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ORIGINAL ARTICLE

Safety and factors contributing to the difficulty of laparoscopic surgery for rectal cancer treated with preoperative chemoradiotherapy

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Abstract
Background The safety of laparoscopic surgery for rectal cancer following chemoradiotherapy (CRT) has not been fully established. The aim of our retrospective study was to examine the outcomes and the factors contributing to the difficulty of laparoscopic surgery after CRT.
Methods Eighty-seven consecutive rectal cancer patients treated with CRT were analyzed. Clinicopathological factors were compared between laparoscopic surgery ($n = 57$) and open surgery ($n = 30$) groups, and factors that correlated with operation time and blood loss were analyzed in low anterior resection (LAR) cases in the laparoscopic surgery group ($n = 46$).
Results There was less blood loss in the laparoscopic surgery group than in the open surgery group (191 vs. 1,043 ml, $p = 0.0001$), and the operation time in the two groups was similar (329 vs. 322 min, $p = 0.8$). The rate of conversion from laparoscopic surgery to open surgery was 1.8 %. There was no significant difference in the morbidity rate (laparoscopic surgery 22.8 % vs. open surgery 33.3 %, $p = 0.3$). All circumferential resection margins were clear. Three-year cumulative rates of local recurrence were as follows: laparoscopic surgery: 1.9 % vs. open surgery: 8.4 % ($p = 0.4$), and distant recurrence was 28.5 % in laparoscopic surgery vs. 22.7 % in open surgery ($p = 0.8$) and these rates were not significantly different. In laparoscopic LAR cases, a shorter distance of the tumor from the anal verge was associated with a longer operation time. A high computed tomography Hounsfield units value of the mesorectum (CTV) was associated with increased blood loss in the first 23 cases, but not in the other 23 cases.
Conclusions Laparoscopic surgery following CRT was safe and feasible. A shorter anal verge was associated with a longer operation time. Blood loss increased in cases with high CTV, but this can likely be mitigated by experience.

Keywords Rectal cancer · Chemoradiotherapy · Laparoscopic surgery · Neoadjuvant therapy

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Introduction

Laparoscopic surgery for colon cancer has been shown to be associated with fewer postoperative analgesics, more rapid recovery of bowel movement and a shorter hospital stay than conventional open surgery, without increasing postoperative complications or compromising oncological outcomes [1–4]. Therefore, laparoscopic surgery is now increasingly accepted as a safe and less invasive alternative to open surgery. However, the safety and effectiveness of laparoscopic surgery for rectal cancer are considered not to have been fully established [5]; in the MRC CLASICC trial conducted in the United Kingdom, laparoscopic surgery for rectal cancer was associated with an increased rate of positive circumferential resection margins (CRM), one of the most important indicators of the oncological quality of rectal surgery, although the local recurrence rate was not different from that of open surgery [2, 6].

Preoperative chemoradiotherapy (CRT) for rectal cancer has been shown to reduce postoperative local recurrence

and may improve postoperative survival [7–9], and CRT has now become widely accepted in the modern surgical treatment of rectal cancer. CRT considerably reduces tumor size and can also cause downstaging in the T stage [10] and thus might result in cancer-free CRM, especially in cases of threatened CRM. The downsizing of large tumors can also improve the exposure of the surgical field, especially in the narrow pelvis; however, tissue edema and fibrosis caused by CRT can hamper the dissection of the tissue, and mist and exudates can block the surgeon's vision in some cases. How these merits and demerits of CRT influence the surgical and oncological outcome of laparoscopic surgery for rectal cancer is not fully understood. In this study, we demonstrate the surgical and oncological outcomes of laparoscopic surgery for rectal cancer treated with CRT and examine the factors associated with the technical difficulty of performing laparoscopic surgery following CRT.

Materials and methods

Patients

A total of 87 consecutive rectal cancer patients (cT3–cT4, M-) treated with CRT followed by surgical resection with curative intent from July 2006 to September 2012 were retrospectively analyzed. In this period, we started performing laparoscopic surgery for CRT cases and gradually extended the indications for the procedure; a total of 57 patients were treated with laparoscopic surgery, and 30 patients were treated with open surgery.

Chemoradiotherapy

The patients underwent CRT as described in our previous study [11]. In brief, the total dose of preoperative radiotherapy was 50.4 Gy, which was given in 28 fractions over 6 weeks. Treatment planning was done using computed tomography (CT) scans so that the clinical target volume included the primary tumor, anus and regional lymph nodes. The regional lymph nodes included nodes around the inferior mesenteric, internal iliac and middle rectal vessels; the presacral nodes; and the nodes around the obturator foramen. Tegafur-uracil with leucovorin (58 cases), or S-1 with or without irinotecan or oxaliplatin (29 cases), was given concomitantly with radiotherapy.

Surgery

Eight weeks after the completion of preoperative CRT, surgery with curative intent was planned. The surgical procedures consisted of low anterior resection (LAR), intersphincteric resection, abdominoperineal resection, Hartmann operation and total pelvic exenteration and were performed or supervised by the chief surgeons of our department (T.W. and Y.H.). All procedures, both in laparoscopic surgery and open surgery, included lymphadenectomy using a standard total mesorectal excision (TME) technique with dissection of the perirectal lymph nodes and the lymph nodes along the superior rectal artery, which was ligated just below the branch of the left colonic artery. Lateral pelvic nodes were dissected in selected cases in which lateral node involvement prior to CRT was suspected. In LAR cases, the rectum was transected using a linear stapler cutter and reconstructed by a double stapling technique. The anastomosis was checked for air leaks and bleeding by intraoperative colonoscopy as described previously [12]. A protective ileostomy was selectively constructed in patients with low colorectal or coloanal anastomosis, or in those with significant comorbidities, based on the discretion of the operating surgeons. Drains were placed for the drainage of the pelvic floor and to achieve decompression of the anastomosis. In laparoscopic surgery cases, pneumoperitoneum was obtained from the camera port inserted through a small incision at the umbilicus. Another 4 ports were placed in the right and left flank and iliac fossa. The specimen was extracted from the incision at the umbilicus extended to 4 cm.

Outcome variables

Clinical and pathological factors and surgical and oncological outcomes were examined in the laparoscopic surgery and open surgery groups. In LAR cases in the laparoscopic surgery group, we analyzed the factors that were correlated with operation time and the amount of blood loss, which can be considered markers of the difficulty of the operation [13]. A high computed tomography Hounsfield units value of the mesorectum (CTV) might indicate the presence of edema and fibrosis of the mesenteric tissue [14]. Therefore, addition to other known variables, we examined the significance of the mesorectal CTV before and after CRT. CTV was measured as the mean value of the small area gated in the mesorectum (Fig. 1a, b). The gate was so set in the homogenous area of the mesorectum so that vascular or membrane structures were excluded as much as possible, and the standard deviation of CTV in the gated area did not exceed 15 Hounsfield units (HU). CTV was determined by a radiological technician (N.Y.) who was not aware of the background and outcome of the patients.

Statistical analysis

A paired *t* test or Welch's test was used for the comparison of continuous variables, and the chi-square test or Fisher's

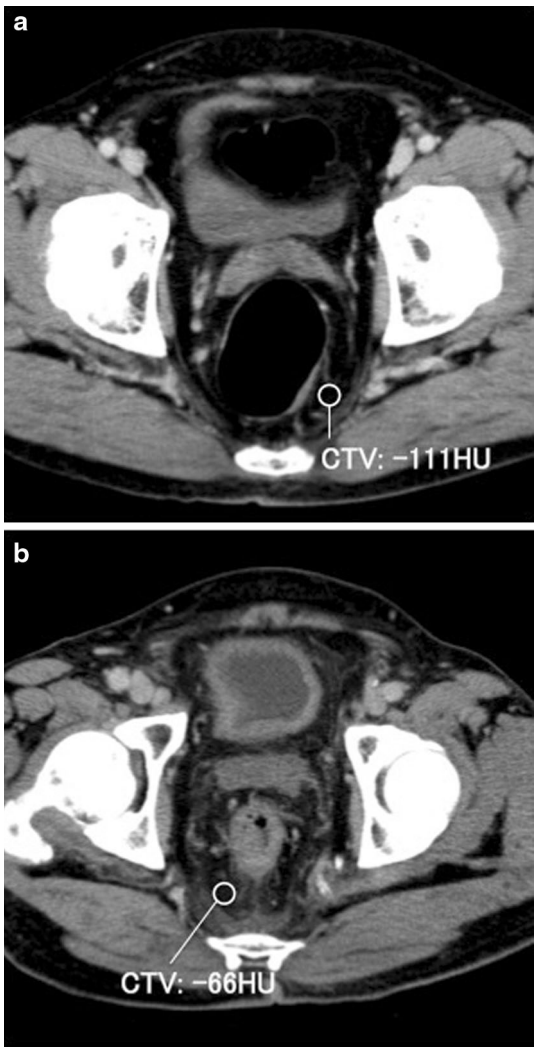

Fig. 1 Computed tomography value of the mesorectum. The computed tomography value (CTV) of the mesorectum was relatively low (−111HU) in Case 1 (**a**) and high (−55HU) in Case 2 (**b**)

exact test was used for the comparison of categorical data. The Kaplan–Meier method and logrank test were used for the estimation and comparison of patient survival. *P* values less than 0.05 were considered to denote statistical significance. Data analyses were performed with the JMP statistical software package (SAS Institute Inc., Cary, NC, USA).

Results

Clinicopathological factors and surgical and oncological outcomes

In the first half of the study period (July 2006–September 2009), 16 of 42 patients (38 %) were treated with laparoscopic surgery, and in the second half (October 2009–September 2012), 41 of 45 patients (91 %) were treated with laparoscopic surgery. One case with very low rectal cancer was converted from laparoscopic surgery to open intersphincteric resection (for a conversion rate of 1.8 %) and included in the laparoscopic surgery group. Irinotecan or oxaliplatin was given in recent cases, resulting in the preferential use of these agents in the laparoscopic surgery group (laparoscopic surgery 44 % vs. open surgery 7 %, $p = 0.0004$). The mean (range) follow-up period was 26.2 (1.1–74.5) months in the laparoscopic surgery group and 45.3 (2.7–73.9) months in the open surgery group.

The clinical features before treatment, pathological factors in the resected specimens, surgical outcome and prognosis of the patients were compared between the laparoscopic surgery ($n = 57$) and open surgery ($n = 30$) groups (Table 1). There was no difference between the groups as regards tumor size, clinical T stage and N stage before CRT. More patients in the laparoscopic surgery group showed downstaging in the pathological T stage; however, downstaging in the pathological N stage was more evident in the open surgery group, although these differences were not statistically significant. Tumor distance from the anal verge was greater in the laparoscopic surgery group (laparoscopic surgery 65.5 mm vs. open surgery 47.8 mm, $p = 0.007$), and sphincter-preserving surgery (LAR, intersphincteric resection) was performed in more patients in the laparoscopic surgery group than in the open surgery group (laparoscopic surgery 93 % vs. open surgery 63 %, $p = 0.006$). Lateral pelvic node dissection was performed in 1 intersphincteric resection case in the laparoscopic surgery group and in 1 abdominoperineal resection case in the open surgery group. There was no difference between the groups as regards operation time, but blood loss was significantly less in the laparoscopic surgery group (laparoscopic surgery 183 ml vs. open surgery 1,031 ml, $p = 0.0001$). The postoperative morbidity rate, which included anastomotic leak, wound infection, ileus, intestinal ischemia and pneumonia, was lower in the laparoscopic surgery group, but the difference was not statistically significant. The CRM was clear in all cases in both the laparoscopic surgery and open surgery groups. The 3-year overall survival, disease-free survival, local recurrence and distant recurrence rates were similar in the two groups.

We examined LAR cases in the laparoscopic surgery ($n = 46$) and open surgery ($n = 15$) groups (Table 2). There was no difference between the groups as regards pretreatment clinical features including tumor distance from the anal verge and pathological factors in the resected specimen, except for the pathological T stage, in which a non-significant tendency of more downstaging in the laparoscopic surgery group was recognized. There was less blood loss in the laparoscopic surgery group (laparoscopic

Table 1 Clinicopathological factors and outcomes of laparoscopic surgery (LAP) and open surgery (OPEN)

	Laparoscopic surgery ($n = 57$)	Open surgery ($n = 30$)	p value
Age (years)	62.9	66.2	0.1
Sex			0.5
Male	44 (77.2 %)	21 (70.0 %)	
Female	13 (22.8 %)	9 (30.0 %)	
Body mass index	22.0	21.7	0.7
CEA[a] (ng/mL)	10.0	18.4	0.4
Tumor size before CRT[b] (mm)	45.6	48.9	0.4
Tumor size in specimen (mm)	27.8	30.2	0.5
Distance from anal verge (mm)	65.5	47.8	0.007
cT before CRT[b]			0.2
3	55 (96.5 %)	27 (90.0 %)	
4	2 (3.5 %)	3 (10.0 %)	
pT			0.09
0 (complete response)	8 (14.0 %)	3 (10.0 %)	
is	0	1 (3.3 %)	
1	9 (15.8 %)	1 (3.3 %)	
2	10 (17.5 %)	5 (16.7 %)	
3	29 (50.9 %)	18 (60.0 %)	
4	0	2 (6.7 %)	
cN (+) before CRT[b]	27 (47.4 %)	10 (34.5 %)	0.3
pN (+)	17 (30.4 %)	4 (13.3 %)	0.07
Procedure			0.006
Low anterior resection	46 (80.1 %)	15 (50.0 %)	
Intersphincteric resection	7 (12.3 %)	4 (13.3 %)	
Hartmann	0	2 (6.7 %)	
Abdominoperineal resection	4 (7.0 %)	8 (26.7 %)	
Total pelvic exenteration	0	1 (3.3 %)	
Operation time (min)	329	322	0.8
Blood loss (mL)	191	1043	0.001
Morbidity	13 (22.8 %)	10 (33.3 %)	0.3
Circumferential margin (+)	0	0	
3 year overall survival (%)	92.9	87.3	0.9
3 year relapse-free survival (%)	69.8	69.4	0.9
3 year local recurrence rate (%)	1.9	8.4	0.4
3 year distant recurrence rate (%)	28.5	22.7	0.8
Follow-up (months)	26.2	45.3	

[a] *CEA* carcinoembryonic antigen

[b] *CRT* chemoradiotherapy

surgery 139 ml vs. open surgery 977 ml, $p = 0.05$), and the operation time was longer in the laparoscopic surgery group than in the open surgery group (laparoscopic surgery 305 min vs. open surgery 255 ml, $p = 0.05$). The rate of covering stoma creation was not different, and the rate of anastomotic leak was also low in the laparoscopic surgery group and was not significantly different from that in the open surgery group. The 3-year overall survival, relapse-free survival, local recurrence and distant recurrence rates were similar in the two groups. In abdominoperineal resection cases, the operation time was shorter (laparoscopic surgery 294 min vs. open surgery 406 min, $p = 0.07$) and blood loss was less (laparoscopic surgery 176 mL vs. open surgery 1,172 mL, $p = 0.06$) in the laparoscopic surgery group, although these differences were not statistically significant due to the small number of cases (4 laparoscopic surgery cases vs. 8 open surgery cases).

Factors associated with operation time and blood loss

We examined the influence of clinical and pathological factors on operation time and blood loss in the LAR cases in the laparoscopic surgery group (Table 3). The operation

Table 2 Clinicopathological factors and outcomes in low anterior resection cases

	Laparoscopic surgery ($n = 46$)	Open surgery ($n = 15$)	p value
Age (years)	64	65.9	0.5
Sex			0.4
Male	38 (82.6 %)	11 (73.3 %)	
Female	8 (17.4 %)	4 (26.7 %)	
Body mass index (kg/m^2)	22.5	22.6	0.9
CEA (ng/mL)	6.7	10.2	0.3
Tumor size before CRT[b] (mm)	45.3	46.4	0.8
Tumor size in specimen (mm)	27	28.1	0.8
Distance from anal verge (mm)	73.3	64.7	0.2
cT before CRT			0.3
3	45 (97.8 %)	14 (93.3 %)	
4	1 (2.2 %)	1 (6.7 %)	
pT			0.09
0 (complete response)	6 (13.0 %)	2 (13.3 %)	
is	0	1 (6.7 %)	
1	7 (15.2 %)	0	
2	10 (21.7 %)	1 (6.7 %)	
3	22 (47.8 %)	10 (66.7 %)	
4	0	1	
cN (+) before CRT	24 (52.2 %)	5 (33.3 %)	0.2
pN (+)	12 (26.1 %)	2 (13.3 %)	0.4
Operation time (min)	305	254	0.05
Blood loss (mL)	139	977	0.05
Covering stoma	15 (32.6 %)	6 (40.0 %)	0.6
Morbidity	10 (21.7 %)	3 (20.0 %)	1
Anastomotic leak	2 (4.3 %)	2 (13.3 %)	0.2
Circumferential margin (+)	0	0	
3-year overall survival (%)	91.2	100	0.1
3-year relapse-free survival (%)	73.5	71.4	0.8
3-year local recurrence rate (%)	2.4	0	0.5
3-year distant recurrence rate (%)	24.3	28.6	0.6
Follow-up (months)	24.4	51.8	

CEA carcinoembryonic antigen, *CRT* chemoradiotherapy, *cT* clinical T stage, *cN* clinical N stage, *pT* pathologic T stage, *pN* pathologic N stage

time was longer in cases with a shorter distance from the anal verge (anal verge ≤ 60 mm: 336 min vs. anal verge > 60 mm: 283 min, $p = 0.04$). CTV increased after CRT from −89.7HU to −81.7HU, and a high CTV after CRT, but not before CRT, was associated with increased blood loss (CTV ≤ -90HU: 52 ml vs. CTV > -90HU: 199 ml, $p = 0.02$).

Two representative cases with low and high CTV are shown in Figs. 1 and 2. In Case 1, there was a relatively low CTV after CRT (−111 HU), and during the operation, tissue dissection around the mesorectum could be performed without extensive mist and exudates (Figs. 1a, 2a); moreover, there was relatively little blood loss (44 ml). In contrast, in Case 2, the CTV after CRT (−66HU) was relatively high, and the plane of dissection was hard to recognize. Extensive mist and exudates resulted in bad visibility in the pelvis (Figs. 1b, 2b) and loss of a relatively large amount of blood (720 ml).

The amount of blood lost in the first 23 cases was larger than that in the other 23 cases. When the impact of CTV after CRT on blood loss was examined separately in the first half and in the second half of the cases, it was found to be associated with increased blood loss only in the first 23 cases and not in the others (Table 4).

Discussion

In the present study, laparoscopic surgery after CRT could be performed with a very low conversion rate, a small blood loss and a low incidence of postoperative morbidity, without apparently compromising oncological outcomes.

Table 3 Correlation of clinicopathological factors with operation time and blood loss in low anterior resection cases in laparoscopic surgery group

	Number	Operation time (min)	*p* value	Blood loss (mL)	*p* value
Age (years)					
65≥	24	292	0.2	102	0.3
66≤	22	319		179	
Sex					
Male	38	304	0.8	152	0.2
Female	8	312		76	
Body mass index (kg/m^2)					
22≥	22	290	0.2	105	0.3
22<	23	320		172	
Tumor size before CRT (mm)					
40≥	20	316	0.06	153	0.9
40<	19	271		153	
Tumor size in specimen (mm)					
40≥	39	306	0.9	145	0.9
40<	7	302		137	
Distance from anal verge (mm)					
60≥	19	336	0.04	167	0.5
60<	25	283		122	
cT before CRT					
3	45	306	0.9	139	0.8
4	1	260		100	
pT					
0 (complete response)	6	293	0.8	44	0.5
is	0	–		–	
1	7	334		148	
2	10	302		43	
3	22	294		195	
4	0	–		–	
cN before CRT					
−	24	290	0.2	122	0.6
+	22	321		156	
pN					
−	33	294	0.2	115	0.4
+	13	333		198	
CTV before CRT (HU)					
≥−90	22	291	0.2	116	0.5
<−90	23	321		163	
CTV after CRT (HU)					
≥−90	19	289	0.3	52	0.02
<−90	27	316		199	
Period					
First	23	299	0.6	228	0.01
Latter	23	311		48	

CRT chemoradiotherapy, *CTV* CT value of the mesorectum, *cT* clinical T stage, *cN* clinical N stage, *pT* pathologic T stage, *pN* pathologic N stage, *HU* Hounsfield units

During the study period, we were able to safely increase the number of cases of laparoscopic surgery, and in the latter half of the period, more than 90 % of CRT cases were operated on laparoscopically laparoscopic surgery for rectal cancer is considered technically demanding [15, 16] because the most essential part of the procedure is the dissection of the rectum in the narrow pelvis. CRT for rectal cancers might both decrease and increase the

technical difficulty of laparoscopic surgery. Rectal cancers undergo downsizing and downstaging following CRT [10], as is also shown in this study, and this can help increase laparoscopic exposure of the surgical field in the narrow pelvic cavity, which might otherwise be obstructed by a large tumor mass. On the other hand, tissue edema and fibrosis caused by CRT may hamper dissection of the tissue [17]. Studies comparing CRT cases and surgery-alone cases have shown that CRT does not apparently have a negative impact on the short-term surgical outcome of laparoscopic surgery for rectal cancer with regard to operation time, conversion rate and morbidity rate, except for a slight increase in blood loss in CRT cases [17–19]. In a case-matched study of CRT, cases comparing laparoscopic surgery and open surgery, blood loss and morbidity were not different between the laparoscopic surgery and open surgery groups, although the operation time was longer in the laparoscopic surgery group [16]. Recently, in a well-organized randomized controlled trial studying rectal cancers treated with CRT (COREAN trial), Kang et al. [20] reported that laparoscopic surgery was performed with less blood loss (200.0 ml vs. 217.5 ml) and with an equally low postoperative complication rate (21.2 vs. 23.5 %), but with a longer operation time (244.9 min vs. 197.0 min) compared to open surgery and the conversion rate was very low (1.2 %). The results of the present study match the results of these previous studies, except for the relatively large amount of blood lost in our open surgery group. Several cases in the open surgery group resulted in large amount of blood loss because of extensive edema and fibrosis around the rectum which seems to increase the mean blood loss in this group. Studies about laparoscopic surgery following CRT also showed a shorter time to the resumption of a normal diet, resulting in a shorter hospital stay. In our study, this factor was not examined because oral feeding was started uniformly 1 week after the operation unless an anastomotic leak or ileus was present.

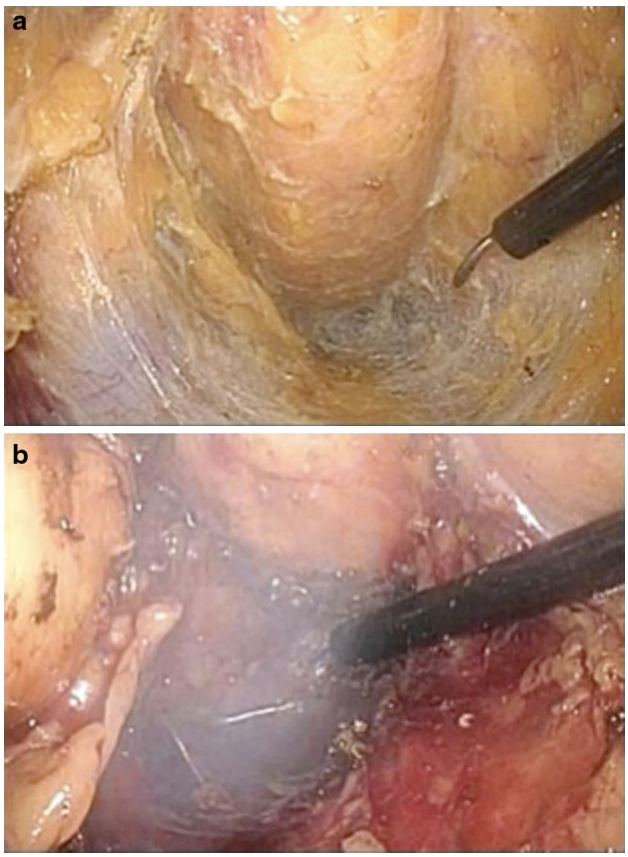

Fig. 2 Operative finding. Edema and fibrosis were more extensive in Case 2 (**b**) than in Case 1 (**a**) during the operation, and the amount of blood loss was larger in Case 2 (720 ml) than in Case 1 (44 ml)

Table 4 Correlation of computed tomography value of the mesorectum (CTV) with blood loss

	CTV after CRT		
	≥−90HU	<−90HU	*p* value
First 23 cases (mL)	45	327	0.01
Latter 23 cases (mL)	58	40	0.7

CRT chemoradiotherapy

In this study, there were clear CRM in all cases and the local recurrence rate was low, both in the laparoscopic surgery and open surgery groups. In the MRC CLASSIC trial, a multicenter randomized trial comparing open surgery and laparoscopic surgery for both colon and rectal cancers, CRM positivity was higher in laparoscopic surgery than open surgery in LAR cases (laparoscopic surgery 12 % vs. open surgery 6 %), and the authors suggested that routine use of laparoscopic LAR is not yet justified [6]. It is unclear how many rectal cancer cases in the MRC CLASSIC trial were treated with CRT. CRT reduces tumor size and can also cause downstaging in the T stage [10] and thus CRT might result in cancer-free CRM especially in cases of threatened CRM. In the COREAN trial examining only CRT cases, CRM positivity was equally low both in laparoscopic surgery and open surgery groups (2.9 vs. 4.1 %) [20]. Other small studies of laparoscopic surgery after CRT have reported similar low rates of positive CRM (0–4 %) [19, 21, 22]. Therefore, CRT might help in obtaining a safe CRM when performing laparoscopic surgery, and one could say that CRT and laparoscopic surgery form a good partnership that offers an oncologically safe and less invasive option for rectal cancer patients.

Our results, combined with the results of prior reports, indicated that laparoscopic surgery following CRT seems to be safe and feasible, although CRT might slightly increase blood loss in laparoscopic surgery, and operation time for CRT cases might be longer in laparoscopic surgery

than in open surgery. During the study period, we experienced a learning curve, as indicated by the decrease in blood loss in the later cases, and we assessed the factors that contributed to the technical difficulty of laparoscopic surgery following CRT. Akiyoshi et al. [13] analyzed the factors affecting the difficulty of laparoscopic TME in rectal cancer cases, the majority of which were in less advanced T and N stages and were treated without CRT. They reported that a small size of the bony pelvis measured radiologically, body mass index (BMI), tumor distance from the anal verge and T stage were predictive of long operation time, but blood loss was associated only with operative time (but was not a "predictor" because it can only be determined after the operation). In this study with CRT cases, the operation time was also longer when the tumor was closer to the anal verge, a reasonable result because further dissection in deeper areas in the pelvis is necessary in such cases. CTV increased after CRT, and high CTV after CRT was associated with increased blood loss. This might be due to the edema and fibrosis of the mesenteric tissue following CRT, as indicated by a high CTV [14]. When performing laparoscopic surgery following CRT, we often experience difficulty in dissecting around the mesorectum while recognizing a proper layer for TME and being hampered by fibrosis and extensive mist and exudates when using electrocautery or ultrasonic dissectors, resulting in increased blood loss. On the other hand, there are cases in which TME can be done without these difficulties just as in cases treated without CRT. This might be due to the difference in the tissue reaction to CRT among patients as we suggested previously [11, 23], and the CTV might indicate this difference. There was a learning curve regarding blood loss, and in the second half of the study period, laparoscopic surgery could be performed with little blood loss regardless of whether the CTV was high or low. In this study, a high BMI tended to be associated with a longer operation time and increased blood loss; however, the differences were not statistically significant. This might be because of the relatively low BMI of our study population compared to the reports from Western countries [16, 17].

As this study is a retrospective review of our clinical experience, the backgrounds of the patients in the laparoscopic surgery and open surgery groups were different, especially in terms of the tumor location and thus in the surgical procedure performed. More patients in the laparoscopic surgery group showed downstaging in the pathological T stage, which might be due to the preferential use of irinotecan or oxaliplatin in this group. These agents are reported to enhance the response to CRT [24, 25]. Therefore, we cannot directly compare the superiority or inferiority of laparoscopic surgery and open surgery for treating rectal cancer after CRT. However, our results suggest that laparoscopic surgery does not jeopardize safety or short-term surgical outcomes. The follow-up period in the present study was short, especially in the laparoscopic surgery group, and it differed between the groups in this study; therefore, a randomized controlled trial with a longer follow-up is necessary to clarify the long-term oncological outcomes.

Conclusions

Laparoscopic surgery for rectal cancer treated with CRT is feasible and can be performed safely with a low conversion rate and with little blood loss, and the results of this study warrant a randomized controlled trial comparing laparoscopic surgery and open surgery. High CTV after CRT might be correlated with extensive edema and fibrosis of the mesorectum and might identify cases that could cause difficulty for surgeons who have not completed the learning curve.

Conflict of interest None.

References

1. Clinical outcomes of surgical therapy study group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
2. Jayne DG, Guillou PJ, Thorpe H et al (2007) Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. J Clin Oncol 25:3061–3068
3. Lacy AM, Delgado S, Castells A et al (2008) The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. Ann Surg 248:1–7
4. Buunen M, Veldkamp R, Hop WC et al (2009) Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. Lancet Oncol 10:44–52
5. Ceelen WP (2007) Use of laparoscopy for rectal cancer: a word of caution. J Clin Oncol 25:5040; author reply 5040–5041
6. Guillou PJ, Quirke P, Thorpe H et al (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
7. Folkesson J, Birgisson H, Pahlman L, Cedermark B, Glimelius B, Gunnarsson U (2005) Swedish rectal cancer trial: long lasting benefits from radiotherapy on survival and local recurrence rate. J Clin Oncol 23:5644–5650
8. Peeters KC, Marijnen CA, Nagtegaal ID et al (2007) The TME trial after a median follow-up of 6 years: increased local control but no survival benefit in irradiated patients with resectable rectal carcinoma. Ann Surg 246:693–701
9. Sauer R, Becker H, Hohenberger W et al (2004) Preoperative versus postoperative chemoradiotherapy for rectal cancer. N Engl J Med 351:1731–1740
10. Ishihara S, Hayama T, Yamada H, Nozawa K, Matsuda K, Watanabe T (2011) Benefit of tegafur-uracil and leucovorin in chemoradiotherapy for rectal cancer. Hepatogastroenterology 58:756–762
11. Ishihara S, Watanabe T, Akahane T et al (2011) Prognostic significance of adverse events associated with preoperative radiotherapy for rectal cancer. Int J Colorectal Dis 26:911–917

12. Ishihara S, Watanabe T, Nagawa H (2008) Intraoperative colonoscopy for stapled anastomosis in colorectal surgery. Surg Today 38:1063–1065
13. Akiyoshi T, Kuroyanagi H, Oya M, Konishi T et al (2009) Factors affecting the difficulty of laparoscopic total mesorectal excision with double stapling technique anastomosis for low rectal cancer. Surgery 146:483–489
14. Mindelzun RE, Jeffrey RB Jr, Lane MJ, Silverman PM (1996) The misty mesentery on CT: differential diagnosis. AJR Am J Roentgenol 167:61–65
15. Kuroyanagi H, Oya M, Ueno M, Fujimoto Y, Yamaguchi T, Muto T (2008) Standardized technique of laparoscopic intracorporeal rectal transection and anastomosis for low anterior resection. Surg Endosc 22:557–561
16. Denoya P, Wang H, Sands D, Nogueras J, Weiss E, Wexner SD (2010) Short-term outcomes of laparoscopic total mesorectal excision following neoadjuvant chemoradiotherapy. Surg Endosc 24:933–938
17. Denost Q, Laurent C, Paumet T, Quintane L, Martenot M, Rullier E (2012) Laparoscopic surgery for rectal cancer: preoperative radiochemotherapy versus surgery alone. Surg Endosc 26:1878–1883
18. Rosati R, Bona S, Romario UF, Elmore U, Furlan N (2007) Laparoscopic total mesorectal excision after neoadjuvant chemoradiotherapy. Surg Oncol 16(Suppl 1):S83–S89
19. Akiyoshi T, Kuroyanagi H, Oya M et al (2009) Safety of laparoscopic total mesorectal excision for low rectal cancer with preoperative chemoradiation therapy. J Gastrointest Surg 13:521–525
20. Kang SB, Park JW, Jeong SY et al (2010) Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): short-term outcomes of an open-label randomised controlled trial. Lancet Oncol 11:637–645
21. Cone MM, Lu KC, Herzig DO, Rea JD, Diggs BS, Oommen SC (2011) Laparoscopic proctectomy after neoadjuvant therapy: safety and long-term follow-up. Surg Endosc 25:1902–1906
22. Motson RW, Khan JS, Arulampalam TH, Austin RC, Lacey N, Sizer B (2011) Laparoscopic total mesorectal excision following long course chemoradiotherapy for locally advanced rectal cancer. Surg Endosc 25:1753–1760
23. Ishihara S, Iinuma H, Fukushima Y et al (2012) Radiation-induced apoptosis of peripheral blood lymphocytes is correlated with histological regression of rectal cancer in response to preoperative chemoradiotherapy. Ann Surg Oncol 19:1192–1198
24. Rodel C, Liersch T, Becker H et al (2012) Preoperative chemoradiotherapy and postoperative chemotherapy with fluorouracil and oxaliplatin versus fluorouracil alone in locally advanced rectal cancer: initial results of the German CAO/ARO/AIO-04 randomised phase 3 trial. Lancet Oncol 13:679–687
25. Sato T, Ozawa H, Hatate K et al (2011) A Phase II trial of neoadjuvant preoperative chemoradiotherapy with S-1 plus irinotecan and radiation in patients with locally advanced rectal cancer: clinical feasibility and response rate. Int J Radiat Oncol Biol Phys 79:677–683