World J Surg (2020) 44:1569–1577
https://doi.org/10.1007/s00268-020-05382-9

ORIGINAL SCIENTIFIC REPORT

Prediction of Postoperative Mortality in Patients with Organ Failure After Gastric Cancer Surgery

Ji-Ho Park[1,2] · Hyuk-Joon Lee[1,3] · Seung-Young Oh[1,4] · Shin-Hoo Park[1] · Felix Berlth[1,5] · Young-Gil Son[1,6] · Tae Han Kim[1,2] · Yeon-Ju Huh[1,7] · Jun-Young Yang[1,8] · Kyung-Goo Lee[1,9] · Yun-Suhk Suh[1] · Seong-Ho Kong[1] · Han-Kwang Yang[1,3]

Published online: 28 January 2020

Abstract

Background Scarce data are available on the characteristics of postoperative organ failure (POF) and mortality after gastrectomy. We aimed to describe the causes of organ failure and mortality related to gastrectomy for gastric cancer and to identify patients with POF who are at a risk of failure to rescue (FTR).

Methods The study examined patients with POF or in-hospital mortality in Seoul National University Hospital between 2005 and 2014. We identified patients at a high risk of FTR by analyzing laboratory findings, complication data, intensive care unit records, and risk scoring including Acute Physiology and Chronic Health Evaluation (APACHE) IV, Sequential Organ Failure Assessment (SOFA) score, and Simplified Acute Physiology Score (SAPS) 3 at ICU admission.

Results Among the 7304 patients who underwent gastrectomy, 80 (1.1%) were identified with Clavien–Dindo classification (CDC) grade $\geq$ IVa. The numbers of patients with CDC grade IVa, IVb, and V were 48 (0.66%), 11 (0.15%), and 21 (0.29%), respectively. Pulmonary failure (43.8%), surgical site complication (27.5%), and cardiac failure (13.8%) were the most common causes of POF and mortality. Cancer progression (100%) and cardiac events (45.5%) showed high FTR rates. In univariate analysis, acidosis, hypoalbuminemia, SOFA, APACHE IV, and SAPS 3 were identified as risk factors for FTR ($P < 0.05$). Finally, SAPS 3 was identified as an independent predictive factor for FTR.

Conclusions Cancer progression and acute cardiac failure were the most lethal causes of FTR. SAPS 3 is an independent predictor of FTR among POF patients after gastrectomy.

✉ Hyuk-Joon Lee
appe98@snu.ac.kr

1 Department of Surgery, Seoul National University College of Medicine, Seoul, South Korea

2 Department of Surgery, Gyeongsang National University Hospital, Jinju, South Korea

3 Department of Surgery, Cancer Research Institute, Seoul National University College of Medicine, Seoul, South Korea

4 Critical Care Center, Seoul National University College of Medicine, Seoul, South Korea

5 Department of General, Visceral and Cancer Surgery, University Hospital of Cologne, Cologne, Germany

6 Department of Surgery, Keimyung University School of Medicine, Daegu, South Korea

7 Department of Surgery, Ewha Womans University Mokdong Hospital, Seoul, South Korea

8 Department of Surgery, Gachon University Gil Medical Center, Incheon, South Korea

9 Department of Surgery, Myongji Hospital, Goyang, South Korea

Introduction

Gastrectomy is the mainstay treatment for patients with gastric cancer. The prediction and management of postoperative morbidity become more important as a trend is seen recently in older and more fragile patients [1, 2]. Despite significant efforts to reduce complications, the morbidity rate following gastrectomy is reported to be 10–28% [3–9].

Among postoperative complications of gastric cancer surgery, organ failure and in-hospital mortality after gastrectomy are rare. Based on the Clavien–Dindo classification (CDC) [10], grade IV is defined as life-threatening complications requiring intensive care unit (ICU) management. In addition, grade IVa is defined as single organ dysfunction requiring dialysis, or mechanical ventilation, and grade IVb refers to multiple organ failure. Grade V is defined as the complication-related death of patients. In previous reports, the rates of grade IV and V complications were 0.6–1.1% and 0.1–0.5%, respectively [6, 11]. In most other studies addressing postoperative complications after gastrectomy for gastric cancer, grade IV complication rates have not been specifically mentioned [3–5]. Reasons for lack of data might cause difficulty in clearly defining the CDC grade IV complications, complexity of ICU treatments, and vast number of other parameters that influence the appropriate classification.

Failure to rescue (FTR) patients with complications account for a substantial proportion of postoperative mortality and is an emerging indicator of the quality of medical care [12, 13]. Understanding the factors responsible for FTR helps surgeons predict and avoid operative mortality. However, there are very few studies related to FTR in the field of gastric cancer surgery [14].

Hence, in this study, we described the causes of organ failure and mortality related to gastrectomy for gastric cancer and identified patients with postoperative organ failure who are at a risk of FTR.

Materials and methods

Patient population and data source

We screened the Seoul National University Hospital gastric cancer database from 2005 to 2014 and identified patients with postoperative organ failure and in-hospital mortality. A total of 7304 patients underwent gastrectomy for histologically confirmed gastric cancer within the study period. Among these patients, we collected data for patients meeting the following inclusion criteria: 30-day and in-hospital mortality (CDC grade V); transfer to ICU because of organ failure (CDC grade IV); and continuous postoperative ICU care for 3 or more days and occurrence of any organ failure (CDC grade IV). Patients who underwent palliative procedures without gastrectomy (e.g., gastro-jejunostomy and explorative laparotomy) or procedures in cooperation with other surgical techniques (e.g., coronary artery bypass graft and abdominal aorta aneurysm operation) were excluded. Patients who underwent combined organ resection (e.g., colon resection, cholecystectomy, and pancreaticoduodenectomy) owing to gastric cancer were included in our analysis.

Demographics, comorbidity, operative procedures, pathological results based on the American Joint Committee on Cancer (AJCC) TNM 7th edition [15], ICU medical record, laboratory data, and postoperative complications were reviewed. Preoperative comorbidity data were collected and graded using the Charlson comorbidity index, which is the most widely used method to determine the overall burden of comorbidities and includes 19 medical conditions with corresponding weights [16]. Complications data based on CDC were collected prospectively through weekly team meetings [10]. The type of complications was divided into two categories: local and systemic. Complications were defined and grouped based on our previous report on complication following gastrectomy [11]. We calculated the time to the development of the first complication as the number of days between the operation and the first documented postoperative complication. This study was approved by the Institutional Review Board of our institution (H-1305-043-488).

Assignment of causes of organ failure and mortality

The causes of organ failure and mortality were systematically described by applying the methodology proposed by Waljee et al. [17]. In this classification, the complication that most commonly contributed to patient's ICU transfer or death was defined as a "seminal" complication. We adopted this concept when determining the cause of organ failure and mortality. Based on this classification and clinical relevance and frequency of occurrence, we allocated the cases based on the causes of organ failure and mortality into six categories with slight modifications: pulmonary failure (pneumonia, prolonged ventilator assistance, pulmonary edema, pulmonary thromboembolism, pneumothorax); surgical site complications (hemorrhage and surgical site infection); cardiac complication (myocardial infarction, congestive heart failure, arrhythmia, and unexplained cardiac arrest); cerebrovascular complications (stroke); cancer progression; and other complications (urinary tract infection and suicide). Three attending surgeons (HJ Lee, JH Park, and SY Oh) independently reviewed all medical records including ICU data and

Table 1 Variables included in the prognostic models

Predictor variable	SAPS 3	APACHE IV	SOFA
Age	+	+	–
Length of hospital stay before ICU admission	+	+	–
ICU admission source (number of items)	3	8	–
Chronic comorbidities (number of items)	6	7	–
Surgical status at ICU admission	+	+	–
Anatomic site of surgery	+	–	–
Reasons for ICU admission/acute diagnosis (number of items)	10	116	–
Acute infection at ICU admission	+	–	–
Mechanical ventilation	+	+	+
Vasoactive drug therapy	+	–	+
Clinical physiological variables (number of items)	4	6	3
Laboratory physiological variables (number of items)	6	10	5

SAPS Simplified Acute Physiology Score; *APACHE* Acute Physiology and Chronic Health Evaluation; *SOFA* Sequential Organ Failure Assessment; *ICU* intensive care unit

determined the cause of organ failure and death. In case of disagreement, the medical record was reviewed by the entire committee. After discussion, a final consensus on the cause of organ failure and death was reached.

Outcomes for risk analysis of failure to rescue

To identify risk factors for FTR, risk scoring including the Charlson comorbidity index, Acute Physiology and Chronic Health Evaluation (APACHE) IV, Sequential Organ Failure Assessment (SOFA; formerly, Sepsis-Related Organ Failure Assessment) score, and SAPS (Simplified Acute Physiology Score) 3; laboratory findings; complication details; and ICU clinical data were reviewed. All clinical and laboratory data references for risk scoring were collected within the initial 24 h after ICU admission. Two patients who died suddenly without ICU care and one patient who committed suicide were excluded from FTR risk analysis.

APACHE IV is a widely used scoring system for assessing the severity of illness and prognosis of ICU patients [18]. This scoring system includes age, chronic health conditions, and physiologic data required to calculate an acute physiology score of APACHE III [19]. This score also involves the primary reason for ICU admission (ICU admission diagnosis), patient's location (admission source), length of stay before ICU admission, need of mechanical ventilation or emergency surgery, PaO_2/FiO_2 ratio, and whether sedation or paralysis resulted in an inability to assess the Glasgow Coma Scale (GCS).

SAPS 3 is a model for predicting mortality and is one of the several ICU scoring systems. It was designed to provide a real-life prediction of mortality for patients. The model is based on a mathematical model that needs calibration [20]. SAPS 3 represents the arithmetic sum of three boxes: (1) Box I: age, comorbidities, use of vasoactive drugs before ICU admission, intrahospital location before ICU admission, and length of stay in the hospital before ICU admission; (2) Box II: reasons for ICU admission, planned/unplanned ICU admission, surgical status at ICU admission, anatomical site of surgery, and presence of infection at ICU admission; and (3) Box III: lowest estimated GCS, highest heart rate, lowest systolic blood pressure, highest bilirubin, highest body temperature, highest creatinine, highest leukocytes, lowest platelets, lowest hydrogen ion concentration (pH), and ventilatory support and oxygenation.

The SOFA score is used to track a patient's status during the stay in an ICU in order to determine the extent of a patient's organ function or rate of failure [21]. The score is based on six different sub-scores, one each for the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems.

These scoring data were collected for the first 24 h of admission to the ICU and were entered into a computer-based calculator (APACHE IV, https://intensivecarenetwork.com/Calculators/Files/Apache4.html; SAPS 3, http://www.saps3.org/resources-downloads/user-agreement/downloads/; and SOFA, https://www.mdcalc.com/sequential-organ-failure-assessment-sofa-score). A comparison of the three scores is shown in Table 1.

Statistical analysis

The categorical variables were presented as numbers and percentages, and the groups by FTR were compared using the chi-square test. Continuous variables were expressed as means and standard deviations, and the means were

Table 2 Patients' characteristics

Variable	Total (N = 80)
Age	67.3 (35–83)
Sex ratio (M/F)	67:13
Comorbidity	67 (83.8%)
ASA score (I:II:III)	11:55:13
Complication grade[a]	
IVa	48 (60.0%)
IVb	11 (13.8%)
V	21 (26.3%)
Extent of gastrectomy	
Distal gastrectomy	39 (48.8%)
Pylorus-preserving gastrectomy	4 (5.0%)
Proximal gastrectomy	3 (3.8%)
Total gastrectomy	34 (42.5%)
Surgical method	
Open	66 (82.5%)
Laparoscopic or robotic	14 (17.5%)
Lymph node dissection	
D1 or D1+	20 (25.0%)
D2 or more	60 (75.0%)
Combined resection	
No	55 (68.8%)
Yes	25 (31.3%)
Surgical radicality	
R0	67 (83.8%)
R1 or R2	13 (16.2%)
Tumor invasion	
EGC	30 (37.5%)
AGC	50 (62.5%)
Lymph node metastasis	
Negative	37 (46.3%)
Positive	43 (53.7%)
TNM stage	
I	36 (45.0%)
II	7 (8.8%)
III	26 (32.5%)
IV	11 (13.8%)

ASA American Society of Anesthesiologists; *EGC* early gastric cancer; *AGC* advanced gastric cancer

[a]According to the Clavien–Dindo classification

compared using the Student's t test. Univariate analysis was conducted to evaluate the association of each factor with FTR. The identified risk factors for FTR were adjusted by multivariate logistic regression. For this purpose, significant variables ($P < 0.05$) in the univariate analysis were entered into the multivariate analysis. In multivariate analysis, the adjusted odds ratios (exponential beta) were calculated with a 95% confidence interval (CI). All tests were two-sided and performed at a significance level of 5% using IBM® SPSS® Statistics version 20 (IBM Corporation, Armonk, NY, USA).

Results

Patient characteristics, comorbidities, and complications

Among the 7304 patients who underwent gastrectomy, 80 (1.1%) were identified with postoperative organ failure and/or mortality (CDC grade $\geq$ IVa). The numbers of patients with CDC grade IVa, IVb, and V complications were 48 (0.66%), 11 (0.15%), and 21 (0.29%), respectively. All 80 patients were examined, and their clinicopathological characteristics are shown in Table 2. The study cohort included 67 men and 13 women, with a mean age of 67.3 (35–83) years. Eighty-three percent (67/80) of the patients had preoperative medical comorbidities. Additionally, 85% of the patients received an American Society of Anesthesiologists (ASA) score of 2 or higher (ASA I:II:III = 11:55:13). In terms of tumor invasion, advanced gastric cancer occurred more frequently than did early gastric cancer, and more than half of the patients (53.7%, 43/80) had lymph node metastasis. The distribution of TNM stage I, II, III, and IV was found to be 36 (45%), 7 (8.8%), 26 (32.5%), and 11 (13.8%), respectively.

Comorbidities and complication details are shown in Table 3. Hypertension (52.5%), diabetes mellitus (27.5%), heart disease (18.8%), lung disease (17.5%), and neurological diseases (15%) were common comorbid conditions. Detailed complications were grouped as local and systemic complications. All patients had systemic complications. Local complications developed in about half of the patients (52.5%, 42/80). Pulmonary (86.3%), cardiac (38.8%), and renal complication (25%), fluid collection (23.8%), bleeding (22.5%), and operation site leakage (20%) were the common complications seen.

Causes of organ failure and mortality

Table 4 shows the detailed causes of organ failure and ICU admission of the 80 patients included in this study. The most common causes of organ failure were respiratory failure (35, 43.8%) and surgical site complications (22, 27.5%), followed by cardiac events (11, 13.8%), cerebrovascular complications (6, 7.5%), cancer progression (4, 5%), and other complications (2, 2.5%). The most common seminal complications were pneumonia (24, 30%) and surgical site infection (13, 16.3%), such as bowel leakage and intra-abdominal abscess, followed by hemorrhage (9, 11.3%), stroke (6, 7.5%), acute myocardial infarction (5,

Table 3 Comorbidity and complication details

Variable	Total (N = 80)
Comorbidity	67 (83.8%)
Hypertension	42 (52.5%)
Diabetes	22 (27.5%)
Tuberculosis	12 (15.0%)
Chronic liver disease	8 (10.0%)
Pulmonary disease	14 (17.5%)
Cardiac disease	15 (18.8%)
Neurologic disease	12 (15.0%)
Renal disease	9 (11.3%)
Other malignancy	6 (7.5%)
Other disease	3 (3.8%)
Local complication	42 (52.5%)
Wound problem	11 (13.8%)
Fluid collection	19 (23.8%)
Intra-abdominal bleeding	12 (15%)
Intra-luminal bleeding	6 (7.5%)
Stenosis	1 (1.3%)
Ileus/motility disorder	11 (13.8%)
Anastomotic leakage	16 (20%)
Other leakage/fistula	4 (5%)
Vascular insufficiency	2 (2.5%)
Systemic complication	80 (100%)
Pulmonary	69 (86.3%)
Urinary	5 (6.3%)
Renal	20 (25.0%)
Hepato-biliary	9 (11.3%)
Cardiac	31 (38.8%)
Endocrine	1 (1.3%)
Neurologic	17 (21.3%)
Vascular	5 (6.3%)
Others[a]	1 (1.3%)

[a]One patient died of suicide

Table 4 Classification of the cause of organ failure

Cause of organ failure	Seminal complication	N = 80
Pulmonary failure	Pneumonia	24 (30.0%)
	Prolonged ventilator assistance	4 (5.0%)
	Pulmonary edema	4 (5.0%)
	Pulmonary thromboembolism	2 (2.5%)
	Pneumothorax	1 (1.5%)
Surgical site complication	Hemorrhage	9 (11.3%)
	Surgical site infection	13 (16.3%)
Cardiac complication	Myocardial infarction	5 (6.3%)
	Congestive heart failure	2 (2.5%)
	Arrhythmia	2 (2.5%)
	Unexplained cardiac arrest	2 (2.5%)
Cerebral vascular complication	Stroke	6 (7.5%)
Cancer progression	Cancer dissemination	4 (5.0%)
Others	Urinary tract infection	1 (1.3%)
	Suicide	1 (1.3%)

6.3%), prolonged ventilator assistance (4, 5%), pulmonary edema (4, 5%), and cancer dissemination (4, 5%). One patient (1.3%) committed suicide in the ward 3 days after surgery.

The grouped cause of organ failure affects the FTR rate (Fig. 1). Cancer progression had the highest mortality rate (100%, 4/4). Cardiac events (45.5%, 5/11) and surgical site complication (31.8%, 7/22) showed a relatively high FTR rate. However, the lowest mortality rate was observed with pulmonary complications (8.6%, 3/35).

Clinical data related to failure to rescue

In univariate analysis (Table 5), low albumin level and acidosis were significantly different between patients with rescue and FTR (P = 0.026 and P = 0.001, respectively) at initial ICU laboratory findings. In terms of risk scoring methods, APACHE IV, SOFA, and SAPS 3 were significantly associated with the FTR rate (P = 0.001, $P < 0.001$, and $P < 0.001$, respectively). Complication-related data, including type, timing, and time, to the development of the organ failure were not related to FTR.

In multivariate analysis, SAPS 3 was found to be the only independent predictor of FTR (OR 1.09, 95% CI 1.033–1.149; P = 0.002) (Table 6).

Discussion

To our knowledge, this is one of the first reports addressing the causes of organ failure and mortality in patients undergoing gastrectomy for gastric cancer. In this context, we conducted a cohort-based study using large-volume data to be able to describe the causes of organ failure and mortality related to gastrectomy. In addition to comparing outcomes between the rescued and FTR patients, we assessed the risks for in-hospital death. Severe complications (CDC grade ≥ IV) developed in only 1.1% of the patients. The characteristics of these patients were heterogenous in terms of demographics, underlying diseases, and complications. The main causes of organ failure and death were pulmonary failure and surgical site complications that accounted for more than 70%. On the other hand, in relation to the grouped number of patients with organ failure, pulmonary failure had the lowest mortality

Fig. 1 Morality rate according to cause of organ failure

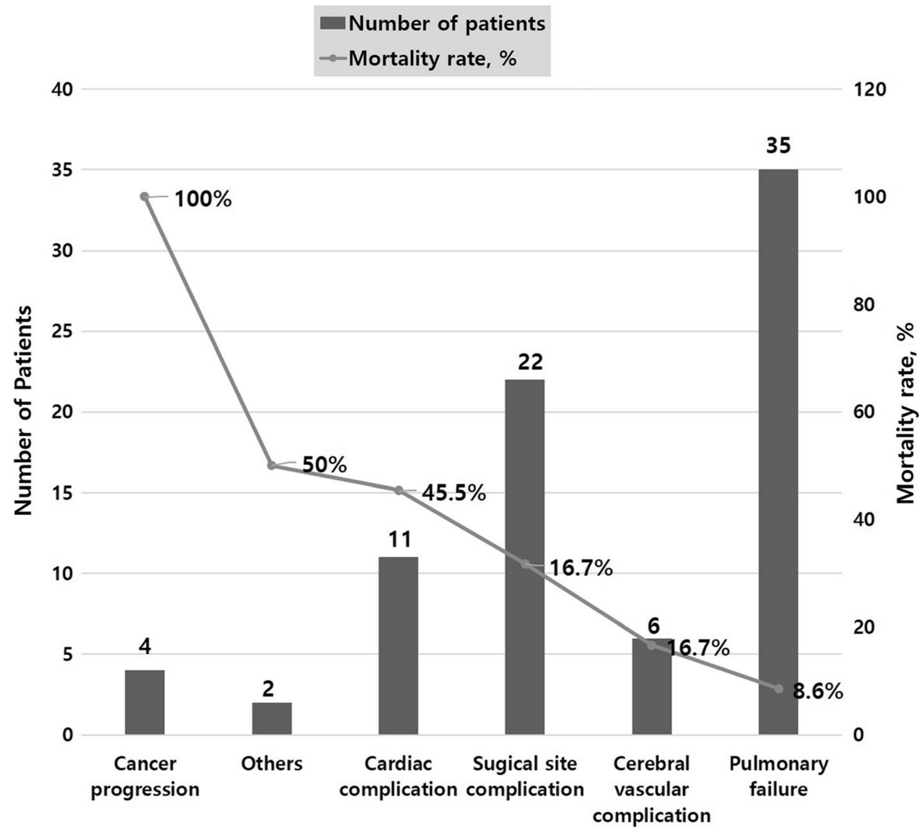

Table 5 Clinical and laboratory data at intensive care unit related to failure to rescue

Variable	Rescue (*N* = 59)	FTR (*N* = 18)	*P*
Age	68.0 ± 10.0	66.9 ± 11.5	0.688
Charlson comorbidity score	3.1 ± 1.1	3.7 ± 1.5	0.144
Platelet (× 10^3/μL)	181.8 ± 78.3	187.6 ± 143.7	0.871
Bilirubin (mg/dL)	1.6 ± 0.9	4.2 ± 5.9	0.076
Albumin (g/dL)	2.6 ± 0.4	2.4 ± 0.4	0.026
Creatinine (mg/dL)	1.4 ± 1.4	1.6 ± 0.9	0.645
pH	7.36 ± 0.08	7.27 ± 0.12	0.001
APACHE IV	69.7 ± 25.7	96.1 ± 39.6	0.001
SOFA	7.2 ± 3.0	11.1 ± 3.3	<0.001
SAPS 3	58.6 ± 14.0	79.2 ± 15.0	<0.001
Type of 1st complication (local/systemic)	19:40	10:8	0.092
Postoperative day of 1st complication	3.9 ± 4.5	5.8 ± 6.7	0.250
Postoperative day of ICU admission	4.1 ± 5.0	25.0 ± 60.9	0.161
Day from 1st complication to ICU admission	0.6 ± 1.5	19.8 ± 58.6	0.183

FTR failure to rescue; *APACHE* Acute Physiology and Chronic Health Evaluation; *SOFA* Sequential Organ Failure Assessment; *SAPS* Simplified Acute Physiology Score; *ICU* intensive care unit

rate among the five groups. SAPS 3 risk scoring was the most powerful predictor for FTR in ICU patients.

The mortality rate after gastrectomy in this study was 0.29%. The literature reports operative mortality rates that range from 0 to 13%, with higher mortality rates in Western studies (the least reported at 4%) [3–5, 8, 9, 14, 22–25]. The most recently published East Asian, multicenter, randomized controlled trials have reported a very low mortality rate of less than 0.5% [3, 24, 25], which was similar to that seen in our study.

Table 6 Predictive factors for failure to rescue by multivariate analysis

Variable	*P*	Exponential (ß)	95% CI
Albumin (g/dL)	0.354		
pH	0.177		
APACHE IV	0.270		
SOFA	0.257		
SAPS 3	0.002	1.090	1.033–1.149
Type of 1st complication (local/systemic)	0.652		

APACHE Acute Physiology and Chronic Health Evaluation; *SOFA* Sequential Organ Failure Assessment; *SAPS* Simplified Acute Physiology Score

However, our retrospective analysis included all gastric cancer patients who underwent gastrectomy unlike randomized controlled trials with strict inclusion and exclusion criteria.

Organ failure is organ dysfunction to such a degree that homeostasis cannot be maintained without external clinical intervention. If it involved two or more organ systems, it is defined as multiple organ failure, which is the most common cause of death in the surgical ICU [26]. Most studies on postsurgical morbidity focused on major complications (more than CDC grade III) and mortality. However, there was no analysis of specific details published with a focus on organ failure (grade IV) with or without consecutive mortality (grade V) after gastrectomy for gastric cancer. In this study, we investigated the characteristics of patients with organ failure after gastrectomy. Compared to our previous two studies that dealt with the association of underlying diseases and complications after gastrectomy [27, 28], we found a higher prevalence of comorbidities (83.8%, 67/80) that was associated with the development of organ failure. In particular, the proportion of hepatic, pulmonary, cardiac, renal, and neurological underlying diseases were highly related to the patients' vitality. Among the complications, all patients had systemic complications, and the rate of surgical complications such as bleeding or leakage was also high.

To our knowledge, there is no study that classifies the causes of organ failure after surgery. Therefore, we introduced the methodology proposed by Waljee et al. [17] for classifying the cause of death after cancer surgery. Gerestein et al. [29] reported the causes of postoperative mortality after surgery for ovarian cancer. Surgical site complications and pulmonary failure were common causes of mortality in that study. In our study, organ failure was caused by pulmonary failure, surgical site complication, cardiac complication, and cerebrovascular complications, sequentially. Whereas pulmonary failure had a mortality of 8.6%, mortality rate according to the cause of organ failure was the highest in cancer progression (100%), followed by cardiac complications and surgical site infections. These results can be mainly explained by sudden cardiac death, myocardial infarction, and sepsis caused by surgical site infection. In particular, surgical site infections influenced organ failure included bowel leakage, intraperitoneal abscess, bile leakage, and gallbladder abscess.

Although several reports identified patients' factors predicting postoperative death, few reports investigated the risk for FTR among patients who were admitted to the ICU with organ failure. Bartlett et al. [30] investigated specific patient factors associated with mortality after total gastrectomy using the American College of Surgeons National Surgical Quality Improvement Program database. Age >70 years, weight loss, albumin <3 g/dL, and combined resection of the pancreas were independently associated with increased 30-day mortality. Another American study showed that patient characteristics, including age and comorbidity, were highly significant predictors of mortality [31]. Recently, Japanese surgeons have reported a risk stratification study for gastrectomy when treating gastric cancer using a nationwide Web-based database [8, 9]. This risk models included age, need for total assistance in activities of daily living, American Society of Anesthesiologists grade 4 or 5, disseminated cancer, preoperative dialysis requirement, cerebrovascular disease history, more than 10% weight loss, uncontrolled ascites, leukocytosis, thrombocytopenia, anemia, hypoalbuminemia, hyponatremia, and elevated alkaline phosphatase level.

In our study, hypoalbuminemia and acidosis were remarkable factors for FTR. Additionally, risk scoring using APACHE IV, SOFA, and SAPS 3 was significantly associated with mortality. Finally, SAPS 3 was identified as an independent predictive factor for FTR among patients with organ failure after gastrectomy. In the acute care surgical field, characteristics of complications such as type of seminal complication and number of complications were reported as significant prognostic factors for FTR [32, 33]. However, details about complication (type of 1st complication, duration, timing of complication) did not influence FTR in our study.

Prognostic scoring systems have been developed by the critical care community as an effort to quantify the severity of the illness of a given patient or group of patients [34]. Many prognostic models exist, suggesting that the optimum model has not been established. In particular, few studies have applied risk scoring systems to ICU patients with gastric cancer. The most commonly used adult ICU prognostic scoring systems are APACHE and SAPS. Major revisions of these models were published between 2005 and 2006, namely APACHE IV in 2006 and SAPS 3 in 2005 [18, 20]. Moreover, the SOFA score is used to track a patient's status during the stay in an ICU to determine the organ function or rate of failure. In this study, we analyzed these three systems and SAPS 3 was most useful in predicting FTR among gastric cancer patients with organ failure. Unlike other systems, SAPS 3 includes data regarding the anatomical site of surgery, presence of acute infection at ICU admission, and vasoactive drug therapy before ICU admission (Table 1). These factors might contribute to the accuracy of the analysis of gastric cancer patients. Future studies are needed to evaluate the role of risk scoring or benchmarking, performance improvement, resource use, and clinical decision support.

According to the SAPS 3 system, the patient prognosis factor can be divided into three categories: (a) previous medical/surgical history, (b) the circumstances of ICU admission, and (c) the degree and presence of physiologic dysfunction, and the prognostic value to resuscitate in each category is 50%, 22.5%, and 27.5%, respectively [20]. More than half of the risk for mortality is already determined when a patient is admitted to the ICU. In order to reduce mortality, it is advisable to correct physiologic indices when a high risk of mortality is suspected as soon as possible and perform prompt assessments to identify patient status. In this system, mortality differs in the etiology for ICU admission; transient organ failure shows a better chance of recovery compared to definite conditions such as intracranial mass or severe pancreatitis.

After gastrectomy, organ dysfunction and death are rare events and are therefore difficult to investigate. We performed analyses with mortality and organ failure of patients after gastric cancer surgery through complementary crossing over review using well-organized data from the large-volume gastric cancer center. Prevention of mortality rate is crucial for control of healthcare quality. Our results are intended to contribute to the management of patients with severe complications leading to death after gastric cancer surgery. This is expected to lead to an improvement in the quality of surgery.

In summary, postoperative organ failure and mortality after gastrectomy have heterogeneous causes. Information on morbidities and causes of organ failure or mortality seems essential for managing fatal complications. Cancer progression and acute cardiac failure were the most lethal causes of FTR. SAPS 3 is an independent predictor of FTR among organ failure patients after gastrectomy. By characterizing fatal morbidity and mortality after gastric cancer surgery, it is possible to provide vital information in efforts to reduce hospital mortality.

Acknowledgements This study was supported by a research grant from the Seoul National University Hospital Research Fund (No. 0420133080).

Funding This study was funded by a research grant from the Seoul National University Hospital Research Fund (No. 0420133080).

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflict of interest.

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