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ORIGINAL ARTICLE

Short- and long-term results of laparoscopic surgery for transverse colon cancer

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Abstract
Purposes We investigated the feasibility of laparoscopic surgery for transverse colon cancer (TCC) by examining the results of this procedure, and comparing the short- and long-term outcomes with those for right-sided and sigmoid colon cancer (OSCC).
Methods The subjects consisted of 117 patients with TCC. Their complications, forms of recurrence and disease-free and 5-year survival rates were compared to those of 564 patients with OSCC.
Results There were no significant between-group differences in the patient background. The average length of the operation in the TCC group was 215 min and that in the OSCC group was 184 min ($p < 0.05$). There were also no significant between-group differences in the average blood loss, which was 83.9 and 70.5 g, respectively. No significant difference was observed between groups by stage in terms of the disease-free survival rates, which were 94.4 and 79.1 % for stage II and III in the TCC group, and 92.4 and 78.8 % for stage II and III in the OSCC group. The incidence of intraoperative and postoperative complications was low, and the five-year survival rate was favorable. As favorable results of laparoscopic colectomy (LAC) for TCC were also obtained at other sites in a multicenter randomized controlled trial, LAC is expected to become a standard therapy for TCC.

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Introduction

In recent years, favorable data about both short- and long-term outcomes of laparoscopic colectomy (LAC) have been accumulating, and LAC is now increasingly recognized as a standard therapy similar to laparotomy [1]. However, LAC has been excluded from large-scale randomized control trials of transverse colon cancer laparoscopy. The reasons include differences in the surgical techniques and lymphadenectomy depending on the position of the tumor, and also the high degree of difficulty in dissecting the root of the middle colic artery (MCA). We herein assessed the short- and long-term clinical outcomes of LAC for transverse colon cancer, and also compared them with those of LAC for right-sided and sigmoid colon cancer.

Materials and methods

From 1994 to 2012, 1897 LAC procedures were performed, of which 1580 were for colon cancer, including 155 for transverse colon cancer, which was defined as cancer occurring between the hepatic flexure and splenic flexure, and requiring treatment of the MCA. The exclusion criteria for subjects were (1) a bulky tumor (2) rectal cancer (3) descending colon cancer (4) colostomy creation (5) adjacent organ resection (6) cases with a degree of complete curability of B or C and (7) single-incision surgery. The excluded cases included 15 with no curative resection, six

Table 1 The background of the patients with transverse or other segment colon cancer

Patients background	TCC 117	OSCC 564	*p* value
Stage (%) 0/1/II/III	8/28/36/27	8/26/34/32	0.8256
Male/female (%)	37/63	44/56	0.1811
Mean age	66.4 ± 10	64.8 ± 11	0.1465
Mean BMI	23.0 ± 3.1	22.7 ± 3.3	0.3663
Tumor differentiation (%) well/mod/por/muc	64/30/3/3	59/36/2/3	0.2106
pT category (%) T1/T2/T3/T4	26/11/49/13	34/16/38/12	0.0888
Lymph nodes	18.0 ± 11.8	18.7 ± 11.1	0.5394

who underwent adjacent organ resection, and two single-incision surgeries, leaving 117 cases for comparison. These subjects were compared to 564 cases of colon cancer, including 231 with ascending colon cancer or cecal cancer, and 333 with sigmoid colon cancer. The patient backgrounds are shown in Table 1.

All patients gave informed written consent for participation in this study, and surgery was performed by four surgeons experienced in advance laparoscopic surgery. The patients' backgrounds, postoperative progress, intraoperative contingencies, postoperative early and late complications, forms of relapse and 5-year survival rates were compared.

Surgical technique

Patients were put in the lithotomy position and video screens were placed at both sides of their head. A 10-mm camera port was inserted into the navel, and air insufflation was performed. The procedure was performed using a 10-mm 30°-angled rigid endoscope with the five port setting.

An ultrasonically activated device or bipolar scissors was used for the mobilization of the intestinal tract. In cases where the lesion was transverse colon cancer on the hepatic flexure, extended right hemicolectomy was performed. In cases where the lesion was centrally located, transverse colon resection or extended right hemicolectomy was performed. In cases where the lesion was on the splenic flexure, left hemicolectomy was performed.

Radical dissection was D2 for cases up to T2 and N0. Radical dissection was D3 for cases of T3 and N1 or higher. The extent of the intestinal tract resection was performed accorded with the Japanese Guidelines on Handling Colon Cancer, 7th edition, as amended, and radical dissection was performed. Mobilization of the intestinal tract was achieved with a laparoscope, and the umbilical port wound was extended by approximately 4 cm for the anastomosis. A functional end-to-end anastomosis was performed using an automatic stapling device. To identify the origin of the MCA, detachment from the lower end of the pancreas was performed to expose the superior mesenteric vein with the operation being performed from the ventral side of the transverse mesocolon. Thereafter, the transverse mesocolon was spread in the shape of a fan, the procedure was moved to the caudal side, and detachment was performed in the direction from the duodenojejunal flexure to the descending part of the duodenum.

Surgeons

In principle, procedures were carried out by four surgeons who were providing education for younger surgeons about laparoscopic surgery. However, since our institution is a teaching hospital, we provide opportunities to surgeons with 10–15 years of experience even if they are not certified. In such cases, certified doctors participate in the operation at all times as instructors. The procedure progresses with noncertified surgeons and certified assistants performing parts of the operation in turn.

Statistical analyses

The statistical software program used for all analyses was the Mac version of Graph Pad Prism 5. The statistical comparisons were made using the χ^2 test and the Mann–Whitney *U* test. Differences with a value of $p < 0.05$ were deemed significant. The cumulative survival curves were calculated using the Kaplan–Meier method, and the log-rank test was used to detect differences in survival curves.

Results

Background factors

The patients' background information is shown in Table 1. Comparing the 117 cases in the TCC group with the 564 cases in the OSCC group, no significant differences were observed in the patient age (66.4 ± 10 vs. 64.8 ± 11 years), gender (37 % M: 63 % F vs. 44 % M: 56 % F) or BMI (23.0 ± 3.1 vs. 22.7 ± 3.3). There were also no significant differences between the two groups in the tumor

differentiation and pT category, or in the number of lymph nodes dissected (18.0 ± 11.8 vs. 18.7 ± 11.1). In the TCC group, right hemicolectomy was performed in 22 cases (18 %), extended right hemicolectomy in 27 (22 %), transverse colon resection in 59 (50 %), extended left hemicolectomy in four (4 %) and left hemicolectomy in five (5 %). In the OSCC group, sigmoid colon resection was performed in 321 cases (57 %), anterior resection in 11 (2 %), right colon resection in 108 (19 %), right hemicolectomy in 91 (16 %), extended right hemicolectomy in five (1 %) and ileocecal resection in 28 patients (5 %).

The length of the operation, bleeding volume, time to oral intake and postoperative hospitalization

The intraoperative and postoperative results are shown in Table 2. The length of the operation was 215.5 ± 71 vs. 184.4 ± 58 min, with the operations in the TCC group being significantly longer. However, there were no significant between-group differences in the bleeding volume (83.9 ± 73 vs. 70.5 ± 86 mL), time to postoperative oral intake (2.6 ± 3.4 vs. 2.2 ± 2.6 days) or the number of days of postoperative hospitalization (17.7 ± 10.4 vs.15.5 ± 8.7).

Intraoperative complications

As shown in Table 2, intraoperative complications were not observed in the TCC group, but there were complications in five cases in the OSCC group, comprising two cases of hemorrhage (0.3 %), one case of injury of the inferior epigastric artery (0.2 %) and two cases of injury of the gastrointestinal tract (0.3 %). All of them were dealt with through endoscopic procedures, and laparotomy was unnecessary.

Conversion to laparotomy

Two cases in the TCC group (1.7 %) and six in the OSCC group (1.1 %) underwent conversion to laparotomy. In the TCC group, one case (0.8 %) was converted due to progression to D3 lymph node dissection and one (0.8 %) because of dense adhesions. In the OSCC group, conversion to laparotomy was performed in one case (0.2 %) due to progression to D3 lymph node dissection, one (0.2 %) due to hemorrhage from misclipping at the IMA root, one (0.2 %) due to inflammatory adhesion to the bladder, one (0.2 %) in which infiltration to the retroperitoneum was observed, and in two (0.4 %) cases in which dense adhesions due to past operations were observed. There were no significant differences between the two groups in terms of the conversion rate, and there were no complications observed specific to transverse colon cancer.

Early postoperative complications

The early postoperative complications are shown in Table 3. There were 17 cases with early postoperative complications in the TCC group, and 44 in the OSCC group. The major complications included eight cases of wound infection (6.8 %), two of anastomotic leakage (1.7 %) and three of ileus (2.5 %) in the TCC group. There were 25 cases of wound infection (4.4 %), six of leakage (1.1 %) and four of ileus (0.7 %) in the OSCC group. There were no significant between-group differences for these early complications.

Late postoperative complications

There were three cases with late postoperative complications in the TCC group, comprising two incisional hernias (1.7 %) and one case of ileus (0.8 %). There were seven cases with late postoperative complications in the OSCC group, comprising four cases of ileus (0.7 %), two incisional hernias (0.4 %) and one case of anastomotic stenosis (0.2 %). There were also no significant differences between the groups in terms of the late complications.

Table 2 The intraoperative and postoperative results of surgeries for transverse or other segment colon cancer

Operative result	TCC 117	OSCC 564	*p* value
Operating time (min)	215.5 ± 71	184.4 ± 58	0.0031
Bleeding volume (ml)	83.9 ± 73	70.5 ± 86	0.1165
Open conversion	2 (1.8 %)	6 (1.1 %)	0.6312
Oral feeding (days)	2.6 ± 3.4	2.2 ± 2.6	0.1531
Hospital stay	16.7 ± 10.4	15.5 ± 8.7	0.1904
Intraop complication	0	5 (0.93 %) hemorrhage 2 injury of the inferior epigastric artery 1 intestinal damage 2	

Table 3 The postoperative complications associated with surgery for transverse or other segment colon cancer

Complication	TCC 117	OSCC 564	*p* value
Early period	17	44	
Wound infection	8 (6.8 %)	25 (4.4 %)	0.3407
Leakage	2 (1.7 %)	6 (1.1 %)	0.6312
Ileus	3 (2.5 %)	4 (0.7 %)	0.1021
Enteritis	1 (0.8 %)	4 (0.7 %)	1.0000
Pneumonia	1 (0.8 %)	3 (0.5 %)	0.5301
Delayed gastric emptying	2 (1.7 %)	0	
Anastomotic bleeding	0	2 (0.3 %)	
Late period	3	7	
Ileus	1 (0.8 %)	4 (0.7 %)	1.0000
Incisional hernia	2 (1.7 %)	2 (0.3 %)	0.1386
Anastomotic stenosis	0	1 (0.2 %)	

Long-term postoperative results by disease stage

As shown in Table 4 and Fig. 1, there were two cases of recurrence at stage II and seven at stage III in the TCC group. In the OSCC group, there were two cases of recurrence at stage I, nine at stage II and 27 at stage III. Figure 1 summarizes the oncological outcomes for the various groups. For patients with stage II disease, the median (range) follow-up period was 58 (4–199) months in the OSCC group and was 66 (4–170) months in the TCC group. For patients with stage III, the median (range) follow-up period was 55 (6–189) months in the OSCC group and 51 (9–133) months in the TCC group. In the TCC group, the disease-free survival rate by stage was 94.4 % for stage II and 79.1 % for stage III, and there were no significant differences between the TCC and OSCC groups. In the TCC group, the five-year overall survival rates by stage were 93.5 % for stage II and 81.4 % for stage III, and there were no significant differences between the TCC and OSCC groups.

Discussion

There have been many reports of favorable results of LAC over the long term, such as a reduced need for analgesics, and in the short term, such as a shorter hospitalization time, as well as in terms of the oncological safety. Laparoscopic surgery is gradually becoming widely used. Our department introduced LAC in 1994, and has expanded its applications for colon cancer. At the time of introduction, we started using LAC for sigmoid colon cancer, right-sided colon cancer and early-stage cancers, except in cases with ileus, adhesions or for patients considered to be at high risk for surgery. Laparoscopic surgery is currently performed in 95 % of cases undergoing colon and rectal cancer operations at our institute. One of the contributing factors to this situation is the widespread benefit of LAC with regard to the short-term results, including that in the early postoperative period. For the application of LAC to advanced cancers, mid- to long-term oncological evaluations have been required to determine whether it is possible to obtain comparable outcomes, invasiveness and safety to those associated with early-stage cancers.

The indications for LAC at our institution for transverse colon cancer are the same as that for cancers at other sites. In the present study, we compared and investigated right-sided colon cancer and sigmoid colon cancer, for which the safety and feasibility of laparoscope surgery has been recognized. Laparoscopy for transverse colon cancer has been excluded from many randomized control trials, such as the COST trial and the COLOR trial [2–7]. However, there have been some reports on comparative investigations of laparoscopy for transverse colon cancer [8–13]. The reasons for exclusion have included the low incidence of transverse colon cancer, which comprises approximately 10 % of all colon cancers [14–16], and the further advanced technology required when performing surgery for such cancers.

Table 4 The sites of recurrence in patients who underwent surgery for transverse or other segment colon cancer

Recurrence				
Stage	TCC		oscc	
	117		564	
	Case		Case	
0	0/9		0/40	
1	0/32		2/149	Local 1, Liver 1
II	2/42	Liver2	9/191	Liver5, Lung 2,1, Peritoneum 1
III	7/32	Liver4, LN 1	2 7/184	Liver 19, Lung 1, Brain 1
		Lungl, Port site 1		Local 1, Peritoneum 2, LN 2, Port site 1

UICC TNM classification

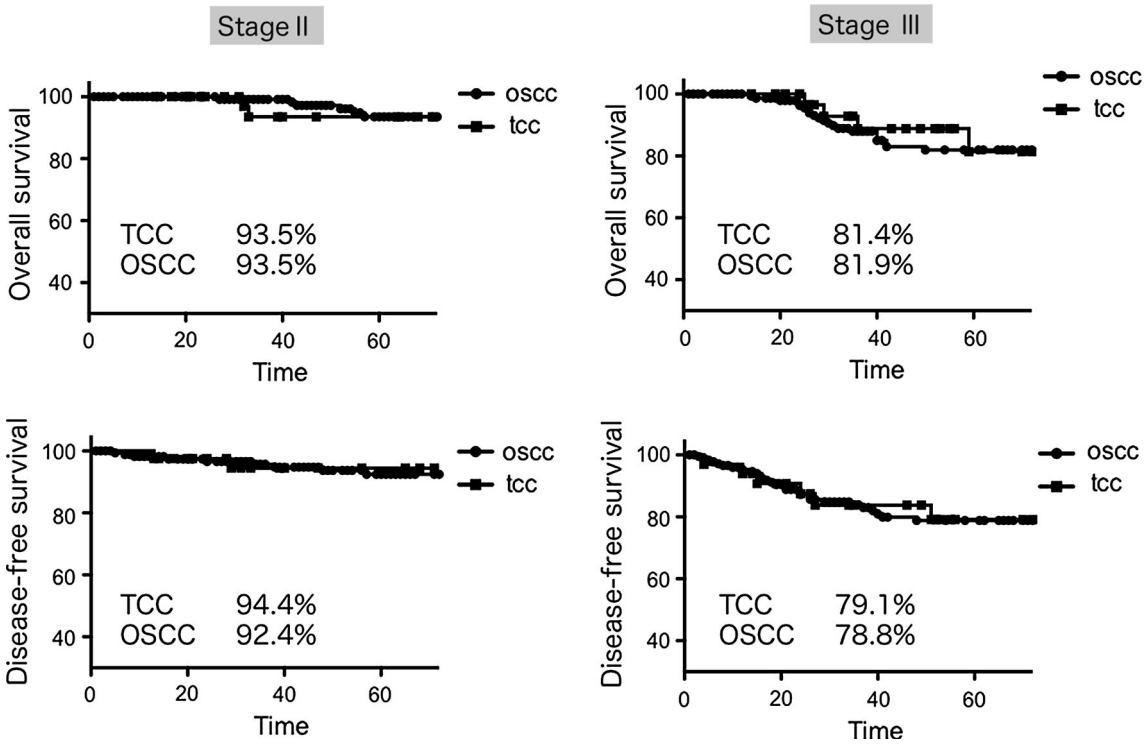

Fig. 1 The 5-year oncological outcomes of patients who underwent surgery for transverse or other segment colon cancer

The reasons for the high level of difficulty in performing surgery for transverse colon cancer include the fact that the veins to be radically dissected and treated vary depending on the site of the tumor, that MCA branches from the superior mesenteric artery (SMA) can have various morphologies, that the site of radical dissection in the periphery of the MCA root is close to important organs, such as the pancreas and duodenum, and that it is necessary to perform mobilization over a wider range compared to that required in surgery for colon cancer at other sites.

It is necessary to conduct comprehensive preoperative evaluations before performing surgery for transverse colon cancer, such as evaluating the radical dissection range, branching of vessels and mobilization range. We perform clipping on endoscopy prior to surgery, check the vessel paths on 3DCT, check lesion sites with a virtual enema, check the length and morphology of the transverse colon and identify the dominant vessels. Based on the findings of these examinations, we select the surgical procedure, extent of radical dissection and extent of mobilization.

During surgery, the serous membrane of the transverse colon is covered with the greater omentum and lesser omentum, and physiological adhesion is relatively common. Consequently, it is sometimes difficult to find the lesion site, even if the cancer is advanced. We therefore use India ink on colonoscopy prior to surgery to check the lesion sites, in addition to checking the sites prior to surgery with clipping and 3DCT. As a result of these checks, we have never incorrectly identified a lesion site. When comparing the results of investigations, the outcomes of surgery (length of surgery and blood loss), and postoperative progress (the time to commence oral intake and the postoperative hospitalization), the length of the operation was significantly longer in the TTC group than in the OSCC group, in agreement with results reported by Schlachta et al. [8]. To ensure the safety of the procedure, we take several steps in the approach to the root of the MCA. It is also considered that a wide range of mobilization at sites such as the hepatic flexure and the splenic flexure give rise to the extended operation. While there was a tendency for the blood loss to be slightly higher in the TTC group due to the longer operation, the difference was not significant, and the amount was considered to be tolerable. The other surgical outcomes were similarly favorable to those reported to date [8, 9, 13]. We did not experience any intraoperative complications. Although there were some cases of problems in previous reports in which lesions could not be identified [8], we have never experienced such problems; thanks to our staining and checking procedures described above.

Due to radical dissection and advanced adhesions, two cases (1.8 %) proceeded to laparotomy. In most reports to date, 1.1–5 % of cases proceeded to laparotomy, which is equivalent to the proportion in our study. The reasons for this include the need for radical dissection, extensive adhesions and advanced obesity [9–11, 13]. In addition,

Schlachta et al. experienced four out of 22 cases (18 %) which progressed to laparotomy due to intestinal tract injury and an inability to confirm the lesion sites. There were no differences between our study groups in the early postoperative complications.

Although, the factors in the present study were comparable to those reported to date, such as the incidence rates of ileus, wound infections and incomplete suturing [8–13], we experienced two cases of delayed gastric emptying. To the authors' knowledge, this disorder has not been reported to date. However, we consider it to be a complication specific to transverse colon cancer surgery, and it is considered that the operation from the MCA route to the periphery of the duodenum may affect gastric excretion. Additionally, Zmora et al. reported that one out of their 22 cases (4.5 %) developed anastomotic leakage, and Yamamoto et al. similarly reported leakage in two out of 99 cases [11, 17], however, there have been no such cases reported elsewhere. We found no significant differences in anastomotic leakage between our two groups, but observed it in two cases (1.8 %) in the transverse colon cancer group. These included one case of transverse colon resection and one case of extended left hemicolectomy. One case of transverse colectomy required reoperation and colostomy, and in the case that underwent extended left hemicolectomy, we performed conservative treatment. It is considered that the typical causes of the anastomotic leakage are circulatory disorders and tension at anastomotic sites. We apply sufficient mobilization in such cases to avoid tension. Moreover, while the dominant vessels are detached laparoscopically, we treat marginal vessels by viewing them directly for an extracorporeal operation, so that sufficient blood flow can be assured.

Since there were few cases of recurrence in our study, it is difficult to compare them. However, we experienced one case of recurrence at the port site in the TCC group (0.92 %), and one in the OSCC group (0.18 %). At present, we prevent the implantation of tumor cells at the port side in SE cases prior to wound closure using alcohol gaze, and we have not observed recurrence at the port in such cases. Overall, there were no significant differences between the two groups, and it is considered that the rate of curability in laparoscopy for transverse colon cancer is not compromised.

There have been several previous reports on the feasibility and safety of laparoscopy for transverse colon cancer; however, there have only been a few reports on its long-term outcomes [11]. The results of the present investigation are limited to cases in which the degree of complete curability was A, and in which laparoscopy was performed for transverse colon cancer, so that further studies would be needed to fully investigate the curability of the procedure.

At the annual meeting of the ASCO in 2012, the results of the Japanese JCOG0205 RCT were announced. In that study, the OS of stage III patients was 87 %, which was comparable to our results for the OSCC group. In our study, no significant differences were observed between the TCC and OSCC groups in terms of the disease-free and overall survival rates. These results suggest that, in addition to favorable short-term results, the long-term clinical outcomes confirm that laparoscopy is applicable for transverse colon cancer, and it is likely to become a standard procedure in the future.

Our study has some limitations that should be considered when interpreting the results. First, it was a retrospective study. It is difficult to carry out prospective randomized clinical trials recruiting subjects at a single facility, due to the low incidence (approximately 10 % of all colon cancers) of transverse colon cancer. Therefore, it is desirable to perform a large-scale multicenter clinical trial.

Transverse colectomy is categorized as a procedure with a high degree of difficulty, and the number of surgeons who can perform laparoscopy for transverse colon cancer is limited. Therefore, we are making efforts to maintain the quality of such surgeons. We can assume that these efforts lead to favorable results. Currently, it is considered necessary to adopt a careful approach to laparoscopy for transverse colon cancer according to the level of development of the facilities and the level of experience of the surgeons carrying out the laparoscopy for transverse colon cancer.

Conflict of interest We have no conflicts of interest or financial ties to disclose.

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