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ORIGINAL ARTICLE—ALIMENTARY TRACT

Laparoscopic surgery for colorectal cancer is safe and has survival outcomes similar to those of open surgery in elderly patients with a poor performance status: subanalysis of a large multicenter case–control study in Japan

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Abstract

Background It remains controversial whether open or laparoscopic surgery should be indicated for elderly patients with colorectal cancer and a poor performance status.

Methods In those patients aged 80 years or older with Eastern Cooperative Oncology Group performance status score of 2 or greater who received elective surgery for stage 0 to stage III colorectal adenocarcinoma and had no concomitant malignancies and who were enrolled in a multicenter case–control study entitled "Retrospective study of laparoscopic colorectal surgery for elderly patients" that was conducted in Japan between 2003 and 2007, background characteristics and short-term and long-term outcomes for open surgery and laparoscopic surgery were compared.

Results Of the 398 patients included, 295 underwent open surgery and 103 underwent laparoscopic surgery. There were no significant differences in the baseline characteristics between open surgery and laparoscopic surgery patients, except for previous abdominal surgery and TNM stage. The median operation duration was shorter with open

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surgery (open surgery, 153 min; laparoscopic surgery, 202 min; $P < 0.001$), and less blood loss occurred with laparoscopic surgery (median open surgery, 109 g; median laparoscopic surgery, 30 g; $P < 0.001$). An operation duration of 180 min or more (odds ratio, 1.97; 95 % confidence interval, 1.17–3.37; $P = 0.011$) and selection of laparoscopic surgery (odds ratio, 0.41; 95 % confidence interval, 0.22–0.75; $P = 0.003$) were statistically significant in the multivariate analysis for postoperative morbidity. Moreover, laparoscopic surgery did not result in an inferior overall survival rate compared with open surgery (log-rank test $P = 0.289$, 0.278, 0.346, 0.199, for all-stage, stage 0–I, stage II, and stage III disease, respectively).
Conclusions Laparoscopic surgery in elderly colorectal cancer patients with a poor performance status is safe and not inferior to open surgery in terms of overall survival.

Keywords Colon cancer · Rectal cancer · Laparoscopic surgery · Elderly patient · Performance status

Introduction

In recent years, considerable progress has been made in the treatment of colorectal cancer (CRC), particularly in the use of laparoscopic surgery. Several randomized controlled trials (RCTs) have demonstrated comparable oncological results but improved short-term outcomes with laparoscopic surgery relative to open surgery [1–11]. As a result, laparoscopic surgery for CRC is thought to compare favorably with open surgery.

At the same time, the treatment of elderly CRC patients has emerged as an important consideration given the aging population. Age itself is a major risk factor for carcinogenesis, and comorbidities that could contribute to postoperative morbidity and mortality are often present in elderly patients [12–19]. Several studies have demonstrated, in elderly CRC patients, that laparoscopic surgery is favorable to open surgery in terms of short-term outcomes [20–24] and is similar in terms of survival outcomes [24, 25]; therefore, laparoscopic surgery is an acceptable alternative to open surgery. However, there is considerable variation in the health of elderly CRC patients, with some as healthy as younger individuals and others experiencing poorer performance status (PS), which encompasses disease progression and the ability to carry out activities of daily living, owing to the presence of comorbidities. From the analyses of the recent large multicenter case–control study in Japan, in which surgical outcomes were investigated among elderly patients with CRC aged 80 year or older [24], both perioperative morbidity and overall survival were worsen as PS became worse (electronic supplementary material 1) Therefore, the indication of laparoscopic surgery in these frailer patients remains controversial, because the surgical stress relating to longer operation durations and cardiopulmonary stress from the extreme Trendelenburg position and pneumoperitoneum resulting from laparoscopic surgery may increase the risk of postoperative mortality and morbidity in these patients [23, 26, 27]. Conversely, other studies have reported that laparoscopic surgery results in earlier mobilization, earlier bowel recovery, and a shorter length of stay, resulting in less morbidity and mortality, particularly in high-risk patients with older age, obesity, high American Society of Anesthesiologists (ASA) score, serosal invasion (T4), or preoperative radiotherapy [22, 23, 28, 29]. Evidence is lacking to provide guidance for the surgical approach in elderly CRC patients with poor PS. Thus, the decision is left to the discretion of individual surgeons and hospitals. In fact, Japanese surgeons who are skilled in both open surgery and laparoscopic surgery tend to select open surgery in the presence of poor PS (electronic supplementary material 2). Therefore, we aimed to evaluate both the short-term and the long-term outcomes of laparoscopic surgery, compared with open surgery, in elderly CRC patients with poor PS.

Methods

Study design and participants

The study included data that were collected in the multicenter case–control study entitled "Retrospective study of laparoscopic colorectal surgery for elderly patients," which aimed to assess the safety and efficacy of laparoscopic CRC surgery in patients aged 80 years or older [24] Forty-one member hospitals of the Japan Society of Laparoscopic Colorectal Surgery participated in the study, and 2065 elderly CRC patients who underwent open surgery or laparoscopic surgery were enrolled between January 2003 and December 2007. Of these, we included the patients who received elective surgery for stage 0–III CRC with an Eastern Cooperative Oncology Group PS (ECOG-PS) score of 2 or greater [30], and excluded patients for the following reasons: cancer other than adenocarcinoma, including squamous cell carcinoma, neuroendocrine tumor, or cystadenocarcinoma, stage IV CRC or stage unknown, emergency surgery, and multiple cancers under treatment or followed up (Fig. 1).

Statistical analyses

The following baseline characteristics were compared between patients who underwent open surgery and those who underwent laparoscopic surgery: age, sex, body

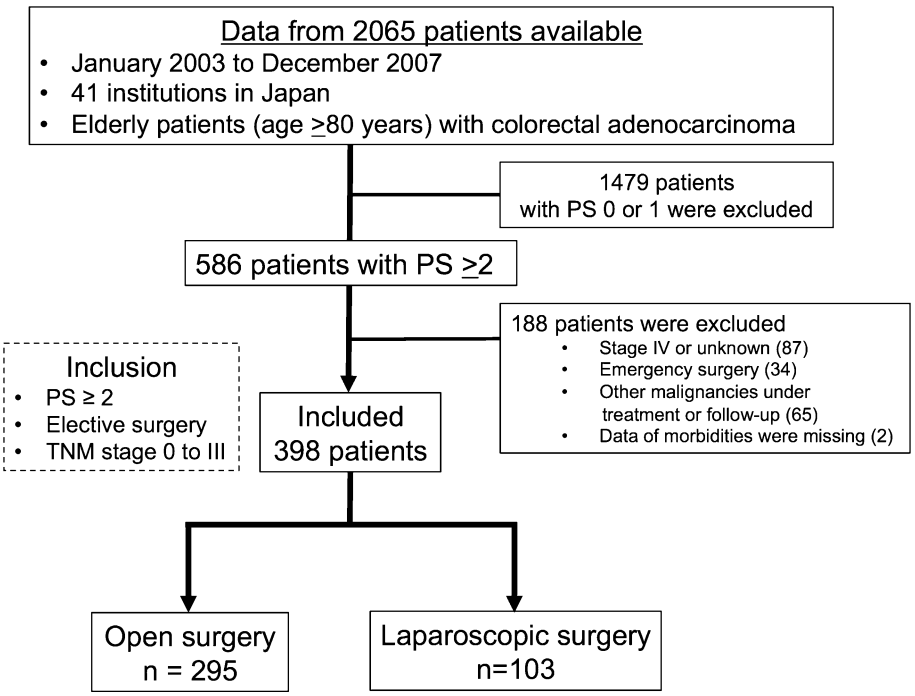

Fig. 1 Patients and inclusion criteria for data analysis relating to the surgical approach in elderly patients (80 years or older) with colorectal cancer and poor performance status (*PS*)

mass index, ECOG-PS score, ASA score, previous abdominal surgery, preoperative comorbidity (including overall comorbidity, hypertension, diabetes mellitus, and cardiac, respiratory, and cerebrovascular disease), tumor location, invasion depth, nodal metastasis, and TNM stage (Union for International Cancer Control 7th edition [31]). The following short-term outcomes were also compared between the open surgery group and the laparoscopic surgery group: operative result (including surgical procedure, stoma creation, operative duration, blood loss, harvested lymph node, and resection margin), performance of blood transfusion, postoperative course (including length of stay, and number of days until a fluid diet, a solid diet, and defecation), mortality, and morbidity. Morbidity was defined as all adverse events that were associated with the surgical treatment and anesthesia, and overall morbidity, delirium, postoperative ileus, pneumonia, bleeding after surgery, incisional surgical site infection, deep/organ surgical site infection, anastomotic leakage, and cardiovascular occurrence were studied between the groups. The open conversion rate was also studied only in the laparoscopic surgery group.

To determine the risk factors for postoperative morbidity, a univariate analysis was first performed using Fisher's exact tests. Subsequently, a multivariate analysis was conducted using a logistic regression model that included all variables at $P < 0.1$ in the univariate analysis and/or the surgical approach (open surgery or laparoscopic surgery).

Survival outcomes were compared between the open surgery group and the laparoscopic surgery group using log-rank tests and were summarized as Kaplan–Meier curves and hazard ratios with 95 % confidence intervals. We separately analyzed overall survival and disease-free survival, with the events for each type of survival being defined as all-cause death and death or relapse, respectively. Moreover, a multivariate analysis for overall survival was conducted using a Cox proportional hazards model that included all variables at $P < 0.1$ in the univariate analysis and/or the surgical approach (open surgery or laparoscopic surgery).

The results are reported as the median and the interquartile range for quantitative variables and as frequencies for categorical variables. Comparisons were conducted using Wilcoxon's rank-sum tests for quantitative variables and Fisher's exact tests (binary) or Pearson's chi square tests (more than three variables) for categorical variables. The results of the multivariate analysis for morbidity and overall survival are presented as the odds ratio or hazard ratio and 95 % confidence intervals with the corresponding *P* value.

Statistical analyses were performed using JMP 10 (SAS Institute, Cary, NC, USA).

Table 1 Comparison of baseline characteristics in patients aged 80 years or older with colorectal cancer and poor performance status between the open surgery group (*OP*) and the laparoscopic surgery group (*LAP*)

	OP ($N = 295$)	LAP ($N = 103$)	*P*
Patient characteristics			
Age (years)	83 (81–86)	84 (81–86)	0.600
Sex			
Male	156 (52.9 %)	59 (57.3 %)	0.491
Female	139 (47.1 %)	44 (42.7 %)	
BMI (kg/m^2)	20.9 (18.8–23.7)	21.8 (19.6–23.6)	0.335
ECOG-PS score			
2	220 (74.6 %)	82 (76.6 %)	0.487
3	65 (22.0 %)	17 (16.5 %)	
4	10 (3.4 %)	4 (3.9 %)	
ASA score			
1	13 (4.4 %)	1 (1.0 %)	0.524
2	164 (55.6 %)	57 (55.3 %)	
3	103 (34.9 %)	40 (38.8 %)	
4	4 (1.4 %)	2 (1.9 %)	
Unknown	11 (3.7 %)	3 (2.9 %)	
Previous abdominal surgery	118 (40.3 %)	24 (23.5 %)	0.003
Comorbidities			
Overall comorbidity	227 (77.0 %)	84 (81.6 %)	0.406
Hypertension	93 (31.5 %)	46 (44.7 %)	0.022
Diabetes mellitus	41 (13.9 %)	15 (14.6 %)	0.870
Cardiac disease	73 (24.8 %)	20 (19.4 %)	0.344
Respiratory disease	28 (9.5 %)	6 (5.8 %)	0.309
Cerebrovascular disease	40 (13.6 %)	16 (15.5 %)	0.624
Tumor characteristics			
Tumor location			
Cecum	26 (8.8 %)	15 (14.6 %)	0.361
Ascending colon	67 (22.7 %)	24 (23.3 %)	
Transverse colon	45 (15.3 %)	7 (6.8 %)	
Descending colon	13 (4.4 %)	3 (2.9 %)	
Sigmoid colon	57 (19.3 %)	24 (23.3 %)	
Rectosigmoid colon	32 (10.9 %)	11 (10.7 %)	
Mid rectum	25 (8.5 %)	9 (8.7 %)	
Lower rectum	30 (10.2 %)	10 (9.7 %)	
Invasion depth (T factor)			
Tix	4 (1.4 %)	6 (5.8 %)	<0.001
T1	17 (5.8 %)	18 (17.5 %)	
T2	43 (14.6 %)	20 (19.4 %)	
T3	146 (49.5 %)	39 (37.9 %)	
T4a	74 (25.1 %)	17 (16.5 %)	
T4b	11 (3.7 %)	3 (2.9 %)	
Nodal metastasis (N factor)			
N0	195 (66.1 %)	66 (64.6 %)	0.690
N1a	45 (15.3 %)	20 (19.4 %)	
N1b	0	0	
N1c	30 (10.2 %)	7 (6.8 %)	
N2a	15 (5.1 %)	7 (6.8 %)	
N2b	10 (3.4 %)	3 (2.9 %)	

Table 1 continued

	OP ($N = 295$)	LAP ($N = 103$)	P
TNM stage			
0	4 (1.4 %)	5 (4.9 %)	0.001
I	52 (17.6 %)	31 (30.1 %)	
II	139 (47.1 %)	30 (29.1 %)	
III	100 (33.9 %)	37 (35.9 %)	

Values are reported as the number and percentage (in *parentheses*) or the median and interquartile range (in *parentheses*)

ASA American Society of Anesthesiologists, *BMI* Body mass index, *ECOG-PS* Eastern Cooperative Oncology Group performance status

Results

Of the 398 patients that were included, open surgery was performed in 295 patients and laparoscopic surgery was performed in 103 patients (Fig. 1). Both groups had a higher proportion of patients with an ECOG-PS score of 2 than those with an ECOG-PS score of 3 or 4, but there were no significant differences in ECOG-PS score between the two groups. There were also no significant differences between open surgery and laparoscopic surgery in age, sex, body mass index, ASA score, preoperative comorbidity, or tumor location. Patients with previous abdominal surgery were commoner in the open surgery group. The lower degree of invasion depth was frequently observed in laparoscopic surgery, but nodal metastasis was not. Similarly, laparoscopic surgery was selected in patients with earlier-TNM-stage disease, but the proportion of patients with stage III disease was statistically equivalent between the groups (33.9 % in the open surgery group and 35.9 % in the laparoscopic surgery group; $P = 0.719$). The open conversion rate in laparoscopic surgery patients was 2.9 % (Table 1).

Although laparoscopic surgery required a longer surgical duration than open surgery, the following short-term outcome variables were significantly less or shorter in the laparoscopic surgery group: blood loss, performance of blood transfusion, postoperative length of stay, number of days to a fluid diet, number of days to a solid diet, and number of days to defecation. The operative procedure, stoma creation rate, number of harvested lymph nodes, and resection margin were not statistically different. With regard to complications, overall morbidity and incisional surgical site infection were significant less in the laparoscopic surgery group, whereas other types of complications were equivalent between the two groups (Table 2).

In the univariate and multivariate analysis for postoperative morbidity, the selection of open surgery and an operation duration of 180 min or more as well as male sex, ECOG-PS score of 4, and deeper tumor invasion were significant risk factors (Table 3).

In the survival analyses, overall survival was not significantly different between the two groups in all-stage, stage 0–I, stage II, and stage III disease, respectively (Fig. 2), and the same result was observed with regard to disease-free survival (electronic supplementary material 3). The median follow-up time in the laparoscopic surgery group and the open surgery group was 37.0 and 39.0 months, respectively. In the multivariate analysis for overall survival, ECOG-PS score of 4, age, and lymph node metastasis were determined significant risk factors, whereas the approach was not (Table 4).

Discussion

The results of the current study indicate that laparoscopic surgery is as favorable as open surgery in terms of short-term outcomes in patients with poor PS, and that the approaches were also similar in terms of cardiac and respiratory complications, which are expected to result from pneumoperitoneum or the extreme Trendelenburg position. Previous abdominal surgery and invasion depth were statistically different between the open surgery group and the laparoscopic surgery group because of the retrospective nature of the study. However, no differences were observed for overall morbidity with or without previous abdominal surgery in univariate analysis. Moreover, an operation duration of 180 min or more and selection of open surgery were determined as the independent risk factors, after the degree of tumor invasion had been included in the multivariate analysis because univariate analysis showed morbidity was more frequent as tumor invasion became deeper. However, at the same time, these results raise a new question regarding which approach is better: laparoscopic surgery, which requires a longer surgical duration, or open surgery, which requires a shorter duration but results in more surgical stress. In the current study, we observed a similar morbidity rate between open surgery with a duration less than 180 min and laparoscopic surgery with a duration 180 min or more (34.4 and 29.0 %, respectively;

Table 2 Comparison of short-term postoperative outcomes in patients aged 80 years or older with colorectal cancer and poor performance status between the open surgery group (*OP*) and the laparoscopic surgery group (*LAP*)

	OP ($N = 295$)	LAP ($N = 103$)	*P*
Operative results			
Surgical procedure			
Ileocecal resection	9 (3.1 %)	3 (2.9 %)	0.194
Right hemicolectomy	91 (30.9 %)	35 (34.0 %)	
Transverse colectomy	28 (9.5 %)	6 (5.8 %)	
Left hemicolectomy	55 (18.6 %)	23 (22.3 %)	
Sigmoidectomy	16 (5.4 %)	2 (1.9 %)	
Hartmann operation	27 (9.2 %)	10 (9.7 %)	
Abdominoperineal resection	15 (5.1 %)	3 (2.9 %)	
High anterior resection	17(5.8 %)	13 (12.6 %)	
Low anterior resection	37 (12.5 %)	8 (7.8 %)	
Open conversion	–	3 (2.9 %)	NA
Stoma			
None	242 (82.0 %)	89 (86.4 %)	0.295
Permanent	12 (4.1 %)	1 (1.0 %)	
Diverting	41 (13.9 %)	13 (12.6 %)	
Operation duration (min)	153 (115–210)	202 (150–252)	<0.001
Blood loss (g)	109 (48–250)	30 (10–90)	<0.001
Blood transfusion	52 (18.1 %)	7 (6.9 %)	0.006
Harvested lymph nodes			
<12	126 (42.7 %)	52 (50.5 %)	0.205
≥12	167 (57.3 %)	51 (49.5 %)	
Resection margin			
R0	282 (95.6 %)	99 (96.1 %)	0.703
R1	11 (3.7 %)	4 (3.9 %)	
R2	2 (0.7 %)	0	
Length of stay (days)	15 (12–23)	12 (8.3–18.8)	<0.001
Days to fluid diet	3 (2–4)	1 (1–2)	<0.001
Days to solid diet	5 (4–7)	3 (2–4)	<0.001
Days to defecation	5 (4–6)	4 (2–5)	<0.001
Complications			
Mortality	3 (1.0 %)	0	0.572
Overall morbitidy	119 (40.3 %)	26 (25.2 %)	0.006
Delirium	22 (7.5 %)	8 (7.8 %)	1.00
Postoperative ileus	29 (9.8 %)	6 (5.8 %)	0.311
Pneumonia	14 (4.8 %)	1 (1.0 %)	0.129
Bleeding	3 (1.0 %)	1 (1.0 %)	1.00
Incisional SSI	33 (11.2 %)	4 (3.9 %)	0.030
Organ/space SSI	11 (3.7 %)	0	0.073
Anastomotic leakage	10 (3.4 %)	1 (1.0 %)	0.302
Cardiovascular occurrence	3 (1.0 %)	0	0.572

Values are reported as the number and percentage (in *parentheses*) or the median and interquartile range (in *parentheses*)

NA not applicable, *SSI* surgical site infection

electronic supplementary material 4). Furthermore, open surgery was completed within 180 min in about two thirds of cases (64.1 % in the open surgery group). Therefore, both approaches are thought to be effective, and surgeons can safely choose the approach with which they are most familiar.

Table 3 Univariate and multivariate analysis for morbidity in patients aged 80 years or older with colorectal cancer and poor performance status and who underwent surgery

Factor	Number	Univariate analysis		Multivariate analysis	
		Morbidity (%)	*P*	Odds ratio[a]	*P*
Age					
80–82 years	163	35.6	0.832	–	–
≥83 years	235	37.0			
Sex					
Male	183	41.5	0.060	Reference	
Female	215	32.1		0.64 (0.42–0.99)	0.044
BMI					
<18.5 kg/m^2	85	31.8	0.443	–	–
≥18.5 kg/m^2	302	36.8			
ECOG-PS score					
2	302	35.1	0.085	Reference	
3	82	36.6		1.09 (0.64–1.85)	0.745
4	14	64.3		3.17 (1.03–10.9)	0.045
ASA score					
1–2	235	36.2	0.74	–	–
3–4	149	34.2			
Previous abdominal surgery					
Absent	253	36	0.828	–	–
Present	142	37.3			
Overall comorbidity					
Absent	87	36.9	1.000	–	–
Present	311	36.3			
Hypertension					
Absent	295	39.4	0.102	–	–
Present	103	30.9			
Diabetes mellitus					
Absent	342	37.1	0.550	–	–
Present	56	32.1			
Cardiac comorbidity					
Absent	305	35.7	0.624	–	–
Present	93	38.7			
Respiratory comorbidity					
Absent	364	36.3	0.853	–	–
Present	34	38.2			
Cerebrovascular comorbidity					
Absent	342	36.8	0.765	–	–
Present	56	33.9			
Tumor location					
Colon	324	34.9	0.183	–	–
Rectum	74	43.2			
Invasion depth					
T0–T1	45	22.2	0.006	Reference	
T2–T3	248	34.3		1.45 (0.68–3.31)	0.344
T4	105	47.6		2.52 (1.10–6.14)	0.029
Lymph node metastasis					
N0	261	34.5	0.379	–	–

Table 3 continued

Factor	Number	Univariate analysis		Multivariate analysis	
		Morbidity (%)	*P*	Odds ratio[a]	*P*
N1	102	42.2			
N2	35	34.3			
Approach					
Open	295	40.3	0.0063	Reference	
Laparoscopic	103	25.2		0.41 (0.22–0.75)	0.003
Operation duration					
<180 min	223	31.8	0.036	Reference	
≥180 min	175	42.3		1.97 (1.17–3.37)	0.011
Blood loss					
<200 g	288	33.3	0.047	Reference	
≥200 g	110	44.6		0.78 (0.43–1.38)	0.400

ASA American Society of Anesthesiologists, *BMI* body mass index, *ECOG-PS* Eastern Cooperative Oncology Group performance status

[a] The 95 % confidence interval is given in *parentheses*

Previous RCTs for younger, healthier CRC patients have demonstrated that the survival rate is similar between laparoscopic surgery and open surgery [1–11]. However, elderly CRC patients with poor PS may be at higher risk of mortality related to surgical stress; therefore, the previously reported results may not have generalized well to this more vulnerable patient group. In the present study, there were no significant differences in overall survival and disease-free survival between the two groups. In addition, because the TNM stage was different between laparoscopic surgery and open surgery patients in the baseline characteristics, we tried to compare survivals separately in stage 0–I, stage II, and stage III disease between the two groups, and there were also no significant differences in overall survival and disease-free survival for each TNM stage. With regard to the effect of postoperative chemotherapy for stage III CRC on survival analysis, two patients in the open surgery group and one patient in the laparoscopic surgery group received 5-fluorouracil-based chemotherapy. Infrequent use of postoperative chemotherapy is thought to arise from lack of evidence for the safety and benefit in these elderly patients with poor PS during the investigation period, and not have any impact on the survival analyses in the current study. Although our results may be affected by confounding factors not accounted for in the current study, the finding that laparoscopic surgery may not be inferior to open surgery in terms of survival outcomes is considered clinically valuable.

This study has some limitations. First, there may be some differences for the general application at the present time, compared with what was found for the investigation period from 2003 to 2007 when the primary data were accumulated. The delay between the investigation and the publication occurred because 5 years was needed to accumulate sufficient numbers of samples and a further 3 years at least was needed to estimate survival outcome in the primary study. However, the 41 institutes that participated in the primary study were the leading hospitals for laparoscopic colorectal surgery in which surgery was performed by a qualified surgeon (Endoscopic Surgical Skill Qualification System of the Japan Society for Endoscopic Surgery). As many general hospitals currently follow these leading hospitals in Japan, these results reflect the current situation to some degree. Certainly, as updates for surgical outcome are still needed accompanied by the progression of adjuvant chemotherapy even for these elderly patients as well as by the proficiency for laparoscopic surgical skills, additional studies are being conducted to investigate whether there is improvement with time. Second, owing to the retrospective case–control nature of the study, the decision regarding the type of surgery was at the discretion of each surgeon, and therefore this may have resulted in selection bias. Even among the 41 leading institutes that participated in the primary study and the current study, differences were observed in the proportion of laparoscopic surgery between the institutes (electronic supplementary material 5). However, despite the benefits of RCTs, the ability to analyze data from a large sample in a short time should be considered a strength of the current study. Furthermore, RCTs targeting elderly CRC patients with poor PS tend to be impractical, and, to the best of our knowledge, there are no ongoing RCTs concerning this issue. Consequently, the results of the current study may offer the best evidence at present regarding surgical treatments for elderly CRC

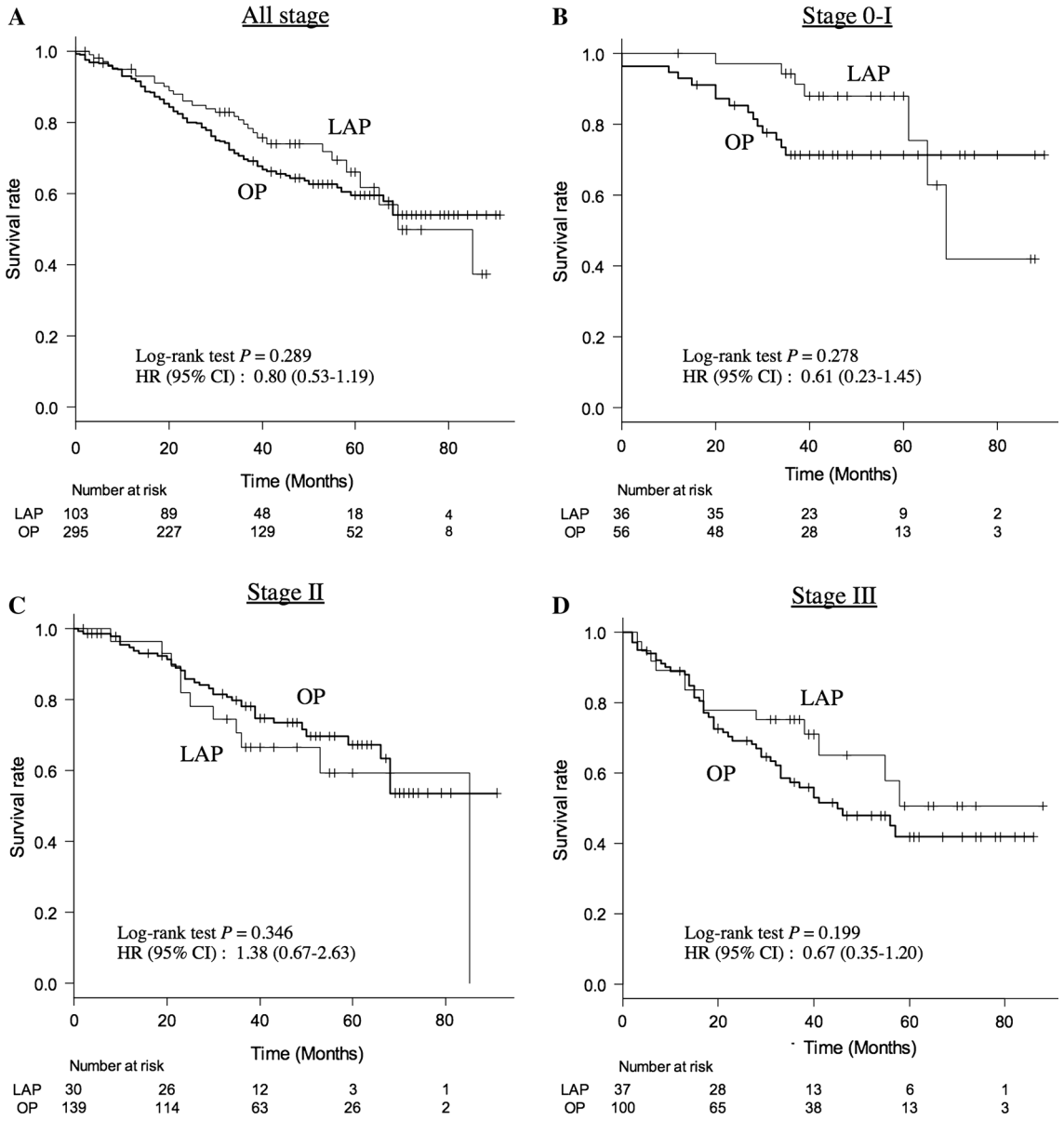

Fig. 2 Comparison of overall survival between the surgical approaches: **a** all-stage disease, **b** stage 0–I disease, **c** stage II disease, and **d** stage III disease. The data are summarized as the hazard ratio (*HR*) with the 95 % confidence interval (*CI*) and *P* value based on a log-rank test. *LAP* laparoscopic surgery group, *OP* open surgery group

patients with poor PS. Third, differences in demographics between the two groups seem to be a problem. In the primary study, case-matching using propensity scores was performed to eliminate these effects as much as possible. Conversely, the parent population was smaller in the current study owing to the nature of the subanalysis, and it was difficult to apply the same case-matching method in parallel with a sufficient sample size. Although differences in the TNM stage and the presence of previous abdominal surgery in the current study (Table 1) may influence the outcomes, no statistical differences were observed in survival analyses between the laparoscopic surgery group and the open surgery group for the stage and morbidity with or without previous abdominal surgery. However, because a potential type II error may still exist, the results of our study are not definitive, and this issue should be investigated in an RCT, or at least in a case-matched cohort study.

In conclusion, laparoscopic surgery for elderly CRC patients with poor PS is safe and similar to open surgery in terms of overall survival. It is considered best practice for each surgeon to choose the approach with which he or she

Table 4 Univariate and multivariate analysis for overall survival in patients aged 80 years or older with colorectal cancer and poor performance status and who underwent surgery

Factor	Number	Univariate analysis		Multivariate analysis	
		Hazard ratio[a]	*P*	Hazard ratio[a]	*P*
Age					
80–82 years	163	Reference	<0.001	Reference	
≥83 years	235	1.91 (1.32–2.82)		1.71 (1.16–2.55)	0.006
Sex					
Male	183	Reference	0.721	–	–
Female	215	1.07 (0.75–1.51)		–	
BMI					
<18.5 kg/m^2	85	Reference	0.213	–	–
≥18.5 kg/m^2	302	0.77 (0.51–1.19)		–	
ECOG-PS score					
2	302	Reference	<0.001	Reference	
3	82	1.49 (0.97–2.22)		1.46 (0.91–2.28)	0.118
4	14	3.63 (1.69–6.82)		3.30 (1.48–6.62)	0.005
ASA score					
1–2	235	Reference	0.022	Reference	0.172
3–4	149	1.51 (1.05–2.15)		1.33 (0.88–1.99)	
Previous abdominal surgery					
Absent	253	Reference	0.512	–	–
Present	142	0.88 (0.61–1.27)		–	
Overall comorbidity					
Absent	87	Reference	0.141	–	–
Present	311	0.75 (0.51–1.12)		–	
Hypertension					
Absent	295	Reference	0.466	–	–
Present	103	0.87 (0.60–1.25)		–	
Diabetes mellitus					
Absent	342	Reference	0.102	–	–
Present	56	1.46 (0.90–2.27)		–	
Cardiac comorbidity					
Absent	305	Reference	0.490	–	–
Present	93	1.15 (0.76–1.70)		–	
Respiratory comorbidity					
Absent	364	Reference	0.901	–	–
Present	34	1.04 (0.54–1.80)		–	
Cerebrovascular comorbidity					
Absent	342	Reference	0.718	–	–
Present	56	1.10 (0.64–1.75)		–	
Tumor location					
Colon	324	Reference	0.158	–	–
Rectum	74	1.34 (0.88–1.99)		–	
Invasion depth					
T0–T1	45	Reference	<0.001	Reference	
T2–T3	248	1.13 (0.62–2.28)		0.81 (0.43–1.68)	0.552
T4	105	3.33 (1.82–6.71)		1.87 (0.95–3.95)	0.069
Lymph node metastasis					
N0	261	Reference	<0.001	Reference	

Table 4 continued

Factor	Number	Univariate analysis		Multivariate analysis	
		Hazard ratio[a]	*P*	Hazard ratio[a]	*P*
N1	102	1.76 (1.20–2.56)		1.80 (1.18–2.71)	0.006
N2	35	2.58 (1.47–4.27)		2.49 (1.33–4.39)	0.005
Approach					
Open	295	Reference	0.289	Reference	
Laparoscopic	103	0.80 (0.53–1.19)		0.90 (0.57–1.36)	0.614
Operation duration					
<180 min	223	Reference	0.303	–	–
≥180 min	175	0.83 (0.58–1.18)		–	
Blood loss					
<200 g	288	Reference	0.593	–	–
≥200 g	110	1.11 (0.75–1.60)		–	

ASA American Society of Anesthesiologists, *BMI* body mass index, *ECOG-PS* Eastern Cooperative Oncology Group performance status

[a] The 95 % confidence interval is given in *parentheses*

is familiar, but the laparoscopic approach is an acceptable option for effective treatment in elderly CRC patients with poor PS.

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Conflict of interest The authors declare that they have no conflict of interest.

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