ORIGINAL ARTICLE

Totally laparoscopic colectomy with intracorporeal anastomosis achieved using a laparoscopic linear stapler: experience of a single institute

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Abstract

Purpose Laparoscopic colonic surgery is now widely accepted. We assessed the safety and effectiveness of using a total intracorporeal surgical strategy to perform intracorporeal functional end-to-end anastomosis with an endoscopic linear stapler to treat colon cancer.

Methods Forty-three selected patients underwent elective laparoscopic colon resection for carcinoma. A total intracorporeal colon resection was performed in all patients, using a functional end-to-end anastomosis with an endoscopic linear stapler.

Results Good results were achieved in all 43 patients, none of whom required conversion to open surgery with extracorporeal anastomosis. There have been no intraoperative complications related to this technique and no instances of postoperative anastomotic leakage, intraabdominal abscess, or wound infection.

Conclusion Intracorporeal functional end-to-end anastomosis using a linear stapler can be performed safely and easily for the resection of any part of the colon. We consider it an effective modality for totally laparoscopic colon resection. Favorable results have been achieved by this method, particularly for small tumors, since natural-orifice transluminal endoscopic surgery remains a challenging method to perform.

Introduction

Laparoscopic colon resection is superior to open surgery in relation to postoperative pain, recovery, and hospital stay [1–4]. With the recent publication of several landmark trials confirming the safety and effectiveness of a laparoscopic approach for both benign and malignant colorectal pathology [5–7], it is expected that the demand for a laparoscopic colorectal surgery will increase. However, most operations are performed using a laparoscopically assisted technique, whereby extracorporeal bowel division and anastomosis are carried out after laparoscopic mobilization of the bowel [8, 9]. This technique limits the ability to choose an extraction site and is associated with intestinal alignment problems after extraction. A completely intracorporeal anastomosis may reduce the likelihood of intestinal twisting while offering the possibility of using any abdominal location for specimen extraction. Although there have been reports of intracorporeal anastomosis with a circular stapler for left-side colon resection and intracorporeal anastomosis for right hemicolectomy [3, 10–15], a method for performing functional end-to-end anastomosis as an open anastomosis method for any part of a colon resection has not yet been described. Therefore we conducted this study to clarify whether functional end-to-end anastomosis, which has already been proven as safe and effective for an open colectomy [16–18], can also be used successfully to

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perform totally intracorporeal anastomosis in laparoscopic colectomy.

Patients and methods

Patients

Between July 2002 and June 2010, 43 selected patients (27 men and 16 women with a mean age of 64.5 years; range 40–84 years) underwent elective laparoscopic colon resection for adenocarcinoma. The exclusion criteria were a large, fixed tumor >6 cm in diameter, a history of extensive abdominal surgery, and past or present treatment for a malignant disease. Table 1 summarizes the characteristics of the patients.

Technique

All patients had mechanical bowel preparation consisting of oral sodium picosulfate and magnesium citrate, and a glycerin enema preparation. We did not give oral antibiotics preoperatively, but all patients received systemic intraoperative and postoperative antibiotics, usually cefotiam hydrochloride (Pansporin; Takeda, Tokyo, Japan) as two postoperative doses.

All laparoscopic operations were performed by the same surgeon (T.I.), who was experienced in both laparoscopic and open colorectal surgery. The initial port was placed using the open technique and pneumoperitoneum was induced with carbon dioxide. Three or four other ports were then made under laparoscopic guidance. The colon and vascular pedicles were divided and mobilized together with intracorporeal draining of the lymph nodes. The marginal artery, mesentery, and mesenteric vascular pedicles were also divided intracorporeally. The proximal and distal margins of the specimen were divided with an intestinal 60-mm Endo-GIA Universal stapler (United States Surgical, Norwalk, CT, USA). The specimens were removed by using an Endocatch II (United States

Surgical) via a 15–18-mm infraumbilical port. A 60-mm Endo-GIA was inserted from the infraumbilical port, and a functional end-to-end anastomosis was constructed intracorporeally using two 60-mm Endo-GIA staples (Fig. 1). The antimesenteric borders of the proximal and distal side of the bowel to be anastomosed were apposed using a 4-0 silk suture. At the edges, 10-mm transverse incisions were made in the antimesenteric borders of both bowels. The 60-mm Endo-GIA was inserted into the abdominal space and each end of the stapler was inserted into each bowel limb, then closed along the antimesenteric border of the bowel and fired (Fig. 1a). Thereafter, the center and both ends of the portion of the bowel where the stapler was inserted were raised using 4-0 silk suture. A reloaded, 60-mm Endo-GIA was then placed across the three raised sutures, and the stapler was fired (Fig. 1b). Some hand sutures were added for reinforcement purposes, corresponding to the conditions of the
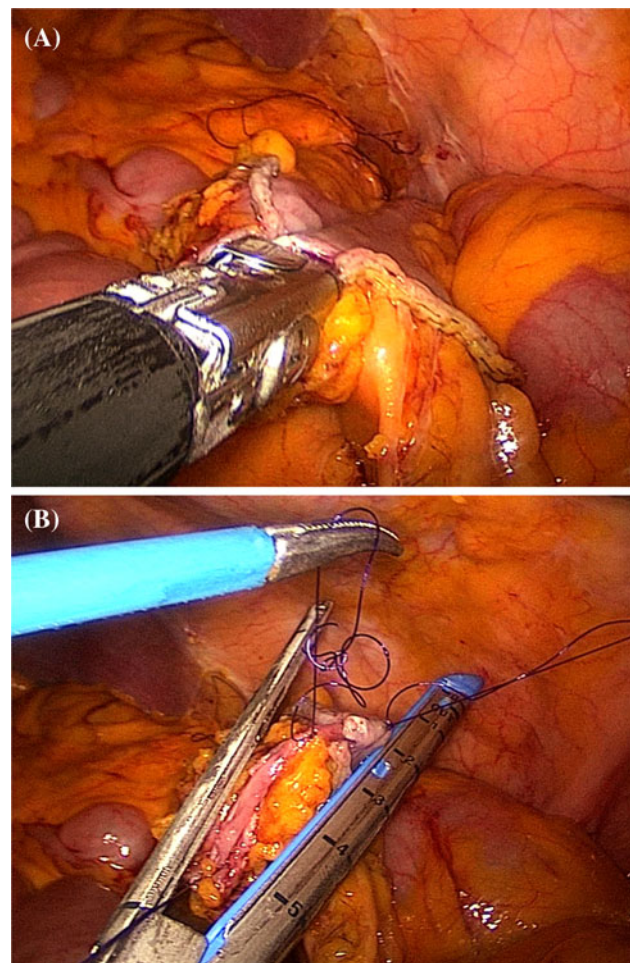
Table 1 Clinical characteristics of the 43 patients

Age (years), range (mean)	40–84 (64.5)
Male:female	27:16
Body mass index (kg/m^2)	22.1 ± 3.4
Tumor localization [n (%)]	
Cecum	4 (9)
Ascending	19 (44)
Transverse	6 (14)
Descending	7 (16)
Sigmoid	7 (16)

Fig. 1 a A 60-mm Endo-GIA is inserted intracorporeally into each bowel limb, and the stapler is closed along the antimesenteric border of the bowel and fired. **b** Another Endo-GIA is placed intracorporeally across the three raised sutures, and the stapler is fired

anastomosis. Finally, the mesenteric defect was closed in the usual manner.

Results

Table 2 outlines the surgical results and postoperative courses of the 43 patients. The following operations were performed: ileocecal resection ($n = 4$), right hemicolectomy ($n = 19$), transverse colectomy ($n = 16$), left colectomy ($n = 19$), and sigmoidectomy ($n = 7$). The average operation time was 213 min and the average time required for anastomosis was 19 min. The estimated blood loss was 28 g, and none of the patients required blood transfusion. There was no case of conversion to an open surgery. The average length of postoperative ileus was 1.3 days. The average hospital stay was 10 days. There was no postoperative mortality or major complications such as anastomotic leakage, intra-abdominal abscess, or intra-abdominal bleeding. Minor postoperative complications developed in three patients (5%): a wound infection in two patients and paralytic ileus in one. All of these patients recovered well with conservative management. Fluoroscopic examination (Fig. 2a) 1 month after

the operation and endoscopy (Fig. 2b) 1 year after the operation confirmed the anastomosis to be of sufficient size, demonstrating good passage. Figure 3 shows the well-healed operative wounds of one patient 1 month after sigmoidectomy; the scars were only slightly visible. Three patients had lymph node metastasis, but each of these patients had fewer than three metastatic nodes. Two of these patients received adjuvant chemotherapy for stage III disease. During the median follow-up period of 28 months (range 2–94 months), two patients died of other causes, and no cases of cancer recurrence had been observed at the time of writing.

Table 2 Surgical results and postoperative courses of the 43 patients

| Operation performed [n (%)]	
Ileocecal resection	4 (9)
Right hemicolectomy	19 (44)
Transverse colectomy	6 (14)
Left colectomy	7 (16)
Sigmoidectomy	7 (16)
Operating time (min)	213 ± 84
Anastomotic time (min)	19 ± 8
Estimated blood loss (g)	28 ± 43
Transfusion [n (%)]	0 (0)
Open conversion [n (%)]	0 (0)
Length of postoperative ileus (days)	1.3 ± 0.9
Complications [n (%)]	
Wound infection	2 (5)
Paralytic ileus	1 (2)
Mortality [n (%)]	0 (0)
Postoperative hospital stay (days)	10 ± 2.3
TNM stage [n (%)]	
0	7 (16)
1	16 (37)
2	17 (40)
3	3 (7)
4	0 (0)
Follow-up period (months), range (mean)	2–94 (28)
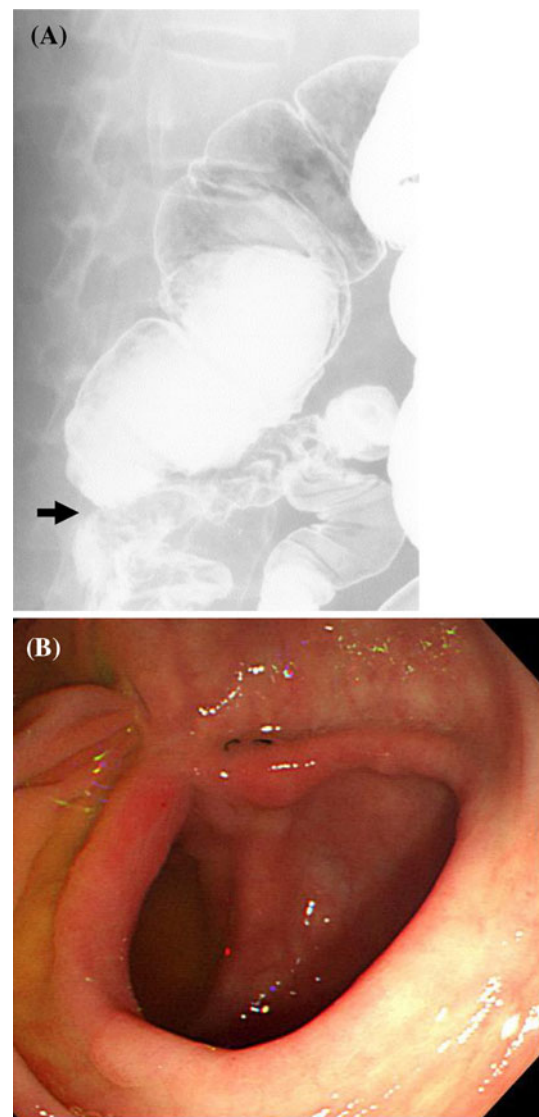
Fig. 2 Typical follow-up results, as seen in patient 9. **a** Fluoroscopic examination 1 month postoperatively and **b** endoscopy 1 year thereafter showed the anastomosis to be of sufficient size with good passage
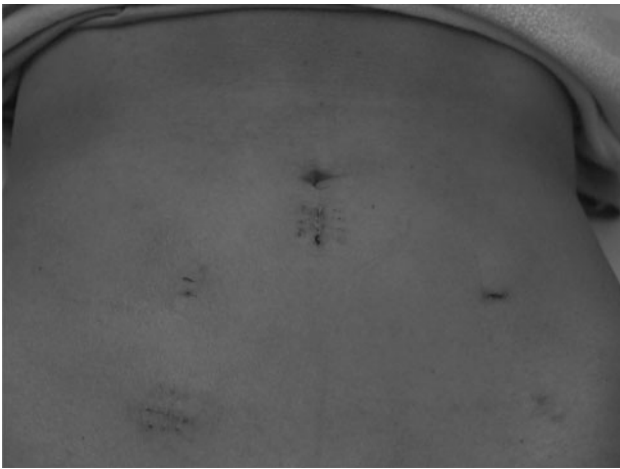
Fig. 3 Operative wounds 1 month after sigmoidectomy (patient 10)

Discussion

When we first began to perform this operation, the only candidates deemed suitable were patients with a tumor no larger than about 1 cm in diameter or those with a very thick abdominal wall. Consequently, over the first 8 years of the study this method was used to treat 43 of a total 208 patients undergoing laparoscopic colectomy, whereas in the last 6 months it was used to treat 20 of 22 patients. The two patients excluded had extremely large tumors.

Laparoscopic surgery for colon cancer generally involves pulling the portion of colon including the carcinoma out through a small incision and then performing both resection and reconstruction [8, 9]. By using the method we describe here, both the resection and reconstruction are able to be performed intracorporeally. All specimens are removed in a plastic bag via a 15–18-mm port after cutting the proximal and distal ends with an endoscopic stapler to excise the main site of the disease. The four main advantages of this method over extracorporeal anastomosis are as follows. First, a thick abdominal wall associated with obesity does not affect the anastomosis. Second, because there is no need to extracorporeally position the bowel that needs to be resected, the extent of bowel isolation is minimized. For example, with a right hemicolectomy, the ileum, which is originally isolated, is sent to the colon, which is hard to move, and then both these parts of bowel are anastomosed. Third, it is not necessary to make a new incision for anastomosis, so the abdominal incision size can be even smaller. Fourth, the likelihood of intestinal twisting is reduced.

There was some concern that the bowel contents might flow out into the abdominal cavity while additional incisions were made for the insertion of the linear stapler; however, we observed almost no outflow of the bowel contents, mainly because manual pressure is not applied to

the intestines during laparoscopic surgery and medications to induce intestinal peristalsis, such as epidural analgesia, are avoided. Hellan et al. [11] compared intracorporeal anastomosis with extracorporeal anastomosis in right hemicolectomy. Although there were no significant differences in the hospital stay or the duration of postoperative ileus, there appeared to be a trend toward a smaller incision length in the intracorporeal anastomosis group and more anastomosis-related complications in the extracorporeal anastomosis group. Ikeda et al. [14] found that totally laparoscopic distal gastrectomy had several advantages over laparoscopic-assisted distal gastrectomy for gastric cancer, including a smaller wound size, less invasiveness, and a better feasibility of secure ablation and safe anastomosis independent of the patient's constitution and cancer location.

Most reported cases of intracorporeal anastomosis for colorectal resection involved methods that used a circular stapler. According to these methods, the anvil head was inserted into the oral side of the colon and then combined with the body of the circular stapler inserted from the anus [10, 12, 13]. Therefore, these methods can be used only to anastomose the intestine located within 20 cm of the anus. We found two reports describing intracorporeal anastomosis in which a linear stapler was used. According to both reports, the anastomosis was performed partly using hand-sewn sutures and, as a result, took a longer time to complete than extracorporeal anastomosis [11, 19]. The method of anastomosis reported here is not a novel procedure, since it has already been proved to be safe and effective for open colectomy [16, 17]. The anastomosis is completed after firing two or three linear staples as necessary.

Recently, natural-orifice transluminal endoscopic surgery (NOTES) has evoked much interest among surgeons and gastroenterologists specializing in minimally invasive procedures. Performing surgery through the body's natural orifices decreases the degree of injury that occurs with more invasive abdominal wall surgery [20, 21]. For humans, various procedures using a hybrid technique that combines the natural-orifice approach with standard laparoscopic vision (hybrid NOTES) have been tested [15, 19, 22]. In the field of standard laparoscopic surgery, some reports describe totally intracorporeal anastomosis combined with extraction of the specimen through natural orifices. However, difficulty in performing intracorporeal anastomosis has prevented this procedure from becoming widely accepted.

In conclusion, this report verifies that functional end-to-end anastomosis can be performed safely and easily for totally intracorporeal anastomosis during laparoscopic colectomy. Regardless of the physique of the patient and the part of the intestine that needs to be excised, this method can be used to successfully perform the anastomosis. As this

intracorporeal stapled reconstruction technique can also be applied to NOTES, its future application in this regard is expected.

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