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Failure to rescue after reoperation for major complications of elective and emergency colorectal surgery: A population-based multicenter cohort study

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ABSTRACT

Background: As surgical complications inevitably occur, minimizing the failure-to-rescue rate is of paramount interest. Most of the failure-to-rescue research in colorectal surgery has previously focused on elective surgery and anastomotic dehiscence. The aim of this study was to characterize and compare the major postoperative complications demanding reoperation after elective versus emergency colorectal surgery, and to the identify risk factors for failure-to-rescue.

Methods: In this population-based retrospective multicenter cohort study, adult patients undergoing a reoperation for colorectal surgery complication between 2006 and 2017 in 10 hospitals were included. The data were manually extracted. Failure-to-rescue was defined as 90-day mortality after the reoperation.

Results: In total, 14,290 patients underwent index colorectal resection, of which 862 (5.8%) underwent emergency reoperation within 30 days (438 [4.3%] after elective, 424 [10.4%] after emergency index operation, $P < .001$). The failure-to-rescue overall rate was 17.4% (8.0% after elective vs 27.1% after emergency index operation, $P < .001$). The 4 most common complications were anastomotic dehiscence (36.6%, 316 patients), fascial rupture (23.5%, 203 patients), intra-abdominal bleeding (15.3%, 131 patients), and bowel obstruction (10.2%, 88 patients). The majority (640 patients, 74.2%) had 1 of these complications; 261 patients (30.3%) had multiple complications. In multivariable analyses, the only possibly preventable independent risk factor for failure-to-rescue was perioperative organ failure at the time of reoperation.

Conclusion: Major complications requiring reoperation occur more than twice as often after emergency surgery and have a higher failure-to-rescue rate of >3× compared with elective surgery. The 4 most common complication types constitute three-fourths of the complications, providing a target for quality improvement.

Introduction

More than 300,000, 19,000, and 4,000 patients undergo colorectal surgery annually in the United States, the UK, and Finland, respectively.[1–3] Colorectal surgery is a high-risk procedure associated with 20% to 37% risk of postoperative complications, 6% to 8% risk of emergency reoperation, and 2% to 19% of mortality, depending on the series.[4–9] A postoperative complication is a significant risk factor for postoperative mortality,[5] and different measures have been taken in an attempt to diminish complications in elective surgery.[10] A large proportion of colorectal surgery is carried out as emergency surgery. For example, 15% to 20% of patients with colorectal cancer present with obstruction,[11] and 10% to 20% of patients with acute diverticulitis require emergency intervention.[12] Colorectal procedures comprise almost half of all emergency laparotomies.[13] Emergency operation is associated with higher in-hospital

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mortality and as well as poorer long-term outcome in case of malignant disease.[14,15]

Anastomotic dehiscence is the most common, and most studied, complication after colorectal surgery.[16] A Spanish multicenter, prospective trial reported an anastomotic leak rate of 9%, 78% needed a reoperation, and mortality rate after diagnosed leakage varied between 6% and 39%.[17,18] However, other complications causing a need for reoperation are less well known and studied.

Although there is huge variation among centers and countries on mortality after colorectal surgery, postoperative complications seem to occur at a similar rate even between high- and low-volume centers and high- and low-income countries.[19,20] However, the mortality rate after a complication has occurred (ie, failure-to-rescue [FTR] rate) varies. High-volume hospitals and high-income countries seem to be better at rescuing patients after an adverse event has occurred.[21]

Further, studies on FTR usually focus on complications after major elective surgery. Whereas most upper gastrointestinal, liver, and pancreatic operations are carried out electively, a major proportion of colorectal surgery is carried out as emergency surgery. It is currently unclear whether similar factors play a role in FTR in emergency colorectal surgery compared to elective surgery. As most of the research on colorectal surgery complications focuses on anastomotic dehiscence, it is unclear how other types of complications requiring reoperation affect FTR.

The aim of this study was to characterize the burden and spectrum of postoperative complications requiring a reoperation after an elective versus emergency colorectal surgery in a geographically defined area using a population-based approach. In addition, this study also aimed to identify risk factors for FTR, defined as mortality for any cause within 90 days after a reoperation after elective or emergency colorectal surgery. Instead of 30-day mortality, 90-day mortality was chosen because nearly half of the mortality occurs between 30 and 90 days, thus 90-day mortality serves as a better quality measure.[22–25] Our hypothesis was that reoperation and FTR rates, as well as the spectrum of complications, differ between elective and emergency colorectal surgery. These results may guide in targeting the quality improvement programs and research of colorectal surgery complications.

Methods

Adult patients (>18 years) undergoing colorectal surgery between January 1, 2006 and December 31, 2017 in Hospital District of Helsinki and Uusimaa were included. The Helsinki and Uusimaa hospital district is comprised of 10 hospitals (3 university hospitals acting as both tertiary and secondary referral centers and 7 secondary referral centers) and serves a population of 1.7 million within a geographically defined area of 12,800 km^2 in southern Finland. The patients were identified from the electronic patient records (EMR) by querying for Nordic Medico-Statistical Committee Surgical Procedural codes for colorectal resection (JFB20-JFB97, JFH00-JFH96, JGB03-JGB97), which includes total or partial colectomy, proctocolectomy, and proctectomy. This first colorectal operation is hereafter referred to as the index operation. The identified patients were further queried from the EMR for a subsequent emergency reoperation within 30 days from the index operation these patients formed the final study cohort. Their patient records were browsed and data regarding pre-, peri-, and postoperative characteristics were manually extracted. All of the hospitals used the same shared EMR system during the study period. Patients undergoing an operation within 30 days after the index operation for reasons not related to the index operation were excluded. In addition patients with multiorgan trauma, pancreatitis, or ruptured abdominal aortic aneurysm as the reason for index surgery were excluded.

The FTR was defined as mortality for any cause within 90 days after a reoperation. Perioperative organ failure was defined as the onset of a new organ failure due to the complication leading to reoperation.

The categorical variables were compared using the χ^2 analysis or Fisher exact test if the expected cases in 1 cell were <5. The normalities of the distribution of continuous variables were tested using the Kolmogorov-Smirnov test. As all continuous variables were non-normally distributed, they were analyzed using Mann-Whitney *U* test. Multivariable analyses were carried out using logistic regression. The parameters were selected to the model based on significance level $P < .1$ on univariable analysis, and additional parameters could be introduced if judged clinically important. Statistical analyses were conducted using IBM SPSS software, version 24 (IBM Corp, Armonk, NY). Patients with missing values were excluded from analyses of that particular variable.

The Helsinki University Hospital Institutional Review Board approved the study. Ethical committee approval was not needed as this was a retrospective review of patient medical reocrds.

Results

During the study period, 14,290 patients underwent colorectal resection, of which 10,059 (70.4%) were elective and 4,231 (29.6%) were emergency operations. A total of 862 (5.8%) patients had a reoperation within 30 days that was directly related to the index operation and formed the final study cohort. The patients undergoing emergency index operation needed reoperation >2× as often than did patients undergoing elective colorectal resection: 438 (4.3%) after elective and 424 (10.4%) after emergency colorectal resection ($P < .001$). A total of 176 (20.4%) patients underwent >1 reoperation: 86 (19.6%) after elective, 90 (21.2%) after emergency colorectal resection ($P = .638$). The FTR rate (ie, 90-day mortality after reoperation) was 17.4% (150 patients) for the entire cohort. The FTR rate was >3× higher for patients undergoing reoperation after emergency surgery compared to elective surgery (115 [27.1%] vs 35 [8.0%]), $P < .001$). The FTR after resection for exclusively malignant or premalignant lesions was 14.9% ($n = 56$) (12.3% [$n = 32$] and 20.9% [$n = 24$] for elective and emergency operations, respectively).

The basic patient demographics and comorbidities are shown in Table I. Patients who underwent emergency colorectal surgery were older, more often had dementia, chronic obstructive pulmonary disease, connective tissue disease, metastatic malignancy and were smokers (Table I).

The details of the index operation are shown in Table II. The most common indications for the index surgery were colorectal carcinoma (CRC) or premalignant lesion and diverticulosis, which accounted for >60% of the cases (Table II). For the elective surgeries, CRC or premalignant lesion accounted for 60%, whereas they accounted for only 27% of the emergency surgeries. Overall, the emergency colorectal resections were more often open, carried out because of bowel obstruction, and contaminated; hence, primary anastomosis was performed less often and end colostomies were performed more often compared to elective surgery (Table II).

A detailed list of findings in the reoperation is shown in Table III. Overall, the most common findings in the reoperation were anastomotic dehiscence (36.6%), fascial rupture (23.5%), intra-abdominal bleeding (15.3%), and bowel obstruction (10.2%) (Table III). The majority (640 patients, 74.2%) had 1 or more of these 4 most common findings. Overall, 261 patients (30.3%) had multiple findings.

There was a huge variation in the findings at reoperation after elective versus emergency surgery (Table III). Although

Table I
Patient demographics and comorbidities

	All patients n (%) or median (IQR) $N = 862$	Elective index operation n (%) or median (IQR) $N = 438$	Emergency index operation n (%) or median (IQR) $N = 424$	Difference between elective and emergency index operation P value
Sex, male/female	520/342 (60.3/40.0)	278/160 (63.5/36.5)	242/182 (57.1/42.9)	.055
Age (y) median (IQR)	67.5 (56.1–75.3)	65.6 (55.0–74.1)	68.6 (57.9–76.1)	.005
<50	125 (14.5)	70 (16.0)	55 (13.0)	.210
50–60	157 (18.2)	90 (20.5)	67 (15.8)	.071
60–70	224 (26.0)	113 (25.8)	111 (26.2)	.899
70–80	238 (27.6)	115 (26.3)	123 (29.0)	.366
>80	118 (13.7)	50 (11.4)	68 (16.0)	.048
BMI (kg/m^2)	25.5 (22.5–29.3)	25.6 (22.9–29.4)	25.1 (21.9–28.9)	.030
Current smoker	127 (14.7)	46 (10.5)	81 (19.1)	< .001
Anticoagulation	133 (15.4)	67 (15.3)	66 (15.6)	.913
Immunosuppressants	87 (10.1)	51 (11.6)	36 (8.5)	.124
Cortisone	117 (13.6)	46 (10.5)	71 (16.7)	.007
Previous abdominal operations	0 (0–1)	0 (0–1)	0 (0–1)	.997
Charlson comorbidity index	2.00 (0–5)	3 (0–6)	0 (0–5)	< .001
Atrial fibrillation	107 (12.4)	49 (11.2)	58 (13.7)	.267
Ischemic heart disease	120 (13.9)	57 (13.0)	63 (14.9)	.434
Myocardial infarct	67 (7.8)	32 (7.3)	35 (8.3)	.603
Congestive heart failure	89 (10.3)	47 (10.7)	42 (9.9)	.691
Peripheral vascular disease	56 (6.5)	21 (4.8)	35 (8.3)	.039
Dementia	36 (4.2)	10 (2.3)	26 (6.1)	.005
Cerebrovascular accident or transient ischemic attack	53 (6.1)	27 (6.2)	26 (6.1)	.984
COPD	83 (9.6)	26 (5.9)	57 (13.4)	< .001
Connective tissue disease	66 (7.7)	23 (5.3)	43 (10.1)	.007
Diabetes mellitus	140 (16.3)	62 (14.2)	78 (18.4)	.091
Peptic ulcer	21 (2.4)	9 (2.1)	12 (2.8)	.457
Liver disease	24 (2.8)	15 (3.4)	9 (2.1)	.223
Hemiplegia	33 (3.8)	14 (3.2)	19 (4.5)	.326
Solid tumor, local	288 (33.4)	185 (42.2)	103 (24.3)	< .001
Solid tumor, metastatic	101 (11.7)	37 (8.4)	64 (15.1)	.002
Leukemia	6 (0.7)	3 (0.7)	3 (0.7)	.968
Lymphoma	11 (1.3)	5 (1.1)	6 (1.4)	.721
Chronic kidney disease	42 (4.9)	17 (3.9)	25 (5.9)	.170
Previous thrombosis	53 (6.1)	27 (6.2)	26 (6.1)	.984

BMI, body mass index; *COPD*, chronic obstructive pulmonary disease; *IQR*, interquartile range.

anastomotic dehiscence was the most common finding, present in 50% of reoperations after elective surgery, and only in 23% in reoperations after emergency surgery because of the relatively larger proportion of other complications present in the reoperation after emergency surgery. Of note, the overall incidence of anastomotic dehiscence was similar after elective (218/10,059, 2.2%) and emergency (98/4,231, 2.3%) surgery. Fascial ruptures were found in reoperations nearly 3× more often when the index operation was emergency surgery (12.6% vs 34.7%). The proportion of negative reoperations (ie, no findings at all), was 8.2% for the entire cohort (7.5% and 8.9% in reoperations after elective and emergency index operations, respectively). The FTR rate after negative reoperation was significantly lower after elective index operations (3.0% vs 31.6%, $P = .002$).

There was also a large difference in FTR rates (ie, 90-day mortality after reoperation) between reoperations performed after emergency versus elective surgery, even among the same findings in the reoperation (Table III). The FTR rates were 3× to 10× higher after anastomotic dehiscence (30.6% vs 9.7%), fascial rupture (23.0% vs 5.5%), intra-abdominal bleeding (25.9% versus 2.6%), and bowel obstruction (22.5% vs 4.2%) in the patients undergoing reoperation after emergency surgery compared to elective surgery, respectively (Table III).

Perioperative organ failure requiring intensive care at the time of the first reoperation was present in 246 (28.5%) patients. Perioperative organ failure was more often present at the reoperation after emergency surgery (142 patients, 33.5%) compared to the reoperation after elective surgery (104 patients, 23.7%) ($P = .018$). The median time from index operation to reoperation was 5 days (range 0–30) after elective surgery and 6 days (range 0–30) after emergency surgery ($P = .724$).

In the univariable analysis, the patient risk factors for FTR in the entire cohort were increasing age, body mass index (BMI) <20 kg/m^2, anticoagulation, high comprehensive complication index (CCI), female sex, and previous abdominal operations, whereas immunosuppression was a protective factor (Table IV). Index operation related risk factors for FTR were dirty wound classification at index operation, metastatic malignancy or ischemic disease as the reason for surgery, no continuity made, and emergency operation, whereas laparoscopic approach, left-sided, or subtotal colectomy were protective factors (Table IV). Perioperative organ failure at reoperation was associated with FTR (Table IV). These associations differed in patients undergoing reoperation after elective versus emergency surgery (Table IV). For example, anticoagulation and metastatic malignancy or inflammatory disease as the reason for surgery were risk factors in patients with emergency index operation, whereas age, comorbidity index, and perioperative organ failure at reoperation were the only risk factors for FTR after elective surgery.

In multivariable analysis, independent risk factors for FTR in the entire cohort were increasing age, BMI <20 kg/m^2, anticoagulation, moderate-to-severe chronic kidney disease, metastatic malignancy, either as the reason for surgery or anamnestic, emergency index operation, dirty wound at index operation, and perioperative organ failure at reoperation, whereas left-sided and subtotal colectomy were protective factors (Table V). For the patients undergoing reoperation after elective surgery, only comorbidity index and perioperative organ failure at the time of reoperation were

Table II
Index operation details

	All patients *n* (%) or median (IQR) *n* = 862	Elective index operation *n* (%) or median (IQR) *n* = 438	Emergency index operation *n* (%) or median (IQR) *n* = 424	Difference between elective and emergency index operation *P* value
Approach				
Laparoscopy	186 (21.6)	181 (42.4)	5 (1.2)	< .001
Open	597 (69.2)	195 (45.2)	402 (94.8)	< .001
Converted	76 (8.8)	60 (14.1)	16 (3.8)	< .001
Details				
Operating time (min)	152 (115–194)	157 (119–206)	146 (110–185)	.010
Blood loss (mL)	250 (100–600)	200 (100–500)	300 (150–700)	< .001
Reason for surgery				
Colorectal cancer or premalignant lesion	376 (43.6)	261 (59.6)	115 (27.1)	< .001
Diverticulosis or diverticulitis	187 (21.7)	91 (20.8)	96 (22.6)	.507
Benign colon obstruction	103 (11.9)	16 (3.7)	87 (20.5)	< .001
IBD	73 (8.5)	53 (12.1)	20 (4.7)	< .001
Ischemia	40 (4.6)	0	40 (9.4)	< .001
Other malignancy	28 (3.2)	10 (2.3)	18 (4.2)	.104
Intra-abdominal infection[*]	13 (1.5)	0	13 (3.1)	< .001
Other[†]	45 (5.2)	5 (1.1)	40 (9.4)	< .001
Reason for emergency				
Bowel obstruction			133 (31.4)	
Perforation			163 (38.4)	
Other			128 (30.2)	
Resection type				
Right-sided colectomy	293 (34.0)	134 (30.6)	159 (37.5)	.032
Left-sided colectomy including rectal resections	451 (52.3)	245 (55.9)	206 (48.6)	.031
Subtotal or total colectomy	133 (15.4)	67 (15.3)	66 (15.6)	.365
Surgical wound classification				
Clean contaminated	568 (65.9)	403 (92)	165 (38.9)	< .001
Contaminated	51 (5.9)	19 (4.3)	32 (7.5)	.046
Dirty	243 (28.2)	16 (3.7)	227 (53.5)	.046
Anastomosis type				
Primary anastomosis	649 (75.3)	388 (88.6)	261 (63.0)	< .001
Protective diversion	40 (4.6)	28 (6.4)	12 (2.8)	.018
No continuity	173 (20.1)	22 (5.0)	151 (35.6)	< .001

IBD, inflammatory bowel disease; *IQR*, interquartile range.

[*] Intra-abdominal infections: appendicitis $n = 6$, *Clostridium difficile* colitis $n = 2$, tuberculosis $n = 2$, cholecystitis $n = 1$, chronic pancreatitis $n = 1$.

[†] Other: iatrogenic lesion: elective $n = 1$, emergency $n = 29$; bleeding: elective $n = 0$, emergency $n = 4$; trauma: elective $n = 1$, emergency $n = 2$; perforation for unknown reasons: elective $n = 0$, emergency $n = 3$; endometriosis: elective $n = 1$, emergency $n = 1$; rectum prolapse: elective $n = 1$, emergency $n = 1$; hidradenitis: elective $n = 1$, emergency $n = 0$.

independent risk factors for FTR. For the patients undergoing reoperation after emergency surgery, age, BMI <20 kg/m^2, anticoagulation, metastatic malignancy, either as the reason for surgery or anamnestic, inflammatory or other benign disease as reason for surgery, and perioperative organ failure at the time of reoperation were independent risk factors for FTR, whereas left-sided colectomy or subtotal colectomy were protective factors (Table V).

Discussion

In this large population-based study carried out within a geographically defined area consisting of 10 hospitals serving 1.7 million inhabitants, we found that nearly one-third of colorectal resections are carried out as emergency surgeries. The patients who underwent emergency colorectal resection had a complication that required relaparotomy >2× as often. Further, the patients who did require relaparotomy after emergency colorectal resection were >3× more likely to die within 90 days, (ie, they were failed to be rescued compared to patients who underwent relaparotomy after elective colorectal surgery). Although many quality-improving programs and care bundles aim to improve outcomes after elective colorectal surgery, these findings also highlighted the need to focus on the improvement of emergency colorectal surgery. We identified the 4 most common complications, namely anastomotic dehiscence, fascial rupture, intra-abdominal bleeding, and bowel obstruction, as the main drivers for reoperation. Nearly three-fourths of patients undergoing a reoperation had at least 1 of these complications. These findings provided a target for quality improvement in both elective and emergency colorectal surgery. Metastatic malignancy, either as the reason for surgery or separately as an anamnestic factor, were major risk factors in the entire cohort and for patients with emergency index operation. High FTR for these patients can be explained partly by individual goals of care, but this also underlines the need for improvement in preventative care, minimizing the need for emergency surgery for these patients. In addition, nonoperative palliative care should be considered more often. Further, the only possibly modifiable or preventable factor independently increasing the risk for FTR was perioperative organ failure at the time of the first reoperation for a complication. As organ failure usually takes time to develop after the complication has manifested, this finding highlights the importance of timely detection and treatment of postoperative complications so that development of organ failure can be prevented.

In this study, 4.3% patients needed an emergency reoperation after index elective colorectal resection, which was comparable to other studies or could even be considered low. Reported reoperation rates after elective colorectal resection varies from 4.8% to 12.8%;[7,26–28] for example, the Dutch Surgical Colorectal Audit reported an average 9.7% reoperation rate.[29] The reoperation rate after emergency colorectal resection in our study was 10.4%, which also compared favorably to rates in earlier publications with reported rates of 7.0% to 14.3%.[7,27,30]

The overall FTR rate of 17.4% in our series could also be compared to reported figures. A nationwide Dutch cohort,

Table III
Findings in the first reoperation after elective and emergency index operation (one patient may have more than one finding)

	All patients n (%) ($n = 862$)	FTR in all patients n (%)	Elective index operation n (%) ($n = 438$)	FTR after elective index operation n (%)	Emergency index operation n (%) ($n = 424$)	FTR after emergency index operation n (%)	Difference in FTR between elective and emergency index operation P value
Anastomotic dehiscence	316 (36.7)	51 (16.1)	218 (49.8)	21 (9.6)	98 (23.1)	30 (30.6)	< .001
Fascial rupture	203 (23.5)	37 (18.2)	55 (12.6)	3 (5.5)	148 (34.7)	34 (23.0)	.004
Intra-abdominal bleeding	131 (15.3)	16 (12.2)	77 (17.6)	2 (2.6)	54 (12.7)	14 (25.9)	< .001
Bowel obstruction	88 (10.2)	11 (12.5)	48 (11.0)	2 (4.2)	40 (9.4)	9 (22.5)	.010
Stoma-related complications	56 (6.5)	11 (19.6)	14 (3.2)	0	42 (9.9)	11 (27.0)	.033
Peritonitis (source unclear)	55 (6.4)	11 (20.0)	14 (3.2)	1 (0.2)	41 (9.7)	10 (2.4)	.033
Bowel perforation	54 (6.3)	11 (20.3)	39 (8.9)	5 (12.8)	15 (3.5)	6 (40.0)	.026
Leak in rectal stump	54 (6.3)	11 (20.3)	39 (8.9)	5 (12.8)	15 (3.5)	6 (40.0)	.026
Bowel ischemia	50 (5.8)	19 (38.0)	23 (5.3)	4 (17.4)	27 (6.3)	15 (55.6)	.006
Wound infection*	33 (3.8)	4 (12.1)	10 (2.3)	0 (0)	23 (5.4)	4 (17.4)	.159
Intra-abdominal abscess	34 (3.9)	9 (26.5)	12 (2.7)	1 (8.3)	22 (5.2)	8 (36.4)	.065
Anastomotic stricture	15 (1.7)	0 (0)	10 (2.3)	0 (0)	5 (1.2)	0 (0)	
Wound bleeding	9 (1.0)	1 (11.1)	4 (0.9)	1 (25.0)	5 (1.2)	0 (0)	.236
Cholecystitis	6 (0.7)	1 (16.7)	1 (0.2)	0	5 (1.2)	1 (20.0)	.624
Hernia†	4 (0.5)	1 (25.0)	2 (0.5)	0	2 (0.5)	1 (50.0)	.248
Missed diagnosis in index operation‡	3 (0.3)	1 (25.0)	0	0	3 (0.7)	1 (33.3)	
Urinary leak	3 (0.3)	1 (33.3)	2 (0.5)	0 (0)	1 (0.2)	1 (100.0)	.083
Bile leak§	2 (0.2)	0 (0)	1 (0.2)	0 (0)	1 (0.2)	0 (0)	
No findings	71 (8.2)	13 (18.3)	33 (7.5)	1 (3.0)	38 (8.9)	12 (31.6)	.002

FTR, failure to rescue (90-day mortality after reoperation).

* Of all wound infections, 27 were superficial and 6 were deep.

† These patients had an incarcerated inguinal hernia ($n = 3$) or a laparoscopic port site hernia ($n = 1$).

‡ These patients had had a large bowel obstruction, but the reason for obstruction was distal to the primary resection. The reason for obstruction was another tumor ($n = 1$) or benign stricture ($n = 2$).

§ These patients had a lesion on the liver. One of them had had an additional liver resection, and the other one was due to an unintentional iatrogenic lesion of the liver.

including FTR after any complications, reported FTR rates ranging from 14% to 17%; a Swedish nationwide cohort had 10% FTR rate for severe complications with a Clavien-Dindo score of ≥3; and a UK cohort reported rates between 11% and 17% after reoperation, all depending on the hospital status.[28,31,32] However, in all these series FTR was defined as mortality within 30 days, whereas we define FTR as mortality within 90 days after reoperation. As mortality grows according to the length of follow-up, the FTR rates are also expected to be higher with a longer follow-up. Further, in these studies, the index operations included only cancer surgery (compared to only 44% in our series), and only 15% were carried out as emergency surgery (compared to 30% in our series). The FTR rate is expected to be lower in studies with more elective and cancer surgeries. In our series, the overall FTR for only malignant or premalignant lesions was 15%, and still 30% of these were carried out as emergency operations. In a German cohort based on nationwide records, comprising all colorectal resections irrespective of indication or urgency, reported FTR for operative complications ranging from 14.5% to 18.0%. The FTR was the highest (18.0%) for hospitals with the highest percentage of urgent operations (29.2%), which is quite similar to our series. However, in the German study, FTR was defined for all operative complications, not only those requiring reoperation, in which the FTR rate is likely higher.[33]

Due to the increased risk of both mortality and morbidity, unnecessary reoperations should be avoided. The proportion of negative reoperations was 8.2% in our study, which is lower than in previous reports.[34] Although the proportion of negative reoperations was similar for both elective and emergency index operations, the FTR rate was 10× higher in the emergency group.

The FTR rate after elective index colorectal resection was 8.0% in our series, which was at the low end of the reported rates varying between 7.9% and 13.2%.[7,35] The FTR rate of 27.1% after emergency index colorectal resection in our series was comparable to the figures reported in the literature. For example, a large Dutch multicenter study reported a FTR rate of 24%, but this study included all severe complications, not just reoperations, in the denominator and included only cancer surgery as the index operation.[36]

Our results, considering risk factors for FTR, were similar to previous studies for mortality in colorectal surgery.[6,37–39] We found an increased risk for FTR with increasing age, a high CCI, growing number of previous operations, malnutrition, and anticoagulation usage. Some data suggested that the FTR rate does not depend on factors affecting morbidity and overall mortality in colorectal surgery.[21,31,40,41] In our series, these factors were also relevant for FTR. Specifically, increasing age, particularly after emergency index operation, meant a tremendously increased risk for FTR. Patients >80 years had a 20-fold risk for FTR compared with younger patients (age <50). The higher mortality risk for the older patients is thought to partially arise from more comprehensive comorbidity in these patients.[42] In our study patients ≥80 years had a median CCI of 6, whereas the median CCI for patients <80 years was 1. However, both a high CCI and an increasing age were independent risk factors in the multivariable analysis in the entire group and for patients with an emergency index operation. Further, increased age was not an independent risk factor for patients with an elective index operation, even though the median CCI for this group was higher than for patients with an emergency index operation. The higher median CCI in this group was partly explained by a relatively higher incidence of malignancy compared with the emergency index operation group. For patients >80, the individual goals of care might also affect the FTR rate. Increasing age as an independent risk factor and its relation to comorbidity is still unclear and remains a target for future research. Malnutrition is known to increase the risk for FTR,[43,44] and measures to diminish this have been successfully taken for patients undergoing elective surgery. In this study, malnutrition was more common in the emergency index

Table IV
Rates and univariable analysis of risk factors for failure-to-rescue (ie, 90-day mortality after reoperation)

	All patients ($n = 862$)	Odds ratio (95% CI)	Patients with elective index operation ($n = 438$)	Odds ratio (95% CI)	Patients with emergency index operation ($n = 424$)	Odds ratio (95% CI)
	Failure to rescue n/total n (%)		Failure to rescue n/total n (%)		Failure to rescue n/total n (%)	
Patient characteristics						
Age (y)						
<50	4/125 (3.2)	Ref	1/70 (1.4)	Ref	3/55 (5.5)	Ref
50–60	13/157 (8.3)	2.731 (0.868–8.594)	2/90 (2.2)	1.568 (0.139–17.654)	11/67 (16.4)	3.405 (0.899–12.889)
60–70	36/224 (16.1)	5.793 (2.011–16.685)	5/113 (4.4)	3.194 (0.365–27.927)	31/111 (27.9)	6.717 (1.953–23.104)
70–80	52/238 (21.8)	8.457 (2.982–23.985)	13/115 (11.3)	8.794 (1.124–68.776)	39/123 (31.7)	8.048 (2.366–27.373)
>80	45/118 (38.1)	18.647 (6.441–53.998)	14/50 (28.0)	26.833 (3.391–212.307)	31/68 (45.6)	14.128 (4.128–51.086)
Sex, female	71/342 (20.7)	1.463 (1.026–2.085)	13/160 (8.1)	1.029 (0.503–2.104)	58/182 (3.9)	1.518 (0.987–2.335)
BMI (kg/m^2)						
20–25	49/301 (16.3)	Ref	13/156 (8.3)	Ref	36/145 (24.8)	Ref
<20	29/89 (32.6)	2.486 (1.451–4.260)	5/34 (14.7)	1.897 (0.628–5.732)	24/55 (43.6)	2.344 (1.221–4.502)
25–30	40/277 (14.4)	0.868 (0.551–1.366)	11/151 (7.3)	0.864 (0.375–1.994)	29/126 (23.1)	0.905 (0.517–1.585)
30–35	18/122 (14.8)	0.890 (0.495–1.600)	5/65 (7.7)	0.917 (0.313–2.685)	13/57 (22.8)	0.895 (0.434–1.846)
>35	7/56 (12.5)	0.735 (0.314–1.717)	1/31 (3.2)	0.367 (0.046–2.911)	6/25 (24.0)	0.956 (0.355–2.579)
Previous operations[*]		1.182 (1.007–1.388)		1.200 (0.878–1.640)		1.188 (0.978–1.443)
Cortisone	24/117 (14.0)	1.268 (0.778–2.062)	1/46 (2.2)	0.234 (0.031–1.751)	23/71 (32.4)	1.359 (0.784–2.358)
Immunosuppression	7/87 (8.1)	0.387 (0.175–0.855)	1/51 (2.0)	0.208 (0.028–1.551)	6/36 (16.7)	0.512 (0.207–1.264)
Smoking	27/127 (21.3)	1.343 (0.842–2.143)	3/46 (6.5)	0.785 (0.231–2.672)	24/81 (29.6)	1.166 (0.684–1.988)
Anticoagulation	39/133 (29.3)	2.310 (1.511–3.531)	12/67 (17.9)	3.301 (1.554–7.014)	27/66 (40.1)	2.124 (1.230–3.669)
Chronic kidney dysfunction	14/42 (33.3)	2.515 (1.290–4.902)	5/17 (29.4)	5.431 (1.794–16.435)	9/25 (36.0)	1.555 (0.667–3.624)
Metastatic disease (other than reason for surgery)	9/16 (56.3)	6.429 (2.355–17.547)	1/2 (50.0)		8/14 (57.1)	3.776 (1.281–11.132)
Charlson comorbidity index[†]		1.115 (1.061–1.171)		1.389 (1.237–1.560)		1.092 (1.029–1.160)
Index operation						
Reason for surgery						
Nonmetastatic malignant disease	32/270 (11.9)	Ref	22/187 (11.8)	Ref	10/83 (12.0)	Ref
Metastatic malignant disease	31/86 (36.0)	4.192 (2.360–7.445)	6/36 (16.7)[‡]	1.500 (0.561–4.008)	25/50 (50.0)	7.300 (3.081–17.296)
Ischemic disease	13/40 (32.5)	3.581 (1.679–7.639)			13/40 (32.5)	3.515 (1.380–8.954)
Inflammatory or other benign disease[§]	74/466 (15.9)	1.404 (0.900–2.191)	7/215 (3.3)	0.252 (0.105–0.605)	67/251 (26.7)	2.658 (1.297–5.448)
Resection						
Right-sided	75/293 (25.6)	Ref	16/134 (11.9)	Ref	59/159 (37.1)	Ref
Left-sided including rectal resections	62/451 (13.7)	0.456 (0.313–0.665)	16/245 (6.5)	0.500 (0.241–1.036)	46/206 (22.3)	0.482 (0.303–0.765)
Subtotal or total colectomy	14/133 (10.5)	0.332 (0.180–0.614)	3/67 (4.5)	0.331 (0.093–1.180)	11/66 (16.7)	0.331 (0.160–0.683)
Laparoscopic operation	12/186 (6.5)	0.269 (0.145–0.497)	12/181 (6.6)	0.722 (0.350–1.492)	0/5	
Anastomosis type						
Primary anastomosis	104/649 (16.0)	Ref	31/388 (8.0)	Ref	73/261 (28.0)	Ref
Protective diversion	6/40 (15.0)	0.925 (0.376–2.258)	3/28 (10.7)	1.382 (0.395–4.836)	3/12 (25.0)	0.858 (0.226–3.260)
No continuity	40/173 (23.1)	1.576 (1.045–2.377)	1/22 (4.5)	0.548 (0.71–4.215)	39/151 (25.8)	0.897 (0.570–1.412)
Surgical wound classification						
Clean Contaminated	71/568 (12.5)	Ref	33/403 (8.2)	Ref	38/165 (23.0)	Ref
Contaminated	10/51 (19.6)	1.707 (0.819–3.559)	1/19 (5.3)	0.623 (0.081–4.814)	9/32 (28.1)	1.30 (0.558–3.065)
Dirty	69/243 (28.4)	2.776 (1.910–4.33)	1/16 (6.3)	0.747 (0.096–5.837)	68/227 (30.0)	1.429 (0.902–2.265)
Emergency index operation	115/424 (27.1)	4.285 (2.854–6.434)				
Reoperation						
Perioperative organ failure[‖]	79/246 (32.1)	3.631 (2.522–5.228)	16/104 (45.7)	3.014 (1.488–6.105)	63/142 (44.4)	3.527 (2.255–5.518)
Intra-abdominal infection	68/393 (17.3)	0.987 (0.693–1.406)	25/258 (9.7)	1.824 (0.853–3.898)	43/135 (31.9)	1.409 (0.899–2.208)
Intra-abdominal bleeding	16/131 (12.2)	0.620 (0.358–1.080)	2/77 (2.6)	0.265 (0.062–1.129)	14/54 (25.9)	0.932 (0.487–1.786)
Fascial rupture	37/203 (18.2)	1.077 (0.715–1.623)	3/55 (5.5)	0.633 (0.187–2.141)	34/148 (23.0)	0.718 (0.452–1.140)
Bowel obstruction	11/88 (12.5)	0.653 (0.338–1.260)	2/48 (4.2)	0.470 (0.109–2.025)	9/40 (22.5)	0.761 (0.351–1.653)

CI, confidence interval.
[*] Per an increase of 1 operation.
[†] Per an increase of 1 point.
[‡] 33 elective index operations for metastatic disease were done with curative intent, and 3 were palliative.
[§] Premalignant lesion ($n = 51$), inflammatory bowel disease ($n = 74$), diverticulosis ($n = 187$), volvulus ($n = 50$), trauma ($n = 3$), iatrogenic ($n = 30$), gynecological hernia ($n = 2$), endometriosis ($n = 2$), hernia ($n = 9$), colitis ($n = 3$), coprostasis ($n = 38$), bleeding ($n = 4$), hidradenitis ($n = 1$), perforation ($n = 3$), polyposis ($n = 3$), appendicitis ($n = 6$), tuberculosis ($n = 2$), pancreatitis ($n = 1$), cholecystitis other benign tumor ($n = 2$).
[‖] Perioperative organ failure: Organ failure due to complication leading to reoperation.

Table V
Multivariable analysis on risk factors for failure to rescue (ie, 90-day mortality after reoperation)

	All patients	*P* value	Patients with elective index operation	*P* value	Patients with emergency index operation	*P* value
	Odds ratio		Odds ratio		Odds ratio	
Patient characteristics						
Age (y)						
<50	Reference		Reference		Reference	
50–60	1.865 (0.516–6.738)	.342	0.826 (0.070–9.755)	.879	2.037 (0.477–8.707)	.337
60–70	5.412 (1.681–17.426)	.005	1.019 (0.103–10.038)	.987	7.943 (2.100–30.039)	.002
70–80	8.946 (2.829–28.286)	< .001	2.368 (0.269–20.870)	.438	10.376 (2.803–38.414)	< .001
>80	22.893 (6.976–75.130)	< .001	5.825 (0.610–55.665)	.126	20.048 (5.091–78.942)	< .001
Sex, female	1.080 (0.676–1.728)	.747				
Previous operations	1.029 (0.825–1.285)	.798				
BMI (kg/m^2) 20–25	Reference				Reference	
<20	2.618 (1.313–5.219)	.006			2.399 (1.046–5.499)	.039
25–30	0.805 (0.473–1.368)	.422			0.853 (0.442–1.645)	.634
30–35	0.919 (0.449–1.882)	.818			0.877 (0.354–2.172)	.776
>35	0.911 (0.334–2.485)	.856			1.171 (0.357–3.844)	.794
Anticoagulation usage	1.997 (1.183–3.372)	.010			2.281 (1.201–4.330)	.012
Immunosuppression	1.018 (0.385–2.687)	.972				
Charlson comorbidity index	1.089 (0.974–1.217)	.134	1.284 (1.118–1.474)	< .001	1.069 (0.924–1.234)	.372
Chronic kidney dysfunction	2.933 (1.284–6.701)	.011	0.397 (0.085–1.846)	.239	0.490 (0.169–1.421)	.189
Metastatic disease (other than reason for surgery)	8.991 (2.844–28.422)	< .001	2.284 (0.086–60.382)	.621	9.128 (2.625–31.740)	.001
Index operation						
Emergency index operation	2.757 (1.540–4.938)	.001				
Laparoscopy	0.749 (0.328–1.708)	.492				
Reason for surgery						
Nonmetastatic malignant disease	Reference		Reference		Reference	
Metastatic malignant disease	4.115 (2.050–8.257)	< .001	1.232 (0.294–5.158)	.775	10.713 (3.958–28.997)	< .001
Ischemic disease	0.884 (0.331–2.365)	.807			1.986 (0.634–6.218)	.239
Inflammatory or other benign disease*	1.076 (0.611–1.897)	.799	0.853 (0.254–2.867)	.797	2.954 (1.310–6.661)	.009
Type of resection						
Right-sided colectomy	Reference				Reference	
Left-sided colectomy	0.504 (0.312–0.812)	.005			0.439 (0.248–0.779)	.005
Subtotal or total colectomy	0.323 (0.147–0.709)	.005			0.249 (0.101–0.612)	.002
Surgical wound classification (index operation)						
Clean contaminated	Reference					
Contaminated	1.894 (0.770–4.660)	.164				
Dirty	1.796 (1.022–3.155)	.042				
Conduit						
Primary anastomosis	Reference					
Protective diversion	1.734 (0.555–5.423)	.344				
No continuity	1.046 (0.564–1.942)	.886				
Reoperation						
Perioperative organ failure†	4.143 (2.630–6.526)	< .001	3.949 (1.771–8.807)	.001	4.128 (2.391–7.128)	< .001

Nagelkerke for all patients, 0.397; for patients with elective index operation, 0.284; and for patients with emergency index operation, 0.365. Hosmer-Lemenshow for all patients, 0.811; for patients with elective index operation, 0.307; and for patients with emergency index operation, 0.565.
BMI, body mass index.

* Premalignant lesion ($n = 51$), inflammatory bowel disease ($n = 74$), diverticulosis ($n = 187$), volvulus ($n = 50$), trauma ($n = 3$), iatrogenic ($n = 30$), gynecological hernia ($n = 2$), endometriosis ($n = 2$), hernia ($n = 9$), colitis ($n = 3$), coprostasis ($n = 38$), bleeding ($n = 4$), hidradenitis ($n = 1$), perforation ($n = 3$), polyposis ($n = 3$), appendicitis ($n = 6$), tuberculosis ($n = 2$), pancreatitis ($n = 1$), cholecystitis other benign tumor ($n = 2$).

† Organ failure due to complication leading to reoperation.

operation group and was not an independent risk factor for patients with an elective index operation. Finding ways to improve nutritional status for patients undergoing emergency surgery is a potential target for improvement but may turn out to be difficult due to a limited timeframe. We did not find a higher risk of FTR for patients who are overweight, although there was evidence to the contrary.[43,44] This might have been explained by the fact that, in our study, only 2.8% patients were classified as morbidly obese (BMI $\geq$40 kg/m^2). Anticoagulants almost doubled the risk for FTR. The increased risk for acute bleeding for patients receiving anticoagulants and the increased risk for mortality when acute bleeding occurs has been described in the literature.[38,39] However, none of the patients with anticoagulant medication in our study died as a result of bleeding or thrombosis. The comorbidities related to the use of anticoagulants might partly explain the increased risk. Immunosuppressant use was not an independent predictive factor.

The majority of the preoperative risk factors are nonmodifiable, especially in emergency settings, reducing the potential clinical applicability. However, recognizing major risk factors can guide surgeons in choosing the less risky operative strategy or choosing alternative treatment modalities.

Dirty wound classification in the index operation was an independent risk factor for FTR. This was similar to previous reports showing increased risk for surgical site infection through dirty wound classification.[45] Although measures to avoid dirty wounds in elective surgery have been taken, further optimization might be diffiicult for emergency surgery patients with dirty wounds.

Risk factors (eg, moderate or severe chronic kidney disease and metastatic malignancy) are usually reported as part of CCI. In our study, these factors were considered separately as they might affect individual goals of care.

Left-sided or subtotal colectomy had a protective effect on FTR compared to right-sided colectomy in the multivariable analysis. One possible explanation is that primary anastomosis is more frequently performed in right-sided colectomies, even in emergency settings, increasing the risk for severe complications.

Perioperative organ failure at the time of the first reoperation meant a 4× greater risk for FTR and was, together with high CCI, the only risk factor also found in the elective surgery subgroup, as well as the only possibly preventable risk factor. This risk factor for FTR has been previously described for patients undergoing esophagectomy.[46] Since the indication for reoperation showed no statistical difference in FTR, it seems that the higher risk of FTR is not related to the type of complication. Comorbidities might act as confounding factors, but this has been taken in consideration in the multivariable analysis. Escalation of care, meaning the process by which a patient's deteriorating clinical status is recognized and acted upon, possibly plays a key role in minimizing perioperative organ failure. However, the development of organ failure cannot always be avoided, emphasizing the need for high-quality intensive care. Many previous studies have suggested that the level of ICU is one of the most important factors affecting hospital-specific FTR rates.[47–49]

This study had limitations. Most importantly, this was a retrospective study with all inherited risks of bias. However, unlike other similar studies, this study was not registry based, and all patient records were screened and data extracted manually, which improves the quality of the data. The study cohort included all patients undergoing colorectal resection, which can be considered both a limitation and a strength. Due to the heterogeneity, the reported outcomes could not easily be comparable to other reports, including only cancer patients. However, by focusing only on cancer patients, 55% of patients undergoing colorectal surgery would be left out of the analyses. A major strength of this study was the population-based approach including all patients within a defined geographical area, the multicenter approach, and the large number of patients.

In conclusion, the results of this study had several implications for future research and clinical practice. As the need for some emergency procedures inevitably will remain, it is important to focus on the perioperative care for these patients. Since patients with emergency index operations are at a higher risk for complications, reoperation, and failure to rescue, they could benefit from more intense perioperative monitoring to improve escalation of care. Good availability of intensive care is also necessary. For patients diagnosed with metastatic cancer, emergency surgery might be avoided through more intense cooperation with the surgical unit throughout the oncologic treatment. Operative strategies for palliative care as well as individual goals of care should be carefully considered preoperatively, even before emergency surgery. Future research also should focus on the prevention and care of complications other than anastomotic dehiscence, namely fascial rupture, bowel obstruction, and postoperative hemorrhage, as these are the most common causes for reoperation. These complications need to be studied in detail, preferably in a prospective multicenter fashion. Lastly, improvements in postoperative surveillance and awareness should be considered in order to detect complications early, before they lead to organ dysfunction increasing the FTR rate.

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Conflict of interest/Disclosure

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