

Perioperative risk factors for in-hospital mortality after emergency gastrointestinal surgery

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Abstract

Few studies have evaluated the risk factors for in-hospital mortality in critically ill surgical patients who have undergone emergency gastrointestinal (GI) surgery. The aim of this study was to identify the risk factors associated with in-hospital mortality in critically ill surgical patients after emergency GI surgery.

The medical records of 362 critically ill surgical patients who underwent emergency GI surgery, admitted to intensive care unit between January 2007 and December 2011, were reviewed retrospectively. Perioperative biochemical and clinical parameters of survivors and nonsurvivors were compared. Logistic regression multivariate analysis was performed to identify the independent risk factors of mortality.

The in-hospital mortality rate was 15.2% (55 patients). Multivariate analyses revealed cancer-related perforation (odds ratio [OR] 16.671, 95% confidence interval [CI] 2.629–105.721, $P=0.003$), preoperative anemia (hemoglobin $<10\text{g/dL}$; OR 6.976, 95% CI 1.376–35.360, $P=0.019$), and preoperative hypoalbuminemia (albumin $<2.7\text{g/dL}$; OR 9.954, 95% CI 1.603–61.811, $P=0.014$) were independent risk factors of in-hospital mortality after emergency GI surgery.

The findings of this study suggest that in critically ill patients undergoing emergency GI surgery, cancer-related peritonitis, preoperative anemia, and preoperative hypoalbuminemia are associated with in-hospital mortality. Recognizing risk factors at an early stage could aid risk stratification and the provision of optimal perioperative care.

Abbreviations: APACHE II = Acute Physiology and Chronic Health Evaluation II, ASA = American Society of Anesthesiologists, BUN = blood urea nitrogen, GI = gastrointestinal, Hb = hemoglobin, ICU = intensive care unit, MPI = Mannheim Peritonitis Index, SAPS II = Simplified Acute Physiology Score II, SOFA = Sequential Organ Failure Assessment.

Keywords: critically ill, emergency surgery, mortality

1. Introduction

Peritonitis is one of the most common surgical emergencies,^[1] and has relatively high morbidity and mortality rates.^[2] However, mortality rates remain high despite advances in surgical techniques, antimicrobial therapy, and intensive care support.^[2,3] The 2009 updated guidelines for managing patients with intra-abdominal infection recommend rapid fluid resuscitation, early initiation of antibiotics, and appropriate source-control procedures.^[4]

Numerous studies have tried to identify prognostic biomarkers in critically ill patients. Of those identified, lactates or lactate clearance,^[5,6] base excess,^[7] and serum pro-calcitonin (PCT)^[8] are used most often in clinical practice. In addition, many scoring systems, such as the Acute Physiology and Chronic Health Evaluation II (APACHE II) score,^[9] the Simplified Acute Physiology Score II (SAPS II),^[10] the Sequential Organ Failure Assessment (SOFA),^[11] and the Mannheim Peritonitis Index (MPI)^[12] systems, have been introduced to estimate disease severity and prognosis in critically ill patients.^[13]

However, with the exception of the MPI system, none of the scoring systems mentioned above is specific for peritonitis. Furthermore, these scoring systems are difficult to implement and little help during decision-making in alone. Few studies have evaluated risk factors in critically ill surgical patients with peritonitis. It is important that these risk factors be identified to stratify risks and optimize perioperative care. Accordingly, we performed this study to identify perioperative risk factors for in-hospital mortality in critically ill patients after emergency gastrointestinal (GI) surgery.

2. Materials and method

2.1. Setting and population

This study was performed using a retrospective cohort design. The analysis was conducted using the records of a surgical intensive care unit (ICU) at a single tertiary referral hospital in Seoul, Korea. The data of 500 patients who underwent emergency GI surgery for peritonitis between January 2007 and December 2011 were reviewed. One hundred thirty-eight

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Table 1
Baseline characteristics of patients.

	Total (362)	Survivors (300)	Nonsurvivors (49)	<i>P</i>
Age, mean \pm S.D	64.1 \pm 14.4	62.9 \pm 14.6	60.9 \pm 16.4	0.375
Sex, n (%)				
Male	212 (60.7)	187 (62.3)	25 (51.0)	0.156
Female	137 (39.3)	113 (37.7)	24 (49.0)	
CVD, n (%)	67 (19.2)	58 (19.3)	9 (18.4)	1.000
Pulmonary, n (%)	43 (12.3)	36 (12.0)	7 (14.3)	0.815
DM, n (%)	61 (17.5)	52 (17.3)	9 (18.4)	1.000
CRF, n (%)	46 (13.2)	39 (13.0)	7 (14.3)	0.820
ASA score, mean (IQR)	3 (3–3)	3 (3–3)	4 (4–4)	<0.001
APACHE II score, mean \pm SD	19.5 \pm 7.2	19.3 \pm 7.2	20.2 \pm 7.5	<0.475
Cause, n (%)				0.219
Ulcerative	53 (15.2)	48 (16.0)	5 (10.2)	
Ischemic	32 (9.2)	28 (9.3)	4 (8.2)	
Diverticulitis	22 (6.3)	19 (6.3)	3 (6.1)	
Cancer	89 (25.5)	71 (23.7)	18 (36.7)	
Obstruction	26 (7.4)	24 (8.0)	2 (4.1)	
Trauma	20 (5.7)	20 (6.7)	0 (0.0)	
Iatrogenic	37 (10.6)	33 (11.0)	4 (8.2)	
Others	70 (20.1)	57 (19.0)	13 (26.5)	

APACHE II=Acute Physiology and Chronic Health Evaluation II, ASA=American Society of Anesthesiologist, CRF=chronic renal failure, CVD=cerebrovascular disease, DM=diabetes mellitus, IQR=interquartile range, pulmonary=pulmonary disease.

patients admitted to a general ward postoperatively or who were below 20 years of age were excluded. Finally, 362 patients were enrolled. Approval for this study was obtained beforehand from our institutional review board (IRB No. 4–2015–0424).

2.2. Variables and definition

Demographic data, such as age, sex, underlying disease, American Society of Anesthesiologist (ASA) score, APACHE II score, and cause of peritonitis, were collected. Lengths of hospital stays, lengths of ICU stays, durations of mechanical ventilation, and information on re-operations were collected and analyzed. Perioperative biochemical parameters, such as hemoglobin (Hb) levels, renal function test results, arterial blood gas analysis (ABGA) findings, serum albumin levels, and the presence of septic shock, were analyzed. Blood culture and peritoneal fluid culture results and times of antibiotic administration were included among perioperative variables. Operative variables were evaluated by surgical approach, operation type, and anatomic origin.

Preoperative biochemical parameters were measured immediately after emergency admission, or for in-patients, were the poorest recorded during the 24 hours before surgery. Postoperative biochemical parameters were measured immediately after surgery.

Initially broad-spectrum antibiotics were administered empirically, and these were changed to specific antibiotics after obtaining blood culture or peritoneal fluid culture results. First results available after hospital arrival were viewed as preoperative biochemical parameters.

Septic shock was defined by a systolic arterial pressure <90 mm Hg, a mean arterial pressure <60 mm Hg, or in case of using vasopressors.^[14]

Patients were divided into 2 groups: survivors (n=307) and nonsurvivors (n=55). These 2 groups were compared with respect to perioperative biochemical and clinical variables.

2.3. Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 20.0 (IBM Co. Armonk, NY). Categorical data were compared using the chi-square or Fisher exact test, and continuous variables were compared using the independent *t* test or Mann–Whitney *U* test. The continuous variables were converted into categorical variables for the analysis. Factors found to be significantly associated with mortality (*P*<0.05) by univariate analysis were included in the multivariate analysis, which was performed using the logistic regression model using the maximum likelihood method and backward stepwise selection. Goodness of fit was assessed using the Hosmer–Lemeshow test.

3. Results

3.1. Baseline characteristics and clinical outcomes

Of the 362 study subjects, 307 (84.8%) survived and 55 (15.2%) patients died. Overall mean subject age was 62.4 \pm 15.0 years. Mean age, sex, and underlying diseases were nonsignificantly different in the survivor and nonsurvivor groups. Mean APACHE II scores in the 2 groups were 18.3 \pm 6.1 and 22.9 \pm 6.8, respectively (*P*<0.001). Malignancy of the GI tract was the most common cause of bowel perforation (Table 1).

Nonsurvivors stayed in the ICU longer, and more frequently required mechanical ventilation (Table 2).

3.2. Analysis of perioperative biochemical parameters

Preoperative anemia (Hb <10 g/dL) was detected in 37 patients, and was more common in nonsurvivors (39.3%) than in survivors (11.8%). Blood urea nitrogen (BUN) was significantly higher in nonsurvivors (*P*=0.008), whereas serum creatinine levels were no different in the 2 groups. Initial hyperlactatemia (>4 mmol/L) was more common in nonsurvivors (37.7% vs 19.8%; *P*=0.073), and hypoalbuminemia (<2.7 g/dL) was significantly higher in nonsurvivors (*P*<0.001) (Table 3). Laparoscopic surgery was more frequently performed in survivors (Table 4).

Table 2
Baseline characteristics of patients.

	Total (349)	Survivors (300)	Nonsurvivors (49)	<i>P</i>
Length of hospital stay, d, median (IQR)	23.0 (14.0–41.2)	22.0 (14.0–40.7)	30.0 (15.2–48.7)	0.046
Length of ICU stay, d, median (IQR)	3.0 (2.0–7.0)	3.0 (2.0–5.7)	6.0 (2.0–18.5)	<0.001
Duration of MV, d, median (IQR)	1.0 (1.0–4.0)	1.0 (0.0–3.0)	5.0 (1.0–13.2)	0.002
Re-operation, n (%)	44 (12.6)	31 (10.3)	13 (26.5)	0.003
Blood culture positive, n (%)	21 (11.4)	14 (8.6)	7 (31.8)	0.005
Peritoneal fluid culture positive, n (%)	145 (70.0)	111 (65.7)	34 (89.5)	0.005

ICU=intensive care unit, IQR=interquartile range, MV=mechanical ventilation.

Table 3
Preoperative parameters by univariate analysis.

	Survivors (307)	Nonsurvivors (55)	P
Hb, n (%)			0.003
≥10 g/dL	195 (88.2)	17 (60.7)	
<10 g/dL	26 (11.8)	11 (39.3)	
BUN, n (%)			0.008
≥30 mg/dL	64 (29.0)	15 (53.6)	
<30 mg/dL	157 (71.0)	13 (46.4)	
Creatinine, n (%)			0.448
≤1.3 mg/dL	150 (67.9)	17 (60.7)	
>1.3 mg/dL	71 (32.1)	22 (39.3)	
pH	7.40±0.08	7.38±0.14	0.544
Lactate, n (%)			0.073
≥4 mmol/L	33 (19.8)	7 (38.9)	
<4 mmol/L	134 (80.2)	11 (61.1)	
Base excess, n (%)			0.028
<-7 mmol/L	69 (35.4)	15 (57.7)	
≥-7 mmol/L	126 (64.6)	11 (42.3)	
Albumin, n (%)			<0.001
≥2.7 g/dL	195 (90.3)	18 (64.3)	
<2.7 g/dL	21 (9.7)	10 (35.7)	
Shock, n (%)	42 (19.1)	13 (48.1)	0.001
Initiation of antibiotics, n (%)			0.395
≤1 h	47 (15.3)	6 (10.9)	
>1 h	260 (84.7)	49 (89.1)	

BUN=blood urea nitrogen, Hb=hemoglobin.

Univariate analysis of postoperative data identified anemia, elevated BUN, hyperlactatemia, base deficit, hypoalbuminemia, and shock as significant factors (Table 5).

3.3. Independent risk factors by multivariate analysis

Multivariate analysis revealed preoperative anemia (odds ratio [OR] 5.109, 95% confidence interval [CI] 1.292–20.205, *P*=0.020), preoperative hypoalbuminemia (OR 10.692, 95% CI 2.321–49.248, *P*=0.002), cancer-related peritonitis (OR 9.664, 95% CI 2.304–40.533, *P*=0.002), and postoperative hyperlactatemia (OR 5.337, 95% CI =1.418–20.094, *P*=0.013) independently predicted in-hospital mortality (Table 6).

4. Discussion

In our cohort of critically ill surgical patients of mean age of 60 years who had undergone emergency GI surgery, overall in-

Table 4
Intraoperative parameters by univariate analysis.

Intraoperative	Survivors (307)	Nonsurvivors (55)	P
Surgical approach, n (%)			0.025
Laparoscopic	36 (11.7)	1 (1.8)	
Open	271 (88.3)	54 (98.2)	
Operation type, n (%)			0.632
Primary repair	97 (31.6)	17 (30.9)	
Wedge resection	4 (1.3)	0 (0)	
Segmental resection	99 (32.2)	15 (27.3)	
Ostomy formation	107 (34.9)	23 (41.8)	
Anatomic origin, n (%)			0.458
Stomach	127 (41.4)	25 (45.5)	
Small bowel	94 (30.6)	16 (29.1)	
Colon and rectum	119 (38.8)	23 (41.8)	

Table 5
Postoperative parameters by univariate analysis.

	Survivors (307)	Nonsurvivors (55)	P
Hb, n (%)			<0.001
≥10 g/dL	226 (73.6)	27 (50.0)	
<10 g/dL	81 (26.4)	27 (50.0)	
BUN, n (%)			<0.001
≥30 mg/dL	55 (18.0)	25 (45.5)	
<30 mg/dL	251 (82.0)	30 (54.5)	
Creatinine, n (%)			0.002
≤1.3 mg/dL	233 (76.1)	31 (56.4)	
>1.3 mg/dL	73 (23.9)	24 (43.6)	
pH	7.33±0.40	7.32±0.11	0.777
Lactate, n (%)			0.002
≥4 mmol/L	54 (18.6)	20 (37.7)	
<4 mmol/L	236 (81.4)	33 (62.3)	
Base excess, n (%)			0.062
<-7 mmol/L	157 (51.8)	36 (65.5)	
≥-7 mmol/L	146 (48.2)	19 (34.5)	
Albumin, n (%)			0.006
≥2.7 g/dL	80 (26.1)	5 (9.1)	
<2.7 g/dL	226 (73.9)	50 (90.9)	
Shock, n (%)	80 (26.1)	36 (65.1)	<0.001

BUN=blood urea nitrogen, Hb=hemoglobin.

hospital mortality was 15.2% which concurs with previous studies.^[1,3,15,16] Although previous studies have found age and sex are risk factors of mortality among peritonitis patients,^[1,17,18] we observed no significant effect.

Elevated blood lactate levels have been used to define the prognostic value of occult hypoperfusion and tissue hypoxemia in critically ill patients. A lactate level of ≥4 mmol/L has been reported to be highly specific (89%–99%) for predicting acute-phase mortality and in-hospital mortality.^[5] In recent years, several reports have been issued on the use of lactate level as a prognostic factor for technical surgery, particularly cardiovascular surgery or for patients with sepsis due to colorectal perforation.^[19] In the present study, postoperative hyperlactatemia (≥4 mmol/L) was observed in the nonsurvivor group (37.7%) and had a specificity of 81.4%. However, multivariate analysis did not show it as a significant independent risk factor.

Acidosis, base deficit, and bicarbonate levels have been considered important outcome markers in conventionally resuscitated patients,^[7] and acidosis at admission has been reported to be associated with higher mortality in the ICU.^[7,20] Serum lactate levels are closely related to metabolic acidosis in septic patients, and lactic acidosis also has been found to predict mortality in patients with severe sepsis and septic shock.^[21] However, in present study, multivariate analysis did not identify base deficit as an independent risk factor.

Cancer-related peritonitis was developed in 21% of 362 study subjects, and univariate analysis showed it to be related to mortality (*P*<0.001). Malignancy is included in MPI as a risk factor,^[12] and the presence of malignant disease is known to be associated with mortality in peritonitis.^[3] We could not get the parameter to calculate the MPI due to the missing data. In the present study, GI cancer was one of them main causes of bowel perforation, and its mortality rate was higher than other causes of peritonitis.

Hypoalbuminemia is commonly developed in acute disease with several mechanisms.^[22] Because the half-life of albumin is about 20 days, it is not a good parameter for identifying or

Table 6**Univariate and multivariate logistic regression model for in-hospital mortality.**

Risk factors	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P	OR (95% CI)	P*
Cancer-related peritonitis	5.044 (2.763–9.209)	<0.001	16.671 (2.629–105.721)	0.003
Length of ICU stay	1.057 (1.028–1.086)	<0.001		
Duration of MV	1.073 (1.035–1.113)	<0.001		
Re-operation	2.570 (1.252–5.276)	0.010		
Blood culture positive	4.474 (1.667–12.011)	0.003		
Preoperative Hb, <10 g/dL	10.833 (4.932–23.797)	<0.001	6.976 (1.376–35.360)	0.019
Postoperative Hb, <10 g/dL	2.790 (1.545–5.037)	0.001		
Preoperative lactate \geq 4 mmol/L	2.584 (0.931–7.175)	0.068		
Postoperative lactate \geq 4 mmol/L	2.649 (1.412–4.969)	0.002		
Preoperative base deficit <−7 mmol/L	2.435 (1.061–5.591)	0.036		
Postoperative base deficit <−7 mmol/L	1.762 (0.967–3.210)	0.064		
Preoperative albumin <2.7 g/dL	5.159 (2.109–12.619)	<0.001	9.954 (1.603–61.811)	0.014
Postoperative albumin <2.7 g/dL	3.540 (1.364–9.190)	0.009		
Preoperative BUN \geq 30 mg/dL	2.831 (1.275–6.284)	0.011		
Postoperative BUN \geq 30 mg/dL	3.803 (2.075–6.969)	<0.001	4.071 (0.883–18.760)	0.072
Preoperative shock	3.935 (1.722–8.993)	0.001		
Postoperative shock	5.376 (2.917–9.909)	<0.001		

BUN = blood urea nitrogen, CI = confidence interval, Hb = hemoglobin, ICU = intensive care unit, MV = mechanical ventilation, OR = odds ratio.

* P value for the Hosmer–Lemeshow goodness-of-fit-test was 0.487.

quantifying malnutrition. However, several studies have reported preoperative hypoalbuminemia is a risk factor of postoperative complications or death.^[22–24] On the contrary, unlike preoperative albumin, albumin at 24 hours postoperatively seems to inadequately predict mortality.^[25] Our findings regarding the relation between hypoalbuminemia and in-hospital mortality concur with previous studies.^[22–25]

Preoperative anemia is known to be independently associated with an increased risk of mortality in patients undergoing cardiac and noncardiac surgery,^[26] and intraoperative hemorrhage and transfusions are associated with poor prognosis.^[27,28] In the present study, preoperative anemia was also found to be an independent risk factor of mortality. It might be associated with the poor patient condition, such as malnutrition, underlying malignancies, or sepsis.

The present study has a number of limitations, which are listed as follows:

- (1) It was conducted at a single tertiary university hospital, so many of the study subjects had an underlying malignancy, and their mean age was relatively high at 60 years. And thus, as mentioned above, age was not found to be a risk factor of mortality.
- (2) Because of the limited patient numbers and groups, risk factors showed wide confidence indices and our results cannot represent all patients who undergo emergency surgery for secondary peritonitis.
- (3) The study was conducted using a retrospective design, and thus, some data were missing, and the timing sampling was not well-controlled. Furthermore, preoperative resuscitation was not performed under the protocol, and emergency department management processes were not adequately recorded and monitored.
- (4) Time from arrival to surgery was not controlled, and the study subjects included emergency room admissions and inpatients, which prevented analysis of the relation between time from arrival and surgery in many cases.

- (5) The MPIs were not calculated, and duration of the symptoms could not be included in the analysis due to missing records.

5. Conclusions

In critically ill surgical patients who underwent emergency GI surgery, cancer-related peritonitis, preoperative anemia (Hb <10 g/dL), and preoperative hypoalbuminemia (<2.7 mg/dL) had been found by multivariate analysis to be independent risk factors of in-hospital mortality. The recognition of risk factors at an early stage could aid risk stratification and the provision of optimal perioperative care.

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