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ORIGINAL ARTICLE

Risk factors for mortality–morbidity after emergency–urgent colorectal surgery

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Abstract
Background The aim of this study was to assess the risk factors associated with mortality and morbidity following emergency or urgent colorectal surgery.
Materials and methods All data regarding the 462 patients who underwent emergency colonic resection in our institution between November 2002 and December 2007 were prospectively entered into a computerized database.
Results The median age of patients was 73 (range 17–98) years. The most common indications for surgery were: 171 adenocarcinomas (37%), 129 complicated diverticulitis (28%), and 35 colonic ischemia (7.5%). Overall mortality and morbidity rates were 14% and 36%, respectively. In multivariate analysis, the only parameter significantly associated with postoperative mortality was blood loss >500 cm^3 (odds ratio (OR)=3.33, 95% confidence interval (CI) 1.63–6.82, p=0.001). There were three parameters which correlated with postoperative morbidity: ASA score ≥3 (OR=2.9, 95% CI 1.9–4.5, p<0.001), colonic ischemia (OR=3.4, 95% CI 1.4–7.7, p=0.006), and stoma creation (OR=2.2, 95% CI 1.4–3.4, p=0.0003).
Conclusions The main risk factors for postoperative morbidity and mortality following emergency colorectal surgery are related to: (1) patients' ASA score, (2) colonic ischemia, and (3) perioperative bleeding. These variables should be considered in the elaboration of future scoring systems to predict outcome of emergency colorectal surgery.

Keywords Outcome · Emergency · Surgery · Colorectal · Mortality

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Introduction

In contrast with elective colectomies, which carry less than 1% mortality, emergency colonic resections might constitute surgical challenges, resulting in high mortality and morbidity rates. It is estimated that 17–20% of patients with colon cancer [1, 2], as well as 22–28% of those with diverticular disease [3, 4], present with septic complications or bowel obstruction and will require an urgent operation. In many primary care institutions, one fourth of all colectomies are performed on a nonelective basis [5], with 10–25% mortality and 30–50% morbidity rates [6, 7]. It is therefore not surprising that the high prevalence of death after emergency colorectal surgery has attracted considerable attention from national authorities involved in quality control of surgical care [8, 9].

Operative mortality is an objective measure of outcome that can be used to monitor surgical performance and compare quality of care. Surgical associations in France [10] and the UK [11] have established scores in order to predict mortality following either elective colorectal surgery or colorectal cancer resection. Various scoring systems, such as the Physiological and Operative Severity Score for

the Enumeration of Mortality and Morbidity (POSSUM) or the Simplified Acute Physiology Score (SAPS) II, have been evaluated in patients undergoing emergency colorectal surgery [12, 13]; however, the POSSUM score seems to underpredict mortality when emergency workload exceeds 20%. Subsequently, efforts have been made to modify POSSUM into a dedicated colorectal scoring system from a series of 6,790 patients [14]: however, only 2.9% of patients in this series underwent emergency surgery (with a 25% mortality rate), and 3,200 patients were operated for benign conditions such as hemorrhoids and fissure or underwent stoma creation–reversal only.

The term "emergency colorectal surgery" encompasses a wide range of clinical situations and operative procedures, not restricted to colorectal cancer and complicated diverticulitis, but involving also colonic ischemia, traumatic perforation, volvulus, and inflammatory bowel disease. In addition, different definitions of what is an emergency versus urgent operation have been proposed, based either upon time, department of admission, or disease severity criterions [15, 16]. We postulated that the proper identification of risk factors for mortality–morbidity in a prospective monocentric series of patients undergoing emergency colorectal surgery was a prerequisite for the development of a new, disease-specific, and dedicated prognostic system. The aim of this study was to assess risk factors for mortality and morbidity following nonelective colonic resection in a consecutive unselected population of patients presenting in the emergency department of a primary care teaching institution.

Materials and methods

From November 2002 until December 2007, all patients undergoing emergency resection of the colon or rectum in our institution were prospectively included in a computerized database. Colorectal procedures which did not result in a formal bowel resection (i.e., rectopexy, transanal excision of rectal tumors, isolated creation or closure of colostomy–ileostomy) were excluded from this analysis. Emergency surgery was defined as a procedure occurring within the first 24 h of an unplanned admission, while urgent surgery was defined as a procedure delayed for up to 72 h after an unplanned admission. Emergency procedures for complications of a prior elective operation were excluded from the study.

The structured sheet of data collection included the following items:

1. Patient characteristics: gender, age, ASA score, body mass index, and comorbidity(ies) (cardiopulmonary, neurological, hepatic, renal)
2. Disease features: cancer, polyp, diverticulosis, diverticulitis, and inflammatory bowel disease and its mode of presentation (pain, sepsis, constipation, obstruction, bleeding, etc)
3. Surgical procedure: urgent or emergency, open or laparoscopic, type of anesthesia, type of incision, duration of the procedure, blood loss, amount of homologous blood transfused, type of resection (right, transverse, left, sigmoid, low anterior, abdominoperineal), type and location of anastomosis (manual or stapled, ileocolic, colocolic, colorectal, coloanal, ileorectal, ileoanal)
4. Postoperative events: mortality and its cause, morbidity (wound infection, prolonged ileus, fever >38.5°C, intra-abdominal abscess, clinical anastomotic leak, pneumonia, cardiopulmonary failure, arrhythmia, renal failure, bleeding, pulmonary embolism, deep vein thrombosis, sepsis), and the need for reintervention

In this study, postoperative mortality and morbidity were defined as death or any complication occurring during hospital stay. The surgeon himself was responsible for completing the data sheet at the end of the operation, and a dedicated clinical nurse (BK) was in charge of prospectively collecting the information regarding postoperative course and the date of discharge. The study nurse identified the complications, and the final verdict was made by the senior author (PG), who was also responsible for stratifying primary (ex. anastomotic leak) and secondary (ex. multiple organ failure) complications in patients who presented more than one adverse event. The University Hospital in Geneva is the only public medical institution in a mainly urban area with a population of approximately 500,000 inhabitants.

Statistical analysis

Descriptive statistics were reported for all variables. Continuous variables were summarized with means, standard deviations, medians, and ranges. Categorical variables were summarized with frequencies and percentages. All descriptive statistics were stratified by mortality and morbidity. The relationships between potential risk factors for mortality and morbidity were explored using univariable logistic regression methods. Multivariable logistic regression techniques were used to develop the final models for mortality and morbidity. SAS V9.1 software was used to summarize and analyze all the data. p values<0.05 were considered statistically significant.

Results

Over the complete period, 462 colectomies were performed in our institution. There were 246 (53.2%) women and 216 (46.8%) men with a median age of 69.1 (range 17–

105) years. The median duration of hospital stay was 20.6 (range 1–205) days. The detailed patients' characteristics, procedures, and indications for surgery are summarized in Table 1. Roughly, two thirds of all operations were performed for cancer or Hinchey III–IV diverticulitis. The median duration of the procedure was 199 (range 50–600) min. In this study, 301 (65%) of patients were ASA≥3, and 79 (17%) of patients were ASA 4–5. The majority of patients were scheduled for laparotomy, while 19 patients (4.1%) underwent explorative laparoscopy with a high (52.6%) conversion rate. In this series, there were 231 anastomoses performed, with a leak rate of 8.6%. Out of 20 patients who suffered an anastomotic leak, seven (35%) died. Eighteen out of 231 anastomoses (7.8%) were protected by a diverting stoma.

Table 1 Patients' demographics, conditions, and procedures performed

Parameter	Number (percentage) or [range]
Gender (male/female)	216/246
Age [median range]	69 [17–105]
<70	296 (64)
≥70	166 (36)
BMI [median range]	25 [15–43]
ASA	
1–2	161 (35)
≥3	301 (65)
Diagnosis	
Carcinoma	171 (37)
Diverticulitis	129 (28)
Perforation (trauma)	39 (8.4)
Ischemia	35 (7.5)
IBD	18 (3.9)
Volvulus	14 (3)
Other	56
Procedure	
Right colectomy	160 (35)
Hartmann's	142 (31)
Left colectomy	94 (20)
Subtotal colectomy	43 (9)
Low anterior resection	23 (5)
Timing	
Emergency	415 (90)
Urgent	47 (10)
Stoma creation	
Ileostomy	56 (12)
Colostomy	193 (42)
No stoma	213 (46)
Duration of surgery	
<180 min	209 (45)
≥180 min	253 (55)
Blood loss	
<500 cm^3	411 (89)
≥500 cm^3	51 (11)

Risk factors for mortality

Overall mortality rate was 14.1%. The main causes of death of 65 patients are summarized in Table 2. In univariable logistic regression (Table 3), the following parameters were associated with increased postoperative mortality: age >70 years, ASA score ≥3, diagnosis of colonic ischemia, perioperative blood loss >500 cm^3, need for perioperative transfusions, subtotal (versus segmental) colectomy, anastomosis technique (a side-to-side technique being associated with reduced mortality), and stoma creation. In multivariable logistic regression (Table 4), the only parameter associated with increased risk of postoperative death was blood loss >500 cm^3. The model shows that patients with perioperative blood loss >500 cm^3 were three times more likely to die than those who experienced less than 500 cm^3 blood loss (odds ratio (OR)=3.3, 95% confidence interval (CI)=1.6–6.8, p=0.001).

Risk factors for morbidity

Among survivors, 166 patients (35.9%) experienced one (118 patients) or more (48 patients) adverse events for a total of 220 nonlethal complications, which are detailed in Table 5. In univariable logistic regression (Table 6), the following parameters were associated with increased postoperative morbidity: age >70 years, ASA score ≥3, diagnosis of colonic ischemia, need for transfusion, emergency (vs. urgent) operation, subtotal (vs. segmental) colectomy, end-to-end technique of anastomosis, and stoma creation.

Table 2 Causes of postoperative death following emergency colorectal surgery

Cause	Number	Percentage
Multiple-organ failure	28	37
Sepsis	11	17
Anastomotic leak	7	11
Acute respiratory failure	2	3
Acute cardiac failure	2	3
Hemorrhage	2	1.5
Acute renal failure	1	1.5
Epilepsy	1	1.5
Pulmonary embolus	1	1.5
Pneumonia	1	6.2
Other	9	

Table 3 Univariable analysis of risk factors for postoperative mortality

Variable	Category	Death rate (%)	*p* value
Age	<70	10	0.002
	≥70	21	
Gender	Female	14	0.870
	Male	14	
BMI	<25	7	0.108
	≥25	15	
ASA score	1, 2	1	<0.001
	≥3	23	
Diagnosis	Cancer	12	<0.001
	Ischemia	34	
	Other	12	
Disease location	Rectum	12	0.259
	Left colon	12	
	Right colon	17	
Duration of surgery	<180	13	0.762
	>180	14	
Blood loss (ml)	<500	12	0.001
	>500	31	
Transfusion	Yes	44	<0.001
	No	14	
Type of colectomy	Subtotal	25	0.030
	Segmental	13	
Anastomosis technique	End-to-end	16	0.038
	Side-to-end	16	
	Side-to-side	3	
Stoma	None	10	<0.001
	Ileostomy	32	
	Colostomy	13	

In multivariable logistic regression (Table 7), the parameters associated with increased risk of postoperative morbidity were ASA score ≥3, colonic ischemia, and stoma creation. Patients with ASA scores ≥3 had a three times higher risk of morbidity than the others (OR=2.96, 95% CI=1.91–4.57, $p<0.001$); patients presenting with colonic ischemia had a more than three times higher risk of morbidity than either of the other two main diagnostic categories (ischemia vs. cancer: OR=3.38, 95% CI=1.48–7.71, $p=0.003$ and ischemia vs. diverticulitis: OR=3.064, 95% CI=1.36–6.89, $p=0.006$); finally, stoma patients (whether an ileostomy or a colostomy) had a more than two times higher risk of morbidity than patients who benefited from an anastomosis (OR=2.23, 95% CI=1.44–3.44, $p<0.001$).

Table 4 Multivariable analysis of risk factors for postoperative mortality

Variable	Odds ratio	95% Wald confidence limits	Wald chi-square	*p*
Blood loss	3.336	1.631–6.82	10.8958	0.001

Table 5 Nonlethal complications following emergency colonic resection

Fever	27
Wound abscess	22
Sepsis	19
Arrhythmia	19
Acute respiratory failure	15
Anastomotic leak	13
Pneumonia	12
Prolonged ileus	11
Myocardial infarctus–ischemia	10
Intra-abdominal abscess	9
Acute renal failure	7
Hemorrhage	7
Anemia	5
Pulmonary embolus	6
Clostridium difficile colitis	4
Multiple-organ failure	4
Deep vein thrombosis	3
MRSA infection	3
Incisional hernia	3
Urinary tract infection	3
Epilepsy	2
High blood pressure	2
Fistula	2
Anaphylactic shock	2
Pneumothorax	1
Urinary retention	1
Other	8
Total	220

Discussion

The data presented here indicate that emergency colorectal surgery is associated with 14% mortality and 36% morbidity rates and that two thirds of procedures are performed either for carcinoma or for complicated diverticular disease. Eleven percent of patients experienced perioperative bleeding in excess of 500 cm^3, which represents the main risk factor for mortality. Of all patients, 7.5% presented with colonic ischemia, which is one of the three main risk factors for postoperative morbidity, in association with ASA score ≥3 and stoma creation.

Emergency surgical management of colorectal disease is a challenge in various situations and the wide difference between mortality rates after elective colonic resections (1–3%) and similar procedures nonelectively performed (12–20%) indicate that multiple parameters are likely to be involved [17, 18]. These parameters can be

Table 6 Univariable analysis of risk factors for postoperative morbidity

Variable	Category	Morbidity (%)	*p* value
Age	<70	44	0.046
	≥70	54	
Gender	Female	48	0.805
	Male	47	
BMI	<25	37	0.097
	≥25	50	
ASA score	1, 2	30	<0.001
	≥3	60	
Diagnosis	Cancer	40	<0.001
	Ischemia	72	
	Diverticulitis	48	
Disease location	Rectum	62	0.325
	Left colon	48	
	Other	46	
Duration of surgery (min)	<180	42	0.098
	>180	51	
Blood loss (ml)	<500	43	0.121
	>500	55	
Transfusion	Yes	76	0.004
	No	44	
Status	Emergency	50	0.024
	Urgent	32	
Type of colectomy	Subtotal	63	0.025
	Segmental	46	
Anastomosis technique	End-to-end	57	<0.001
	Side-to-end	41	
	Side-to-side	33	
Stoma	None	35	<0.001
	Ileostomy	69	
	Colostomy	55	

related (1) to the patient's condition (ASA score, advanced age, comorbidities), (2) to the septic consequences of the disease (fecal or purulent peritonitis), and (3) to the consequences of the procedure itself (bleeding, extent of colectomy, stoma creation). The latter parameter has been underestimated or ignored, in most existing predictive scoring systems [19, 20].

In this study, perioperative bleeding was strongly correlated with postoperative mortality. It is important to note that a significant blood loss by itself is not a surrogate for surgical performance but might be influenced by patient-related variables, such as poor nutrition, liver failure, portal hypertension, or anticoagulation treatment. Perioperative blood loss (overt or occult) was associated with higher postoperative mortality in a large series of colorectal cancer patients [21]. In a recent series of patients with ischemic colitis, intraoperative blood loss was a risk factor for postoperative mortality [22]. Obviously, perioperative bleeding might only reflect a more difficult procedure, but the authors of the latter study rightfully stated that every effort should be made in order to minimize evitable blood losses, contributing to more hemodynamic instability in these high-risk patients. While ASA stage did not emerge as a risk factor in multivariate analysis, it was clearly correlated with mortality in univariate analysis; ASA 1–2 patients had 1% mortality rate, compared with a 23% mortality rate when ASA score was 3 or more. Thus, ASA score remains clinically highly relevant (if not statistically significant) in this series, and the simple combination of ASA score ≥3 and perioperative bleeding >500 cm^3 is a powerful predictor of poor outcome.

In addition, another surgery-related variable, the need for stoma creation (especially an ileostomy), was strongly correlated with postoperative morbidity. There is a great variability in the surgical management of colorectal emergencies: high-volume, as well as colorectal, surgeons are more likely to perform restorative procedures [6, 23] and to achieve better results in terms of perioperative mortality rates [24, 25]. However, correlation is not a synonym for causality, and many clinicians would argue that creating a stoma might just reflect a combination of adverse septic and hemodynamic conditions incompatible with an anastomosis, thus indicating sound surgical judgement. To support this argument, it is interesting to note that the morbidity rates for colonic ischemia (72%), subtotal colectomy (63%), and ileostomy creation (69%) show striking similarities.

In conclusion, the morbidity and mortality rates for emergency colonic resection remains high, largely due to the patients' comorbidities and the septic consequences of large bowel perforation; these variables have been rightfully included in currently available scoring systems. However, the main risk factors identified in this study (blood loss–mortality; stoma creation–morbidity) appear to be directly related to the procedure itself. Our data demonstrate a strong relationship between perioperative bleeding and mortality, thus providing support to the inclusion of this variable in future scoring systems predicting mortality after emergency colorectal surgery.

Table 7 Multivariable analysis of risk factors for postoperative morbidity

	Odds ratio	95% Wald confidence limits		Wald chi-square	*p*
ASA score	2.961	1.918	4.57	24.0332	<0.001
Diagnosis	3.388	1.487	7.718	8.4403	0.003
Ischemia vs. cancer					
Diagnosis	3.064	1.361	6.896	7.3179	0.006
Ischemia vs. diverticulitis					
Stoma	2.23	1.442	3.446	13.0215	0.0003

Indirectly, it emphasizes the role of the surgical performance in the management of these difficult patients.

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