Laparoscopic and open surgery in patients with transverse colon cancer: short-term and oncological outcomes

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Abstract

Background: Studies evaluating the outcomes after laparoscopic resections of transverse colon cancers are scant. This manuscript aimed to compare surgical and oncological outcomes after laparoscopic (Lap) and open procedures for transverse colon carcinomas.

Methods: All consecutive patients who underwent resection for a cancer located in the transverse colon between 2003 and 2019 were reviewed. Patients were categorized according to the surgical approach (Lap *versus* open) and groups were compared. Outcome measures were the short-term results, complications and functional recovery; moreover, recurrence-free survival (RFS) and overall survival (OS) rates were compared overall and after propensity score matching (PSM) based on age, sex, ASA classification, BMI, carcinoembryonic antigen (CEA) level, use of postoperative chemotherapy, location of tumour, stage and grading, operation time, blood loss and complications.

Results: Of 248 transverse resections reviewed, 146 (81 Lap and 65 open) were selected for data analysis. Blood loss, fluid intake and the incidence of wound infection were significantly lower and the hospital stay was significantly shorter in the Lap group ($P < 0.001$). The operation time and incidence of complications (Clavien–Dindo classification grade 3 or above) did not differ significantly between the two groups. Mean follow-up was of 75.4 months in the Lap group and 78.6 months in the open group. Regression analyses showed that OS was associated with the postoperative carcinoembryonic antigen (CEA) level (hazard ratio 1.18 (95 per cent c.i. 1.10 to 1.27); $P < 0.001$), BMI (hazard ratio 0.81 (95 per cent c.i. 0.68 to 0.96); $P = 0.017$), operation time (hazard ratio 0.99 (95 per cent c.i. 0.97 to 1.00; $P = 0.010$), and postoperative chemotherapy (hazard ratio 0.27 (95 per cent c.i. 0.08 to 0.96); $P = 0.042$), while RFS was associated with the postoperative CEA level (hazard ratio 1.13 (95 per cent c.i. 1.07 to 1.20); $P < 0.001$). PSM selected 42 patients for data comparison of long-term results, and showed no significant differences between groups (RFS: $P = 0.530$; OS: $P = 0.561$).

Conclusion: Lap and open resections for transverse colon cancer provided similar outcomes in terms of severe post-operative complication and long-term results.

Introduction

Laparoscopic procedures for colonic cancer surgery have significant benefits compared with open procedures, such as a shorter hospital stay and time until solids can be tolerated, a lower estimated blood loss and an earlier return to normal activity, while enabling similar oncological outcomes[1–5]. However, previous randomized controlled trials have excluded patients with transverse colon cancer because the resection of cancers in the transverse colon is technically more challenging, compared with other cancer locations in the colon, and such procedures are dependent on the variable anatomy of the middle colic vessels, which demand excellent surgical skills, and the anatomical location of the transverse colon in relation to major organs, such as the pancreas, duodenum and spleen[1–3,6–9]. In addition, cancers in the transverse colon only account for about 10 per cent of all colonic cancers. Therefore, surgical treatments for transverse colon cancers are determined by the tumour site or the surgeon's preference and

include an extended right hemicolectomy, transverse colectomy or extended left hemicolectomy. Few studies on laparoscopic surgery for transverse colon cancer have been published, and data regarding the influence of surgical procedures on quality of life and potential long-term results are sparse[10–19]. Laparoscopic and open resection seem to have equal short-term oncological outcomes[12,14,15], whereas the long-term results are relatively unknown[20].

The aims of this study were to compare the short- and long-term outcomes of the laparoscopic (Lap) and an open surgery approach, and to identify variables correlated with oncological outcome.

Methods
Patients

All consecutive patients with an adenocarcinoma of the transverse colon treated with an R0 curative resection between

January 2003 and August 2019 were reviewed retrospectively. The exclusion criteria were bowel obstruction, bowel perforation, adjacent organ invasion, distant metastases, familial polyposis coli and inflammatory bowel diseases, gastrointestinal disease requiring surgical intervention, concurrent or previous malignant tumour and a history of malignant disease within 5 years, preoperative chemotherapy, and severe medical illness. All participants gave written informed consent. This study was approved by the Institutional Review Board of Tsuchiura Kyodo General Hospital (2019-TKGH-873; registration number: jRCT1030210203 (https://jrct.niph.go.jp/re)). This study was conducted in accordance with the Helsinki Declaration (64th WMA General Assembly, Fortaleza, Brazil, October 2013).

All the patients had undergone standardized preoperative evaluations including a total colonoscopy, a CT scan of the chest and abdomen, and a carcinoembryonic antigen (CEA) assay (normal range 5.0 ng/ml or lower) before surgery. The preoperative CEA level was defined as the CEA value measured closest to the time of surgery, and the postoperative CEA level was defined as the last CEA value within 3 months after surgery and before the start of adjuvant chemotherapy. The International Union against Cancer (UICC) tumour–node–metastasis (TNM) classification system of colon cancer (6th edition) was used for disease staging[21]. Collected data included age, sex, BMI, ASA classification, previous abdominal surgery, location of primary tumour, postoperative chemotherapy, pre- and postoperative CEA, operation time and estimated volume of blood loss. The pathological variables included the grade of differentiation, tumour size, proximal and distal resected margin, lymph nodes in resected specimen, number of lymph node metastases, vascular and nerve invasion, pathological T stage, pathological N stage, TNM stage and R stage.

Pathological stage III as diagnosed by a histological examination of the resected specimen was an indication for the use of postoperative adjuvant chemotherapy. Adjuvant chemotherapy was performed using fluorouracil and I-leucovorin infusion or oral fluorouracil for 6 or 12 months, depending on the decision of the attending physician.

Procedures

Laparoscopic and open resections were performed by member of the colorectal surgery group. The choice to perform a laparoscopic or open resection depended on the surgeon's preference at that time. Surgical treatment was performed according to the cancer's location. A right or extended right hemicolectomy was performed for lesions located in the hepatic flexure as well as for lesions located within the distal 10 cm of the hepatic flexure. A left or extended left hemicolectomy was performed for lesions located in the splenic flexure as well as for lesions located within the proximal 10 cm of the splenic flexure. A transverse colectomy was performed for lesions located between the two aforementioned regions. A right hemicolectomy was defined as ligation of the ileocolic, right colic (if present) and right branch of the middle colic vessels at their origins together with a lymphadenectomy. If an extended right hemicolectomy was needed, the origin of the middle colic vessels was ligated. A left hemicolectomy was defined as ligation of the left colic and the left branch of the middle colic vessels at their origins together with a lymphadenectomy. If an extended left hemicolectomy was needed, the origin of the middle colic vessels was ligated. A transverse colectomy was defined as ligation of the middle colic vessels at their origins together with a lymphadenectomy. The anastomosis was performed using a functional end-to-end anastomosis or a hand-sewn anastomosis. The same anastomosis techniques were used in both types of surgeries.

Postoperative surveillance

All the patients were followed by taking a medical history and performing a physical examination and laboratory studies, including serum CEA levels, within 3 months after surgery and at 3–6-month intervals thereafter for the first 3 years, followed by every 6 months for 5 years. At each visit, the patient's symptoms were recorded. Abdominal ultrasonography or CT examinations and thoracic radiography were performed every 6 months until 5 years after surgery, and a total colonoscopy or barium enema was performed every year after surgery during the follow-up period. After 5 years, these evaluations were performed annually.

Outcome measures

The short-term outcomes measured were operative time, blood loss, days of fluid intake, duration of hospital stay, incidence of postoperative complications (anastomotic leakage, wound infection, abdominal hernia after 30 days, death and reintervention after 30 days), and Clavien–Dindo classification of complications[22]. Long-term results investigated were recurrence-free survival (RFS) rate and overall survival (OS) rate. Recurrence was defined as a radiologically or pathologically proven local or systemic metastasis, while OS was defined as death by any cause reported during follow-up.

Statistical analysis

Patients were categorized according to the surgical approach (Lap *versus* open) and groups were compared. Categorical variables were analysed using the χ^2 test or the Fischer exact test. Continuous variables were presented as the mean and standard deviation and were compared using the Student *t*-test. The Cox proportional hazard regression analysis was used for multivariable models. The associations with RFS and OS were evaluated using multivariable Cox proportional hazard regression analyses. Variables with $P < 0.050$ in a univariable analysis were mainly included in the final multivariable model. Hazard ratios and 95 per cent confidence intervals were estimated using Cox regression models and were assessed using the Wald test. The explanatory variables included in the propensity score-matching methods for RFS and OS were age, sex, ASA classification, BMI, preoperative CEA level, postoperative CEA level, use of postoperative chemotherapy, location of tumour (right, middle or left region), grade of differentiation, TNM stage, operation time, blood loss, complications, and vascular invasion (v: vein, ly: lymphatic vessel). After the application of the propensity score-matching methods, both the RFS and OS rates were analysed using the Kaplan–Meier method and the log rank test was used to compare the difference. $P < 0.050$ was considered statistically significant. All the statistical analyses were performed using EZR[TM23], which is a graphical user interface for R.

Results

Baseline patient characteristics

A total of 248 patients (105 Lap, 143 open) with adenocarcinoma of the transverse colon were treated with an R0 curative resection treated between January 2003 and August 2019. However, 102 patients were excluded, leaving 146 patients for data analysis (81 Lap, 65 open) (*Fig. 1*).

No statistically significant differences in age ($P = 0.133$), sex ($P = 1.00$), BMI ($P = 0.770$), ASA classification ($P = 0.699$), previous
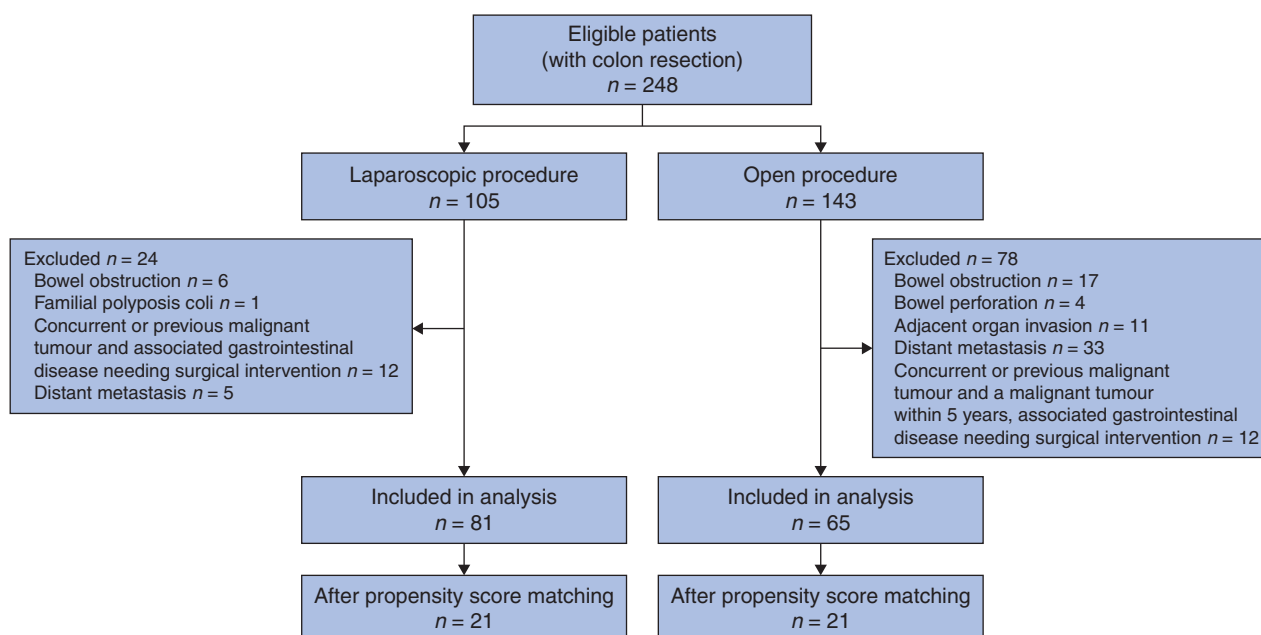
Fig. 1 Study flow diagram

abdominal surgery ($P = 0.328$), use of postoperative chemotherapy ($P = 0.062$) or postoperative CEA level ($P = 0.070$) were observed between the two groups. However, the locations of the primary tumours ($P = 0.007$) and the preoperative CEA level ($P = 0.019$) differed significantly between the two groups, due to a prevalence of right localization in the Lap group (*Table 1*).

Statistically significant differences in tumour size (mean(s.d.) 29.1(18.6) mm for Lap, 46.0(26.0) mm for open, $P < 0.001$), histological grade of differentiation ($P = 0.002$), number of lymph node metastases ($P = 0.020$) and number of vascular invasions (v, $P = 0.004$; ly, $P < 0.001$) were observed between the two groups. However, the resection margins (both proximal and distal), the number of lymph nodes in the resected specimen and the incidence of perineural invasion were not significantly different (*Table 1*). The Lap group reported a prevalence of patients with stage 0 or I compared with the open group which reported more patients with stage II or III ($P < 0.001$); the same trend of early stages was reported for the T stage ($P < 0.001$), although the pathological N stage and R stage were similar in both groups (*Table 1*).

Short-term outcomes

The mean duration of the operation (245.3 *versus* 233.8 minutes $P = 0.348$) was similar in both groups. The estimated mean blood loss (101.2 *versus* 323.6 ml; $P < 0.001$) was significantly less in the Lap group. The mean time until solids could be tolerated (4.1 *versus* 7.0 days; mean difference, 2.8 days (95 per cent c.i. −4.4 to −1.3); $P < 0.001$) and the mean duration of hospital stay (10.9 *versus* 17.4 days; mean difference 6.6 days (95 per cent c.i. −9.0 to −4.1); $P < 0.001$) were significantly shorter in the Lap group (*Table 2*). The incidence of overall complications was significantly lower in the Lap group ($P < 0.001$). However, no significant differences were seen between the two groups in terms of the incidence of Clavien–Dindo classification grade 3 or higher complications, anastomotic leakage, bowel obstruction, or abdominal wall hernia. Wound infection was more frequent in the open group than in the Lap group ($P < 0.001$). No postoperative

reintervention within 1 month or deaths occurred in either group (*Table 3*).

Oncological outcomes and propensity score matching

The survival data were analysed as of October 2019. Mean follow-up was 75.4 months in the Lap group and 78.6 months in the open group.

The use of adjuvant chemotherapy and the postoperative follow-up period were similar in both groups. A Cox proportional hazard regression analysis (multivariable analysis), conducted in the entire cohort, showed that RFS was only associated with the postoperative CEA level (hazard ratio 1.133 (95 per cent c.i. 1.075 to 1.195); $P < 0.001$), whereas OS was associated with BMI (hazard ratio 0.812 (95 per cent c.i. 0.686 to 0.961); $P = 0.017$), postoperative CEA level (hazard ratio 1.183 (95 per cent c.i. 1.106 to 1.265); $P < 0.001$), operation time (hazard ratio 0.985 (95 per cent c.i. 0.975 to 0.996); $P = 0.010$), and the use of postoperative chemotherapy (hazard ratio 0.277 (95 per cent c.i. 0.081 to 0.960); $P = 0.042$) (*Table 4*).

No local recurrences occurred in either group. In the Lap group, two patients developed liver metastasis, three patients developed lung metastasis and one patient developed para-aortic lymph node metastasis. In the open group, three patients developed liver metastasis, three patients developed lung metastasis, three patients developed peritoneal dissemination, and two patients developed para-aortic lymph node metastasis (*Table S1*).

PSM selected 42 (21 Lap, 21 open) patients for RFS and OS analyses. PSM showed that the RFS rates were not available (NA) (median survival not reached) for both the Lap and open groups (95 per cent c.i., 3189 days to NA for Lap; 2370 days to NA for open; $P = 0.530$). The RFS rates were 71.1 per cent at 8.7 years in the Lap group and 71.4 per cent at 6.5 years in the open group (*Fig. 2a*). When compared according to disease stage, no significant differences in RFS were seen between the two groups (for stage I: NA (95 per cent c.i. 716 to NA) for Lap, 4132 (95 per cent c.i. 443 to

Table 1 Patient baseline characteristics

Characteristic	Laparoscopic (n = 81)	Open (n = 65)	P#
Age (years)*	70 (32–86)	69 (50–88)	0.1330
Male sex	68.4 (65)	70.9 (65)	1.0000
BMI (kg/m^2)†	22.5 (3.4)	22.4 (3.9)	0.770
ASA class			0.699
I	60 (74)	44 (68)	
II	19 (24)	19 (29)	
III	2 (3)	2 (3)	
Previous abdominal surgery			0.328
No	58 (72)	40 (62)	
Once	18 (22)	17 (26)	
Twice	5 (6)	6 (9)	
Three or more times	0	2 (3)	
Location of primary tumour			0,007
Right region	39 (48)	16 (25)	
Middle region	22 (27)	31 (48)	
Left region	20 (25)	18 (28)	
Postoperative chemoradiation	26 (32)	31 (48)	0,062
Preoperative CEA (ng/ml)†	4.2 (4.7)	9.4 (19.1)	0,019
Postoperative CEA (ng/ml)†	2.7 (2.1)	4.4 (8.0)	0.070
Grade of differentiation			0,002
Well differentiated	55 (68)	31 (48)	
Moderately differentiated	24 (30)	24 (37)	
Poorly differentiated	1 (1)	3 (5)	
Mucinous	0	6 (9)	
Others	1 (1)	1 (2)	
Tumour size (mm)†	29.1 (18.6)	46.0 (26.0)	<0.001
Resection margins (mm)†			0.780
Proximal margin	150.7 (121.6)	141.3 (98.9)	
Distal margin	102.7 (79.7)	98.7 (94.0)	
Lymph nodes in resected specimen†	17.1 (13.8)	17.8 (12.8)	0.749
Number of lymph nodes with metastasis†	0.5 (1.6)	2.1 (5.7)	0.020
Vascular and nerve invasion			
V (0/1a/1b/1c/2)	(41/21/14/5/0)	(14/29/17/5/0)	0,004
Ly (0/1a/1b/1c)	(60/13/6/2)	(28/27/4/6)	<0.001
Pn (0/1a/1b)	(75/4/2)	(64/0/1)	0.322
Pathological T stage			<0.001
Tis	16 (20)	3 (5)	
T1a	9 (11)	2 (3)	
T1b	12 (15)	4 (6)	
T2	12 (15)	4 (6)	
T3	27 (33)	37 (57)	
T4a	5 (6)	15 (23)	
Pathological N stage			0.124
N0	63 (78)	41 (63)	
N1a	10 (12)	7 (11)	
N1b	5 (6)	8 (12)	
N2a	1 (1)	4 (6)	
N2b	2 (3)	5 (8)	
TNM stage			<0.001
0	17 (21)	3 (5)	
I	30 (37)	9 (14)	
IIa	15 (19)	25 (39)	
IIb	2 (3)	6 (9)	
IIc	0	0	
IIIa	2 (5)	0	
IIIb	12 (15)	14 (22)	
IIIc	3 (4)	8 (12)	
R stage			0.445
R0	81 (100)	64 (97)	
R1	0	1 (2)	

Values in parentheses are percentages unless indicated otherwise; *values are median (range); †values are mean (s.d.). Preoperative carcinoembryonic antigen (CEA) was defined as the CEA value closest to the time of surgery, and postoperative CEA was defined as the last CEA value within 3 months after surgery and before starting adjuvant chemotherapy. V, vein; Ly, lymphatic vessel; Pn, perineural invasion. #Categorical variables were analysed using the χ^2 test or the Fischer exact test. Continuous variables were compared using the Student t-test.

Table 2 Postoperative outcomes and recoveries

	Laparoscopic (n = 81)	Open (n = 65)	Mean difference between groups*	P#
Operation time (min)	245.3(76.1)	233.8(69.4)	11.5 (−12.6, −35.6)	0.348
Blood loss (ml)	101.2(98.3)	323.6(244.3)	222.3 (−281.1, −163.6)	<0.001
Fluid intake (days)	4.1(3.7)	7.0(5.7)	2.8 (−4.4, −1.3)	<0.001
Hospital stay (days)	10.9(6.7)	17.4(8.2)	6.6 (−9.0, −4.1)	<0.001

Values are mean(s.d.) unless indicated otherwise; *values in parentheses are 95 per cent confidence intervals. #Cntinuous variables were compared using the Student t-test.

Table 3 Postoperative morbidity, mortality and related treatments

	Laparoscopic (n = 81)	Open (n = 65)	P#
Overall complications	13 (16)	21 (32)	<0.001
Clavien–Dindo classification (level 3 and above)	7 (9)	4 (6)	0.153
Anastomotic leakage			1.000
Conservative	1 (1)	1 (2)	
Operation	1 (1)	0	
Bowel obstruction			1.000
Conservative	3 (4)	3 (5)	
Operation	1 (1)	0	
Wound infection			<0.001
Mild (within 30 days)	1 (1)	10 (15)	
Severe (over 30 days)	1 (1)	4 (6)	
Abdominal wall hernia			1.000
Conservative	0	0	
Operation	0	1 (2)	
Reintervention (within 1 month)	0	0	
Death (in a hospital)	0	0	

Values in parentheses are percentages. #Categorical variables were analysed using the χ^2 test or the Fischer exact test. Continuous variables were compared using the Student t-test.

Table 4 Oncological outcomes

Events	Recurrence-free survival		Overall survival	
	Hazard ratio	P	Hazard ratio	P
Age	1.05 (0.99, 1.10)	0.103	1.06 (0.99, 1.13)	0.082
Sex	1.60 (0.68, 3.80)	0.284	2.12 (0.73, 6.12)	0.165
ASA	1.09 (0.55, 2.16)	0.814	1.19 (0.54, 2.64)	0.667
BMI	0.94 (0.82, 1.07)	0.322	0.81 (0.69, 0.96)	0.017
Preoperative CEA	1.01 (0.99, 1.03)	0.262	1.01 (0.99, 1.03)	0.417
Postoperative CEA	1.13 (1.08, 1.20)	<0.001	1.18 (1.10, 1.27)	<0.001
Location of tumour	0.63 (0.35, 1.13)	0.121	0.71 (0.36, 1.41)	0.328
Treatment (Lap or open)	0.96 (0.34, 2.74)	0.939	0.97 (0.26, 3.67)	0.966
Grade of differentiation	0.46 (0.13, 1.57)	0.213	0.65 (0.18, 2.37)	0.512
T stage	1.66 (0.75, 3.68)	0.214	2.22 (0.83, 5.96)	0.113
N stage	2.23 (0.76, 6.55)	0.146	1.99 (0.50, 7.95)	0.328
TNM stage	0.60 (0.19, 1.91)	0.385	0.65 (0.16, 2.69)	0.554
v	1.63 (0.83, 3.22)	0.158	0.94 (0.41, 2.16)	0.883
ly	1.17 (0.65, 2.08)	0.606	1.12 (0.55, 2.25)	0.759
Lymph node yield	0.99 (0.95, 1.04)	0.787	1.00 (0.94, 1.06)	0.936
Operation time	0.99 (0.98, 1.001)	0.078	0.99 (0.97, 1.00)	0.010
Blood loss	1.00 (1.00, 1.00)	0.975	1.001 (1.00, 1.00)	0.432
Complications	0.97 (0.35, 2.67)	0.946	1.34 (0.42, 4.34)	0.621
Fluid intake	1.03 (0.91, 1.17)	0.654	1.07 (0.92, 1.25)	0.393
Hospital stay	1.03 (0.94, 1.13)	0.513	1.02 (0.92, 1.13)	0.718
Postoperative chemo-therapy	0.38 (0.14, 1.01)	0.051	0.28 (0.08, 0.96)	0.042

Values in parentheses are 95 per cent confidence intervals. Association with recurrence-free and overall survival was evaluated by multivariable Cox proportional hazard regression analysis. Variables with $P < 0.050$ on univariable analysis were included in the final multivariable model. Hazard ratios and 95 per cent confidence intervals were estimated using the Cox regression models and assessed by the wald test. Preoperative carcinoembryonic antigen (CEA) was defined as the CEA value closest to the time of surgery, and postoperative CEA was defined as the last CEA value within 3 months after surgery and before starting adjuvant chemotherapy. Lap, laparoscopic; v, vein; ly, lymphatic vessel.
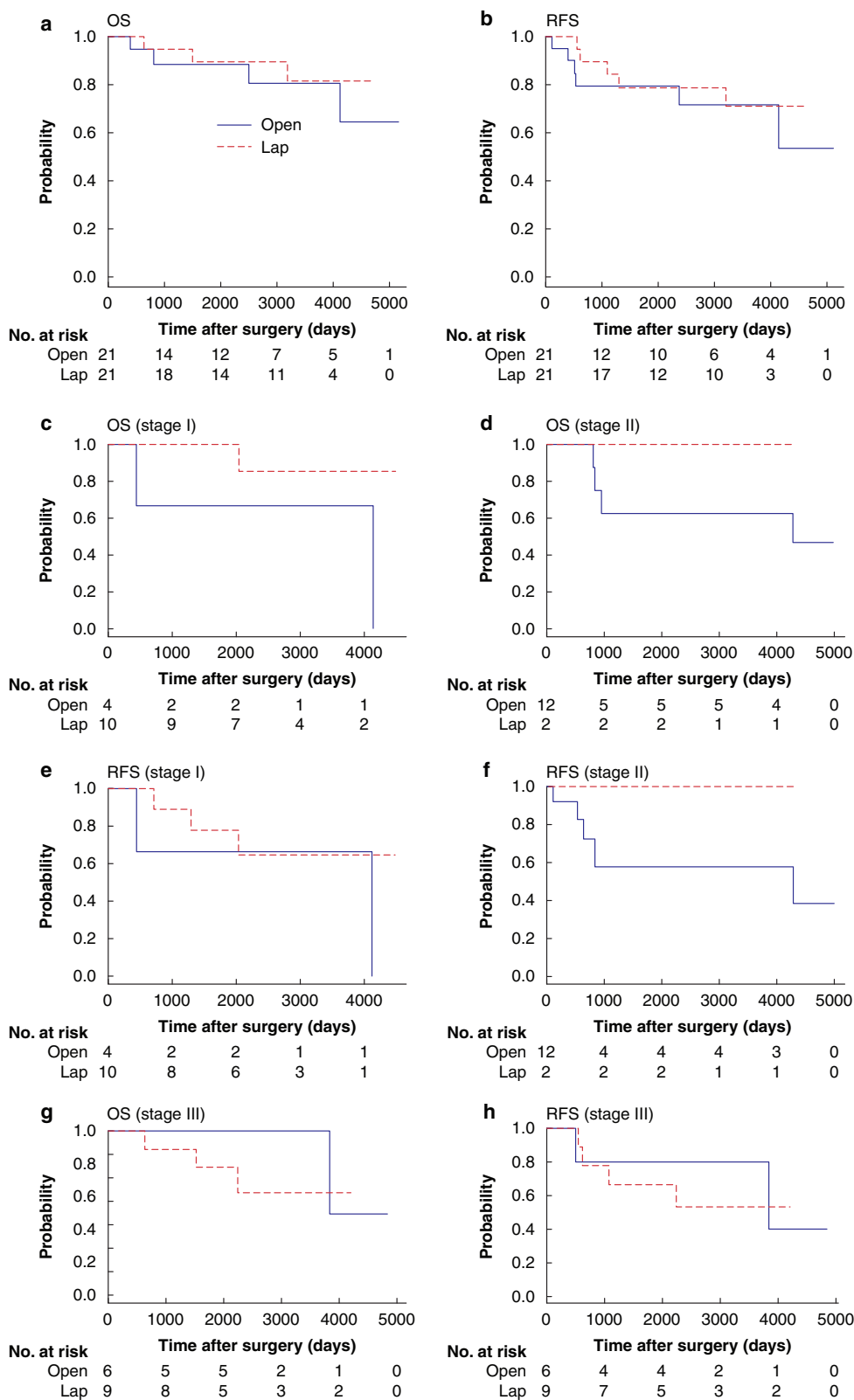
Fig. 2 Kaplan–Meier estimates of overall and recurrence-free survival

a Overall survival (OS) (*P* = 0.561) and **b** recurrence-free survival (RFS) (*P* = 0.530) after propensity score-matching analysis (entire series) for open (Open) and laparoscopic-assisted colectomy (Lap). **c**, **d**, **g** OS after propensity score-matching analysis: **c** stage I (*P* = 0.118), **d** stage II (*P* = 0.351), **g** stage III disease (*P* = 0.450). **e, f, h** RFS after propensity score-matching analysis: **e** stage I (*P* = 0.522), **f** stage II (*P* = 0.315), **h** stage III disease (*P* = 0.795). *P* values determined by log rank test.

NA) for open, *P* = 0.522; for stage II: NA (95 per cent c.i. NA to NA) for Lap, 4281 (95 per cent c.i. 534 to NA) for open, *P* = 0.315; and for stage III: NA (95 per cent c.i. 550 to NA) for Lap, 3838 (95 per cent c.i. 505 to NA) for open, *P* = 0.795) (*Fig. 2c*).

PSM documented that the OS rates were NA for both the Lap and open groups (95 per cent c.i. NA to NA for Lap; 2498 to NA for open; *P* = 0.561). The OS rates were 89.5 per cent at 4.2 years in the Lap group and 80.4 per cent at 6.8 years in the open group

(*Fig. 2a*). When compared according to disease stage, no significant differences in OS were seen between the two groups (for stage I: NA (95 per cent c.i. 2049 to NA) for Lap, 4132 (95 per cent c.i. 443 to NA) for open, $P = 0.118$; for stage II: NA (95 per cent c.i. NA to NA) for Lap, 4281 (95 per cent c.i. 812 to NA) for open, $P = 0.351$; and for stage III: NA (95 per cent c.i. 644 to NA) for Lap, 3838 (95 per cent c.i. 3838 to NA) for open, $P = 0.450$) (*Fig. 2b*).

Discussion

Laparoscopic surgery is being increasingly performed for colon cancer all over the world. However, laparoscopic transverse colon cancer surgery remains controversial. The surgical technique is more challenging for transverse colon cancers than for cancers in other locations because the surgical procedure varies according to the cancer location and because the middle colic artery and vein, as well as the superior mesenteric artery and vein, are anatomically adjacent to important organs such as the duodenum and the pancreas. A relatively larger surgical space is necessary for transverse mobilization manoeuvres, such as splenic flexure and hepatic flexure colon. Thus, refined surgical skill is needed to resect the adjacent omentum and to avoid injury to the transverse colon mesentery, pancreas and spleen. This study compared a laparoscopic and an open approach in patients who had undergone the resection of transverse colon cancer by examining the long-term outcomes after a relatively long-term follow-up period of 16 years. According to univariable analyses, the estimated blood loss and fluid intake were significantly smaller and the hospital stay was significantly shorter in the Lap group. The overall postoperative complication rate and the wound infection rate were also significantly lower in the Lap group. In previous reports, postoperative morbidities in a Lap group were less frequent or equivalent to those in an open group[12–15]. In the present study, a statistically significant difference in the operation time was not observed between the two groups. However, this result was not consistent with those of previous studies[10,12–15]. Other studies also reported that the operation times were longer for Lap procedures involving the transverse colon than for those involving other regions of the colon[13,17]. This result in the present study might be associated with a bias in the patients' cancer characteristics, but it also might suggest that the technical difficulties associated with Lap procedures for the transverse colon have been overcome and that proficiency has been gained.

A systemic review demonstrated that the number of harvested lymph nodes was associated with survival and recommended that surgeons should harvest at least 12 lymph nodes for adequate sampling[24,25]. The numbers of lymph nodes retrieved in the two reported groups were almost equal and were more than the recommended mean: 17.1 in the Lap group, and 17.8 in the open group. This result might explain the equal oncological clearance effects for the two procedures.

The short-term benefits of laparoscopy have been reported in several papers[5,8,9]. Several outcomes for Lap have been shown to be the same as those for an open approach for colon cancer in several multicentre randomized trials[25,27,28]. However, transverse colon cancer was excluded from these previously reported randomized trials. Randomized trials are needed to establish clinical evidence, but transverse colon cancer accounts for only 10 per cent of all colon cancers. Therefore, a planned randomized trial for transverse colon cancer surgery would take a long time and would be difficult to conduct. In the present study, the results of the long-term outcomes could not be simply evaluated because of distribution biases in tumour size, location of the primary tumour and pathological factors, such as tumour stage, grade of differentiation and vascular invasion. In the multivariable analysis, OS was associated with BMI, the postoperative CEA level, operation duration and the use of postoperative chemotherapy, whereas RFS was associated only with the postoperative CEA level. A previous study[26] reported that the postoperative CEA level was independently associated with a shorter RFS, in keeping with the results reported for the present study. Postoperative chemotherapy could also be expected to be quite an important prognosis factor. However, the authors could not analyse the influence of chemotherapy on long-term survival[27], so this was not documented in the present report. Propensity score-matching analysis showed that the RFS rates were 71.1 per cent at 8.7 years in the Lap group and 71.4 per cent at 6.5 years in the open group, compared with rates of 60.3–86.1 and 56.7–78.9 per cent at 5 years in Lap and open groups respectively in a previously reported meta-analysis[27]. The OS rates were 89.5 per cent at 4.2 years in the Lap group and 80.4 per cent at 6.8 years in the open group, compared with rates of 61.0–90.4 and 59.0–90.5 per cent at 5 years in Lap and open groups respectively in the previously reported meta-analysis[27]. No significant differences in OS or RFS were seen between the two groups in the present study; this was also found in previously reported meta-analyses[27,28]. No significant differences in OS and RFS for stages I, II and III were seen between the two groups in this study. In terms of long-term survival, no significant differences were seen between Lap and open groups. However, laparoscopy may be preferable to open surgery for the resection of transverse colon cancer with regard to complications, variables related to recovery, and quality of life. Therefore, laparoscopy can be considered as a feasible alternative to open surgery for patients with transverse colon cancer. It is important to note that the postoperative CEA level within 3 months was strongly associated with long-term outcome, especially RFS.

Disclosure. The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS Open* online.

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