limitations to our study. First, this was a retrospective study on the short-term effects and the outcomes were from a single surgeon and a relatively small number of patients. Therefore, prospective randomized controlled trials from multiple centers with larger sample sizes and longer follow-up periods are now recommended to confirm our results. Second, the

hospitalization expenses were not included in this study; the use of endoscopic linear staplers was one of the concerns with regard to expenses [14]. Our results support a faster recovery period and therefore we believe that the total hospitalization time and cost will decrease significantly with the improvement of the surgical performance.

In IDA, we have some experience and insight. (i) Patients who received this surgery required adequate pre-operative bowel preparation because inadequate bowel preparation increases the risk of intra-abdominal infection. (ii) To avoid intra-abdominal infection and tumor-cell implantation, the resected specimen needs to be collected and stored in a specimen bag immediately after the transection of the intestines, and digestive juices must be removed by complete suctioning of the small incisions in the broken ends of the intestines before anastomosis. (iii) The warehouse and screw anvil should not be placed through the small incisions at the same time, which are cut along the curvature of the two broken ends of the intestines. In our routine procedure, the warehouse was placed in the small incision of one broken end of the intestine first and the jaw was closed temporarily. The other broken end of the intestine was grasped to cover the screw anvil after the jaw was opened and necessary adjustments were performed. (iv) An appropriate length of intestines needs to be freed and the vascular arcade must be protected and maintained to guarantee low tension and adequate blood supply. Both are helpful in avoiding anastomotic leakage [22]. The tension and quality of the anastomotic stoma should be examined after the anastomosis is completed. (v) A 4- to 5-cm Pfannenstiel incision made 2–3 cm above the symphysis pubis at the border of the pubic hair allows for the removal of most specimens. In addition to this, natural orifice specimen extraction surgery (NOSES) can be performed in appropriate patients who underwent IDA in our center.

In conclusion, we reported the application of the IDA technique in laparoscopic right hemicolectomy and proved its clinical safety and feasibility. Our study also found that IDA has the advantages of less post-operative pain and earlier time to first flatus than EA. IDA is a recommendable reconstruction method in laparoscopic right hemicolectomy for patients with right colon cancer.

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Conflict of interest

None declared.

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