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Laparoscopic versus open resection for colon cancer: 10-year outcomes of a prospective clinical trial

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Abstract
Background
Laparoscopic resection (LR) and open resection (OR) for colon cancer have similar oncologic outcomes at 5-year follow-up. However, results from studies with longer follow-up are limited. This study aimed to compare 10-year oncologic outcomes of LR and OR for non-metastatic colon cancer.
Methods
A prospective non-randomized trial comparing patients undergoing LR or OR for non-metastatic colon cancer at a single institution was conducted. Statistical analyses were performed on an ‘‘intention-to-treat’’ basis and by actual treatment. Kaplan–Meier curves were compared to analyze overall survival (OS) and disease-free survival (DFS). A multivariate analysis was performed to identify predictors of poor survival.
Results
The study included 304 colon cancer patients: 154 patients underwent LR and 150 underwent OR. Fifteen (9.7 %) had LR converted to OR. During a median follow-up period of 138 (range, 120–220) months, no significant differences were observed between LR and OR patients in 10-year OS and DFS rates: 87.2 % versus 78.7 % (P = 0.182) and 80.9 % versus 76.8 % (P = 0.444), respectively. Conversion to open surgery was associated with a non-significant reduction in OS and DFS. Stage-by-stage comparison showed no significant differences between the two groups. Both OS and DFS were similar between right colon and left-sided colon cancer patients. On multivariate analysis, pT4 cancer and a lymph node ratio of 0.20 or more were the only independent predictors of both OS and DFS.
Conclusions
The 10-year follow-up results confirm the oncological effectiveness of the laparoscopic approach to non-metastatic colon cancer.
Keywords
Laparoscopy Open colectomy Survival Recurrence Colon cancer
After the first report of laparoscopic-assisted colectomy in 1991 [*1*], many studies have shown the short-term benefits of laparoscopic resection (LR) when compared with open resection (OR) for colon cancer, including reduced intraoperative blood loss and postoperative pain, lower complication rates, shorter length of hospital stay, and reduced costs [*2–5*]. Several large randomized clinical trials (RCTs) also have reported equivalent results in terms of 3-year [*6*] and 5-year [*2*, *7*, *8*] overall survival (OS), disease-free survival (DFS), and recurrence rate between LR and OR for non-metastatic colon cancer.
To date, only two multicenter RCTs [*9*, *10*] have reported long-term results with a follow-up longer than 5 years. In addition, controversial long-term data are available for patients undergoing conversion of LR to OR, since converted patients have been usually analyzed in the laparoscopic group on an “intention-to-treat” basis.
The aim of this prospective comparative clinical trial was to evaluate the 10-year oncologic outcomes of patients who underwent LR, OR, or converted resection for non-metastatic colon cancer in a single institution.

Methods

This is a prospective non-randomized clinical study comparing LR to OR for the treatment of non-metastatic colon cancer. All patients who were admitted to our Institution with caecum, ascending, descending or sigmoid colon cancer above the peritoneal reflection between January 1995 and January 2003 were considered for inclusion in the study.

Exclusion criteria were: cancer of the transverse colon or splenic flexure, rectal cancer, preoperative or intraoperative diagnosis of liver and/or lung metastases or peritoneal carcinomatosis, preoperative evidence of adjacent organs invasion, acute intestinal obstruction or perforation, synchronous colorectal adenocarcinomas, and previous history of colorectal surgery.

Patients underwent LR or OR depending on the referring surgeon. Between January 1998 and January 2003, patients who gave written informed consent were enrolled and randomized in the COLOR (COlon cancer Laparoscopic or Open Resection) trial [5]. The same oncologic principles were followed in both groups, i.e., adequate resection margins, en bloc vascular resection and lymphadenectomy, and minimal intraoperative manipulation of the tumor. LR included laparoscopic bowel mobilization and blood vessels division, with the specimen being removed from the abdominal cavity through a small skin incision. During right hemicolectomy, an extracorporeal end-to-end hand-sewn or side-to-side stapled anastomosis was performed, while during left hemicolectomy or sigmoidectomy the anastomosis was performed by laparoscopic transanal intracorporeal stapled technique.

Conversion from LR to OR was defined as unplanned incision or an incision made longer than that was necessary for specimen retrieval.

Preoperative work-up was standardized for both LR and OR groups, and included physical examination, total colonoscopy with biopsies, abdominal computed tomography (CT) scan, chest x-ray, and serum carcinoembrionyc antigen (CEA) assay.

A single pathologist expert in the field of colorectal tumors evaluated all specimens. Pathological examination included stage of disease (TNM), length of the surgical specimen, number of lymph nodes harvested, lymph node ratio (LNR, defined as number of positive nodes divided by total node harvested), and longitudinal margins of excision. Lymph nodes in the mesocolon fatty tissue were identified after formalin fixation of the specimen. Patients were divided into 3 categories according to the LNR: 0, 0.01–0.19, and $\geq$0.20.

Adjuvant fluorouracil-based chemotherapy was offered to patients with a postoperative diagnosis of high-risk stage 2 colon cancer and to those with a stage 3 colon cancer, after a clinical oncologic evaluation within 8 weeks after surgery.

All patients were followed up prospectively with clinical examination, serum CEA assay every 3 months, and liver ultrasound every 6 months for the first 2 years, then annually. Chest X-ray and a CT scan of the abdomen were performed every year. A colonoscopy was performed at 1 year, then every 3 years.

Long-term oncologic outcomes included local recurrence rate, incidence of abdominal wall and distant metastases, OS, and DFS. Data were collected prospectively from the time of diagnosis of the primary malignancy.

The protocol was approved by the ethical committee of our institution, and patients gave informed consent.

Statistics

Quantitative data are given as median and range. Categorical data are expressed as percentages. Proportions were compared using the χ^2 test or the Fisher exact test, whereever appropriate. Student's t test was used to compare normally distributed variables. Univariate analyses of OS and DFS rates were performed using the Kaplan–Meier method and the evaluation of differences between the groups was performed with the log-rank test. Patients' observations were censored on the date of last examination or death.

A multivariable Cox regression analysis was performed to identify predictive factors of poor OS and DFS, using both forward and backward stepwise selection. Explanatory variables with univariable $p \leq 0.200$ were included in the multivariable analysis. This significance level was chosen to incorporate all potentially important predictor variables in the final modeling process. The following variables were analyzed: age, gender, tumor site, surgical approach, pathological staging, number of harvested lymph nodes, LNR, and adjuvant chemotherapy. Results are reported as hazard ratio (HR) with 95 % confidence intervals (CI).

All analyses were performed on an ''intention-to-treat'' basis (i.e., patients who had LR converted to an OR were analyzed in the LR group) and by actual treatment (patients were analyzed according to the actual treatment received: LR, OR, and LR converted to OR). A level of 5 % was set as the criterion for statistical significance. The data were collected in an Excel spreadsheet. The statistical analysis was performed using SYSTAT Version 10 (Copyright © SPSS Inc., 2000).

Results

Between January 1995 and January 2003, 454 patients underwent elective colon resection for cancer: 231 LR and 223 OR. Of these, 121 (26.7 %) patients were excluded from the study: 79 patients with distant metastases, 37 patients with the tumor located at the splenic flexure or at the transverse colon, and 5 patients who had previous colorectal surgery.

During a median follow-up of 138 (range, 120–220) months, 29 (8.7 %) patients were lost to follow-up: 15 LR and 14 OR. As a result, 154 LR patients and 150 OR patients were available for the 10-year oncologic analysis (Fig. 1). Among them, 54 were randomized to LR and 50 to OR within the COLOR trial.

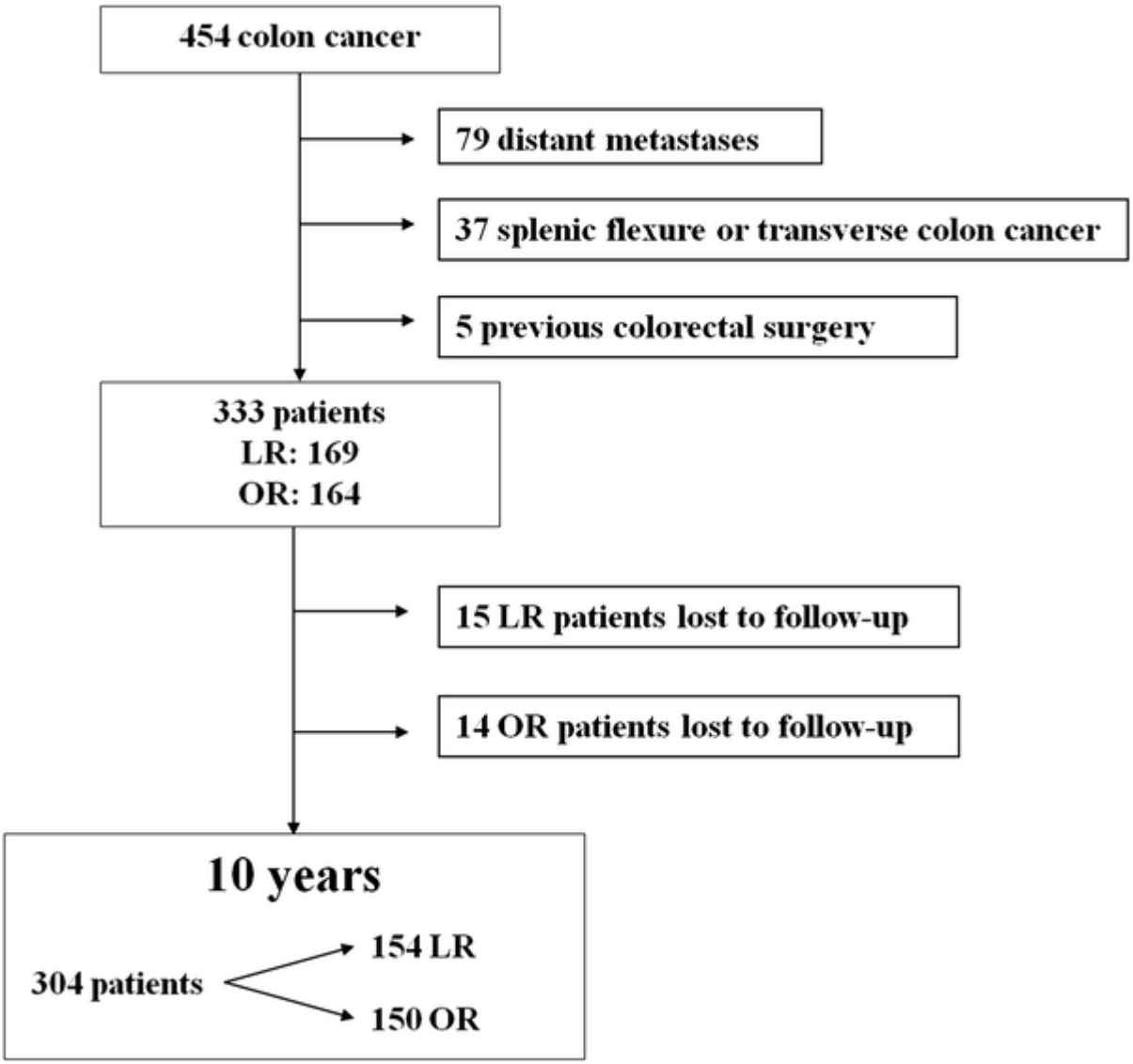

Fig. 1

Study design. LR laparoscopic resection, OR open resection

Patients' characteristics are listed in Table 1. No differences were observed in age, gender, tumor site, type of procedure performed, and administration of adjuvant chemotherapy. Conversion from LR to OR occurred in 15 (9.7 %) patients, reasons for conversion were locally advanced cancer in 13 cases and unclear anatomy in 2 cases.

Table 1

Patient's characteristics

Variable	**LR (n = 154)**	**OR (n = 150)**	**P value**
Gender			
Male, n (%)	91 (59.1)	89 (59.3)	0.941
Age (years)	66 (24–90)	68.5 (33–91)	0.289
Body Mass Index (kg/m^2)	24.5 (20–30)	25 (19–31)	0.449
Tumor site, n (%)			
Coecum	21 (13.6)	21 (14)	0.941
Ascending colon	24 (15.6)	22 (14.7)	0.950
Hepatic flexure	13 (8.4)	14 (9.3)	0.943

Variable	LR (n = 154)	OR (n = 150)	P value
Descending colon	27 (17.6)	33 (22)	0.404
Sigmoid colon	69 (44.8)	60 (40)	0.465
Surgical procedure, n (%)			
Right hemicolectomy	58 (37.7)	57 (38)	0.954
Left hemicolectomy	63 (40.9)	58 (38.7)	0.778
Sigmoidectomy	33 (21.4)	35 (23.3)	0.794
Conversion to open surgery, n (%)	15 (9.7)		
Locally advanced	13 (86.7)		
Unclear anatomy	2 (13.3)		
Positive margins, n (%)	0	0	
Number of lymph nodes harvested	13 (3–38)	13 (3–37)	0.815
pT staging, n (%)			
1	12 (7.9)	6 (4)	0.247
2	27 (17.5)	20 (13.3)	0.393
3	110 (71.4)	113 (75.3)	0.522
4	5 (3.2)	11 (7.3)	0.181
Tumor stage, n (%)			
1	37 (24)	25 (16.7)	0.147
2	65 (42.2)	78 (52)	0.111
3	52 (37.8)	47 (31.3)	0.741
Adjuvant chemotherapy, n (%)	67 (43.5)	65 (43.3)	0.932

LR laparoscopic resection, OR open resection

Median number of lymph nodes harvested and pathologic tumor (pT) stage distribution according to TNM classification were similar between the two groups. (Table 1).

The 10-year OS rate for all patients on an “intention-to-treat” basis was similar between the two groups: 87.2 % for LR patients and 78.7 % for OR patients (P = 0.182). By actual treatments, a lower OS rate was observed for converted patients than LR and OR patients, although the difference was not statistically significant (73.9 vs. 88.4 vs. 78.7 %, respectively; P = 0.203). (Fig. 2A). When a stage-by-stage comparison was performed, a trend towards better OS after LR for stage 1 colon cancer was observed (94.7 vs. 80.1 %, P = 0.055), while no differences were observed between LR and OR patients for stage 2 (89.8 vs. 84.3 %, P = 0.820) and 3 colon cancer (77.8 vs. 69.8 %, P = 0.503).

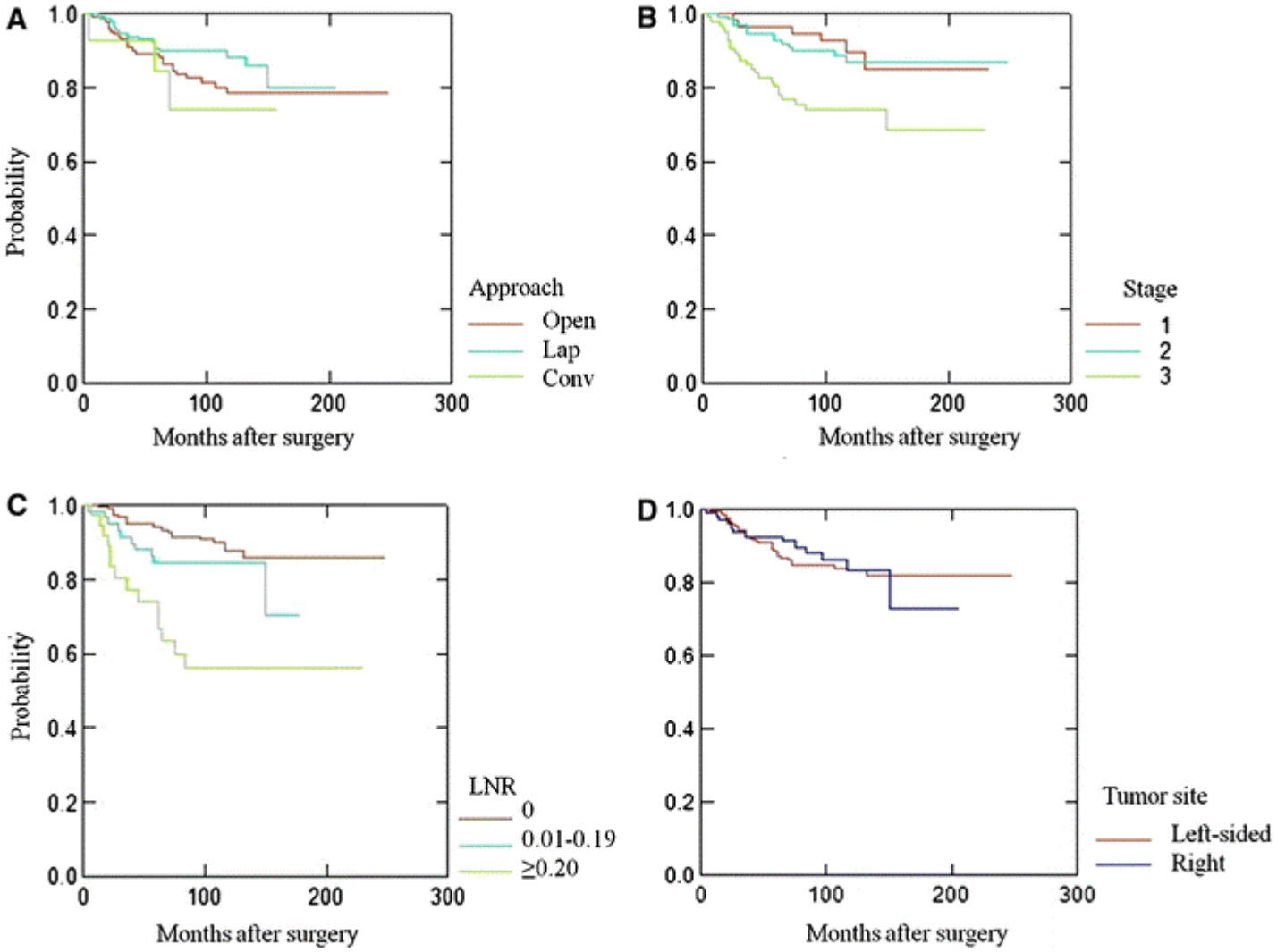

Fig. 2
Overall survival by A surgical approach (P = 0.203; Log-rank test), B stage of disease (P = 0.002; Log-rank test), C Lymph node ratio (P < 0.001; Log-rank test), D tumor site (P = 0.765; Log-rank test). Lap laparoscopically completed, Conv converted, LNR lymph node ratio

The univariate analysis found pT4 stage, stage 3 disease, and LNR of 0.20 or more to be significant risk factors for a poorer OS, whereas an LNR of 0.01–0.19 showed a trend that did not reach statistical significance (Table 2). In particular, the 10-year OS was significantly worse for pT4 patients than pT1-3 patients (56.2 vs. 84.9 %, P = 0.001), for stage 3 patients than stage 1 or 2 patients (74.1 vs. 86.8 vs. 89.5 %, P = 0.002) (Fig. 2B), and for patients with LNR of 0.20 or greater (56.2 vs. 84.3 vs. 87.6 %, P < 0.001) (Fig. 2C). No significant differences were seen in OS between right colon and left-sided colon cancer patients (83.3 vs.82.9 %; P = 0.765) (Fig. 2D).

Table 2
Univariate and multivariate analysis of risk factors for overall survival

Variable	**N 304**	**Univariate analysis**		**Multivariate analysis**	
		Hazard Ratio (95 % CI)	**P value**†	**Hazard Ratio (95 % CI)**	**P value**†
Age (years)					
>67	156	1			
≤67	148	1.06 (0.49–1.78)	0.850		
Gender					
Female	124	1			

Variable	N 304	Univariate analysis		Multivariate analysis	
		Hazard Ratio (95 % CI)	P value†	Hazard Ratio (95 % CI)	P value†
Male	180	1.01 (0.52–1.90)	0.986		
Tumor site					
Left colon	189	1			
Right colon	115	1.16 (0.43–1.73)	0.680		
Surgical approach					
Open	150	1			
Laparoscopic	139	0.70 (0.37–1.34)	0.285		
Converted	15	1.51 (0.41–5.59)	0.535		
pT staging					
T1–T3	288	1		1	
T4	16	5.28 (1.85–15.02)	0.002	4.32 (1.41–13.25)	0.010
Stage of disease					
1–2	205	1		1	
3	99	2.96 (1.54–5.68)	0.001	1.58 (0.66–3.77)	0.305
Number of lymph nodes harvested					
≥12	190	1			
<12	114	1.06 (0.55–2.04)	0.866		
Lymph node ratio					
0	205	1		1	
0.01–0.19	61	1.81 (0.79–4.12)	0.168	1.18 (0.43–1.54)	0.713
≥0.20	38	5.39 (2.41–12.06)	<0.001	3.11 (1.18–8.25)	0.022
Adjuvant chemotherapy					
No	172	1		1	
Yes	132	1.65 (0.85–3.19)	0.140	1.01 (0.48–2.12)	0.977

†Stepwise logistic regression analysis. 95 % CI = 95 % confidence interval

In the multivariate analysis, pT4 cancer and an LNR of 0.20 or more were the only independent predictors of OS (Table 2).

The 10-year DFS for all stages on an “intention-to-treat” basis was 80.9 % for LR patients and 76.8 % for OR patients (P = 0.444). By actual treatment, the DFS rate was lower for converted patients compared to LR and OR, even though the difference did not reach statistical significance (66.8 vs. 76.8 vs. 82.2 %, respectively, P = 0.433) (Fig. 3A). No significant differences were observed in a stage-by-stage comparison between the two groups (stage 1: 91 vs. 82.1 %, P = 0.245; stage 2: 85.3 vs, 85.2 %, P = 0.926; stage 3: 70.5 vs. 60.4 %, P = 0.528).

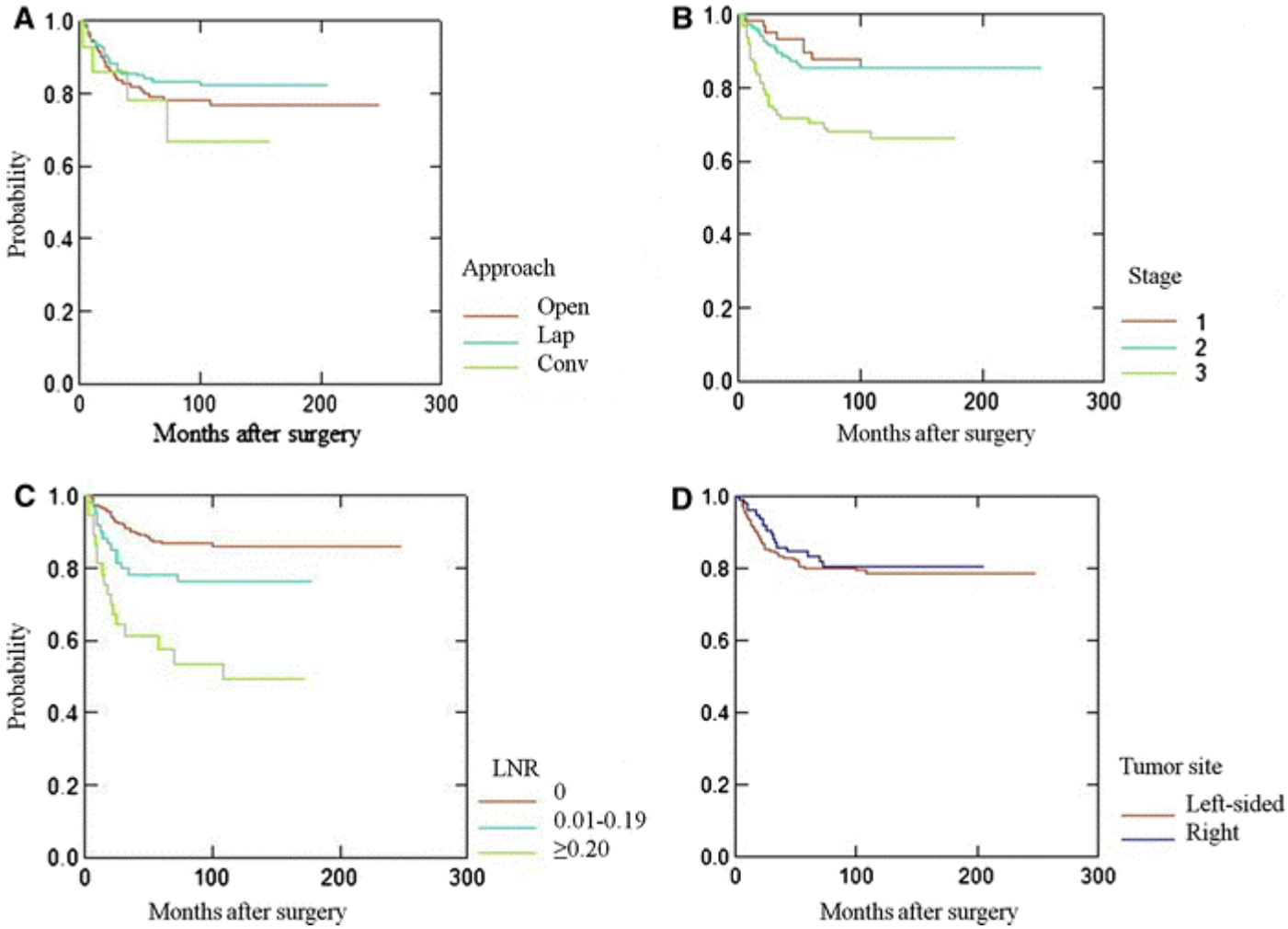

Fig. 3

Disease-free survival by A surgical approach (P = 0.433; Log-rank test), B stage of disease (P < 0.001; Log-rank test), C Lymph node ratio (P = <0.001; Log-rank test), D tumor site (P = 0.562; Log-rank test). Lap laparoscopically completed, Conv converted, LNR lymph node ratio

In the univariate analysis, pT4 cancer, stage 3 disease, and an LNR of 0.20 or more were found to be significant risk factors for a poorer DFS, whereas an LNR of 0.01–0.19 showed a trend that did not reach statistical significance (Table 3). In particular, the 10-year DFS was significantly worse for pT4 patients than pT1-3 patients (50 vs. 80.6 %, P < 0.001), for stage 3 patients than stage 1 or 2 patients (66 vs. 85.4 vs. 85.6 %, P < 0.001) (Fig. 3B), and for patients with LNR of 0.20 or greater (49.1 vs. 76.1 vs. 85.8 %, P < 0.001) (Fig. 3C). No significant differences were observed between right colon and left-sided colon cancer patients (80.1 vs.78.4 %; P = 0.562) (Fig. 2D).

Table 3

Univariate and multivariate analysis of risk factors for disease-free survival

Variable	**N 304**	**Univariate analysis**		**Multivariate analysis**	
		Hazard Ratio (95 % CI)	**P value**†	**Hazard Ratio (95 % CI)**	**P value**†
Age (years)					
>67	156	1			
≤67	148	1.27 (0.71–2.27)	0.419		
Gender					
Female	124	1			
Male	180	1.02 (0.57–1.84)	0.940		

Variable	N 304	Univariate analysis		Multivariate analysis	
		Hazard Ratio (95 % CI)	P value†	Hazard Ratio (95 % CI)	P value†
Tumor site					
Left colon	189	1			
Right colon	115	1.15 (0.47–1.63)	0.666		
Surgical approach					
Open	150	1			
Laparoscopic	139	0.78 (0.44–1.39)	0.399		
Converted	15	1.62 (0.49–5.28)	0.424		
pT staging					
T1–T3	288	1		1	
T4	16	4.88 (1.75–13.62)	0.002	3.79 (1.28–11.32)	0.017
Stage of disease					
1–2	205	1		1	
3	99	3.14 (1.74–5.67)	<0.001	1.77 (0.82–3.81)	0.148
Number of lymph nodes harvested					
≥12	190	1			
<12	114	1.25 (0.44–1.47)	0.472		
Lymph node ratio					
0	205	1		1	
0.01–0.19	61	2.05 (0.99–4.23)	0.065	1.39 (0.70–2.74)	0.450
≥0.20	38	5.57 (2.61–11.92)	<0.001	2.80 (1.15–6.86)	0.024
Adjuvant chemotherapy					
No	172	1		1	
Yes	132	1.81 (0.99–3.29)	0.053	1.14 (0.59–2.21)	0.703

†Stepwise logistic regression analysis. 95 % CI = 95 % confidence interval

In the multivariate analysis, pT4 cancer and an LNR of 0.20 or more were the only independent predictors of DFS.

At 10 years, 57 (18.8 %) patients experienced tumor recurrence: 26 (16.9 %) LR and 31 (20.7 %) OR patients (P = 0.485). Overall local recurrence rate was 4.3 % (13 patients). The median time until recurrence was 24 (range, 7–108) months; in two cases, local recurrence occurred more than 5 years after colon resection. A higher, although not statistically significant, increased local recurrence rate was observed in converted and OR patients, while there were no significant differences between the groups when patients were analyzed by tumor site and stage of disease (Table 4).

Table 4

Incidence of local and distant recurrence for all patients by surgical approach, stage of disease and tumor site

Variable	N	Local recurrence	P value	Distant metastases	P value
Surgical approach					
Laparoscopic	139	2 (1.4)	0.081	20 (14.4)	0.962

Variable	N	Local recurrence	P value	Distant metastases	P value
Converted	15	1 (6.7)		2 (13.3)	
Open	150	10 (6.7)		23 (15.3)	
Stage of disease					
1	62	3 (4.8)		4 (6.5)	
2	143	5 (3.5)	0.817	16 (11.2)	0.001
3	99	5 (5.1)		25 (25.3)	
Tumor site					
Right colon	115	2 (1.7)	0.158	14 (12.2)	0.401
Left colon	189	11 (5.8)		31 (16.4)	

Overall, distant metastases were developed in 45 (14.8 %) patients: 22 liver metastases, 8 lung metastases, 6 liver and lung metastases, 4 peritoneal carcinomatosis, 2 bone metastases, 2 brain metastases, and 1 port-site metastasis. The median time until distant recurrence was 20 (range, 3–72) months: 3 patients had metastases more than 5 years after colon resection. Distant metastases occurred more frequently in stage 3 patients than stage 1–2 patients ($P < 0.001$). No significant differences were observed between patients who had LR, OR or converted LR, and between patients with right- or left-colon cancer (Table 4).

Discussion

Several large RCTs have demonstrated the short-term advantages of LR compared to OR for the treatment of colon cancer, with similar 5-year DFS and OS between the two approaches [*11*].
To date, only two multicenter randomized controlled trials [*9*, *10*] have reported oncologic results in patients with a follow-up longer than 5 years after LR or OR for colon cancer. Lacy et al. [*9*] compared OS, DFS, and local recurrence rate in 106 patients treated with LR and in 102 patients who had undergone OR for non-metastatic colon cancer. After a median follow-up of 95 (range, 77–133) months, a trend towards higher OS and cancer-related survival was observed in the LR patients when compared to OR patients. When the analysis was performed on the basis of the actual treatment received, LR patients had significantly better oncologic outcomes than OR patients. OR was found as an independent predictor of poorer OS, cancer-related survival, and higher tumor recurrence rate. More recently, Green et al. [*10*] presented the long-term follow-up results of the Medical Research Council (MRC) CLASICC trial. After a median follow-up of 62.9 months, no differences were observed in OS and DFS after LR or OR.
The results of the present study show that oncologic outcomes at 10-year follow-up after LR and OR for non-metastatic colon cancer are similar. In particular, the 10-year OS rate for all patients was 87.2 % for LR patients and 78.7 % for OR patients ($P = 0.182$); the 10-year DFS rate for all stages was 80.9 % for LR patients and 76.8 % for OR patients ($P = 0.444$). We did not observe significant differences between LR and OR groups even when a stage-by-stage comparison was performed. Controversial results in terms of survival for stage 3 colon cancer are reported in the literature. The 10-year results of the MRC CLASICC showed a trend towards better OS in stage 3 cancer patients undergoing OR. Interestingly, better long-term survival after LR for stage 3 colon cancer has been reported by Lacy et al. [*2*, *9*], at both 5- and 10-year follow-up reports. They showed in a subgroup analysis that stage 3 patients undergoing LR had better OS and cancer-related survival than patients treated by OR. Presence of lymph node metastases was an independent predictors of OS, cancer-related survival, and tumor recurrence. However, no definitive conclusions could be drawn regarding the relationship between stage of disease, surgical approach, and long-term survival, since the number of patients at risk was too small and LNR was not included in the statistical analysis in both RCTs.

The impact of conversion from a LR to OR on oncologic outcomes is unclear and under debate. Most studies suggesting worse oncologic outcomes in converted patients [*12–16*] have several limitations, including small sample sizes and short follow-up periods. To the best of our knowledge, the MRC CLASICC trial is the only RCT that reported statistical analyses performed by actual treatment (patients were analyzed according to the actual treatment received: LR, OR, and LR converted to OR), therefore investigating specifically the long-term outcomes in converted patients. Both median OS and DFS in patients who underwent a LR converted to OR, were significantly worse than in patients successfully treated by laparoscopy or those who had a planned OR. In the present study, the conversion rate was 9.7 % and the reason for conversion was a locally advanced cancer in 87 % of cases. We observed slightly lower OS and DFS rates, and a trend towards higher rate of local recurrence for converted patients. A statistical significance was not reached probably because of the small number of converted patients. On multivariate analysis, a locally advanced tumor but not conversion to OR was an independent risk factor for poorer OS and DFS. These results are consistent with those previously reported in a large series of 525 patients undergoing LR for non-metastatic colorectal cancer (53 converted) at our Institution with a minimum follow-up of 5 years, showing that a pT4 cancer rather than conversion from LR to OR was a predictor of survival regardless of the tumor site [*17*]: conversion probably selects locally advanced cancers.
LNR is considered a stronger prognostic factor than the number of metastatic lymph nodes and the number of lymph nodes retrieved in the surgical specimen in colon [*18*, *19*] and rectal cancer patients [*20–22*]. For instance, Wang et al. [*18*] performed a retrospective analysis of 24,477 stage 3 colon cancer patients included in the Surveillance, Epidemiology, and End Results (SEER) cancer registry. They found that the LNR was an independent predictor of 5-year survival after adjusting age, tumor size, tumor grading, race, number of metastatic lymph node harvested, and total number of lymph nodes retrieved. Similarly, Sjo et al. [*19*] found a stronger prognostic impact of LNR than lymph node harvest on 5-year survival in 1,481 patients with colon cancer.
However, different threshold values of LNR have been proposed mainly based on quartiles classification, and there is no consensus on the cut-off value to identify patients with a better prognosis. In our study, the 10-year OS was significantly poorer for patients with an LNR of 0.20 or more. In the multivariate analysis, an LNR of 0.20 or more was an independent predictor of OS. Similarly, an LNR of 0.20 or greater was associated with poorer DFS in both univariate and multivariate analysis.
Several studies have investigated the relationship between tumor site and long-term survival, reporting controversial results. Patients with right colon cancer are more likely to be older, to have larger, more advanced, and more poorly differentiated tumors than patients with left-sided colon cancer. In addition, the tumor biology, such as microsatellite instability, and higher rates of incomplete adjuvant chemotherapy may influence the prognosis in these patients. For instance, Mequid et al. [*23*] performed a retrospective survival analysis using the SEER database including all patients who underwent colon resection for stage 1–4 colon cancer. Median survival for right-sided cancer patients was significantly shorter than left-sided cancer patients (78 vs. 89 months, $P < 0.001$). By Cox proportional hazard regression analysis, a 5 % increased mortality risk was found for right-sided cancer patients when compared with left-sided colon cancer patients. Similar results were reported by Benedix et al. [*24*] in 17,641 stage 1–stage 4 colon cancer patients, with a 12 % increase in mortality for patients with right colon cancer, and by Green et al. [*10*] in the (MRC) CLASICC trial , who found a significantly worse DFS and a trend towards a higher local recurrence rate in patients with right-sided colon cancer.
In the present study, we did not observe significant differences in OS (83.3 vs.82.9 %; $P = 0.765$) and DFS (80.1 vs.78.4 %; $P = 0.562$), local recurrence, and distant metastases rates, between 115 non-metastatic right colon and 189 non-metastatic left-sided colon cancer patients. These results are consistent with those recently published by Weiss et al. [*25*] who retrospectively analyzed 53,801 Medicare patients with stage 1–3 colon cancer (36,006 right-sided cancers and 17,735 left-sided

cancers). They found no differences in 5-year mortality between the two groups of patients after adjusting for several patient, disease, and treatment variables.
However, further large prospective studies focusing on tumor biology are needed to better define the association between tumor site and long-term survival.
In conclusion, this large prospective comparative study shows similar long-term oncologic outcomes at 10 years after LR and OR for non-metastatic colon cancer, with no significant impact of conversion to OR on long- term survival.

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