

## Retrospective Study

# High morbidity in myocardial infarction and heart failure patients after gastric cancer surgery

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## Abstract

**AIM:** To evaluate to morbidity and mortality differences between 4 underlying heart diseases, myocardial infarction (MI), angina pectoris (Angina), heart failure (HF), and atrial fibrillation (AF), after radical surgery for gastric cancer.

**METHODS:** We retrospectively collected data from 221 patients of a total of 15167 patients who underwent radical gastrectomy and were preoperatively diagnosed with a history of Angina, MI, HF, or AF in 8 hospitals.

**RESULTS:** We find that the total morbidity rate is significantly higher in the MI group (44%) than the Angina (15.7%), AF (18.8%), and HF (23.1%) groups ( $P < 0.01$ ). Moreover, we note that the risk for postoperative cardiac problems is higher in patients with a history of HF (23.1%) than patients with a history

of Angina (2.2%), AF (4.3%), or MI (6%;  $P = 0.01$ ). The HF and MI groups each have 1 case of cardiogenic mortality.

**CONCLUSION:** We conclude that MI patients have a higher risk of morbidity, and HF patients have a higher risk of postoperative cardiac problems than Angina or AF.

**Key words:** Stomach neoplasm; Comorbidity; Morbidity; Heart disease; Heart failure

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**Core tip:** The present study assessed morbidity and mortality differences among gastrectomy patients with underlying histories of myocardial infarction (MI), angina pectoris (Angina), heart failure (HF), and atrial fibrillation (AF). The authors concluded that gastric cancer patients with a history of MI had a higher risk for complications after gastrectomy, and patients with a history of HF had a higher risk for postoperative cardiac problems than patients with a history of Angina or AF. Therefore, patients with MI or HF require careful pre- and postoperative evaluation, and these patients should be informed about the possibility of postoperative morbidity, particularly intra-abdominal abscess and postoperative cardiac problems.

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## INTRODUCTION

Gastric cancer is the fourth most common type of cancer, and it has the second highest mortality rate worldwide<sup>[1]</sup>. Nearly one million new cases are diagnosed each year. The rate of detection of early tumors has improved in the East, particularly Japan and South Korea, following the introduction of mass screening for gastric cancer<sup>[2-4]</sup>. The incidence and mortality of gastric cancer in Japan and South Korea have gradually decreased, but it remains the second most frequent cause of death in South Korea<sup>[5-8]</sup>.

Many studies investigated the perioperative risk factors for postoperative morbidity in abdominal surgery<sup>[9-11]</sup>. A significant association between prolonged operation time and excessive blood loss and postoperative morbidity was reported in elderly patients<sup>[12,13]</sup>. Old age ( $\geq 65$  years), advanced tumor stage, and combined organ resection were identified as significant risk factors for postoperative mortality and morbidity<sup>[14-17]</sup>. Our earlier study reported that a high

tumor, node, metastasis (TNM) stage, long operating time, and multi-organ resection were significant independent risk factors for postoperative morbidity following radical surgery for gastric cancer<sup>[9]</sup>.

Several studies investigated the perioperative and comorbidity risk factors for postoperative morbidity, but few studies specifically investigated these factors in gastric cancer surgery. One study reported that comorbidity was significantly associated with local and systemic complications and observed significantly increased rates of systemic complications and mortality in patients with  $\geq 3$  comorbid diseases<sup>[18]</sup>. A recent study found a significant correlation of postoperative morbidity in patients aged  $\geq 70$  years with hypertension or liver cirrhosis<sup>[19]</sup>.

Histories of ischemic heart disease, heart failure, diabetes, and renal insufficiency are reported risk factors for cardiac death and nonfatal myocardial risk factors in noncardiac surgery<sup>[20]</sup>. We previously reported that underlying heart disease or chronic liver disease was a significant independent risk factor for postoperative morbidity following radical surgery for gastric cancer<sup>[9]</sup>. This study evaluated morbidity and mortality differences between 4 underlying heart diseases, namely myocardial infarction (MI), angina pectoris (Angina), heart failure (HF), and atrial fibrillation (AF), after radical surgery for gastric cancer.

## MATERIALS AND METHODS

We retrospectively collected data from 221 patients who underwent radical gastrectomy and were preoperatively diagnosed with Angina ( $n = 89$ ), AF ( $n = 69$ ), HF ( $n = 13$ ), or MI ( $n = 50$ ) between January 2005 and December 2010 at 8 hospitals among a total of 15167 cases (Gyeongsang National University Hospital, National Cancer Center, Kyungpook National University Hospital, Kosin University College of Medicine, Chonnam National University Hospital, Asan South Korea University, Cheju National University, and Konyang University Hospital). All patients consulted a cardiologist, who evaluated their operative risks.

All data concerning sex, age, duration of postoperative hospital stay, operative risk, American Society of Anesthesiologists (ASA) score, comorbid disease, operative methods (resection, reconstruction, and combined resection), and postoperative morbidity were collected retrospectively.

The following inclusion criteria were used in this study: histologically proven primary gastric adenocarcinoma; no evidence of other distant metastases; subtotal and total gastrectomy as the surgical method; R0 resection; and preoperatively diagnosed underlying heart disease (Angina, AF, HF, or MI): (1) Angina: The patient was diagnosed with I20 [Angina, International Classification of Diseases, Tenth Revision (ICD-10)] and preoperatively evaluated using coronary angiography, treadmill test, cardiac computed tomography (CT), and myocardial single photon emission tomography

**Table 1** Characteristics of patients with underlying heart disease *n* (%)

Factors	Value
Age (yr)	68.8 ± 8.1
Sex	
Male	171 (77.4)
Female	50 (22.6)
Tumor location	
Upper	30 (13.6)
Middle	65 (29.4)
Lower	123 (55.7)
Entire	2 (0.9)
Tumor size	3.9 ± 0.04
TNM stage <sup>1</sup>	
I	130 (58.8)
II	37 (16.7)
III	53 (24)
IV	1 (0.5)
Op time (min)	215 ± 86
Hospital stay	13.6 ± 13.5
Approach methods	
Open	177 (80.1)
Laparoscopy assisted	44 (19.9)
Combined organ resection	
No	180 (81.4)
Yes	39 (17.6)
Operation type	
Subtotal gastrectomy	177 (80.1)
Total gastrectomy	44 (19.9)
LN dissection <sup>2</sup>	
D1	12 (5.4)
D1+	47 (21.3)
D2	162 (73.3)
Reoperation	6 (2.7)
Morbidity rate	52 (23.5)
Mortality rate	6 (2.7)

<sup>1</sup>AJCC TNM stage 7<sup>th</sup> edition; <sup>2</sup>Japanese gastric cancer treatment guidelines 2010 (ver.3). LN: Lymph node.

(M-SPECT); (2) MI: The patient was diagnosed with I21 (acute myocardial infarction, ICD-10) or I25 (chronic myocardial infarction, ICD-10) and preoperatively evaluated using coronary angiography, treadmill test, cardiac CT, and M-SPECT; (3) HF: The patient was diagnosed with I50 (heart failure, ICD-10) and preoperatively evaluated using echocardiography; and (4) AF: The patient was diagnosed with I48 (atrial fibrillation, ICD-10) and preoperatively evaluated using electrocardiography.

We excluded patients with the following conditions: active double cancer (synchronous and metachronous double cancer within 5 disease-free years), carcinoma in situ (lesions equal to intraepithelial cancer), gastric cancer recurrence, or a history of gastrectomy.

### Evaluation of comorbid diseases

Patients with comorbid disease were classified to allow a more precise assessment of the contribution of comorbidity to the risk of postoperative morbidity according to the general category of the underlying disease<sup>[9]</sup>.

We defined postoperative morbidity as a complication that occurred within 30 d after surgery that

delayed the date of discharge or results in the patient who required treatment in an outpatient clinic after discharge. The complication definitions were derived from our earlier studies<sup>[15,21,22]</sup> and other studies<sup>[21,22]</sup>, were used to assess complications.

The Institutional Review Board of Gyeongsang National University Hospital approved this study (GNUH 2015-1-005).

### Surgical procedure

Total or subtotal gastrectomy or total omentectomy and D1+  $\alpha$  or D1 +  $\beta$  lymph node dissection were performed in open surgery when the preoperative diagnosis using gastrofibroscopy and spiral CT scans revealed early gastric cancer (EGC). Lymph node station were identified according to the Japanese Classification of Gastric Carcinoma from 1998<sup>[23]</sup>. Gastric resection and determination of the resection area of the lymph node stations were performed according to the Japanese Gastric Cancer Association (JGCA) guidelines from 2002<sup>[24]</sup>. Partial omentectomy was performed using laparoscopic surgery. Reconstruction was performed based on the surgeon's preference.

Total or subtotal gastrectomy, total omentectomy and D2 lymph node dissection were performed using open surgery in cases of advanced gastric cancer.

### Statistical analysis

A binary and multinomial logistic regression model was used for univariate and multivariate analyses. A value of  $P < 0.05$  (two-sided) was considered statistically significant. SPSS<sup>®</sup> version 18.0 (SPSS, Chicago, IL, United States) was used for statistical analyses.

## RESULTS

### Patient characteristics and morbidities with underlying heart disease

The average patient age was 68.8 years. The male to female ratio was 3.4:1. The most frequent tumor location was the lower body ( $n = 123$ ; 55.7%), followed by the middle body ( $n = 65$ ; 29.4%), upper body ( $n = 30$ ; 13.6%), and entire stomach ( $n = 2$ ; 0.9%). The mean tumor size was  $3.8 \pm 3.0$  cm. Analysis of the TNM stages revealed that 58.8% ( $n = 130$ ), 16.7% ( $n = 37$ ), 24% ( $n = 53$ ), and 0.5% ( $n = 1$ ) of the patients had Stage I, II, III, and IV disease, respectively. The mean operation time was  $215 \pm 86$  min. The mean duration of postoperative hospital stay was  $13.6 \pm 13.5$  days. Open gastrectomy and laparoscopy-assisted gastrectomy were used in 80.1% ( $n = 177$ ) and 19.9% ( $n = 44$ ) of cases, respectively. Subtotal and total gastrectomies were performed in 80.1% ( $n = 177$ ) and 19.9% ( $n = 44$ ) of patients, respectively. Combined organ resection was performed in 17.6% ( $n = 39$ ) of all cases (Table 1). Hypertension ( $n = 105$ ; 47.5%) was the next most frequent underlying comorbid disease, followed by diabetes mellitus (DM;  $n = 55$ ; 24.9%), cerebrovascular disease ( $n = 19$ ; 8.6%), and

**Table 2** Associated heart disease in 4 different heart disease groups *n* (%)

Associated heart disease	Angina	AF	HF	MI
Aortic aneurysm	1 (1.1)			
3 vessels disease	1 (1.1)		2 (15.4)	
MR, TR, AR	5 (5.6)	24 (34.8)	2 (15.4)	16 (32)
Mitral stenosis		2 (2.9)	1 (7.7)	
Aortic stenosis		1 (1.4)		
LVE		1 (1.4)		
LAE		2 (2.9)		
LVH	1 (1.1)	2 (2.9)		
DCMP			1 (7.7)	
Sinus bradycardia	1 (1.1)			
PVC	1 (1.1)	1 (1.4)		2 (4)
AF with RVR	2 (2.2)			
AF with SVR	1 (1.1)			
Complete AV block	1 (1.1)			1 (2)
LBBB	1 (1.1)			
WPW syndrome	1 (1.1)			
Arrhythmia				1 (2)
Dextracardia	1 (1.1)			

PVC: Premature ventricular contractions; MR: Mitral regurgitation; TR: Tricuspid regurgitation; AR: Atrial regurgitation; LVH: Left ventricle hypertrophy; DCMP: Dilated cardiomyopathy; LVE: Left ventricular enlargement; LAE: Left atrial enlargement; AF with RVR: Atrial fibrillation and rapid ventricular response; AF with SVR: Atrial fibrillation and slow ventricular response; AV block: Atrioventricular block; LBBB: Left bundle branch block; WPW syndrome: Wolff-Parkinson-White syndrome.

pulmonary disease (*n* = 16; 7.2%). Angina (*n* = 89; 14%) was the most frequent underlying heart disease, followed by MI (*n* = 50; 22%), AF (*n* = 69; 13%), and HF (*n* = 13; 3%). Seventy six patients had associated heart disease (34.4%) (Table 2).

The overall morbidity rate and cases that required reoperation for radical gastrectomy were 52/221 (23.5%) and 6/221 (2.7%), respectively. The most frequent complications were cardiac problems (*n* = 11; 5.0%), pulmonary issues (*n* = 11; 5.0%), and wound problems (*n* = 11; 5.0%), followed by postoperative bleeding (*n* = 9; 4.1%), intra-abdominal abscess (*n* = 8; 3.6%), anastomosis leakage (*n* = 6; 2.7%), urological problems (*n* = 4; 1.8%), vascular complications (*n* = 4; 1.8%), unknown hypotension (*n* = 1; 0.004%), delayed gastric emptying (*n* = 1; 0.004%), uncontrolled ascites (*n* = 1; 0.004%), pancreatitis (*n* = 1; 0.004%), and paralytic ileus (*n* = 1; 0.004%).

#### Univariate and multivariate analyses of operative risk factors and comorbidity in patients with underlying heart disease

The most significant perioperative risk factors for postoperative morbidity were lymph node metastasis and total gastrectomy in univariate analysis ( $P < 0.05$ ) (Table 3). Underlying cerebrovascular disease and heart disease were significantly different in univariate analysis ( $P < 0.01$ ) (Table 4).

Total gastrectomy (OR = 2.1, 95%CI: 1.0-4.6,  $P = 0.01$ ), underlying cerebrovascular disease (OR = 1.5, 95%CI: 1.07-2.13,  $P = 0.01$ ), and heart disease

**Table 3** Univariate morbidity analysis of operative risk factors in patients with underlying heart disease *n* (%)

Factors	Patient	Complication	<i>P</i> value	OR
Age (yr)			0.11	
> 70	103	19 (18.4)		
≤ 70	118	33 (28)		
Sex			0.85	
Male	171	41 (24)		
Female	50	11 (22)		
OP risk by Cardiologist			0.34	
low	31	5 (16.1)		
moderate	103	27 (26.2)		
high	21	7 (33.3)		
ASA score			0.19	
1	14	1 (7.1)		
2	122	27 (22.1)		
3	85	24 (28.2)		
Preop anticoagulation Tx			1.00	
No	104	24 (23.1)		
Yes	117	28 (23.9)		
Tumor location			0.12	
Lower body	30	12 (40.0)		
Middle body	65	15 (23.1)		
Upper body	123	25 (20.5)		
Whole stomach	2	0 (0)		
Tumor size			0.62	
> 4 cm	129	28 (21.7)		
≤ 4 cm	87	22 (25.3)		
Tumor depth <sup>1</sup>			0.11	
T1 (mucosa, submucosa)	121	23 (29)		
T2 (muscle)	21	5 (23.8)		
T3 (subserosa)	36	8 (22.2)		
T4 (serosa exposure, serosa invasion)	43	16 (37.2)		
LN metastasis <sup>1</sup>			0.01	
N0	141	25 (17.7)		1.0
N1 (1-2)	28	8 (28.6)		1.8
N2 (3-6)	24	6 (25)		1.5
N3 (7-)	28	13 (46.4)		4.0
TNM stage <sup>1</sup>			0.058	
I	130	23 (17.7)		
II	37	10 (28.927)		
III	53	19 (35.8)		
IV	1	0 (0)		
Approach methods			0.12	
Open gastrectomy	177	45 (25.4)		
Laparoscopy assisted gastrectomy	44	7 (15.9)		
Operation type			0.03	
Subtotal gastrectomy	177	36 (20.3)		1.0
Total gastrectomy	44	16 (36.4)		1.3
Operation time			0.75	
< 200	89	21 (23.6)		
> 200	109	29 (26.6)		
LN dissection <sup>2</sup>			0.28	
D1	12	3 (25)		
D1+	47	7 (14.9)		
D2	162	42 (25.9)		
Combined organ resection			0.53	
No	180	41 (22.8)		
Yes	39	11 (28.2)		
Preop chemotherapy			1.00	
No	220	52 (23.6)		
Yes	1	0 (0)		

<sup>1</sup>AJCC TNM stage 7<sup>th</sup> edition; <sup>2</sup>Japanese gastric cancer treatment guidelines 2010 (ver.3). LN: Lymph node; OP risk by cardiologist: Operation risk evaluated by cardiologist; ASA: American society of anesthesiologists; Preop: Preoperative; Tx: Treatment.



**Table 4** Univariate morbidity analysis of comorbidity in patients with underlying heart disease *n* (%)

Factors	Patients	Complication	<i>P</i> value	OR
Hypertension			0.20	
No	116	23 (19.8)		
Yes	105	29 (27.6)		
Diabetes mellitus			0.46	
No	166	37 (22.3)		
Yes	55	15 (27.3)		
Tuberculosis			0.53	
No	206	50 (25.2)		
Yes	15	2 (18.8)		
Chronic liver disease			0.34	
No	215	52 (24.2)		
Yes	6	0 (0)		
Pulmonary disease			0.52	
No	205	48 (23.4)		
Yes	16	4 (25)		
Endocrine disease			1.00	
No	216	51 (23.6)		
Yes	5	1 (20)		
Neurologic disease			0.02	
No	202	43 (21.3)		1.0
Yes	19	9 (47.4)		1.4
Cancer history			0.66	
No	214	50 (23.4)		
Yes	7	2 (28.6)		
Heart disease			< 0.01	
Angina	89	14 (15.7)		1.0
Af	69	13 (18.8)		1.2
Hf	13	3 (23.1)		1.6
Mi	50	22 (44)		4.2

Angina: A history of angina pectoris; AF: A history of atrial fibrillation; HF: A history of heart failure; MI: A history of myocardial infarction.

(Angina, OR = 1; AF, OR = 1.0, 95%CI: 0.4-2.4; HF, OR = 1.7, 95%CI: 0.4-7.3; MI, OR = 4.2, 95%CI: 1.8-9.5) were independent factors of postoperative complications in multivariate analyses ( $P < 0.01$ ) (Table 5).

#### Higher postoperative morbidity in the MI group and greater cardiac problems in the HF group

We found that the total morbidity rate was significantly higher in the MI group (44%) than the Angina (15.7%), AF (18.8%), and HF (23.1%) groups ( $P < 0.01$ ). Intra-abdominal abscesses occurred more often in the MI group (10%) than the Angina (1.1%), AF (2.9%), and HF (0%) groups ( $P < 0.01$ ). Postoperative cardiac problems were significantly more common in the HF group (23.1%) than the Angina (2.2%), AF (4.3%), and MI (6.0%) groups ( $P = 0.01$ ). However, there were no differences in leakage, wound problems, postoperative bleeding, pulmonary complications, urological complications, vascular complications, or mortality between the 4 heart groups ( $P > 0.05$ ) (Table 6).

The HF group had 3 cardiac morbidities: one patient had aggravated HF (pulmonary edema, pleural effusion, and pericardial effusion); one patient had an acute MI; and another patient had elevated B-type natriuretic peptide (3577 pg/mL) and experienced cardiogenic shock on postoperative day 3 without any complications. The Angina group had 2 cases of

**Table 5** Multivariate morbidity analysis of operative risk factors and comorbidity in patients with underlying heart disease *n* (%)

Factors	Patients	Complication	95%CI	<i>P</i> value	OR
LN metastasis <sup>1</sup>				0.13	
N0	141	25 (17.7)			
N1	28	8 (28.6)			
N2	24				
N3	28	13 (46.4)			
Operation type				0.04	
Subtotal gastrectomy	177	36 (20.3)			1.0
Total gastrectomy	44	16 (36.4)	1.0-4.6		2.1
Neurologic disease				0.01	
No	202	43 (21.3)			1.0
Yes	19	9 (47.4)	1.0-2.1		1.5
Heart disease				< 0.01	
Angina	89	14 (15.7)			1.0
AF	69	13 (18.8)	0.4-2.4		1.0
HF	13	3 (23.1)	0.4-7.3		1.7
MI	50	22 (44.0)	1.8-9.5		4.2

<sup>1</sup>AJCC TNM stage 7<sup>th</sup> edition. LN: Lymph node; Angina: A history of angina pectoris; AF: A history of atrial fibrillation; HF: A history of heart failure; MI: A history of myocardial infarction.

**Table 6** Differences in morbidities and mortalities in the 4 different heart diseases groups *n* (%)

Complication	Angina ( <i>n</i> = 89)	AF ( <i>n</i> = 69)	HF ( <i>n</i> = 13)	MI ( <i>n</i> = 50)	<i>P</i> value
Leakage	2 (2.2)	2 (2.9)	0	2 (4.0)	0.85
Intraabdominal abscess	1 (1.1)	2 (2.9)	0	5 (10)	0.04
Wound problem	5 (5.6)	4 (5.8)	0	2 (4.0)	0.81
Postop bleeding	3 (3.4)	1 (1.4)	0	5 (10)	0.09
Pulmonary Cx	2 (2.2)	3 (4.3)	1 (7.7)	5 (10)	0.22
Urologic Cx	2 (2.2)	0 (0)	0	2 (4.0)	0.39
Cardiac problem	2 (2.2)	3 (4.3)	3 (23.1)	3 (6.0)	0.01
Vascular Cx	0 (0)	3 (4.3)	0	1 (2.0)	0.22
Total morbidity	14 (15.7)	13 (18.8)	3 (23.1)	22 (44)	< 0.01
Mortality	2 (2.2)	2 (2.9)	1 (7.7)	1 (2.0)	0.70

Angina: A history of angina pectoris; AF: A history of atrial fibrillation; HF: A history of heart failure; MI: A history of myocardial infarction; postop: Postoperative; Cx: Complication.

cardiac morbidity: one patient experienced another attack of Angina on postoperative day 3, and another patient experienced duodenal stump leakage and acute myocardial infarction (AMI) on postoperative day 14. The AF group had 2 cases of cardiac morbidity: one patient was digitalized because of AF with hypotension, and another patient had complete AV block that improved with anticoagulation medication. The MI group had 3 cases of cardiac morbidities: one patient was digitalized because of AF with hypotension; one patient had an AMI that subsequently improved; and one patient received a pacemaker because of complete AV blockage.

#### Cardiogenic mortality in the HF and MI groups

There were 6 mortality cases in this study: 2 cases of pure cardiogenic shock (one patient in the HF group

and one patient in the MI group) without any other complications; 3 cases of anastomotic leakage; and one case of adult respiratory distress syndrome. The HF group had one case of mortality (8%) because of cardiogenic shock on postoperative day 3. The MI group also had one case of mortality (5%) because of cardiogenic shock on postoperative day 5. The Angina group had 2 cases of mortality (2%): one case of pneumonia with acute respiratory distress syndrome and one case of a duodenal stump leakage and AMI on postoperative day 14. The latter patient was treated in the intensive care unit, but this patient did not survive because operative site bleeding and acute renal failure eventually progressed to multi-organ failure. The AF group had 2 cases of mortality (3%): one case involved septic shock and anastomotic site leakage, and the other case involved intra-abdominal bleeding-associated leakage and anastomotic site leakage.

## DISCUSSION

Few studies examined the perioperative risk factors of underlying diseases, with the exception of hypertension, diabetic mellitus, and liver cirrhosis<sup>[9,19,25]</sup>. Our earlier study found that heart disease and chronic liver disease were associated with morbidity, but we were unable to analyze the risk factors of different types of heart disease<sup>[9]</sup>. Several studies reported high cardiac risk in ischemic heart disease and congestive heart failure<sup>[26-28]</sup>. We selected ischemic heart disease (angina, MI) and congestive heart failure to evaluate the operative risks of gastric cancer surgery. We chose AF because it is the most frequent heart rhythm abnormality.

We found that intra-abdominal abscess and total morbidity were significantly higher in the MI group, and postoperative cardiac problem rates were higher in the HF group. It is possible that the MI patients had larger intra-abdominal abscesses because these patients had decreased wound healing with decreased circulation. There were no differences in neurological disease ( $P = 0.052$ ) in previous study<sup>[9]</sup>, but neurological disease was an independent risk factor in this study. We found that the numbers and proportion of patients with neurological disease increased from 2.2% (17/759) to 8.5% (19/221). There were no differences noted in history of hypertension, DM, or pulmonary disease in this study.

Goldman *et al.*<sup>[26]</sup> reported a cardiac risk model using a multifactorial index in major noncardiac surgery. They scored 53 points using the following 5-item index: (1) history, including age and the occurrence of MI in the previous 6 mo; (2) physical examination, including S3 gallop or jugular vein distention, and important valvular aortic stenosis; (3) electrocardiogram (rhythm other than sinus or premature atrial contractions on the last preoperative electrocardiogram and > 5 premature ventricular contractions at any time before the operation); (4) general status (partial pressure

of oxygen < 60 mmHg or partial pressure of carbon dioxide > 50 mmHg, potassium < 3.0 meq/L or bicarbonate < 20 meq/L, blood urea nitrogen > 50 mg/dL or creatinine > 3.0 mg/dL, abnormal serum glutamine oxalacetic transaminase, signs of chronic liver disease, or patient bedridden from non-cardiac causes); and (5) operation type (intra-peritoneal, intra-thoracic or aortic operation, emergency operation). Recently, Lee *et al.*<sup>[27]</sup> developed a revised cardiac risk index model comprised of 6 risk factors: high-risk surgery type, history of ischemic heart disease, history of congestive heart failure, history of cerebrovascular disease, preoperative treatment with insulin, and preoperative serum creatinine > 2.0 mg/dL. They reported that patients with one or two risk factors had only a 0.5% and 1.3% complication rate, respectively, but patient with three or four risks factor had a 3.6% and 9.1% complication rate, respectively. These risk factors were very similar to the independent risk factors (total gastrectomy, history of myocardial infarction, history of cerebrovascular disease) in our study. Total gastrectomy is a higher risk surgery than subtotal gastrectomy, and a history of ischemic heart disease and cerebrovascular disease are associated with a similar risk. In addition, a history of congestive heart failure is a higher risk factor of postoperative cardiac complications than a history of other heart diseases. Therefore, patients who need total gastrectomy and have more than three risk factors in the revised cardiac risk index model should be consulted about a reduced operation because these patients are expected to have a higher risk of post-operative complication than patients with no risk factors.

One limitation of this study was its lack of control groups for comparisons with the heart disease groups. Moreover, heart disease types were limited to Angina, MI, AF, and HF. We excluded patients with valvular heart disease, arrhythmia, and left ventricular enlargement because of data analysis limitations. Our study was unique and featured a multicenter analysis of patients with gastric cancer who underwent radical gastrectomy.

In conclusion, gastric cancer patients with a history of MI have a higher risk for complication after gastrectomy, and patients with a history of HF have a higher risk for postoperative cardiac problems than patients with a history of Angina or AF. Therefore, patients with MI or HF require careful pre- and postoperative evaluation, and they should be informed about the possibility of postoperative morbidities, particularly intra-abdominal abscess and postoperative cardiac problems.

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## COMMENTS

### Background

The authors previously reported that underlying heart disease or chronic liver disease was a significant independent risk factor for postoperative morbidity following radical surgery for gastric cancer. Histories of ischemic heart disease, heart failure, diabetes, and renal insufficiency are reported risk factors for cardiac death and nonfatal myocardial risk factors in noncardiac surgery.

### Research frontiers

Several studies investigated the perioperative and comorbidity risk factors for postoperative morbidity, but few studies specifically investigated these factors in gastric cancer surgery.

### Innovations and breakthroughs

Myocardial infarction (MI) patients have a higher risk of morbidity, and heart failure (HF) patients have a higher risk of postoperative cardiac problems than patients with angina pectoris (Angina) or atrial fibrillation (AF).

### Applications

Patients with MI or HF require careful pre- and postoperative evaluation, and they should be informed about the possibility of postoperative morbidities, particularly intra-abdominal abscess and postoperative cardiac problems.

### Terminology

Angina, a history of angina pectoris; AF, a history of atrial fibrillation; HF, a history of heart failure; MI, a history of myocardial infarction.

### Peer-review

This is a well written manuscript with reasonable results. The authors evaluate the morbidity and mortality differences between 4 underlying heart diseases - namely, MI, Angina, HF, and AF - after radical surgery for gastric cancer. They conclude that MI patients had a higher risk of morbidity and HF patients had a higher risk of postoperative cardiac problems than patients with Angina and AF.

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