Oncologic Long-Term Outcomes of Emergency Versus Elective Resection for Colorectal Cancer

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Presented at the European Congress for Trauma & Emergency Surgery, May 6-8 2018 Valencia, Spain.

Joël Lavanchy, Tobias Haltmeier and Beat Schnüriger contributed to the study conception and design. Material preparation, data collection and analysis were performed by Joël Lavanchy, Lukas Vaisnora, Tobias Haltmeier and Beat Schnüriger. The first draft of the manuscript was written by Joël Lavanchy and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Abstract

Purpose: Long-term outcomes in patients undergoing emergency versus elective resection for colorectal cancer (CRC) are discussed controversially. This study aims to assess long-term outcomes of emergency versus elective CRC surgery.

Methods: Single center retrospective cohort study. Patients undergoing emergency or elective CRC surgery from July 2002 to January 2013 were included. Primary outcome was 5-year survival, secondary outcomes were in-hospital mortality and local tumor recurrence.

Results: Overall, 475 patients were included. Median age was 69.0 (IQR 59.0-77.0) years. A total of 141 patients (30%) were operated for rectal cancer and 334 patients (70%) for colon cancer. Median follow-up was 445 (IQR 67-1409) days. Emergency resection was performed in 105 patients (22%) due to obstruction, perforation or bleeding. Stage IV tumors and ASA scores≥3 were significantly more frequent in the emergency than in the elective resection group (39.0% vs. 33.5%, $p<0.001$; 75.5% vs. 61.3%, $p=0.003$). The rate of patients with positive lymph nodes was similar in the two groups (46.2% vs. 46.3%, $p=1.000$). In-hospital mortality was significantly higher in the emergency CRC versus the elective CRC group (8.4% vs. 3.0%, $p=0.023$). Five-year survival (aHR 1.38; 95%CI 0.81-2.37, $p=0.237$) or local tumor recurrence (aHR 1.48; 95%CI 0.47-4.66, $p=0.500$) were not significantly different in patients undergoing emergency versus elective surgery for CRC.

Conclusion: In-hospital mortality was increased in emergency versus elective CRC resections. However, 5-year survival and local recurrence after surgery for CRC were determined by the tumor stage, and not by the emergency versus elective setting of surgical resection.

Keywords: Emergency colorectal cancer resection, elective colorectal cancer resection, colorectal cancer, five-year survival, recurrence free survival.

Introduction

Colorectal cancer (CRC) is the third most common cancer worldwide [1]. In 2015, CRC had an incidence of 1.7 million cases and accounted for 832 000 deaths worldwide [2]. Approximately a quarter to a third of CRC patients undergo emergency CRC surgery due to obstruction, perforation or bleeding ahead of termination of a neo-adjuvant chemo-/radiotherapy or scheduled resection [3,4].

As randomization in elective and emergency CRC surgery is not feasible, the literature is inherently non-randomized and therefore mainly retrospective. Some studies suggest that overall survival and disease-free survival after emergency CRC surgery are worse than after elective CRC surgery. However, these studies either have a relatively short follow-up [5,6], small sample sizes [7,8] or do not adjust outcomes for confounding factors [9,10,5,7,8]. Therefore, further assessment of long-term outcomes after emergency versus elective CRC surgery is warranted.

Inconsistent preoperative diagnostics or cancer-related surgery in the emergency setting might be reasons for the suggested worse outcomes in patients undergoing emergency CRC surgery. Most commonly, differences in surgical technique between emergency general surgeons and highly specialized colorectal surgeons are discussed as contributing factors. Nevertheless, there is no consensus in the literature whether emergency CRC surgery negatively influences long-term, cancer-related outcomes [11-13].

Therefore, the aim of this study is to assess long-term outcomes after emergency versus elective CRC surgery in a setting of close collaboration of emergency general and colorectal surgeons.

Material and Methods

Study design

This is a single center retrospective observational study. Patients undergoing CRC surgery at the Bern University Hospital from 07/2002 to 01/2013 were included. Patient data was extracted from the institution's CRC database and electronic patient charts. The following variables were collected: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score[14], Charlson Comorbidity Index (CCI)[15], operative procedure, surgical technique (laparoscopic/open) and strategy (primary anastomosis/primary anastomosis with protective, diverting stoma/definitive stoma), tumor localization, postoperative histologic Union for International Cancer Control (UICC, ed. 2010) tumor stage, overall and positive lymph node yield, neo-adjuvant chemo- and radio-therapy, operation time, postoperative complications (cardio-pulmonary, renal, gastrointestinal, surgical site infections), hospital length of stay (HLOS), in-hospital mortality, length of follow-up, overall survival 5 years survival, rate of local recurrence, and disease free survival. In cases with missing variables, patients and/or responsible general practitioners were contacted by phone.

Patients undergoing emergency resection for CRC were compared to patients undergoing elective resection for CRC. Patients undergoing stoma formation without CRC resection or other palliative surgical techniques were not included into the study.

Short-term outcomes comprised postoperative complications and in-hospital mortality. Long-term outcomes were determined for those patients surviving the index hospitalization. A subgroup analysis for colon cancer (with the exclusion of patients with rectal cancer) was performed in order to reduce heterogeneity of patient populations.

Treatment strategy

All CRC patients were discussed at the Multidisciplinary Team Meeting and treated based on the European Society of Medical Oncology (ESMO) guidelines [16]. This included neo-adjuvant chemo-/radiotherapy in advanced lower- and mid-rectal cancer and adjuvant chemotherapy in patients with advanced CRC. Oncologic resection included high-tie ligation of the feeding colonic vessels in colon cancer or total mesorectal excision [17] in patients with rectal cancer. Surgeons specialized in colorectal procedures performed most of the elective CRC resections. Surgeons from various abdominal surgical subspecialties such as general surgeons, colorectal, pancreatic, hepatobiliary or upper gastrointestinal surgeons performed emergency CRC resections.

Statistical analysis

The Shapiro-Wilk test was used assessing normality of distribution. Categorical variables were reported as numbers and percentages, continuous variables as medians and interquartile ranges (IQR). In univariable analysis categorical variables were compared using Fisher's exact test and continuous variables were compared using Mann-Whitney U test. The effect of emergency CRC surgery on short- and long-term outcomes was adjusted in multivariable logistic and Cox regression analysis, respectively. Clinically relevant predictor variables with $p \leq 0.1$ in univariable analysis were included in the regression models. *P*-values ≤0.05 were considered statistically significant.

Statistical analysis was performed using SPSS Statistics version 25 (IBM Corporation, Armonk, New York).

Ethical requirements

This study is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement [18] and was approved by the cantonal ethics committee of Bern, Switzerland (2017-00792)

Results

Baseline demographics and characteristics

During the 10.5 years study period, a total of 475 patients with CRC resections were included in the study. Median age was 69.0 (IQR 59.0-77.0) years, 62.3% were male and the median BMI was 25.5 (IQR 22.7-28.9) kg/m^2. An ASA score≥3 was found in 61.9% and the CCI≥5 was found in 79.4% of patients. Patients were treated for colon cancer in 70.3% and for rectal cancer in 29.7%, respectively.

A total of 105 (22.1%) patients underwent emergency CRC resections due to obstruction (63.8%), perforation (17.1%) or bleeding (14.3%), respectively. Table 1 summarizes the baseline characteristics of the emergency versus elective CRC resection populations. Patients undergoing emergency CRC surgery were significantly older and presented with a lower BMI compared to the elective CRC surgery patients (72.0 vs. 68.0 years, p=0.018; 24.3 vs. 25.9 kg/m^2, p=0.012). Moreover, in the emergency CRC surgery group ASA scores≥3 were significantly more frequent than in the elective CRC surgery group (75.5% vs. 61.3%, p=0.003).

Median operative time was significantly shorter in the emergency CRC surgery group compared to the elective CRC surgery group (265 vs. 280min., p=0.042). The proportion of laparoscopic resections was significantly smaller in the emergency CRC surgery group compared to the elective CRC group (4.8% vs. 12.4%, p=0.031). Stoma formation was significantly more frequent in the emergency CRC group compared to the elective group (59.2% vs. 44.8%, p=0.003) (*Table 1*).

Tumor characteristics

Table 2 summarizes the tumor characteristics of emergency versus elective CRC patients. T4 carcinomas were significantly more frequent in the emergency compared to the elective CRC group (42.9% vs. 16.5%, p<0.001). Moreover, significantly more lymph nodes were harvested in

the emergency CRC surgery group versus the elective CRC surgery group (26 [IQR 18-33] vs. 20 [15-27] lymph nodes, $p<0.001$). Colon cancer (as compared to rectal cancer) was significantly more frequent in the emergency CRC group (90.5% vs. 64.6%, $p<0.001$). Significantly more patients from the elective CRC group received adjuvant chemotherapy compared to the emergency CRC group (32% vs. 19%, $p=0.028$).

Short-term outcomes

Table 3 summarizes in-hospital outcomes of emergency versus elective CRC patients. The median HLOS was significantly longer in the emergency CRC surgery group compared to the elective CRC surgery group (14 [IQR 11-23] vs. 13 [9-19] days, $p=0.006$). There was a trend towards more in-hospital complications in the emergency versus the elective CRC group. However, this difference did not reach statistical significance (67 complications in 62 [59.0%] emergency CRC patients vs. 201 complications in 187 [50.5%] elective CRC patients, $p=0.150$).

In-hospital mortality was significantly higher in the emergency CRC versus the elective CRC group (8.4% vs. 3.0%, $p=0.023$). However, when adjusting for the effect of ASA score, tumor localization, operative strategy, neoadjuvant chemo- and radiotherapy in-hospital mortality was not significantly different in the emergency versus the elective CRC group (OR 1.82, CI 95% 0.62-5.40, $p=0.278$)

Long-term outcomes

Long-term outcomes are summarized in *Table 3*. Median length of follow-up was 445 (IQR 67-1409) days and was similar between the emergency and elective CRC groups. Neither overall survival nor median disease free survival were significantly different between the emergency and the elective CRC groups (72.4% vs. 78.9%, $p=0.185$; 383 vs. 423 days, $p=0.257$) (*Figure 1*). Multivariable Cox regression analysis confirmed comparable 5-year survival or local tumor recurrence when comparing emergency with elective CRC patients (*Table 4*).

Subgroup-analysis of patients with colon cancer

In order to reduce heterogeneity of the study population, a subgroup-analysis of patients with colon cancer (n=334) was performed. The same baseline characteristics as presented in Table 1 were compared between emergency (28.4%) and elective colon cancer resections (71.6%). As in the overall study population, it was found that the emergency colon cancer group was significantly older (74.0 vs. 69.0 years, *p*=0.017), had a significantly lower BMI (24.3 vs. 25.9 kg/m^2, *p*=0.022) and significantly more often ASA scores≥3 (76.4% vs. 63.0%, *p*=0,013) compared to the elective colon cancer group. Stoma formation was performed in 56.9% of emergency colon cancer patients versus 25.5% of elective colon cancer patients (*p*<0.001). Similar to the entire CRC population, T4 carcinomas were significantly more frequent in the emergency versus elective colon cancer group (43.2% vs. 21.3%, *p*=0.017). Moreover, significantly more lymph nodes were harvested in the emergency versus elective colon cancer group (26 [IQR18-37] vs. 22 [16-30], *p*=0.017). In the emergency surgery group, left-sided colon tumors were significantly more frequent compared to the elective colon cancer group (68.4% vs. 49.0%, *p*=0.001). No differences were found regarding in-hospital complications rates. However, similar to the entire CRC group, the median HLOS was significantly longer in emergency versus elective colon cancer patients (14 [IQR 10-22] vs. 11 [8-17] days, *p*=0.001).

In the subgroup of colon cancer patients, the median length of follow-up was 438 (IQR 50-1465) days and did not differ significantly between emergency and elective resections. As found for the entire CRC group, neither the overall survival nor the median disease free survival were significantly different between the emergency and the elective colon cancer resection group (72.6% vs. 77.8%, *p*=0.321; 389 vs. 434 days, *p*=0.583). Multivariable cox regression analysis showed no statistical significant differences in 5-year survival (aHR 1.40; 95%CI 0.78-2.51,

p=0.260) or local tumor recurrence (aHR 1.44; 95%CI 0.32-6.56, *p*=0.635) when comparing emergency with elective colon cancer patients.

Discussion

The current study assessed long-term outcomes of CRC patients undergoing emergency versus elective CRC surgery based on an institutional CRC database. Emergency CRC patients presented with locally more advanced tumors and less frequent rectal cancer compared to elective CRC patients. In-hospital mortality was significantly increased in the emergency versus the elective CRC group. However, the long-term oncologic outcomes were similar between the groups. Similar results were found for the subgroup of patients with colon cancer.

Tumor characteristics

In the current study, more advanced tumor stages were observed in the emergency CRC compared to the elective CRC group. This finding is not surprising as large tumors are more likely to cause obstruction, perforation or bleeding, which were the reasons for emergency resections. Moreover, in the current study, patients in the emergency CRC group suffered more frequently from colon cancer compared to the elective group (91% vs. 65%). This is due to the higher incidence of colon compared to rectal cancer in general and the fact that the study institution is a referral center for elective rectal cancer treatment. Therefore, a subgroup analysis was performed for patients with colon cancer only to reduce heterogeneity of the populations. However, similar to the entire CRC population, this subgroup analysis revealed comparable results regarding short- and long-term outcomes between the emergency and elective resections.

The higher frequency of neo-adjuvant radio- and chemotherapy is well explained by the higher number of patients with rectal cancer in the elective CRC group. The higher proportion of patients with neo-adjuvant therapy may have resulted in a trend towards less local tumor recurrence in the elective CRC group compared to the emergency CRC group. However, overall

survival was similar between the two groups (*Table 3*). This is in line with previous investigations showing that neo-adjuvant therapy does decrease local tumor recurrence, but not overall survival [19,20]. Significantly more patients from the elective CRC group received adjuvant chemotherapy compared to the emergency CRC group (32% vs. 19%, *p*=0.028). This might be explained by the higher morbidity and in-hospital mortality in the emergency CRC group prohibiting adjuvant chemotherapy. In the subgroup analysis of colon cancer patients no statistical significant difference regarding adjuvant chemotherapy between the elective versus emergency resection group was found (26% vs. 19%, *p*=0.283)

Short-term outcomes

In the current study, 8% in the emergency CRC group and 3% in the elective CRC group died during their hospital stay (*p*=0.023). Cardiopulmonary events were the most common complications, and occurred more frequently in the emergency CRC group *(Table 3)*. The literature on short-term outcomes after emergency versus elective CRC surgery is conflicting. Due to varying methodology and different short-term outcomes measures, the generalizability of these studies is limited [6,5]. It is important to consider acute systemic pathophysiologic derangements when comparing short-term outcomes of emergency to elective patients. In the current study, the ASA scores, as a surrogate marker for acute systemic pathophysiologic derangement, were significantly higher in the emergency than in the elective CRC group *(Table 1)*. To our knowledge, there is currently only one previous study in CRC patients, which similarly found the ASA score to be an independent predictor for in-hospital mortality [6]. In addition, emergency CRC patients often present with reduced physiologic reserves, including a katabolic malnutritional state, due to the advanced malignant disease and no possibility for prehabilitation [21]. In the current study, the worse nutritional state is reflected by the significantly lower BMI in the emergency CRC group compared to the elective CRC group (24 vs. 26 kg/m^2, *p*=0.012). In

order to improve pathophysiology and therefore short-term outcomes in this group of frail patients, an interdisciplinary approach, involving emergency physicians, surgeons, anesthesiologists, nutritionists, and intensivists is required.

Long-term outcomes

Oncologic outcomes in CRC patients are associated to multiple disease- and patient-related factors. As expected, when stratifying the current study population according to the UICC-grades, significant differences between the five-year survival rates were observed (*Figure 2*).

Moreover, the completeness of surgical resection, characterized by the negative resection margins (R0) and the lymph node yield, determines overall survival [22,23]. In the current study, the percentage of R0-resections was 92% versus 95% and the median lymph node yield was 26 versus 20 lymph nodes when comparing emergency with elective CRC patients. Overall, this represents a good quality of oncologic resection for both study groups [22,23]. Unexpectedly, the number of harvested lymph nodes was significantly higher in emergency than in elective CRC resections. This finding accounted for both, colon and rectal resections *(Table 2)*. To our knowledge, three recent studies have compared the lymph node yield of emergency with elective CRC resections [13,24,4]. However, the results are conflicting. In these three studies the percentage of adequate lymph node yield (>12 lymph nodes) is higher [13], equal [24] or lower [4] for emergency compared to elective CRC resections. The reasons for these conflicting findings remain unclear. Differences in training between general emergency surgeons and specialized colorectal surgeons have been discussed, however, only in elective CRC surgery [25]. The good oncologic resection quality in the emergency CRC population might be result of the common trunk education and the close collaboration of general emergency surgeons with specialized colorectal surgeons.

A recent retrospective single-institution study from Canada demonstrated a difference in local tumor recurrence and five-year survival between elective and emergency resection of colon cancer [24]. However, in a selected patient population of stage I to III colon cancer and without adjustment for comorbidities in multivariable analysis. Therefore, this finding needs to be considered carefully.

Limitations of the current study are its retrospective design and relatively low number of patients.

Conclusion

In-hospital mortality in patients undergoing emergency CRC surgery was higher compared to patients undergoing elective CRC surgery. However, adjusted five-year survival, rate and time to local tumor recurrence were similar between the groups. Increased tumor stages and not emergency resections predict long-term outcomes of CRC patients.

Acknowledgements

None.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in this study were in accordance with the ethical standards of the cantonal research committee (Cantonal Ethics Committee of Bern, Switzerland 2017-00792) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Figures and Tables

Table 1: Baseline characteristics

	Overall (N=475)	**Emergency (n=105)**	**Elective (n=370)**	***p* value**
Age, y, median (IQR)	69.0 (59.0-77.0)	72.0 (61.5-79.0)	68.0 (58.8-76.0)	**0.018**[a]
Sex, f (%)/m (%)	179 (37.7)/296 (62.3)	44 (41.9)/61 (58.1)	135 (36.5)/235 (63.5)	0.361[b]
BMI, kg/m^2, median (IQR)	25.5 (22.7-28.9)	24.3 (21.8-27.4)	25.9 (22.9-29.1)	**0.012**[a]
ASA score, n (%)				**0.003**[b]
1	7 (1.5)	1 (1.0)	6 (1.7)	
2	156 (32.8)	23 (23.5)	133 (37.0)	
3	268 (56.4)	62 (63.3)	206 (57.4)	
4	26 (5.5)	12 (12.2)	14 (3.9)	
CCI ≥ 5, n (%)	377 (79.4)	87 (82.9)	290 (78.4)	0.342[a]
Operative procedure, n (%)				**<0.001**[b]
LAR/TME	123 (25.9)	10 (9.5)	113 (30.5)	
APR	43 (9.1)	2 (1.9)	41 (11.1)	
Left hemicolectomy	146 (30.8)	52 (49.6)	94 (25.4)	
Transversectomy	8 (1.7)	2 (1.9)	6 (1.6)	
Right hemicolectomy	114 (24.0)	28 (26.7)	86 (23.2)	
Subtotal/colectomy	33 (6.9)	9 (8.6)	24 (6.5)	
Other	8 (1.7)	2 (1.9)	6 (1.6)	
Operative technique, n (%)				**0.031**[b]
Successful laparoscopic	51 (10.7)	5 (4.8)	46 (12.4)	
Open	424 (89.3)	100 (95.2)	324 (87.6)	
Operative strategy, n (%)				**0.003**[b]
Prim. anastomosis	247 (52.0)	43 (41.0)	204 (55.1)	
Prim. anastomosis, protective stoma	123 (25.9)	26 (24.8)	97 (26.2)	
No prim. anastomosis, definitive stoma	105 (22.1)	36 (34.4)	69 (18.6)	
Operation time, min, median (IQR)	275 (210-355)	265 (197-320)	280 (214-360)	**0.042**[a]

IQR: interquartile range; BMI: body mass index; ASA score: American Society of Anaesthesiologists score; CCI: Charlson comorbidity index; LAR/TME: low anterior resection/total mesorectal excision; APR: abdominoperineal resection [a] Mann Whitney U test; [b] Fisher's exact test

Table 2: Tumor characteristics

	Overall (N=475)	**Emergency (n=105)**	**Elective (n=370)**	***p* value**
Localization distal to proximal, n (%)				**<0.001**[a]
Rectum	141 (29.7)	10 (9.5)	131 (35.4)	
Sigmoid	152 (32.0)	50 (47.6)	102 (27.6)	
Splenic flexure, descending c.	30 (6.3)	15 (14.3)	15 (4.1)	
Transverse c.	17 (3.6)	5 (4.8)	12 (3.2)	
Hepatic flexure, ascending c.	59 (12.4)	12 (11.4)	47 (12.7)	
Cecum	41 (8.6)	11 (10.5)	30 (8.1)	
Other	35 (7.4)	2 (1.9)	33 (8.9)	
Tumor stage (UICC), n (%)				**<0.001**[a]
0	15 (3.2)	2 (1.9)	13 (3.5)	
I	79 (16.6)	6 (5.7)	73 (19.7)	
IIA	92 (19.4)	23 (21.9)	69 (18.6)	
IIB	26 (5.5)	14 (13.3)	12 (3.2)	
IIIA	12 (2.5)	1 (1.0)	11 (3.0)	
IIIB	54 (11.4)	12 (11.4)	42 (11.4)	
IIIC	32 (6.7)	6 (5.7)	26 (7.0)	
IV	165 (34.7)	41 (39.0)	124 (33.5)	
Total lymph node yield, median (IQR)	21 (15-29)	26 (18-33)	20 (15-27)	**<0.001**[b]
Lymph node yield colon, median (IQR)	23 (16-32)	26 (18-37)	22 (16-30)	**0.017**[b]
Lymph node yield rectum, median (IQR)	18 (14-25)	25 (17-33)	18 (13-25)	0.069[b]
Positive lymph node yield, median (IQR)	3 (1-7)	3 (2-8)	3 (1-7)	0.296[b]
Nodal positive (N+), n (%)	219 (46.3)	48 (46.2)	171 (46.3)	1.000[a]
Positive resection margin (R+), n (%)	27 (5.1)	8 (7.6)	19 (5.1)	0.416[a]

Lymphatic vessel invasion (L+), n (%)	77 (16.2)	18 (17.1)	59 (16.0)	0.954[a]
Vein invasion (V+), n (%)	90 (19.0)	22 (21.0)	68 (18.4)	0.918[a]
Neoadjuvant chemotherapy, n (%)	88 (18.5)	3 (2.9)	85 (23.0)	**<0.001**[a]
Neoadjuvant radiotherapy, n (%)	71 (14.9)	2 (1.9)	69 (18.6)	**<0.001**[a]

IQR: interquartile range; c.: Colon; UICC: Union internationale contre le cancer; [a] Fisher's exact test; [b] Mann Whitney U test

Table 3: In-hospital and long-term outcomes

	Overall (N=475)	Emergency (n=105)	Elective (n=370)	*p* value
In-hospital outcomes				
Patients with complications, n (%)	249 (52.4)	62 (59.0)	187 (50.5)	0.150[a]
Cardiac event	15 (3.2)	5 (4.8)	10 (2.7)	0.340[a]
Respiratory event	25 (5.3)	7 (6.7)	18 (4.9)	0.461[a]
Aspiration	11 (2.3)	4 (3.8)	7 (1.9)	0.271[a]
Renal insufficiency	18 (3.8)	5 (4.8)	13 (3.5)	0.565[a]
Ileus	28 (5.9)	7 (6.7)	21 (5.7)	0.646[a]
Anastomotic leakage	33 (6.9)	5 (4.8)	28 (7.6)	0.390[a]
Sepsis	18 (3.8)	4 (3.8)	14 (3.8)	1.000[a]
Surgical site infection	141 (29.7)	33 (31.4)	108 (29.2)	0.717[a]
Superficial	91 (19.2)	21 (20.0)	70 (18.9)	
Deep	11 (2.3)	4 (3.8)	7 (1.9)	0.595[a]
Organ/space	39 (8.2)	8 (7.6)	31 (8.3)	
Hospital length of stay, d, median (IQR)	13 (9-19)	14 (11-23)	13 (9-19)	**0.006**[b]
In-hospital mortality, n (%)	20 (4.2)	9 (8.4)	11 (3.0)	**0.023**[a]
Long-term outcomes				
Length of follow-up, d, median (IQR)	445 (67-1,409)	420 (45-1,289)	450 (82-1,450)	0.387[b]
Adjuvant chemotherapy, n (%)	137 (28.8)	20 (19.0)	117 (31.6)	**0.028**[a]
Overall survival, n (%)	368 (77.5)	76 (72.4)	292 (78.9)	0.185[a]
5-y survival, n (%)	485 (81.1)	79 (75.2)	306 (82.7)	0.091[a]
Local recurrence, n (%)	24 (5.1)	7 (6.7)	17 (4.6)	0.448[a]
Disease free survival, d, median (IQR)	411 (62-1,374)	383 (43-1,209)	423 (78-1,428)	0.257[b]

IQR: interquartile range; [a] Fisher's exact test; [b] Mann Whitney U test

Table 4: The effect of emergency CRC resection on outcomes

In-hospital mortality

	OR	95% CI	*p* value
unadjusted	2.88	1.23-6.77	0.023
adjusted[a]	1.82	0.62-5.40	0.278

Five-year survival

	HR	95% CI	*p* value
unadjusted	1.49	0.95-2.35	0.086
adjusted[b]	1.38	0.81-2.37	0.237

Five-year local tumor recurrence

	HR	95% CI	*p* value
unadjusted	1.59	0.66-3.84	0.299
adjusted[c]	1.48	0.47-4.66	0.500

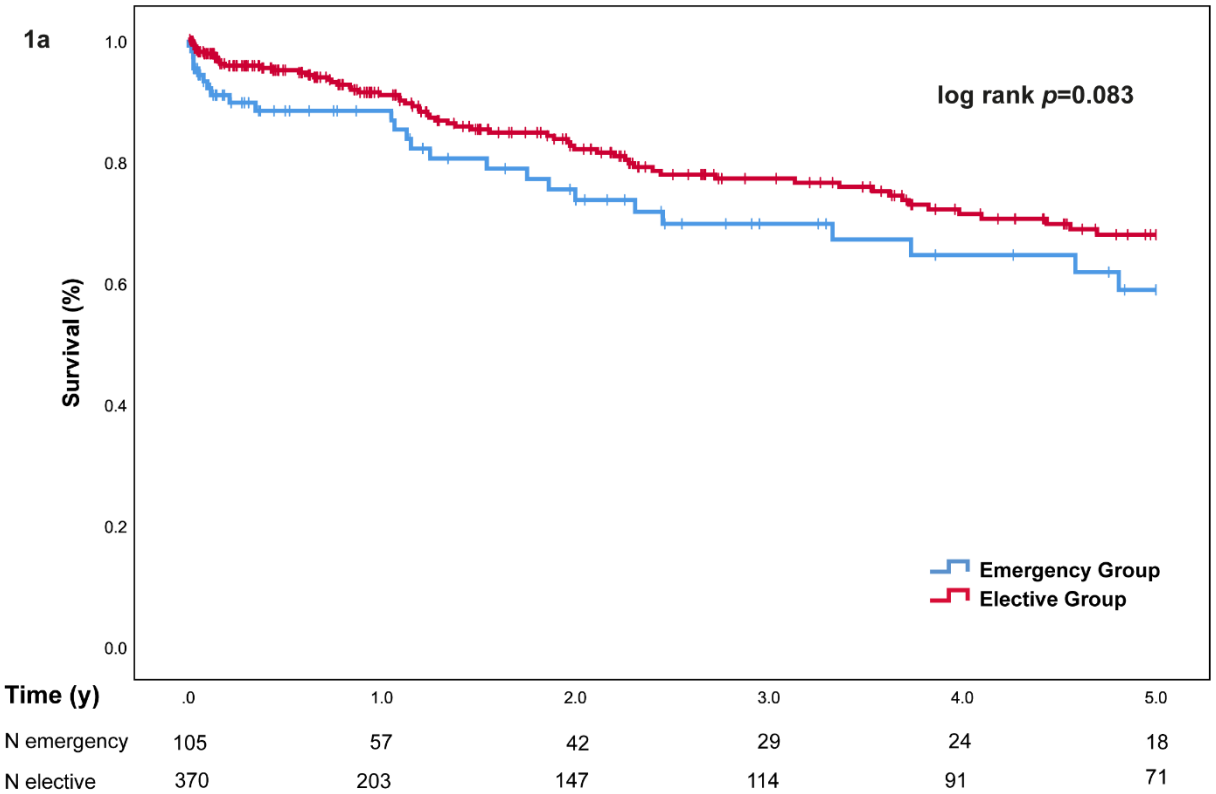
OR: odds ratio; HR: Hazard ratio; CI: confidence interval; ASA score: American Society of Anaesthesiology score; CCI: Charlson comorbidity index; UICC stage: Union for International Cancer Control stage

[a] Multivariable logistic regression analysis adjusted for ASA score, tumour localisation, operative strategy, neoadjuvant chemo- and radiotherapy

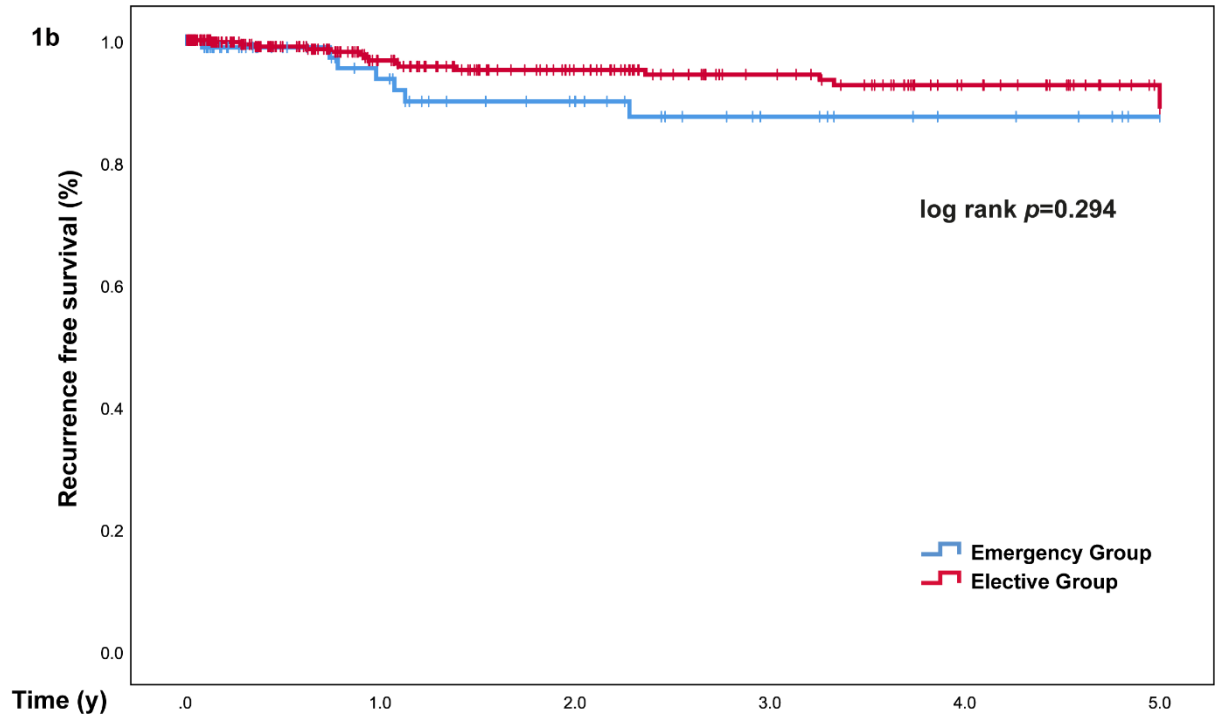
[b] Multivariable cox regression analysis adjusted for age, CCI, operative procedure, UICC stage, neoadjuvant chemo- and radiotherapy

[c] Multivariable cox regression analysis adjusted for age, CCI, operative procedure, UICC stage, neoadjuvant chemo- and radiotherapy

Fig. 1 Kaplan-Meier curves of **a)** five-year survival and **b)** five-year recurrence free survival stratified by emergency versus elective CRC resection

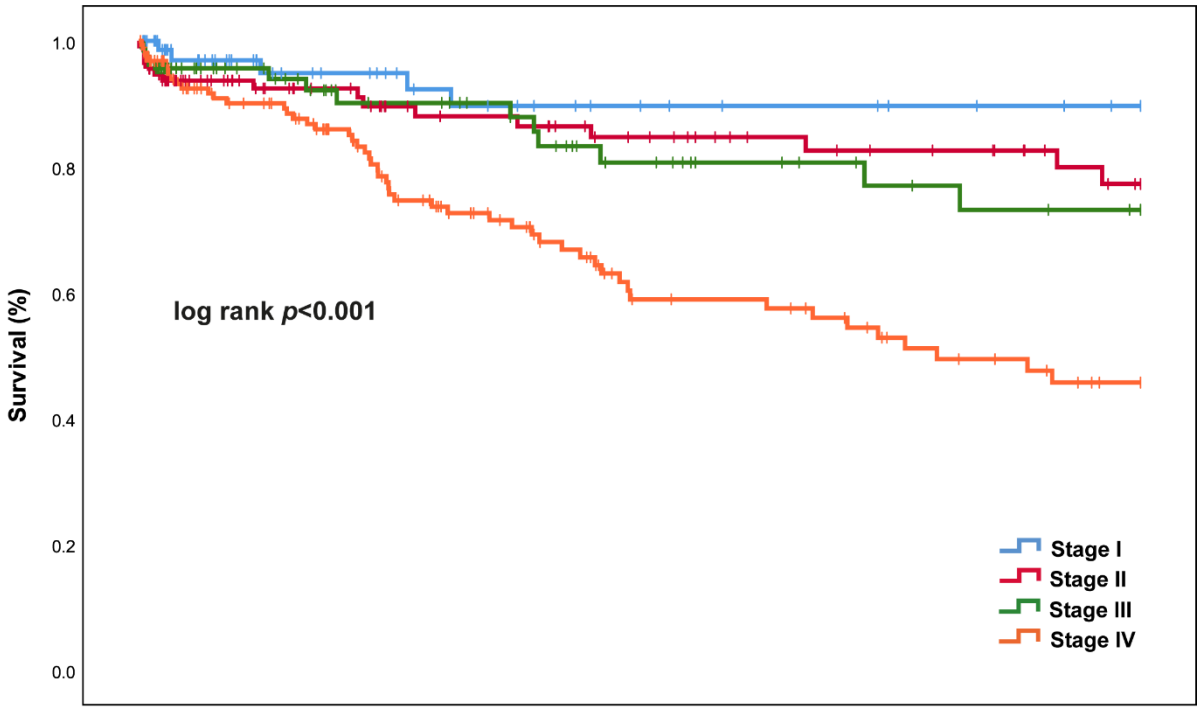


Time (y)	.0	1.0	2.0	3.0	4.0	5.0
N emergency	105	57	42	29	24	18
N elective	370	203	147	114	91	71



Time (y)	.0	1.0	2.0	3.0	4.0	5.0
N emergency	105	53	40	28	23	18
N elective	370	197	144	113	90	71

Fig. 2 Kaplan-Meier curves of five-year survival stratified by UICC stages I-IV



Time (y)	.0	1.0	2.0	3.0	4.0	5.0
N stage I	79	42	31	26	24	20
N stage II	117	66	54	41	36	26
N stage III	98	45	36	25	20	16
N stage IV	156	95	57	41	29	20