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Effect of Left Colonic Artery Preservation on Anastomotic Leakage in Laparoscopic Anterior Resection for Middle and Low Rectal Cancer

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Abstract

Background High morbidity rates related to anastomotic leakage and other factors restrict the application of laparoscopic rectal excision. The aim of the present study was to assess the effect of left colonic artery (LCA) preservation on postoperative complications after laparoscopic rectal excision.

Methods Data from 888 patients from 28 leading hospitals in Japan who underwent laparoscopic-assisted sphincter-preserving resection of middle and low rectal cancers between 1994 and 2006 were analyzed. The effects of LCA preservation were analyzed among all anterior resection (AR) cases ($n = 888$) and among AR cases with radical lymph node excision ($n = 411$).

Results Among all AR cases, the tumor size, number of lymph nodes collected with evidence of metastasis, TNM factor, and TNM staging were smaller in the LCA preservation group. Regarding complications, the rate of anastomotic leak was significantly higher in the LCA non-preservation group among all AR cases, as well as among AR cases with radical lymph node excision. Nevertheless, there was no difference in survival rate between LCA preservation group and non-preservation group, as measured by the Kaplan–Meier method.

Conclusions Our data suggest that the preservation of the LCA in laparoscopic AR for middle and low rectal cancer is associated with lower anastomotic leak rates.

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Introduction

Colorectal cancer is the leading cause of cancer-related death in much of the industrialized world [1]. The status of lymph node metastasis is one of the critical factors influencing the prognosis and treatment of colorectal cancer, which is reflected in various cancer staging systems [2–5]. Therefore, surgical resection of the tumor with an appropriate surgical margin as well as with *en bloc* lymph node resection to the level of the origin of the primary feeding vessels remains the important treatment modality [6]. However, analysis of the literature indicates that there are many issues of concern involved in radical surgery for the cure of rectal cancer, including high and low ligation of the inferior mesenteric artery (IMA).

Laparoscopy-assisted surgery for colon cancer has gradually gained acceptance because of its various advantages, including the cosmetic result, preserved immune function, lesser analgesic requirements, more rapid recovery from surgery, and shorter hospital stay. Although clinical trials have established the safety and feasibility of laparoscopic [7–11], no equivalent evidence exists for the laparoscopic approach in the treatment of rectal cancer. The standardized open surgical procedure for middle and low rectal cancers is generally considered to include initial proximal ligation of the inferior mesenteric vascular pedicle, complete mobilization of the rectum with total mesorectal excision (TME), and anastomosis performed with a stapler. The Guideline 2000 for Colon and Rectal Cancer Surgery [12] sponsored by the National Cancer Institute in the U.S. recommends removal of the blood supply and lymphatics up to the level of the origin of the superior rectal artery, which is immediately distal to the takeoff of the left colic artery (LCA). Although the guideline states that there is a lack of evidence regarding the benefit of ligating the IMA at its origin, it is recommended to remove as much lymph node disease suspicious for metastasis as is technically possible.

In Japan, surgical treatments for colorectal cancer have been performed based on the Japanese general rules for clinical and pathological studies on cancer of the colon, rectum, and anus (JGR), edited by the Japanese Society for Cancer of the Colon and Rectum (JSCCR) [13, 14]. It suggests that the standard practice for lymph node dissection in advanced sigmoid and rectal cancer cases should include dissection of inferior mesenteric trunk nodes. In this study, we performed a multi-center analysis to assess the optimal procedure for ligating primary feeding vessels and dissecting lymphatics around the IMA by focusing on the management of the LCA in relation to the level of IMA ligation.

In all AR cases including early cancers, the overall importance of LCA preservation was analyzed. Furthermore, we investigated the effect of LCA preservation on surgical outcome in advanced cancer cases with radical lymph node excision up to the origin of the IMA to assess the importance of the clearance of the lymphatic drainage around the IMA, as well as to examine the feasibility of the procedure with a reasonable morbidity rate.

Methods

Patients

A multicenter study was initiated by the 28 institutions that are members of the Japan Society of Laparoscopic Colorectal Surgery. The record of all patients who underwent sphincter-preserving laparoscopic surgery for middle and low rectal cancers between May 1994 and February 2006 were analyzed. Stratification of patients according to whether or not the LCA was preserved had been institution dependent without previously described systematic method. None of the patients underwent neoadjuvant radiation or chemoradiation therapy prior to surgery. All the operations were performed by surgeons with experience of at least 30 laparoscopic surgeries for colorectal cancer. Operative mortality was defined as death within 30 days of surgery, and morbidities were defined as complications (e.g., anastomotic leaks, wound infections, ileus, and reoperation) that involved additional treatment or a prolonged hospital stay. With regard to postoperative surveillance, the Japanese guideline recommends periodic patient follow-up with office visits for 5 years; clinical examination and carcinoembryonic antigen (CEA) measurement every 3 months, computed tomography (CT) scan every 6 months, and colonoscopy every year for 3 years, followed by CEA measurement every 6 months and CT scan every year for 2 years. Confirmation of recurrence required imaging or pathological evaluation.

Regarding postoperative treatment, the decision to give adjuvant chemotherapy was based on the current practice in Japan at that time. Oral fluorouracil prodrugs (tegafur-uracil: UFT) has been the standard treatment in stage III surgically resectable rectal cancer with metastasis in the regional lymph nodes in Japan.

Parameters and statistical analysis

Analysis was performed to investigate the following preoperative patient factors: age, height, weight, body mass index (BMI), gender, tumor size, tumor location including distance from the anal verge, main tumor location in relation to the peritoneal reflection, operative time, bleeding volume, size of incision, distal margin, length of hospital stay after operation, International Union Against Cancer (UICC) TNM staging, and number of lymph nodes collected and metastasized. The number of cases requiring open conversion, hand-assisted laparoscopic surgery (HALS) support, and diverting stoma were analyzed in addition to the method of rectal transection and anastomosis. The number of complications related to anastomotic leak, wound infection, ileus, and reoperation were counted and analyzed. Statistical differences in categorical variables were analyzed by the Chi square test, and differences in two variables were analyzed by the Mann–Whitney *U* test. Probability curves were constructed according to the Kaplan–Meier method and compared with the log rank test. All calculations were performed with SPSS software package version16 (SPSS Inc., Chicago, IL).

Preparation and procedure of operation

Patients had standard mechanical bowel preparation before surgery. Cannula positioning, dissection of the colon and rectum, and division of the vessels were performed according to a method described previously [15]. Total mesenteric excision with sphincter preservation was achieved in all patients. The extent of lymphadenectomy, site of ligation, and division of the main vessels was decided according to the JGR guideline edited by JSCCR [13]. In the case of advanced cancer, radical lymph node excision around the IMA was performed either with high ligation of the IMA at its origin from the aorta or with low ligation below the origin of the LCA branch. This procedure was performed by completing a thorough *en bloc* clearance of lymph nodes at the base of the IMA. Dissection of the rectum was accomplished either laparoscopically or through a small suprapubic skin incision using conventional devices for open surgery. The anastomosis was performed using standard double- or single-stapling techniques, or by a coloanal hand-sewn anastomosis. The incision was shielded from direct contact with the specimen with a plastic wound protector. A diverting ileostomy was performed based on the surgeon's technical evaluation of the quality of the anastomosis.

Results

Between May 1994 and February 2006, 888 patients underwent laparoscopic anterior resection (AR) for middle and low rectal cancer in the 28 hospitals participating in the present study. Median follow-up time was 26 months (range 1–140 months), and mean follow-up time with standard deviation was 31 ± 24 months. Patient demographics and tumor characteristics are summarized in Table 1 (left). There were no statistically significant differences between the LCA preservation group and the non-preservation group regarding age, height, weight, and sex distribution, although the BMI of the LCA preservation group was significantly larger ($P = 0.017$). Tumor size in the LCA nonpreservation group was significantly larger than that in the preservation group ($P < 0.001$), suggesting that the LCA was ligated and sacrificed when the tumor size predicted more advanced status. Tumor location, including distance from the anal verge and spatial relation to the peritoneal reflection, showed no significant difference between the LCA preservation and non-preservation groups.

Factors related to the surgical background between the LCA preservation and non-preservation groups in all AR cases were compared (left, Table 2). As expected, operative time was significantly longer in the LCA preservation group ($P < 0.001$), whereas size of incision, distal margin, and length of hospital stay after operation were significantly shorter ($P = 0.001$–0.029). There was no significant difference between the LCA preservation and non-preservation groups with regard to the rate of open conversion ($P = 0.439$), HALS support ($P = 0.143$), diverting stoma ($P = 0.893$), method of rectal transection ($P = 0.231$), or anastomosis ($P = 0.563$). With regard to the factors related

Table 1 Patient demographics and tumor characteristics

	All AR				AR+radical lymph node excision			
	Total ($n = 888$)	LCA preservation ($n = 584$)	LCA non-preservation ($n = 304$)	*P* value	Total ($n = 411$)	LCA preservation ($n = 155$)	LCA non-preservation ($n = 256$)	*P* value
Age, median (IQR) (year)	63 (52–74)	63 (52–74)	61 (60–72)	0.043	62 (51–73)	64 (54–74)	62 (51–73)	0.054
Height, mean ± SD (cm)	160.5 ± 8.9	160.0 ± 9.1	161.3 ± 8.4	0.066	160.6 ± 11.5	159.4 ± 15.2	161.3 ± 8.6	0.21
Weight, mean ± SD (kg)	59.6 ± 10.9	59.6 ± 11.2	58.9 ± 10.3	0.239	59.9 ± 10.8	61.6 ± 11.3	58.9 ± 10.4	0.014
BMI, mean ± SD (kg/m^2)	23.0 ± 4.6	23.3 ± 5.1	22.6 ± 3.2	0.017	22.8. ± 4.2	23.4 ± 4.7	22.4 ± 3.8	<0.001
Sex								
Male	557 (62.7 %)	365 (62.5 %)	192 (63.2 %)	0.828	254 (61.8 %)	92 (59.4 %)	162 (63.3 %)	0.427
Female	331 (37.3 %)	219 (37.5 %)	112 (36.8 %)		157 (38.2 %)	63 (40.6 %)	94 (36.7 %)	
Tumor size, mean ± SD (mm)	33.7 ± 18.0	31.1 ± 17.4	38.5 ± 18.1	<0.001	38.7 ± 17.9	36.7. ± 17.5	39.9 ± 18.0	0.106
Tumor location								
Distance from AV, median (IQR) (cm)	9.1 (6.1–12.1)	9.1 (6.1–12.1)	9.1 (6.2–12.0)	0.775	9.3 (6.5–11.9)	9.4 (6.7–12.1)	9.2 (7.4–12.0)	0.324
Ra (above the peritoneal reflection)	645 (72.6 %)	411 (70.4 %)	234 (77.0 %)	0.045	329 (80.0 %)	123 (79.4 %)	206 (80.5 %)	0.784
Rb (below the peritoneal reflection)	243 (27.4 %)	173 (29.6 %)	70 (23.0 %)		82 (20.0 %)	32 (20.6 %)	50 (19.5 %)	

AR anterior resection, *LCA* left colonic artery, *IQR* interquartile range, *SD* standard deviation, *BMI* body mass index, *AV* anal verge

Table 2 Surgical findings

	All AR				AR + radical lymph node dissection			
	Total ($n = 888$)	LCA preservation ($n = 584$)	LCA non-preservation ($n = 304$)	P value	Total ($n = 411$)	LCA preservation ($n = 155$)	LCA non-preservation ($n = 256$)	P value
Operative time, mean ± SD (min)	277 ± 90	286 ± 90	261 ± 82	<0.001	277 ± 85	303 ± 84	262 ± 83	<0.001
Estimated blood loss, mean ± SD (ml)	140 ± 187	134 ± 180	151 ± 198	0.163	147 ± 184	140 ± 158	152 ± 198	0.828
Size of incision, mean ± SD (cm)	6.2 ± 5.1	5.8 ± 4.3	6.8 ± 6.6	0.029	6.6 ± 5.7	5.6 ± 2.8	7.2 ± 6.9	<0.001
Distal margin, mean ± SD (cm)	2.6 ± 0.1	2.4 ± 1.4	2.8 ± 1.6	0.002	2.9 ± 1.5	2.8 ± 1.4	2.9 ± 1.6	0.512
Hospital stay after operation, mean ± SD (days)	20.4 ± 20.9	18.9 ± 19.9	23.1 ± 22.5	0.001	21.6 ± 21.0	18.6 ± 15.3	23.5 ± 23.6	0.192
Open conversion								
+	73 (8.2 %)	45 (7.7 %)	28 (9.2 %)	0.439	39 (9.5 %)	16 (10.3 %)	23 (9.0 %)	0.654
−	815 (91.8 %)	539 (92.3 %)	276 (90.8 %)		372 (90.5 %)	139 (89.7 %)	233 (91.0 %)	
HALS support								
+	27 (3.0 %)	16 (2.7 %)	11 (3.6 %)	0.143	12 (2.9 %)	2 (1.3 %)	10 (3.9 %)	0.063
−	833 (93.8 %)	545 (93.3 %)	288 (94.7 %)		394 (95.9 %)	153 (98.7 %)	241 (94.1 %)	
NA	28 (3.2 %)	23 (3.9 %)	5 (1.6 %)		5 (1.2 %)	0 (0 %)	5 (2.0 %)	
Method of transection of rectum								
Through skin incision	265 (29.8 %)	179 (30.7 %)	86 (28.3 %)	0.231	111 (27.0 %)	41 (26.5 %)	70 (27.3 %)	0.205
Laparoscopically	595 (67.0 %)	383 (65.6 %)	212 (69.7 %)		295 (71.8 %)	114 (73.5 %)	181 (70.7 %)	
NA	28 (3.2 %)	22 (3.8 %)	6 (2.0 %)		5 (1.2 %)	0 (0 %)	5 (2.0 %)	
Anastomosis								
DST	861 (97.0 %)	567 (97.1 %)	294 (96.7 %)	0.563	399 (97.1 %)	150 (96.8 %)	249 (97.3 %)	0.218
SST	14 (1.6 %)	10 (1.7 %)	4 (1.3 %)		9 (2.2 %)	5 (3.2 %)	4 (1.6 %)	
Hand suture	12 (1.4 %)	6 (1.0 %)	6 (2.0 %)		3 (0.7 %)	0 (0 %)	3 (1.2 %)	
NA	1 (0.1 %)	1 (0.2 %)	0 (0 %)					
Diverting stoma								
+	71 (8.0 %)	47 (8.0 %)	24 (7.9 %)	0.893	24 (5.8 %)	6 (3.9 %)	18 (7.0 %)	0.303
−	815 (91.8 %)	536 (91.8 %)	279 (91.8 %)		386 (93.9 %)	149 (96.1 %)	237 (92.6 %)	
NA	2 (0.2 %)	1 (0.2 %)	1 (0.3 %)		1 (0.2 %)	0 (0 %)	1 (0.4 %)	

HALS hand-assisted laparoscopic surgery, *NA* not applicable, *DST* double stapling technique, *SST* single stapling technique

Table 3 Pathological findings

	All AR				AR+radical lymph node dissection			
	Total ($n = 888$)	LCA preservation ($n = 584$)	LCA non-preservation ($n = 304$)	P value	Total ($n = 411$)	LCA preservation ($n = 155$)	LCA non-preservation ($n = 256$)	P value
Tis (M)	77 (8.7 %)	67 (11.5 %)	10 (3.3 %)	<0.001	7 (1.7 %)	4 (2.6 %)	3 (1.2 %)	0.44
T1 (SM)	313 (35.2 %)	258 (44.2 %)	55 (18.1 %)		66 (16.1 %)	30 (19.4 %)	36 (14.1 %)	
T2 (MP)	184 (20.7 %)	111 (19.0 %)	73 (24.0 %)		99 (24.1 %)	36 (23.2 %)	63 (24.6 %)	
T3 (SS, SE/A)	230 (25.9 %)	110 (18.8 %)	120 (39.5 %)		174 (42.3 %)	64 (41.3 %)	110 (43.0 %)	
T4 (SI, AI)	84 (9.5 %)	38 (6.5 %)	46 (15.1 %)		65 (15.8 %)	21 (13.5 %)	44 (17.2 %)	
N0	664 (74.8 %)	461 (78.9 %)	203 (66.8 %)	<0.001	267 (65.0 %)	102 (65.8 %)	165 (64.5 %)	0.566
N1	166 (18.7 %)	95 (16.3 %)	71 (23.4 %)		107 (26.0 %)	42 (27.1 %)	65 (25.4 %)	
N2	58 (6.5 %)	28 (4.8 %)	30 (9.9 %)		37 (9.0 %)	11 (7.1 %)	26 (10.2 %)	
M0	849 (95.6 %)	568 (97.3 %)	281 (92.4 %)	0.001	384 (93.4 %)	150 (96.8 %)	234 (91.4 %)	0.033
M1	39 (4.4 %)	16 (2.7 %)	23 (7.6 %)		27 (6.6 %)	5 (3.2 %)	22 (8.6 %)	
Stage 0	78 (8.8 %)	68 (11.6 %)	10 (3.3 %)	<0.001	7 (1.7 %)	4 (2.6 %)	3 (1.2 %)	0.245
Stage I	426 (48.0 %)	315 (53.9 %)	111 (36.5 %)		137 (33.3 %)	52 (33.5 %)	85 (33.2 %)	
Stage II	153 (17.2 %)	73 (12.5 %)	80 (26.3 %)		119 (29.0 %)	44 (28.4 %)	75 (29.3 %)	
Stage III	193 (21.7 %)	112 (19.2 %)	81 (26.6 %)		121 (29.4 %)	49 (31.6 %)	72 (28.1 %)	
Stage IV	38 (4.3 %)	16 (2.7 %)	22 (7.2 %)		26 (6.3 %)	5 (3.2 %)	21 (8.2 %)	
Number of collected lymph nodes, mean ± SD	14.9 ± 9.1	13.3 ± 8.1	17.8 ± 10.1	<0.001	19.0 ± 10.0	18.9 ± 9.8	19.0 ± 10.1	0.91
Number of metastasized lymph nodes, Mean ± SD	1.0 ± 3.2	0.8 ± 3.1	1.4 ± 3.2	<0.001	1.3 ± 2.9	0.9 ± 1.8	1.5 ± 3.4	0.436

M mucosal, *SM* submucosa, *MP* muscularis propria, *SS* subserosa, *SE/A* tumor invades serosa (SE) or perirectal tissue (A). *SI*, *AI* tumor directly invades other organs or structures and/or perforates visceral peritoneum

to the pathological background, the LCA preservation group had a lower T factor than the non-preservation group ($P < 0.001$). The LCA preservation group also had a lower N factor than the non-preservation group ($P < 0.001$). As a result, staging differed, with the LCA preservation group at a lower TMN stage than the LCA non-preservation group (<0.001) (left, Table 3).

The numbers of collected lymph nodes and metastasized lymph nodes were smaller ($P < 0.001$) in the LCA preservation group. After analyzing data from all AR cases regardless of the area of lymph node dissection, our results indicated that LCA preservation appears to be associated with a low anastomotic leak rates (Table 4; 7.4 %, $P = 0.005$ and <0.001 by univariate and multivariate analysis, respectively). This compares to an anastomotic leak rate of 13.2 % in the LCA non-preservation group, although this result might be biased because of the different surgical and pathological backgrounds between two groups, with more advanced cancer/stage in LCA non-preservation group.

To minimize the differences between the two groups, and to analyze the significance of LCA preservation, we next focused on the more advanced rectal cancer cases where there was a higher risk of morbidity because of the radical dissection. Of the 888 patients (46.3 %), 411 underwent *en bloc* radical excision of lymphatic drainage either with high ligation of the IMA up to its origin from the aorta (LCA non-preservation group) or with ligation of the IMA just distal to the LCA branch (LCA preservation group). In the Japanese guideline, the recommended level of proximal vascular ligation for advanced rectal cancer is at the origin of the IMA from the aorta. In the LCA preservation group, the fat tissue, including lymph nodes between the IMA origin and the LCA branch, was dissected along the IMA. Therefore the area of lymphadenectomy is considered to be theoretically identical except that the LCA branch is preserved to provide more blood supply to the anastomosis. As shown on the right side of Table 1, the patient demographics and tumor characteristic assessment revealed that there is no statistically significant difference between the LCA preservation and non-preservation groups with regard to age ($P = 0.054$), height ($P = 0.210$), sex distribution ($P = 0.427$), tumor size ($P = 0.106$), and tumor location

Table 4 Univariate and multivariate analysis of complications

Type of complications	Total	LCA preservation	LCA non-preservation	Univariate	Multivariate	
				P value	Hazard ratio (95 % CI)	P value
All AR	888	584	304			
Morbidity	199 (22.4 %)	130 (22.3 %)	69 (22.7 %)	0.882	0.586 (0.326–1.053)	0.074
Anastomotic leak	83 (9.3 %)	43 (7.4 %)	40 (13.2 %)	0.005	0.269 (0.131–0.550)	<0.001
Wound infection	49 (5.5 %)	32 (5.5 %)	17 (5.6 %)	0.944	0.714 (0.341–1.499)	0.374
Ileus	29 (3.3 %)	20 (3.4 %)	9 (3.0 %)	0.136	0.690 (0.270–1.767)	0.440
Reoperation	55 (6.2 %)	36 (6.2 %)	19 (6.3 %)	0.960	1.602 (0.771–3.328)	0.207
AR+radical lymph node excision	411	155	256			
Morbidity	104 (25.3 %)	42 (27.1 %)	62 (24.2 %)	0.515	0.539 (0.247–1.175)	0.120
Anastomotic leak	48 (11.8 %)	11 (7.1 %)	37 (14.5 %)	0.024	0.235 (0.085–0.650)	0.005
Wound infection	34 (8.3 %)	18 (11.6 %)	16 (6.3 %)	0.056	1.487 (0.592–3.738)	0.399
Ileus	11 (2.7 %)	4 (2.6 %)	7 (2.7 %)	0.925	0.497 (0.121–2.037)	0.332
Reoperation	26 (6.3 %)	8 (5.2 %)	18 (7.0 %)	0.450	1.163 (0.388–3.483)	0.788

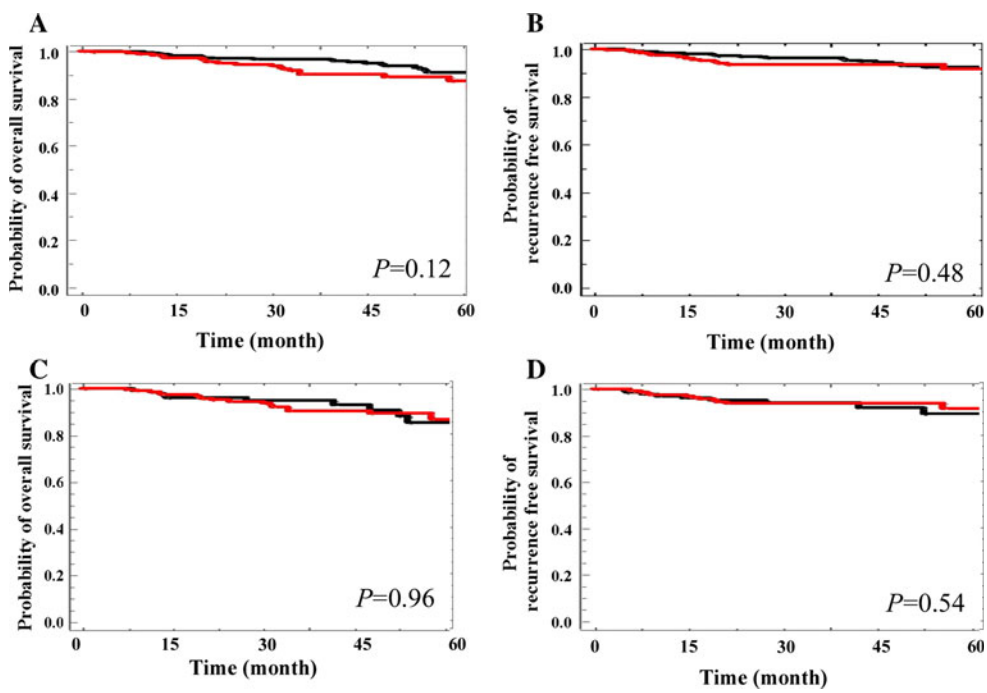

Fig. 1 Kaplan–Meier estimates of overall and recurrence-free survival for all AR cases (**a**, **b**) and the overall and recurrence-free survival for AR cases with radical lymph node dissection (**c** and **d**, respectively). The *black line* and the *red line* indicate, respectively, survival curves of the LCA preservation group and the LCA non-preservation group

($P = 0.324$). In contrast, the patients in the LCA preservation group were heavier ($P = 0.014$) and had a higher BMI ($P < 0.001$).

Of note, there is no difference in surgical and pathological background between the two groups with the exception of operative time and size of incision (right, Tables 2, 3). The TNM factor and staging, with the exception of the M factor ($P = 0.033$), are almost equivalent between the LCA preservation and non-preservation groups. With regard to the complication rate (Table 4), only anastomotic leak showed a significant difference ($P = 0.024$ and 0.005, univariate and multivariate analysis, respectively): 7.1 % in the LCA preservation group versus 14.5 % in the LCA non-preservation group. This result strongly suggests that status of LCA preservation is a significant factor for low anastomotic leak rates after laparoscopic AR for middle and low rectal cancers, regardless of size of tumor, extent of lymph node metastasis, and extent of excision.

There is no significant difference in the survival rate between the LCA preservation and non-preservation groups as analyzed by the Kaplan–Meier method (Fig. 1).

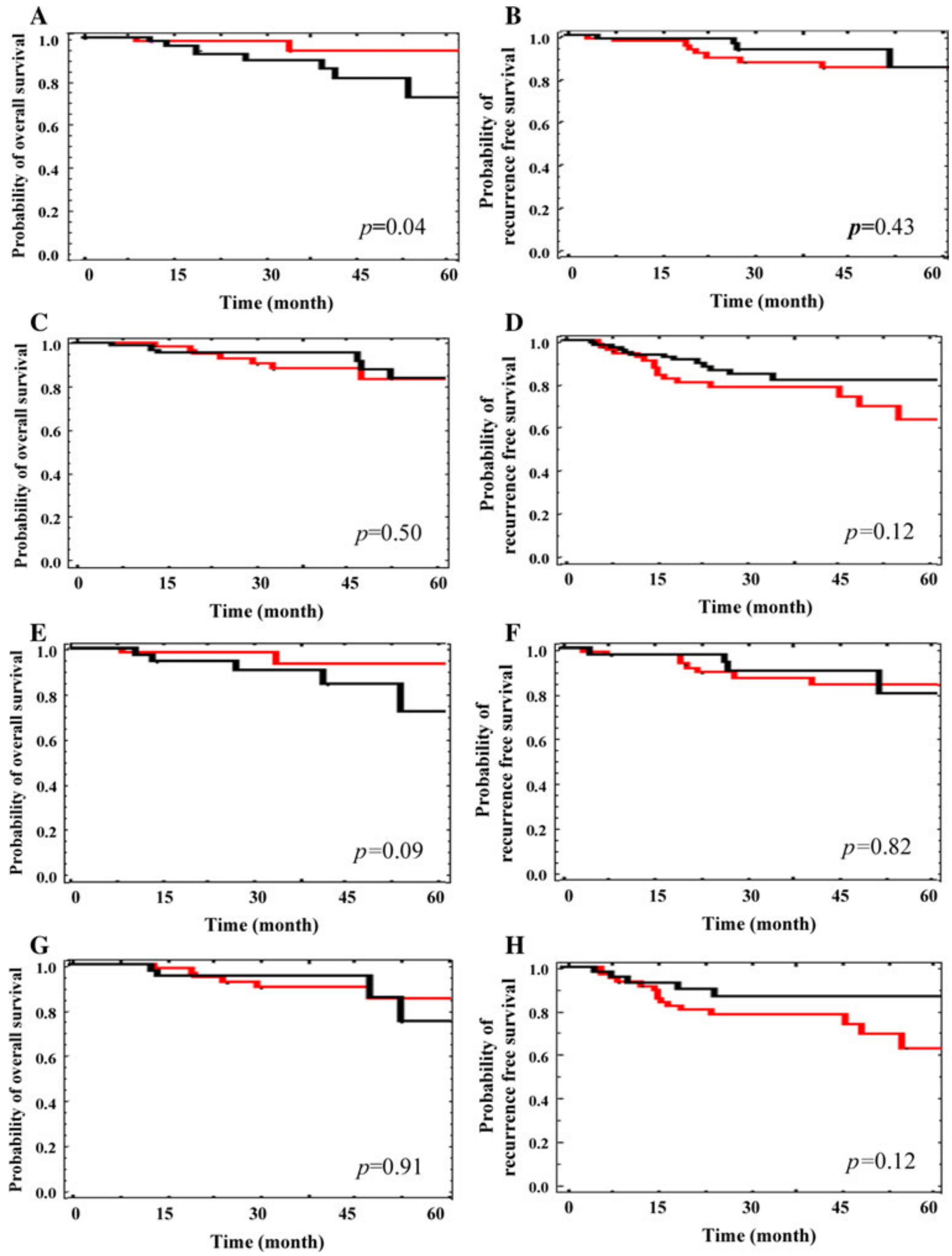

Fig. 2 Kaplan–Meier estimates of overall survival and recurrence-free survival for all AR cases in stage II (**a** and **b**, respectively) and stage III (**c** and **d**, respectively). For AR cases with radical lymph node dissection of overall and recurrence-free survival in stage II (**e** and **f**, respectively) and stage III (**g** and **h**, respectively). *Black line* and *red line* indicates survival curve of LCA preservation group and LCA non-preservation group, respectively

We further performed analysis of stage-by-stage overall survival rates and progression-free survival in stage II and stage III cases (Fig. 2). There was no statistically significant difference between LCA preserved cases and LCA non-preserved cases, except in the overall survival rates in stage II with all AR cases ($P = 0.04$; Fig. 2a). Eleven of 153 stage II patients died, although only four of those patients died from the recurrence of cancer. Two of those 4 patients underwent AR with LCA preservation. However, six of seven patients with non-cancer-related death belong to the LCA preservation group, suggesting that the difference in overall survival between the LCA preserved and non-preserved groups in stage II might be due to the biased population with non-cancer-related death. The oncological feasibility regarding LCA preservation was confirmed in more advanced cases, which in this study are categorized as AR cases with radical lymph node dissection. There is no statistically significant difference in overall and progression-free survival rates between the LCA preserved group and the LCA non-preserved group in both in stage II and stage III (Fig. 2e–h). With regard to central vascular pedicle recurrence at the preserved

IMA origin due to the LCA preservation, no recurrence has been reported among the cases we investigated in this study.

Discussion

Several studies have demonstrated that laparoscopic surgery for rectal cancer is safe and feasible [9, 16–19]. The present study regarding laparoscopic surgery for middle and low rectal cancers is the first multicenter study by 28 leading facilities, in which surgeons performed laparoscopic operations according to the JGR guideline [20]. In this guideline, which has been used for open surgery, the recommended level of proximal vascular ligation for advanced rectal cancer is the root of the IMA. Alternatively, in some facilities, ligation of the IMA below the level of the LCA branch was performed to preserve the LCA; the modified procedure included additional dissection of adipose tissue along the IMA between its root and the LCA branch [21].

With regard to the level of proximal lymphovascular ligation for rectal cancer, it is suggested by level II–III evidence that an appropriate proximal lymphatic resection for rectal cancer is provided by removal of the blood supply and lymphatics up to the level of the origin of the primary feeding vessels [12]. A French multicenter randomized trial [22], as well as other studies [23–26], showed no significant differences with regard to long-term survival between ligation of the IMA and ligation of the superior rectal artery. The analysis of lymph node metastasis distribution along the IMA indicated that in only 1 of 135 patients (0.7 %) was a positive lymph node found at the root of the IMA [27]. However, a large series from Columbia-Presbyterian Hospital in New York City [28], a German study [29], and studies from Japan [30, 31] showed improved survival in certain stages of disease by performing high IMA ligation. These findings suggest that the more extensive resection of mesenteric lymphatic drainage associated with high ligation increased the survival rate and reduced the recurrence rate after curative resections.

This sets up a situation where radical nodal excision with high ligation of the IMA is associated with better long-term outcome, while LCA preservation results in blood supply for anastomosis after AR even in the case of the 5 % of patients lacking the marginal artery in the left colic flexure called Riolan's arcade or Haller's anastomosis and resulting in ischemia in the oral side of anastomosis [32]. Critical factors determining the appropriate level of IMA ligation [30] include detection of lymph node metastasis and pN status. Both *en bloc* resection of the tumor-bearing segment and observation through laparoscopy may reduce the accuracy of the intraoperative diagnosis, so decision making is best done according to clinical TNM staging. For radical lymphatic dissection with LCA preservation equivalent to a flush aortic tie (high ligation), low ligation of the IMA distal to the LCA branch is performed after dissection of the adipose tissue, including lymph nodes between the base of the IMA and the branch of LCA, allowing both better outcome of the operation and long survival [21]. In this study, the lower anastomotic leak rates observed even with radical lymph node excision with LCA preservation suggest the adequacy of the procedure for advanced cancer cases in laparoscopic surgery. A possible reason for the high leakage rate noted in the LCA non-preservation group in laparoscopic operations but not in open surgery [33] is that the high ligation of the inferior mesenteric vein and the resection of the lateral side of the mesocolon tissue along the inferior mesenteric vessels pedicle with bipolar electrosurgery instruments or high-power ultrasonic dissection devices, might cause injury to the marginal artery of the sigmoid colon resulting in lack of blood supply to the anastomosis. To confirm that early outcome, as well as oncological outcome such as survival rate, is not inferior or superior to that of open surgery, we have to await the results of a randomized controlled study.

In conclusion, our data suggest that preservation of the LCA in laparoscopic AR for middle and low rectal cancers is associated with lower anastomotic leak rates.

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