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Original Research Article

Résultats de la chirurgie du cancer du côlon gauche en occlusion : Etude multicentrique de l'Association Française de Chirurgie sur 1 500 patients

Surgical management of obstructive left colon cancer at a national level: Results of a multicentre study of the French Surgical Association in 1 500 patients

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STRUCTURED ABSTRACT (250 words)

Purpose: Surgical management of obstructive left colon cancer (OLCC) is controversial. The objective is to report on postoperative and oncological outcomes of the different surgical options in patients operated on for OLCC.

Methods: From 2000-2015, 1500 patients were treated for OLCC in centers members of the French Surgical Association. Colonic stent (n=271), supportive care (n=5), palliative derivation (n=4) were excluded. Among 1220 remaining patients, 456 had primary diverting colostomy (PDC), 329 a segmental colectomy (SC), 246 a Hartmann's procedure (HP) and 189 a subtotal colectomy (STC) as first-stage surgery. Perioperative data and oncological outcomes were compared retrospectively.

Results: There was no difference between the 4 groups regarding gender, age, BMI and comorbidities. Postoperative mortality and morbidity were 4-27% (PDC), 6-47% (SC), 9-55% (HP), 13-60% (STC), respectively (p=0.005). Among the 431 living patients after PDC, 321 (70%) patients had their primary tumour removed. Cumulative mortality and morbidity favoured PDC (7-39%) and SC (6-40%) compared to HP (1-47%) and STC (13-50%) (p=0.04). At the end of follow-up definitive stoma rates were 39% (HP), 24% (PDC), 10% (SC), and 8% (STC) (p<0.0001). Five-year overall and disease-free survival was: SC (67-55%), PDC (54-48%), HP (54-37%) and STC (48-49%). After multivariate analysis, SC and PDC were associated with better prognosis compared to HP and STC.

Conclusion: In OLCC, SC and PDC are the two preferred options in patients with good medical conditions. For patients with severe comorbidities PDC should be recommended, reserving HP and STC for patients with colonic ischaemia or perforation complicating malignant obstruction.

Keywords: Colon cancer, Obstruction, Surgery, morbidity, oncological outcomes

INTRODUCTION

About 20% of patients with CRC are diagnosed with acute colonic obstruction, which is located in the left colon in two thirds of them [1-2]. Urgent surgery for obstructive colon cancer is associated with increased risk of postoperative morbidity, mortality and permanent stoma rates as it usually occurs in elderly patients with poor medical condition or in those with high comorbidities [3–5]. Furthermore, 40 to 60% of obstructive colon cancers are locally advanced or metastatic at diagnosis and, at equal tumour stage, obstruction itself impaires oncological outcomes in colon cancer patients [2, 6–9].

Surgical management of obstructive left colon cancer (OLCC) is still a matter of debate and several options may be discussed including primary diverting colostomy (PDC) as a bridge to elective colectomy, Hartmann's procedure (HP), segmental colectomy with primary anastomosis with or without intraoperative colonic irrigation (SC) and total or subtotal colectomy with anastomosis (STC) [10–12]. Only two randomised controlled trials have compared the different surgical options in the treatment of OLCC. Kronborg and colleagues [13] demonstrated that PDC followed by resection and anastomosis in second instance significantly decreases the rates of permanent colostomy, blood transfusion and wound infection compared to HP followed by restoration of continuity in second instance. No difference in cancer specific survival was observed in this trial. The SCOTIA trial [14] showed that STC impairs functional results and increases the risk of permanent stoma compared to SC with intraoperative colonic irrigation with no difference in operative time, anastomotic leak, mortality and length of hospital stay. Despite numerous studies published since these two randomised trials [4, 6, 15–19], it is still hard to draw any conclusion on the best surgical strategy of patients with OLCC as the included population is heterogeneous, patients in these studies were often recruited over a long time period and surgical management included patients operated on after colonic stent insertion [20]. Finally, not all

published series reporting on postoperative outcomes for OLCC yielded a global long-term picture of the different surgical options as they focussed on the first-stage urgent operation without any details on the second or third surgery when performed [19]. The aim of our multicentre French cohort study was therefore to provide an overview of the different surgical options and related mortality and morbidity in patients operated on for OLCC with a special interest in cumulative postoperative morbidity, long-term stoma rate and oncological outcomes.

MATERIALS AND METHODS

Study population

Data from all consecutive patients who were managed for OCC between January 2000 and December 2015 in surgical centers members of the French National Surgical Association (Association Française de Chirurgie) were retrospectively analyzed. The collected data were provided by the surgeons of each centre after institutional approval. The diagnosis of colonic obstruction was established in patients with clinical symptoms of intestinal obstruction and confirmed by abdominal X-ray, as performed in the early 2000's, and/ or abdominal computed tomography (CT). OLCC was defined as a colonic tumour located between splenic flexure and rectum. Patients who had colonic stent insertion, those treated only with palliative supportive care because of poor medical condition and patients who had internal derivation as a palliative surgical procedure were excluded from the study.

Study endpoints

The primary endpoint of the study was to report the postoperative outcomes (mortality and morbidity) of surgery for OLCC with a particular focus on cumulative postoperative morbidity. Secondary endpoints included: definitive stoma rate, as well as overall and disease-free survival.

Variables and Outcomes measures

Data were collected from the French National Surgical Association database. Postoperative morbidity was defined as any complication occurring during the hospital stay or within 30 days after surgery. Complications were classified according to Clavien-Dindo [21]. Overall survival was defined as the period of time between the date of surgery and the date of death,

whatever the cause. For patients with non-metastatic disease, disease-free survival was defined as the period of time between the date of surgery and the date of the first relapse of the disease (locoregional or distant) or death. Living patients with no evidence of disease at last follow-up were censored.

Statistical analysis

Quantitative data were reported as median and range or mean and standard deviation, and categorical data were reported as absolute numbers and percentages (percentages were calculated with available data). Normally distributed quantitative data were analysed with Student's *t* test, Mann-Whitney test or Kruskal-Wallis test, as appropriate. Qualitative data were compared using Pearson's χ^2 test or Fisher's exact test, as appropriate. Survival curves were plotted according to the method of Kaplan and Meier and differences between survival distributions were assessed by log-rank test. Multivariate analysis for survival analysis was computed using Cox proportional hazards regression. All the variables that were significant in univariate analysis were included in the multivariate model. All tests were 2-sided, with a level of significance set at $p < 0.05$. Statistical analyses were performed using GraphPad Prism (version 5.0; California, USA) and JPM (version 12.1.0; SAS Institute, Cary, North Carolina, USA) software. This study was conducted according to the ethical standards of the Committee on Human Experimentation of our institution and reported according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [22].

RESULTS

Patient characteristics

Between 2000 and 2015, 1500 patients with OLCC were identified. Patients who had colonic stent insertion (n = 271), those who received supportive care because of poor medical condition (n = 5) and those who had palliative internal derivation (n = 4) were excluded from the study. The 1220 remaining patients were divided into four groups: PDC (n = 456), SC (n = 329), HP (n = 246) and STC (n = 189) (**Figure 1, Table 1**). The obstruction was confirmed by imaging in 1139 patients (93%). There was no difference between the four groups regarding gender, age, BMI and comorbidities. Patients who had SC were in better medical condition (ASA score, p=0.008, and performance status, p<0.0001) than the other groups. On preoperative CT scan, synchronous metastatic disease was more frequently suspected in patients who had PDC (32%) than in other groups (SC 23%, HP 26% and STC 21%, respectively, p=0.01). The following CT scan features of colonic obstruction related complications were more frequently reported in patients who had HP and STC than those who had PDC or SC: pneumoperitoneum (16 and 10% vs. 2 and 5%, p<0.0001), bowel parietal pneumatosis (8 and 26% vs. 4 and 4%, p<0.0001), and absence of vascular bowel wall enhancement (9 and 12% vs. 2 and 2%, p<0.0001).

Intraoperative data (Table 2)

In the PDC group, the primary tumour was more frequently reported as locally advanced and unresectable than in the other groups. HP and STC were more frequently performed in patients with perforated tumour, ischaemic lesions of the distended colon, caecal perforation or peritonitis. PDC was performed by median laparotomy in 41% of patients, by an elective incision in 46% and laparoscopically in 13% of patients, respectively. Among the 272 patients who had SC with primary anastomosis, 84 (31%) had intraoperative colonic irrigation and 42

(15%) had a defunctioning ileostomy. In patients who had HP, an extended colectomy with closing of the distal colonic stump and confection of an end-ileostomy was necessary in 35 patients (14%). Resection of neighbouring organs (i.e small bowel, wound, bladder or ovary) due to locally advanced primary tumour was reported in 15%, 13% and 13% of patients who had SC, HP and STC, respectively (p=0.7). Per-operative complications consisting mainly of iatrogenic tumour opening, ureteral, bowel or splenic injuries were reported in 39 (3%) patients; they occurred more frequently during STC (7%) than in the other groups (PDC 1%, SC 4% and HP 5%, p=0.006).

Postoperative outcomes

Postoperative mortality rate was significantly higher in patients with STC and HP than in patients with SC or PDC (**Table 3**). Overall, surgical and medical morbidity rates were higher after STC and HP than after SC or PDC. Anastomotic complications were similar between patients who had SC (36/272, 13%) and STC (26/189, 14%, p=0.4) with primary anastomosis. Median length of hospital stay was significantly lower after SC than after PDC, HP and STC. Patients who had SC or STC were more likely to have redo surgery for postoperative complications than patients who had PDC or HP. At multivariate analysis, age >70 years, ASA score $\geq$3, pulmonary and neurological comorbidities and haemodynamic instability at admission were independent predictors of postoperative mortality after first-stage surgery (**Table 4**).

Five hundred and twenty-two patients had a planned second surgical stage. Among the 431 living patients after PDC, 321 (74%) had resection of the primary tumour, with anastomosis in 268 of them. In the other three groups, the second surgical stage consisted of restoration of intestinal continuity. The postoperative results of second surgical stage procedures are summarised in **Table 5**. Postoperative mortality and morbidity after resection of the primary

tumour in the PDC group was 3% and 35% respectively with a 7% rate of anastomotic leak. Overall 19 patients had a third surgical stage for stoma closure, 15 in the PDC group and 4 in the HP Group. Cumulative postoperative outcomes, including all surgical stages are given in **Table 6**. Cumulative overall and major morbidity and mortality favoured the PDC and SC groups.

At the end of follow-up (16 months, range: 0.03-179 months), the rate of living patients with permanent stoma was significantly higher after HP than after PDC, SC or STC ($p<0.0001$). Systemic chemotherapy, as adjuvant or metastatic treatment, was given after resection of the primary tumour, in 230 (50%) patients from the PDC group, 190 (58%) from the SC group, 107 (43%) from the HP group and 90 (48%) from the STC group ($p=0.006$).

Pathology results

At admission, 25% of patients had metastatic disease, with no difference between the four groups. At pathological examination, among patients who had resection of the primary tumour (n = 1089), 34% were found stage III. There was no difference between the four groups regarding tumour size, TNM stage, positive lymph nodes, lymphatic, vascular and perineural invasion (**Table 7**). Tumour perforation was more frequently observed after HP than after PDC, SC and STC. The median number of harvested lymph nodes was lower after HP than after PDC, and STC.

Long-term outcomes

Median overall survival was 24.5 months for the entire cohort. Five-year overall survival (**Figure 2A**) was significantly higher after SC (67%) than after PDC (54%), HP (54%) and STC (48%) ($p=0.0002$). Similarly, 5-year disease-free and cancer-specific survival (**Figure 2B and C**) was higher after SC (55% and 73%, respectively) than after PDC (48% and 63%,

respectively), HP (37 and 69%, respectively) and STC (49% and 55%, respectively). At multivariate analysis, nine independent factors were associated with the risk of death (**Table 8)**: ASA grade, performance status, pulmonary comorbidity, neurological comorbidity, renal comorbidity, per-operative macroscopic invasion of a neighbouring organ, type of surgical management, stage IV disease and postoperative chemotherapy. In our series, SC and PDC were associated with better prognosis than the two other procedures. No difference was found between SC and PDC (OR: 0.83; 95%CI: 0.47-1.49; p=0.53).

DISCUSSION

For patients admitted for OLCC, surgery was the preferred strategy during the study period in France and most of them (62%) had up-front resection of the primary tumour. In our series, the mortality rate after acute resection ranged from 6 to 13%, as reported by other large series of resected patients for OLCC (7-18%) [2, 4, 15, 23]. Several risk factors have been demonstrated to be correlated with mortality after surgery for OLCC. In a recent multicentre retrospective series of 1816 patients operated on for OLCC in the Netherlands, increasing age, high ASA score, respiratory and neurological comorbidities were independent predictors of postoperative mortality [4]. In a study conducted in Great Britain and Ireland in a population of 989 patients who had resection for obstructive colonic cancer, age, ASA score, tumour stage and urgency of surgery were found to be independent predictors of postoperative mortality [15]. In our series, after multivariate analysis, age >70 years, ASA score $\geq$3, patients' comorbidities (pulmonary and neurological) and haemodynamic failure at admission were found to be predictors of postoperative mortality. Some authors emphasise the fact that surgeons' high colorectal expertise may decrease mortality after surgery for OLCC by allowing the right choice of procedures, avoiding contamination of the operative field during surgery or decreasing operative time [9]. In our series we were not able to evaluate this specific point but at multivariate analysis, the type of hospital where patients were managed (academic vs. non-academic) and the type of urgent surgery (acute resection or PDC) did not influence postoperative mortality. These results suggest that a surgeon's decision should be tailored to patient-related factors and per-operative findings. In our series, patients who had HP or STC were found to have locally advanced or perforated primary tumour, ischaemic lesions of the dilated colon or caecal diastatic perforation. Similarly, HP and STC were more frequently performed in patients with higher ASA score compared to PDC or SC. Our results

are in accordance with those reported in a retrospective multicentre German study of 743 patients who had resection for OLCC [17]. In this latter study, HP was the preferred surgical option in patients with more comorbidities or for those with peritonitis, tumour infiltration of neighbouring organs, and synchronous metastasis [17]. In the series reported by Chereau and colleagues [18], HP was limited to patients with perforation and peritoneal seeding or in severely ill patients for whom cure was not possible.

Keeping patients' selection biases in mind, postoperative morbidity was significantly higher after first-stage HP and STC than after SC and PDC in our series. Kronborg and colleagues [13] reported that blood transfusion (55% vs. 14%, $p<0.01$) and wound infection (22% vs. 5%, $p=0.01$) rates were significantly higher after HP compared to PDC. Likewise, Chereau and colleagues [18] have shown that PDC was associated with lower morbidity (9.8% vs. 54.5% vs. 45.5%) and 30-day mortality (4.9% vs. 27.3% vs. 9%) than HP and STC. The rates of overall (42%) and major (16%) morbidities observed after SC in our study are in accordance with previous published series [11], suggesting that SC is technically demanding in emergency settings compared to PDC. Some authors have argued that cumulative morbidity and mortality is so high after staged surgery for OLCC that less conservative surgery is justified [11, 24]. In our series, the cumulative mortality, overall and major morbidities reported in the PDC group were similar to those observed after SC, although patients in the latter group had better medical condition (ASA score and performance status). Our results are in accordance with those reported in a recent meta-analysis [19].

The risk of permanent stoma formation is a major concern in patients with OLCC and operated on with multi-stage procedures. In the present series, 74% of patients managed by PDC had resection of the primary tumour during a second stage, and 15 of them (5%) needed a third surgical procedure for stoma closure. The definitive stoma rate after PDC was thus

24% at the end of follow-up. In contrast, in the HP group, stoma reversal was achieved in only 35% of patients, in line with the literature [18]. In our series, 99 out of the 329 patients for whom SC was performed, had either a protective anastomosis (n = 42) or a double colostomy (Bouilly-Volkmann). These two procedures may represent an attractive option since postoperative morbidity after second-stage surgery and permanent stoma rates are low.

Little is known on long-term prognosis in patients operated on for OLCC since most studies emphasised surgical techniques and short-term outcomes in this setting. In our series, we show that five-year overall, disease-free and cancer-specific survival is significantly improved after SC or PDC compared to HP or STC. Jiang and colleagues [6] reported that PDC tended to be associated with higher overall survival than one–stage procedures (105 vs. 66 months, p=0.088). Chereau and colleagues [18] reported that PDC was associated with better median overall survival (26 months) than HP (7 months) and STC (18 months). As reported by Chereau et al [18], the number of harvested lymph nodes in our series was significantly lower after HP compared to the other procedures. In a recently published series, Öistämö and colleagues [25] showed that the number of harvested lymph nodes in the resected specimen was higher in the planned resection group (n = 43) compared with the acute resection group (n = 57) (21 vs. 8.7; p = 0.001). Added to the previously mentioned histological factor, the lower number of longitudinal resection margins and the greater number of perforated tumours reported in the HP group may explain the worse disease-free survival reported in patients with non-metastatic disease treated by HP. In addition, in our series, in line with others [25], a small proportion of patients in the HP group received postoperative chemotherapy which may also negatively impact prognosis.

The present study has some limitations. It is retrospective series, the population was heterogeneous, some data are missing, functional results and quality of life could not be

assessed, but these disadvantages are offset by the large sample of patients. In addition, the present study is the first to compare the four main surgical options for OLCC with detailed results in terms of postoperative outcomes including all surgical stages and long-term oncological outcomes.

In conclusion, patients who are considered for surgery for OLCC should be given information on cumulative morbidity, permanent stoma rate and oncological outcomes as a necessary part of their initial counselling. For those operated on, this is essential. Given these postoperative considerations, segmental colectomy (in experienced hands) and primary loop colostomy are the two preferred options in patients with good medical condition (ECOG 0 or 1) and no colonic ischaemic features above the obstruction. For those with severe comorbidities, primary diverting colostomy should be recommended as the first-stage surgical procedure, reserving Hartmann's procedure and (sub)total colectomy for patients with colonic ischaemia or perforation complicating malignant obstruction.

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FIGURE LEGENDS

Figure 1: Flow chart of patients admitted with Obstructive Left Colon Cancer

Figure 2: Overall **(A)**, disease-free **(B)** and cancer-specific **(C)** survival according to the four main surgical managements of Obstructive Left Colon Cancer: Hartmann's procedure (red line), (sub)total colectomy (green line), primary diverting colostomy (blue line) and segmental colectomy (brown line)

Table 1: Demographic characteristics of the 1 220 patients operated on for OLCC according to the first-step surgical management

		Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n		456	329	246	189	
Gender						0.7
Male		250 (55) [(a)]	178 (54)	144 (59)	109 (58)	
Female		206 (45)	151 (46)	102 (41)	80 (42)	
Age (years)		72 [26-102] [(b)]	70 [30-100]	75 [24-104]	75 [23-100]	0.09
		70 ±14 [(c)]	69 ±14	72 ±14	71 ±15	
BMI (kg/m²)		23 [16-43]	24 [15-38]	24 [14-52]	23 [15-41]	0.6
		24 ±5	24 ±4	25 ±6	25 ±5	
ASA score						**<0.0001**
1		101 (24)	79 (29)	34 (16)	25 (14)	
2		198 (47)	117 (43)	86 (40)	73 (42)	
3		109 (26)	71 (26)	84 (39)	65 (37)	
4		16 (4)	8 (3)	12 (6)	11 (6)	
	NA	32	54	30	15	
ECOG Performance Status						**<0.0001**
0		119 (33)	115 (44)	57 (29)	39 (29)	
1		126 (35)	84 (32)	52 (26)	44 (33)	
2		74 (21)	43 (17)	52 (26)	35 (27)	
3		34 (10)	15 (6)	26 (13)	13 (10)	
4		5 (1)	2 (1)	11 (6)	1 (1)	
	NA	98	70	48	57	
Comorbidities						
Vascular		184 (44)	145 (50)	120 (54)	89 (55)	0.05
Respiratory deficiency		65 (16)	31 (11)	31 (14)	32 (20)	0.06
Neurologic deficiency		63 (15)	30 (10)	36 (16)	26 (16)	0.2
Renal deficiency		29 (7)	16 (6)	13 (6)	8 (5)	0.8
Hepatic deficiency		14 (3)	5 (2)	6 (3)	6 (4)	0.5
Malnutrition		73 (18)	33 (11)	33 (15)	23 (14)	0.15
	NA	41	39	23	26	
Other cancer		54 (13)	48 (15)	28 (12)	15 (9)	0.2
	NA	26	18	17	19	

(a): number (percentage); (b): median [range]; (c): mean (standard deviation);

BMI: body mass index; ASA: American Society of Anesthesiologists; ECOG: Eastern Cooperative Oncology Group; NA: not available; $p < 0.05$ was considered as significant (in bold)

Table 2: Intra-operative data of the 1 220 patients operated on for OLCC according to the first-step surgical management

		Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n		456	329	246	189	
Tumor characteristics						
Perforated tumour		7 (2) [(a)]	16 (5)	34 (14)	13 (7)	**<0.0001**
	NA	90	12	15	6	
Contact with organs		40 (12)	45 (14)	45 (20)	29 (18)	**0.03**
Small bowel/Wound		9/17	17/7	12/7	12/4	
Omentum/Duodenum		2/-	3/1	3/-	3/1	
Bladder/Genital organs		3/4	11/8	5/12	3/2	
Others		5	10	10	6	
	NA	112	16	24	23	
Unresectable tumour		39 (12)	3 (1)	7 (3)	4 (2)	**<0.0001**
	NA	139	14	25	24	
Suspected involved lymph nodes		37 (13)	50 (18)	43 (24)	24 (18)	**0.02**
	NA	164	53	64	55	
Metastases		97 (29)	78 (25)	72 (32)	55 (30)	0.3
Carcinosis		50	24	20	23	
Liver		52	59	58	44	
Others		3	3	4	1	
	NA	117	11	18	7	
Severity of obstruction						
Ischaemic lesion		13 (4)	22 (7)	36 (16)	86 (51)	**<0.0001**
Cecum alone		7	14	21	45	
Cecum and right colon		-	3	5	15	
Whole colon		6	5	10	26	
	NA	100	15	27	20	
Cecal perforation		4 (1)	8 (3)	20 (9)	53 (29)	**<0.0001**
	NA	92	15	15	5	
Peritonitis		14 (4)	17 (5)	52 (22)	26 (14)	**<0.0001**
	NA	87	14	14	6	

(a): number (percentage); $p<0.05$ was considered as significant (in bold)

Table 3: Post-operative data of the 1 220 patients operated on for OLCC according to the first-stage surgical management

	Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n	456	329	246	189	
Length of hospital stay (days)	15 [0-203] [(a)]	13 [0-86]	15 [0-214]	15 [0-185]	**0.01**
	19 ±20 [(b)]	15 ±10	19 ±18	21 ±21	
Overall morbidity	103 (23) [(c)]	137 (42)	112 (46)	90 (48)	**<0.0001**
Surgical morbidity	56 (12)	89 (27)	69 (28)	63 (33)	**<0.0001**
Anastomotic complication	-	36[§] (13)	5 (2)*	26 (14)	**<0.0001**
Wound complication	16 (4)	29 (9)	34 (14)	19 (10)	**<0.0001**
Stoma-related complication	31 (7)	6 (2)	18 (7)	5 (3)	**0.001**
Haemorrhage	4 (1)	8 (2)	9 (4)	8 (4)	**0.03**
Prolonged ileus	6 (1)	16 (5)	9 (4)	12 (6)	**0.005**
Medical morbidity	74 (16)	96 (29)	96 (39)	76 (40)	**<0.0001**
Mortality	19 (4)	19 (6)	23 (9)	24 (13)	**0.005**
Dindo classification					0.5
I-II	67 (15)	86 (26)	73 (30)	58 (31)	
III-IV	36 (8)	51 (16)	39 (16)	32 (17)	
Unplanned reoperation	20 (4)	38 (12)	23 (9)	29 (15)	**<0.0001**
Radiological drainage	0	4 (1)	5 (2)	6 (3)	**0.005**

(a): median [range]; (b): mean ± standard deviation; (c): number (percentage); [§] among the 272 patients who underwent anastomosis; * from an ileo-ileal anastomosis following an associated small bowel resection; $p<0.05$ was considered as significant (in bold)

Table 4: Predictive factors for postoperative mortality after the first-step surgery in 1 220 patients operated on for OLCC

	Univariate analysis			Multivariate analysis		
Variables	**No postoperative death**	**Postoperative death**	***P*-value**	**Odds Ratio**	**95%CI**	***P*-value**
Gender			0.35			
Male	620 (92%)	55 (8%)				
Female	500 (93%)	36 (7%)				
Age, years			**<0.0001**			**0.008**
> 70	585 (89%)	72 (11%)		2.45	1.27-4.87	
≤ 70	529 (97%)	19 (3%)		1		
BMI, kg/m²			0.41			
≥ 25	289 (93%)	22 (7%)				
< 25	453 (94%)	27 (6%)				
ASA score:			**<0.0001**			**0.01**
≥ 3	320 (86%)	53 (14%)		2.18	1.19-3.98	
< 3	680 (96%)	30 (4%)		1		
Vascular comorbidity			0.079			0.35
Yes	487 (91%)	47 (9%)		0.76	0.42-1.36	
No	516 (94%)	33 (6%)		1		
Pulmonary comorbidity			**<0.0001**			**0.04**
Yes	135 (85%)	24 (15%)		2.00	1.05-3.81	
No	868 (94%)	56 (6%)		1		
Neurological comorbidity			**0.004**			**0.049**
Yes	133 (87%)	20 (13%)		1.89	1.00-3.56	
No	870 (94%)	60 (6%)		1		
Renal comorbidity			0.33			
Yes	59 (89%)	7 (11%)				
No	944 (93%)	73 (7%)				
Liver comorbidity			0.072			0.45
Yes	26 (84%)	5 (16%)		1.71	0.42-6.94	
No	977 (93%)	75 (7%)		1		
Malnutrition			0.10			
Yes	145 (90%)	17 (10%)				
No	857 (93%)	63 (7%)				
Hemodynamic failure			**<0.0001**			**0.0007**
Yes	41 (75%)	14 (25%)		4.51	1.89-10.77	
No	924 (94%)	63 (6%)		1		
Colon ischemia			**0.04**			0.41
Yes	63 (77%)	19 (23%)		0.72	0.33-1.57	
No	802 (85%)	139 (15%)		1		
Peritonitis			**0.04**			0.81
Yes	96 (87%)	14 (13%)		0.90	0.38-2.13	
No	916 (93%)	70 (7%)		1		
Type of procedure			**0.006**			
HP	220 (91%)	23 (9%)		1.56	0.66-3.68	0.31
STC	165 (87%)	24 (13%)		1.86	0.75-4.66	0.18
PDC	427 (94%)	25 (6%)		1.07	0.47-2.44	0.87
SC	308 (94%)	19 (6%)		1		
Per-operative			0.21			
Yes	34 (87%)	5 (13%)				
No	1086 (93%)	86 (7%)				
Academic hospital			0.87			
Yes	1402 (91%)	133 (9%)				

No	413 (92%)	38 (8%)

BMI: body mass index; ASA: American Society of Anesthesiologists; PDC: primary diverting colostomy; HP: Hartmann's procedure: SC: segmental colectomy; STC: (sub)total colectomy; $p<0.05$ was considered as significant (in bold)

Table 5: Postoperative outcomes of 522 patients who underwent a planned second surgical stage

	Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n / Alive patients after the first stage	321/ 431 (74) [(a)]	99 / 310 (32)	78 / 223 (35)	24 / 165 (14)	
Time interval, days*	16 [1-362] [(b)]	117 [1-421]	190 [34-854]	195 [41-374]	**<0.0001**
	47 ±67 [(c)]	159 ±104	225 ±150	190 ±93	
Length of hospital stay (days)	11 [1-153]	6.5 [2-28]	9 [4-26]	13 [6-41]	**<0.0001**
	15 ±13	9 ±6	11 ±6	18 ±13	
Overall morbidity	111 (35)	18 (18)	11 (14)	9 (38)	**<0.0001**
Surgical morbidity	90 (28)	7 (7)	9 (12)	7 (29)	**<0.0001**
Anastomotic complication	22 (7)	5 (5)	2 (3)	3 (13)	0.3
Wound complication	39 (12)	4 (4)	5 (6)	3 (13)	0.07
Stoma-related complication	8 (2)	-	1 (1)	-	1.00
Haemorrhage	14 (4)	3 (3)	1 (1)	1 (4)	0.6
Prolonged ileus	22 (7)	1 (1)	1 (1)	2 (8)	**0.04**
Medical morbidity	67 (21)	6 (6)	6 (8)	5 (21)	**0.0006**
Mortality	14 (3)	1 (1)	2 (3)	0	0.25
Dindo classification					0.34
I-II	71 (22)	9 (9)	5 (6)	4 (17)	
III-IV	40 (12)	9 (9)	6 (8)	5 (21)	
Unplanned reoperation	12 (4)	6 (6)	3 (4)	4 (17)	**0.03**
Radiological drainage	2 (1)	0	0	0	-

(a): number (percentage); (b): median [range]; (c): mean ±standard deviation; *after the 1st surgical stage; $p<0.05$ was considered as significant (in bold)

Table 6: Cumulative postoperative results of 1220 patients with left colonic malignant obstruction

	Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n	456	329	246	189	
Length of hospital stay (days)	24 [1-176] [(a)]	14 [1-86]	17 [1-214]	15 [1-185]	**<0.0001**
	27 ±26 [(b)]	16 ±12	19 ±20	19 ±22	
Mortality	34 (7) [(c)]	20 (6)	25 (10)	24 (13)	**0.04**
Overall morbidity	176 (39)	133 (40)	116 (47)	92 (50)	**0.04**
Dindo classification					0.9
I-II	115 (25)	81 (25)	74 (30)	57 (30)	
III-IV	61 (13)	52 (16)	42 (17)	35 (19)	
Unplanned reoperation	46 (10)	37 (11)	25 (10)	28 (15)	0.3
Definitive stoma	108 (24)	32 (10)	96 (39)	15 (8)	**<0.0001**

(a): median [range]; (b): mean ± standard deviation; (c): number (percentage); $p<0.05$ was considered as significant (in bold)

Table 7: Pathological results of 1089 patients who underwent the resection of the OLCC

	Primary diverting colostomy (PDC)	**Segmental colectomy (SC)**	**Hartmann's procedure (HP)**	**(Sub)total colectomy (STC)**	***P value***
n	321	329	246	189	
Tumour size (cm)					0.52
≤2	30 (11) [(a)]	31 (11)	13 (6,5)	14 (10)	
>2-≤5	141 (51)	144 (51)	102 (51)	78 (54)	
>5-≤10	96 (34.5)	96 (34)	82 (41)	49 (34)	
>10	10 (3.5)	11 (4)	3 (1.5)	3 (2)	
NA	44	147	46	45	
Longitudinal resection margin (cm)	6 [1-30] [(b)]	6.5 [1-30]	6 [0,5-48]	9 [1-58]	**<0.0001**
	7 ±5 [(c)]	8 ±5	8 ±7	12 ±10	
Tumour perforation	22 (8)	25 (9)	37 (18)	21 (14)	**0.001**
NA	22	39	38	43	
TNM classification					0.29
Stage 0-II	101 (36)	123 (39)	75 (32)	62 (34)	
Stage III	121 (39)	102 (32)	79 (33)	58 (32)	
Stage IV	90 (29)	94 (29)	82 (35)	62 (34)	
NA	9	10	10	7	
Harvested lymph nodes	18 [2-79]	17 [1-58]	15 [0-76]	22 [3-160]	**<0.0001**
	21 ±12	19 ±10	17 ±10	28 ±21	
Involved lymph nodes	1 [0-32]	1 [0-20]	1 [0-26]	1 [0-28]	0.73
	2 ±4	2 ±3	2 ±4	2 ±4	
Vascular invasion	146 (51)	140 (49)	100 (51)	77 (47)	0.9
NA	33	44	48	26	
Lymphatic invasion	112 (45)	101 (42)	73 (44)	69 (50)	0.5
NA	73	88	78	50	
Perineural invasion	151 (53)	135 (49)	88 (45)	68 (44)	0.13
NA	35	53	51	36	

(a): number (percentage of available data); (b): median [range]; (c): mean ±standard deviation; NA: not available; TNM: Tumour Node Metastasis stage; $p<0.05$ was considered as significant (in bold)

Table 8: Predictive factors of overall survival after surgery for left malignant colonic obstruction at univariate and multivariate analysis

	Univariate analysis			Multivariate analysis			
Characteristics	**5-year overall survival**		**Log-rank *P*-value**	**n**	**Odds Ratio**	**95%CI**	***P*-value**
Sex							
Male / Female	55%	59%	0.59				
Age at operation, years							
≥ 75 / < 75	48%	63%	**<0.0001***		1.46	0.98-2.16	0.060
Body mass index, kg/m²							
≥ 30 / < 30	64%	56%	0.48				
ASA grade							
≥ 3 / < 3	42%	62%	**<0.0001***		1.67	1.13-2.46	**0.0099***
ECOG performance status							
≥ 3 / < 3	46%	61%	**<0.0001***		2.09	1.17-3.58	**0.014***
Vascular comorbidity							
Yes / No	58%	57%	0.11				
Pulmonary comorbidity							
Yes / No	40%	60%	**<0.0001***		1.82	1.14-2.81	**0.012***
Neurological comorbidity							
Yes / No	53%	58%	**0.020***		1.91	1.13-3.40	**0.016***
Renal comorbidity							
Yes / No	35%	59%	**0.0004***		2.22	1.22-3.79	**0.010***
Liver comorbidity							
Yes / No	29%	58%	**0.014***		2.79	0.82-7.18	0.093
Malnutrition							
Yes / No	44%	59%	**0.0004***	551	1.08	0.63-1.74	0.78
Hemodynamic failure							
Yes / No	41%	61%	**<0.0001***		1.25	0.59-2.44	0.54
Obstruction revealing colon cancer							
Yes / No	57%	40%	0.13				
Upstream ischemia of the colon							
Yes / No	56%	61%	0.12				
Peritonitis							
Yes / No	43%	60%	**0.0086***		1.29	0.73-2.20	0.37
Macroscopic invasion of a neighboring organ							
Yes / No	48%	62%	**0.0018***		2.22	1.40-3.43	**0.0010***
Surgical procedure							
PDC / SC / HP / STC	54% / 67% / 54% / 47%		**0.0002***				
STC / HP					1.10	0.68-1.76	0.70
PDC / HP					0.58	0.33-0.98	**0.042***
PDC / STC					0.53	0.29-0.93	**0.027***
SC / HP					0.48	0.29-0.78	**0.0027***
SC / STC					0.44	0.25-0.75	**0.0030***
SC / PDC					0.83	0.47-1.49	0.53
Synchronous metastases							
Yes / No	28%	69%	**<0.0001***		2.89	1.94-4.28	**<0.0001***
Number of lymph nodes examined							
≥ 12 / < 12	63%	61%	**0.029***		0.86	0.55-1.37	0.51
Postoperative chemotherapy							
Yes / No	62%	51%	**<0.0001***		0.44	0.29-0.68	**0.0002***

ASA: American Society of Anesthesiologists; DC: diverting colostomy; ECOG: Eastern Cooperative Oncology Group; HP: Hartmann's procedure; SC: segmental colectomy; STC: (sub)total colectomy; * p-value significant at the 0.05 level (in bold)

Figure 1: Flow chart of patients admitted with OLCC

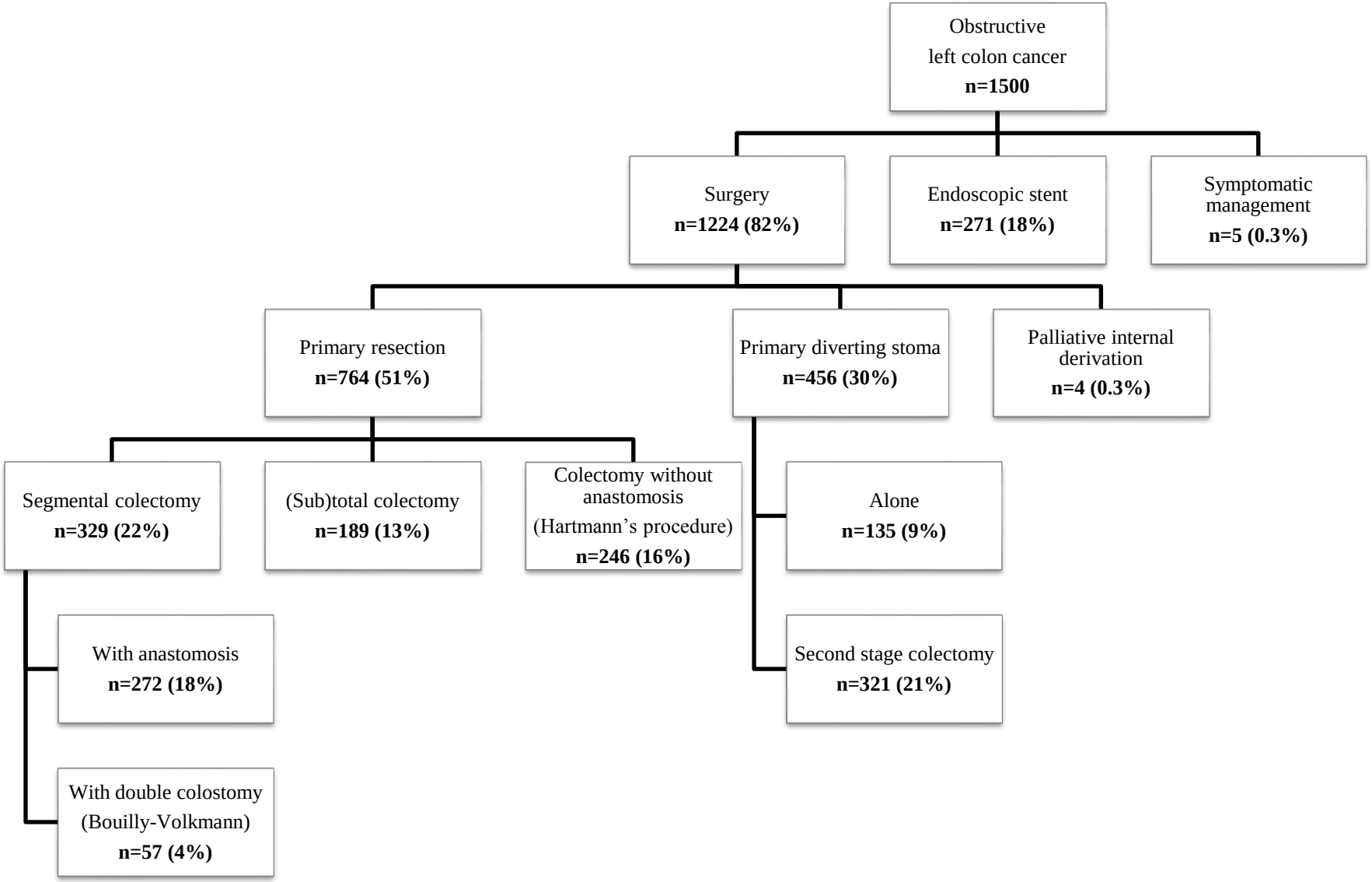
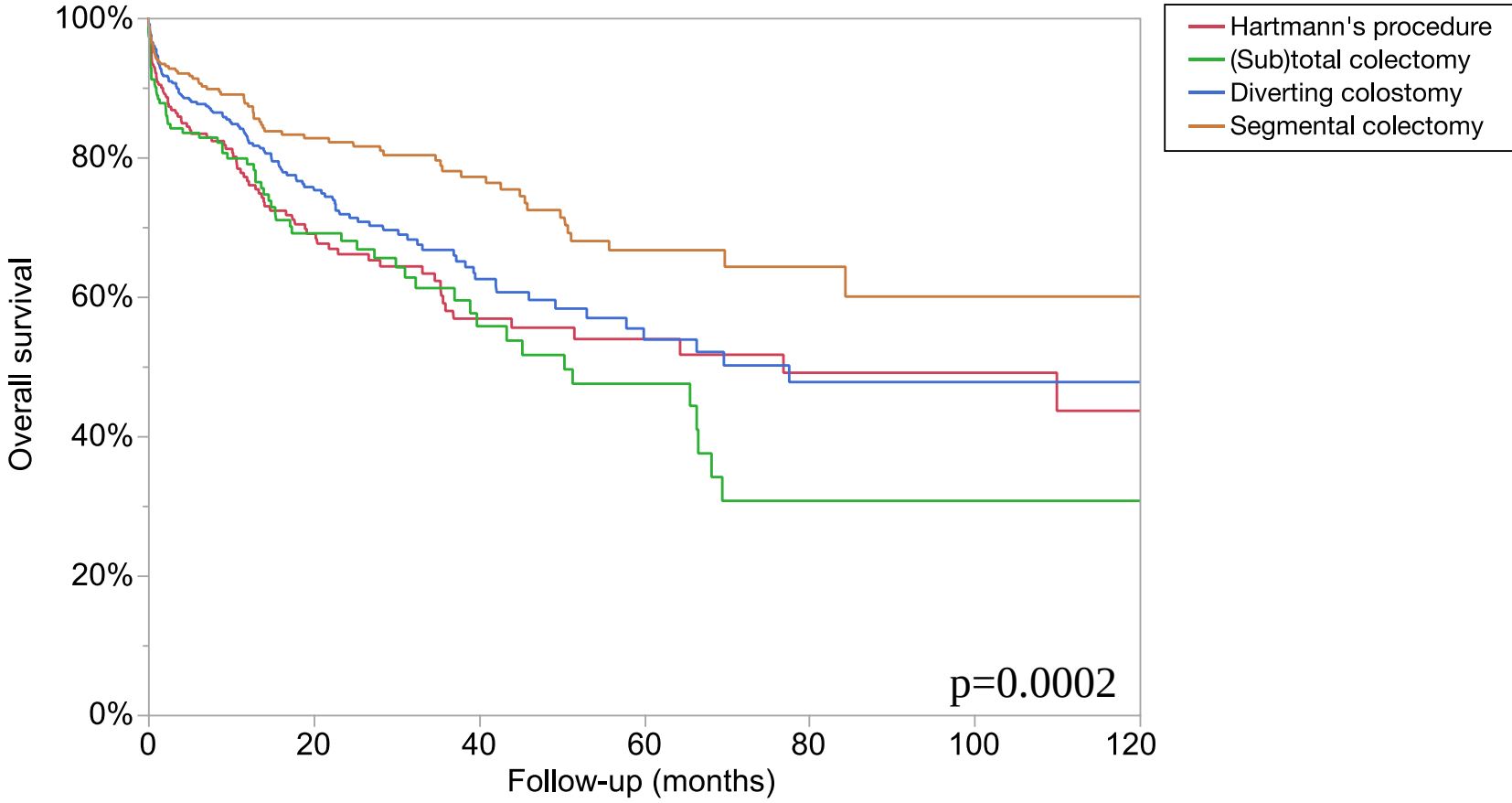


Figure 2: Overall **(A)**, disease-free **(B)** and cancer-specific **(C)** survival according to the four main surgical management of left colonic malignant obstruction

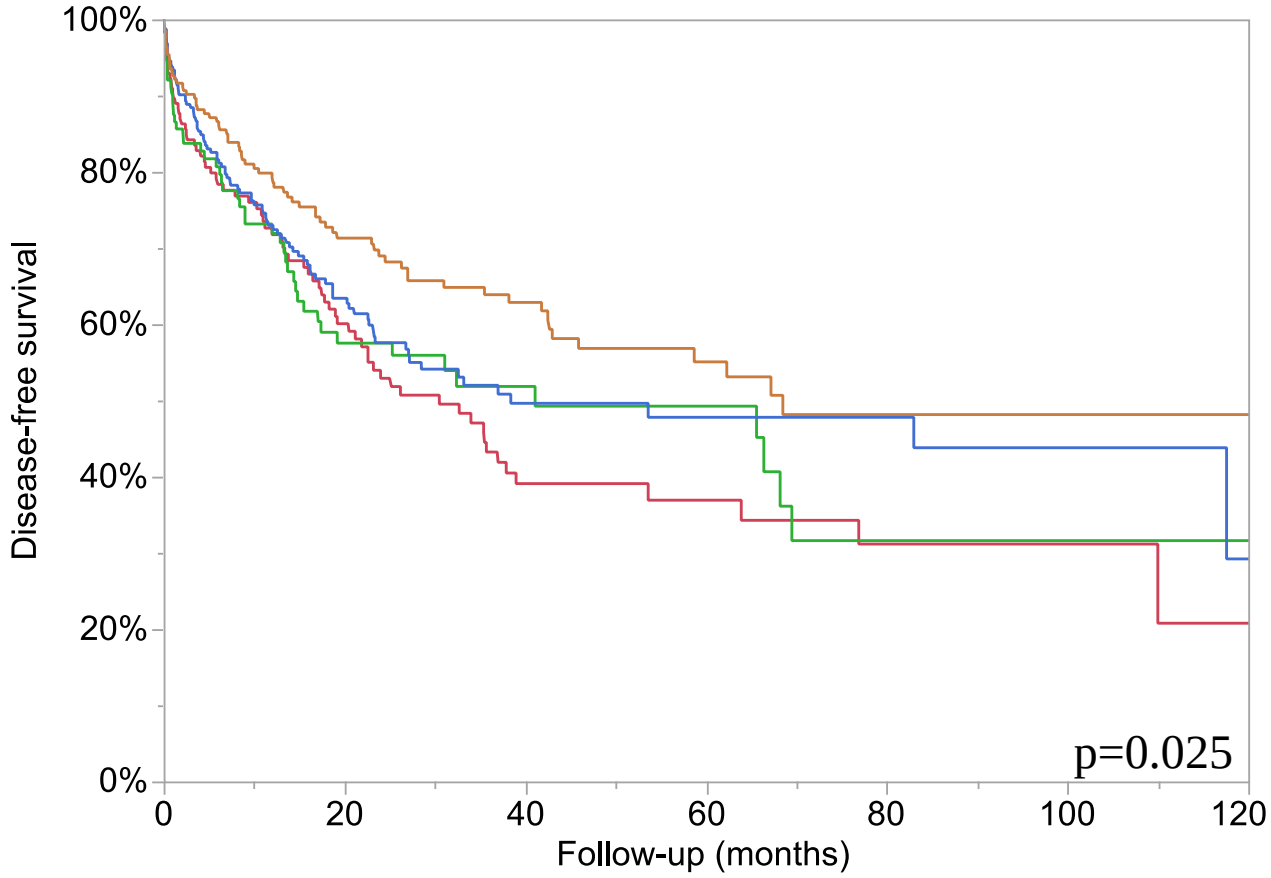
A



Number at risk:

Hartmann's procedure	246	100	48	27	16	11	7
(Sub)total colectomy	189	68	30	20	9	5	4
Diverting colostomy	456	169	74	35	20	13	6
Segmental colectomy	329	157	91	45	18	11	4

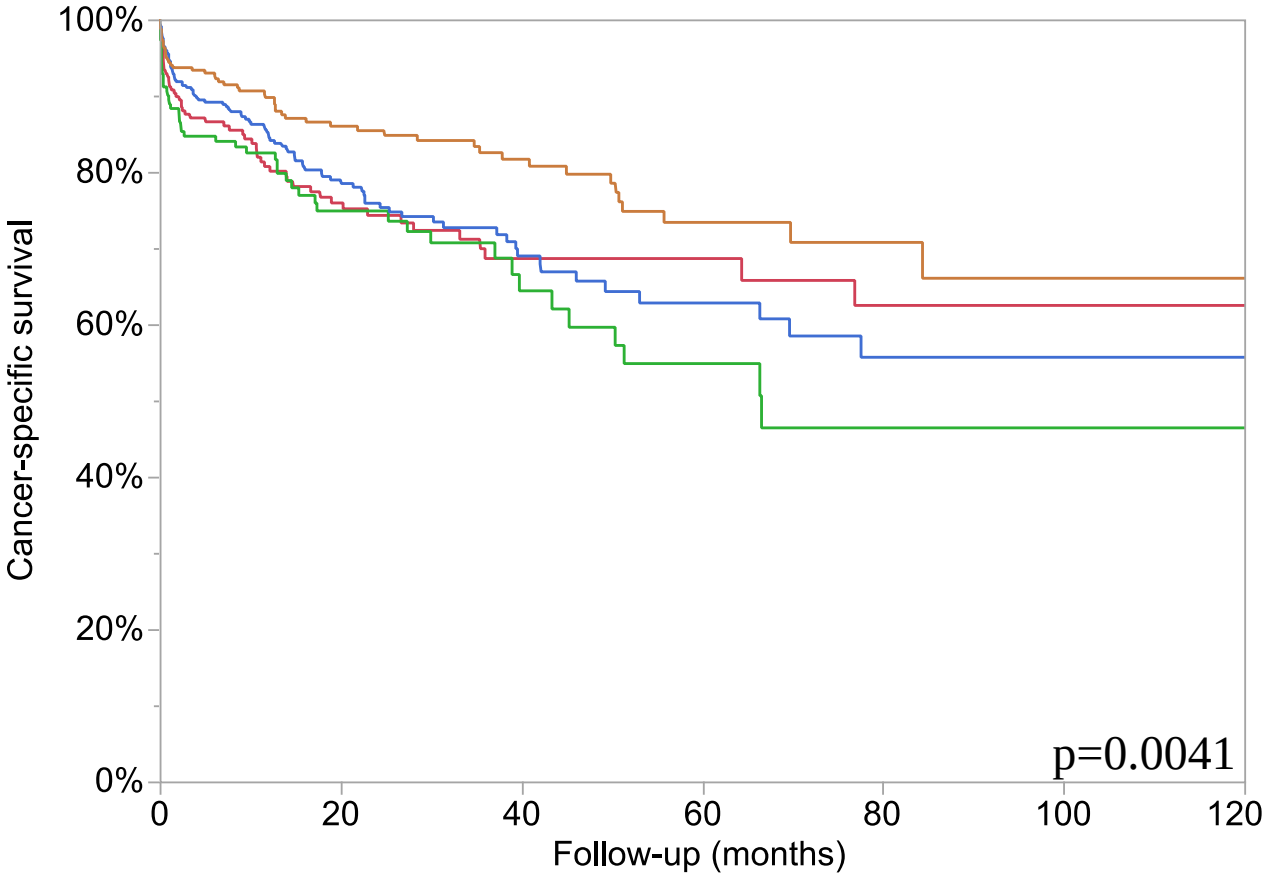
B



Number at risk:

Hartmann's procedure	164	62	28	16	10	5	2
(Sub)total colectomy	127	39	21	17	7	4	3
Diverting colostomy	258	97	42	23	14	9	2
Segmental colectomy	235	98	59	31	12	10	3

C



Number at risk:

Hartmann's procedure	246	100	48	27	17	10	7
(Sub)total colectomy	189	68	30	20	9	5	4
Diverting colostomy	456	170	74	35	20	13	6
Segmental colectomy	329	157	91	45	18	11	4