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Incidence, Causes and Risk Factors for 30-Day Unplanned Reoperation After Gastrectomy for Gastric Cancer: Experience of a High-Volume Center

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Abstract

Background: To investigate the incidence, causes and risk factors for unplanned reoperation because of early complications within 30 days of radical gastrectomy for gastric cancer.

Methods: The study cohort comprised 1,948 patients who underwent radical gastrectomy for gastric cancer between November 2010 and April 2017. The incidence, causes and outcomes of unplanned reoperation were examined and the risk factors were identified using univariate and multivariate analyses.

Results: In total, 24 patients (1.2%) underwent unplanned reoperations because of early complications after radical gastrectomy. The main causes more frequently requiring reoperation were adhesive intestinal obstruction (eight cases, 33.3%), intra-abdominal bleeding (five cases, 20.8%), wound dehiscence (five cases, 20.8%), anastomotic leakage and intra-abdominal infection (five cases, 20.8%), and iatrogenic common bile duct injury (one case). Multivariate analysis identified that only combined multi-organ resection (odds ratio (OR) = 4.060, 95% confidence interval (CI): 1.645 - 10.023, P = 0.002) was an independent risk factor. Two patients (8.3%) who underwent reoperation died from disseminated intravascular coagulation or sepsis, respectively, which was significantly higher than the remaining 1,924 patients who did not require reoperation (six cases, 0.3%, P < 0.001). Moreover, patients who underwent reoperation experienced higher morbidity rates (37.5% vs. 6.8%, P < 0.001), requiring intensive care (20.8% vs. 2.4%, P < 0.001) and longer postoperative hospital stays (33.6 days vs. 11.0 days, P < 0.001) compared with patients required no reoperation.

Conclusions: Combined multi-organ resection was an independent risk factor for unplanned reoperation following radical gastrectomy.

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Avoiding multi-organ resection as possible will decrease the likelihood of patients requiring reoperation.

Introduction

Gastric cancer is the fourth most common cancer worldwide and the second most frequent cause of cancer-related mortality in China [1-2]. Gastrectomy with lymph node dissections was previously considered to be the only curative treatment for gastric cancer. Although postoperative complications after surgical resection of gastric cancer have decreased with advances in surgical techniques and perioperative care, unplanned reoperation because of early complications, which occurred in 1-10% of patients, remains clinically important because it results in prolonged hospital stays, increased healthcare costs and even death [3-10]. On the other hand, unplanned reoperation has been widely accepted as an important evaluation index for monitoring quality across hospitals and identifying opportunities for quality improvements, with an increasing focus on outcomes-driven healthcare [11-12]. Therefore, to reduce unplanned reoperation, it is important to understand the risk factors and to identify those patients most at risk. Reoperation usually aimed to manage some rare, severe or life threatening postoperative complications following gastrectomy and has rarely been reported, hence the incidence, causes and potential risk factors remain unknown. The current study from a high-volume center in China was initiated to investigate the incidence, causes and risk factors of unplanned reoperation following radical gastrectomy for gastric cancer.

Patients and Methods

Patients

Between November 2010 and April 2017, a total of 2,351 patients underwent operations for gastric cancer in Hunan Cancer Hospital. Eligibility criteria for this study were: patients who underwent primary radical gastrectomy for gastric cancer

aged ≥ 18 years with adequate organ functions. Exclusion criteria were: patients who needed emergency surgery; had other synchronous malignancies; had residual gastric cancer; or with incomplete clinical-pathological data. Of the 2,351 patients, 136 underwent only laparoscopic exploration and cytology or biopsy due to intra-peritoneal metastasis, and 127 palliative gastrectomy or gastrojejunostomy because of metastasis and pyloric obstruction or bleeding; 140 patients meeting the exclusion criteria were excluded from the study. Thus a total of 1,948 patients were included in the present retrospective study. Each tumor was pathologically diagnosed and staged according to the seventh UICC (Union for International Cancer Control) TNM (Tumor-Lymph Node-Metastasis) Staging System of Gastric Cancer [13]. The study was approved by the Hunan Cancer Hospital Ethics Committee, and informed consent was obtained from all patients. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Surgical procedures and perioperative management

Surgeons with sufficient experience of radical gastrectomy performed all operations. Lymph node dissection and gastric reconstruction were determined according to the fourth Japanese gastric cancer treatment guidelines [14]. Combined multi-organ resection was performed in patients with a locally advanced tumor suspected of invading adjacent organs for the purpose of achieving a R0 resection. Additional resection was defined as simultaneous resection of other organs because of benign disease, such as cholecystectomy in patients with gallstones. Laparoscopic surgery was usually performed in patients with early stage gastric cancer, and an open procedure was the main surgical type for advanced cancer. Patients with clinical T1a or T1b with N0 underwent a D1 or D1 + lymphadenectomy; those with clinical T2-4 or N+ underwent a D2 or D2 + lymphadenectomy [14]. Patients undergoing total gastrectomy were given a Roux-en-Y reconstruction, while those patients undergoing distal sub-total gastrectomy, Billroth I, Billroth II or Roux-en-Y, reconstructions were performed. Proximal sub-total gastrectomy was carried out for proximal early stage gastric cancer, with esophagogastrostomy reconstructions being performed in these patients. A 6-mm silicon drain tube was placed in the Morrison pouch and sub-hepatic space, and another placed in the splenic fossa if radical total gastrectomy or combined distal pancreatectomy and splenectomy were performed, these tubes were subsequently removed 1 or 2 days after starting feeding.

Clinical and surgical outcomes

The following variables were obtained from the medical records: gender, age, body mass index (BMI), American Society of Anesthesiologists (ASA) score, history of abdominal operations, comorbidities (diabetes mellitus, hypertension, chronic pulmonary/kidney/liver disease, cardiovascular and cerebrovascular disease), preoperative albumin and hemoglobin levels, type of gastrectomy, combined multi-organ resection, additional resection, operation time, estimated blood loss, perioperative blood transfusion and the pathological TNM stage. Postoperative morbidity and mortality were graded using a modified Clavien-Dindo classification of surgical complications [15]. Postoperative mortality was defined as deaths that occurred within 30 days after the initial surgery. The 30-day reoperation was defined as any unplanned relaparotomy involving general anesthesia within 30 days for complications following the index surgery.

Statistical analysis

Statistical analyses were performed with IBM SPSS Statistics for Windows (Version 19.0. Armonk, NY: IBM Corp.). All continuous variables are expressed as the mean ± standard deviation (SD), and potential differences between groups were assessed using an independent-samples t-test or a Mann-Whitney U-test, as appropriate. Categorical variables are reported as the total number of cases and prevalence, and differences between groups were compared by χ^2 or Fisher's exact tests. Risk factors for unplanned reoperation were subjected to univariate analyses using a χ^2 test to assess the effects of each factor. Multivariate logistic regression analysis was performed for factors with P-values ≤ 0.1 on univariate analysis. A P-value < 0.05 was considered to be statistically significant.

Results

Incidence and clinical outcomes

The baseline clinical and operative characteristics of the 1,948 patients are shown in Table 1. A total of 106 patients underwent combined multi-organ resection for locally advanced gastric cancer. The organ that was most frequently resected was the pancreas (n = 45), followed by the spleen (n = 37), colon (n = 23) and liver (n = 20). More than one organ simultaneous resection was necessary in 31 cases (29.2%) and the remaining 75 patients underwent only one organ resection. With respect to simultaneous additional resection, there were 46 cases of cholecystectomy for gallstones, nine oophorocystectomies for ovarian cysts, five partial liver resections for hepatic hemangioma, four liver cyst fenestrations, four myomectomies for myoma uterus, three segmental resections of small intestine, one cystectomy for pancreatic cyst and one splenectomy for splenic hemangioma. One hundred and seventy-eight postoperative complications occurred in 155 patients of the entire cohort of patients (8.0%). Twenty-four patients (1.2%) underwent unplanned reoperation because of early complications within 30 days of the initial gastrectomy. Of these patients, 20 (83.3%) were male and four (16.7%) were female, and the mean patient age was 58.8 years (range, 38 - 77 years). Patients who underwent reoperation were more likely to have lower preoperative albumin levels, larger tumor sizes, longer opera-

Table 1. Clinicopathological Characteristics of the Entire Study Cohort Stratified by Undergoing Unplanned Reoperation or Not (n = 1,948)

Variables	Reoperation group (n = 24)	Non-reoperation group (n = 1,924)	χ^2 or t value	P value
Sex (male: female)	20:4	1,265:659	3.27	0.07
Age (years)	58.75 ± 10.00	55.20 ± 10.52	1.63	0.10
Body mass index (kg/m^2)	21.51 ± 2.11	21.79 ± 2.98	0.46	0.65
American Society of Anesthesiologist score			1.74	0.19
1 + 2	19	1,693		
3 + 4	5	231		
Smoking history (yes: no)	13:11	812:1,112	1.39	0.24
Any comorbidities (yes: no)	6:18	577:1,347	0.28	0.60
History of abdominal surgery (yes: no)	4:20	192:1,732	1.17	0.28
Neoadjuvant chemotherapy (yes: no)	1:23	110:1,814	0.11	0.75
Preoperative albumin (g/L)	36.00 ± 5.09	38.13 ± 4.58	2.23	0.02
Preoperative hemoglobin (g/L)	118.63 ± 26.11	118.80 ± 24.45	0.03	0.97
Complication due to the tumor	6:18	429:1,495	0.10	0.75
Pyloric obstruction	6:18	254:1,670	2.85	0.09
Bleeding	1:23	191:1,733	0.89	0.50
Operation method			0.48	0.49
Open	22	1,671		
Laparoscopy	2	253		
Type of resection			2.72	0.10
Subtotal gastrectomy	15	1,478		
Total gastrectomy	9	446		
Additional organ resection			1.42	0.23
Yes	2	71		
No	22	1,835		
Combined multi-organ resection			26.58	< 0.001
Yes	7	99		
No	17	1,825		
Tumor size (cm)	5.24 ± 2.08	4.09 ± 2.05	2.74	0.006
Tumor location			6.26	0.1
Upper	3	158		
Middle	5	396		
Lower	13	1,301		
Diffuse	3	69		
Depth of invasion*			3.84	0.28
T1	1	367		
T2	4	296		
T3	1	111		
T4	18	1,150		
Lymph node metastasis*			1.21	0.75
N0	8	749		
N1	3	324		
N2	5	378		
N3	8	473		
pTNM stage*			3.02	0.22
I	4	489		
II	3	414		
III	17	1,021		
Intraoperative blood loss (mL)	242.5 ± 158.6	203.9 ± 116.1	1.61	0.11
Operation time (min)	232.0 ± 46.7	200.9 ± 53.7	2.83	0.01
Perioperative blood transfusion (yes: no)	11:13	382:1,542	9.93	0.002
Morbidity (%)	9:15	131:1,793	33.47	< 0.001
Mortality (%)	2:22	6:1,918	37.29	< 0.001
Transferring to Intensive Care Unit post-operation	5:19	46:1,878	31.62	< 0.001
Postoperative hospital stays (days)	33.63±28.85	11.01 ± 4.86	19.12	< 0.001

*Tumor stages are based on the seventh edition of the Union for International Cancer Control TNM classification.

Table 2. Clinical Courses From Gastrectomy to Treatment of Reoperation

No	Gastrectomy	Reconstruction	Interval(d)	Cause	Treatment	Morbidity
1	Distal sub-total	B-I	20	Wound dehiscence	Relaxation suture	None
2	Proximal sub-total	Gastroesophagal anastomosis	26	Adhesive intestinal obstruction	Enterolysis	None
3	Distal sub-total	B-I	7	Right gastro-omental vein bleeding	Suture	Intra-abdominal infection
4	Distal sub-total	B-I	15	Intra-abdominal infection	Debridement and drainage	Pleural effusion
5	Total	Roux-en-Y	12	Intra-abdominal infection	Debridement and drainage	None
6	Proximal sub-total	Gastroesophagal anastomosis	18	Wound dehiscence	Relaxation suture	None
7	Distal sub-total	B-I	14	Wound dehiscence	Relaxation suture	Intra-abdominal infection
8	Total	Roux-en-Y	11	Pancreatic fistula and intra-abdominal infection	Debridement and drainage	None
9	Distal sub-total	B-I	13	Adhesive intestinal obstruction	Enterolysis + intestine anastomosis	None
10	Distal sub-total	B-I	14	Gastroduodenal anastomosis leakage	Debridement and drainage	Sepsis and death
11	Distal sub-total	B-II	15	Wound dehiscence	Relaxation suture	Intra-abdominal infection
12	Distal sub-total	B-I	17	Adhesive intestinal obstruction	Enterolysis	Pulmonary infection
13	Distal sub-total	B-I	13	Adhesive intestinal obstruction	Enterolysis + intestine anastomosis	Intestine anastomosis leakage
14	Total	Roux-en-Y	11	Adhesive intestinal obstruction	Enterolysis	None
15	Distal sub-total	B-I	19	Wound dehiscence	Relaxation suture	None
16	Total	Roux-en-Y	10	Adhesive intestinal obstruction	Enterolysis	None
17	Total	Roux-en-Y	26	Obstructive jaundice due to common bile duct injury	Bovine Roux-en-Y anastomosis	DIC and death
18	Distal sub-total	B-I	0.1	Right gastric artery bleeding	Suture	None
19	Total	Roux-en-Y	0.1	Left gastro-omental vein bleeding	Suture	None
20	Total	Roux-en-Y	6	Liver section bleeding	Suture	None
21	Distal sub-total	B-I	3	Intra-abdominal bleeding (unexplained)	Exploratory	None
22	Distal sub-total	B-I	22	Intra-abdominal infection	Debridement and drainage	None
23	Total	Roux-en-Y	8	Adhesive intestinal obstruction	Enterolysis	None
24	Total	Roux-en-Y	22	Adhesive intestinal obstruction	Enterolysis + intestine anastomosis	Pulmonary infection and respiratory failure

B-I: Billroth I reconstruction; B- II: Billroth II reconstruction; Roux-en-Y: Roux-en-Y reconstruction.

tive times, higher rates of combined multi-organ resection and perioperative blood transfusion. Nine patients (37.5%) in the reoperation group suffered complications following the second laparotomy, which was significantly greater than that in the non-reoperation group (6.8%, P < 0.001). Five patients (20.8%) in the reoperation group needed intensive care because of sepsis, respiratory failure or disseminated intravascular coagulation (DIC), which was more frequent than in the non-reoperation group (46 patients, 2.4%, P < 0.001). Moreover, two patients (8.3%) died from DIC or sepsis, which was

Table 3. Univariate Analysis of Possible Predictors of Risk for unplanned Reoperation Following Gastrectomy for Gastric Cancer (n = 1948)

Variables	Reoperation group (n = 24)	Non-reoperation group (n = 1,924)	χ^2 value	P value
Sex (male: female)	20:4	1,265:659	3.27	0.07
Age(years) $\geq$ 65/< 65	9:15	379:1,545	4.71	0.03
Age(years) $\geq$ 70/< 70	3:21	145:1,779	0.83	0.36
BMI (kg/m^2) $\geq$ 25/< 25	1:23	272:1,652	1.96	0.16
ASA score $\geq$ 3/< 3	5:19	231:1,693	1.74	0.19
Comorbidity; yes/no	6:18	577:1,347	0.28	0.60
Smoking history; yes/no	13:11	812:1,112	1.39	0.24
History of abdominal surgery; yes/no	4:20	192:1,732	1.17	0.28
Neoadjuvant chemotherapy; yes/no	1:23	110:1,814	0.11	0.75
Preoperative albumin (g/L) <35/$\geq$ 35	11:13	433:1,491	7.33	0.007
Preoperative hemoglobin (g/L) <100/$\geq$ 100	6:18	401:1,523	0.25	0.62
Complication due to the tumor; yes/no	6:18	429:1,495	0.1	0.75
Operation method: open/laparoscopy	2:22	253:1,671	0.48	0.49
Extent of gastric resection: subtotal/total	15:9	1,478:446	2.72	0.10
Combined multi-organ resection; yes/no	7:17	99:1,825	26.58	< 0.001
Additional resection; yes/no	2:22	71:1,853	1.42	0.23
Intraoperative blood loss (mL): $\geq$ 300/< 300	5:19	399:1,525	0	0.99
Operation time (min): $\geq$ 240/< 240	15:9	427:1,497	21.95	< 0.001
Tumor size (cm); $\geq$ 5/< 5	15:9	699:1,225	6.99	0.008
Depth of invasion; T4/T1-3	18:6	1,150:774	2.29	0.13
Lymph node metastasis; positive/negative	16:8	1,175:749	0.31	0.58
TNM stage: III/I-II	17:7	1,021:903	3.01	0.08
Perioperative blood transfusion; yes/no	11:13	382:1,542	9.93	0.002

BMI: body mass index; ASA: American Society of Anesthesiologist.

significantly more common than in the non-reoperation group (six patients, 0.3%, P < 0.001). The mean postoperative hospital stay was 33.6 days for patients undergoing reoperation and 11.0 days for the non-reoperation group (P < 0.001).

Detailed clinical courses of the 24 reoperation patients

The median time between the initial gastrectomy and reoperation was 15 days (range: 0.1 - 26 days) (Table 2). Among the 24 patients, the main causes of reoperation were adhesive intestinal obstruction (eight cases, 33.3%), wound dehiscence (five cases, 20.8%), intra-abdominal bleeding (five cases, 20.8%), anastomotic leakage and intra-abdominal infection (five cases, 20.8%), and iatrogenic common bile duct injury (one case). Two patients required a third operation because of intra-abdominal bleeding or wound dehiscence, respectively.

Risk factors

On univariate analysis (Table 3), older patients ($\geq$ 65 years),

preoperative albumin < 35 g/L, combined multi-organ resection, operation time $\geq$ 240 min, tumor size $\geq$ 5 cm and perioperative blood transfusion were identified as risk factors for reoperation. In addition, male gender and pyloric obstruction appeared to bemore common in the reoperation group, though the difference were not statistically significant (P = 0.07 and 0.09, respectively). On multivariate analysis, including factors that had P-values $\leq$ 0.1 on univariate analysis, only combined multi-organ resection (odds ratio (OR) = 4.060, 95% confidence interval (CI): 1.645 - 10.023, P = 0.002) was an independent risk factor for reoperation. Patients with longer operative time ($\geq$ 240 min) appeared to have a trend toward a higher incidence of reoperation (OR = 2.829, 95% CI: 0.974 - 8.212), but the difference was not statistically significant (P = 0.056) (Table 4).

Correlation between reoperation rate and operative period

The 1,948 patients were divided into five operative period groups based on a cutoff of 400 for surgical cases. The rates

Table 4. Multivariate Analysis of Possible Predictors of Risk for Unplanned Reoperation Following Gastrectomy for Gastric Cancer (n = 1,948)

Variables	Odds ratio (OR)	95% CI	P value
Combined multi-organ resection	4.060	1.645 - 10.023	0.002
Operation time $\geq$ 240 min	2.829	0.974 - 8.212	0.056

of combined multi-organ resection in each operative period group were 8.3% (33/400), 5.5% (22/400), 4.3% (17/400), 5.5% (22/400) and 3.0% (12/348), respectively (Table 5). The percentage of patients undergoing combined multi-organ resection was obviously decreased over time (P=0.04). The mean operative time of the initial gastrectomy was 220 $\pm$ 41 min, 214 $\pm$ 55 min, 204 $\pm$ 59 min, 195 $\pm$ 53 min and 170 $\pm$ 43 min, respectively. The difference was significant according to general linear model univariate analysis (P < 0.001). The rates of reoperation in each operative period group were 2.0% (8/400), 2.0% (8/400), 1.3% (5/400), 0.5% (2/400) and 0.3% (1/348), respectively. There was a decreased tendency for reoperation rates with increased surgical experience and case volume, but the difference was not significant (P = 0.09).

Discussion

In this retrospective study of a large cohort of patients from a single center in China, we found that unplanned reoperation usually aimed to manage severe postoperative complications following radical gastrectomy for gastric cancer, such as adhesives intestinal obstruction, intra-abdominal infection and uncontrolled bleeding which was not responsive to conservative management. However, reoperation leads to prolonged postoperative hospital stays and a higher frequency of complications, intensive care and mortality. Therefore, it is very important for surgeons to assess the potential risk factors before surgery in order to reduce the incidence of reoperation. However, there are a paucity of studies that have specifically investigated the incidence and risk factors for reoperation following gastrectomy. One previous study examined the rate of reoperation following gastrectomy. But in this study, the patients underwent an initial gastrectomy for benign disease and the reoperation included surgical procedure for acalculous cholecystitis or incisional herina that occurred more than 1 year after the initial surgery (mean 457 days) [6]. The incidence and risk factors may be different from those requiring reoperation because of early complications within 30 days following radical gastrectomy for gastric cancer. It is important to investigate the inci-

dence, causes, risk factors and treatments for reoperation following gastrectomy focus in gastric cancer patients. We found that the incidence of reoperation was 1.2%, which was similar to the 1.1-2.1% reported by researchers in Eastern countries [3, 6-8]. However, it was significantly lower than the 7.9-10% reported in Western countries [4, 9], where patients generally are heavier. Moreover, overweight patients with a BMI $\geq$ 25 kg/m^2 have been shown to be at a greater risk of suffering postoperative complications, with overweight being identified as an independent risk factor for reoperation following laparoscopic gastrectomy [8, 16-18].

Intestinal obstruction due to adhesive formation was the most frequent complication for reoperation, a finding consistent with the results reported by Oh et al [6]. Regardless of the type of abdominal surgery, adhesions are the most common cause of long-term complications, with the most severe consequence of adhesions being small bowel obstructions, which normally require reoperation. Laparoscopy has been confirmed to be associated with a lower incidence, extent, and severity of adhesions to parietal surfaces in colorectal cancer resection [19]. Although there is no similar multicenter observational study for gastric cancer operations, Li et al [8] reported that only one patient required reoperation due to adhesive intestinal obstruction after laparoscopic gastrectomy for gastric cancer in a series of 2,608 patients. The rate was significant lower than those mainly based on open surgery [6-7], including the present study. In contrast, uncontrolled bleeding was the main cause for reoperation following laparoscopic gastrectomy [8]. Most postoperative bleeding is preventable and can be controlled by careful and attentive surgical manipulation. However, precise anatomical lymph node dissection and suture ligation, which has been identified to be important and effective in preventing postoperative bleeding during an open procedure, was difficult during laparoscopic gastrectomy. Thus, surgeons must bear in mind that the causes for necessary reoperation after open or laparoscopic gastrectomy might be very different. As for independent risk factors, tumor size, age > 70 years, male, BMI $\geq$ 25kg/m^2, smoking and all-cause morbidity were the predisposing factors for unplanned reoperation following gastrectomy according to the previous literature [7-9]. Howev-

Table 5. Relationship Between Unplanned Reoperation and Operative Period

Period	First	Second	Third	Fourth	Fifth
Cases	1 - 400	401 - 800	801 - 1,200	1,201 - 1,600	1,601 - 1,948
Combined multi-organ resection cases (%)*	33 (8.3%)	22 (5.5%)	17 (4.3%)	22 (5.5%)	12 (3.0%)
Operation time (min)†	220 $\pm$ 41	214 $\pm$ 55	204 $\pm$ 59	195 $\pm$ 53	170 $\pm$ 43
Unplanned reoperation cases (%)‡	8 (2.0%)	8 (2.0%)	5 (1.3%)	2 (0.5%)	1 (0.3%)

*χ^2 = 9.93, P = 0.04; †F = 59.24, P < 0.001; ‡χ^2 = 8.19, P = 0.085.

er, our study clearly demonstrated that combined multi-organ resection was the only factor that increased the risk for reoperation. There appeared to be an association between longer operation times ($\geq$ 240 min) and reoperation but the finding was marginally statistically insignificant (P = 0.056).

As reported in our previous studies, combined multi-organ resection (such as splenectomy and distal pancreatectomy) for locally advanced gastric cancer was positively associated with overall morbidity and intra-abdominal infection, which may increase the possibility of reoperation [17-18]. In a systematic review summarized by Brar et al [20] of 1,343 patients who underwent combined multi-organ resection, morbidity ranged from 11.8% to 90.5% and mortality was found to be 0-15%, which was significantly higher than in patients who underwent gastrectomy only. When the tumor invades the adjacent organs (T4b), combined en-bloc resection can be performed to achieve R0 resection, which has been identified as the most important indicator of long-term survival for patients undergoing curative surgery for gastric cancer [21]. The pancreas and spleen were the most common resected organs involved in combined multi-organ resection in this study. Distal pancreatectomy, as well as manipulation of the tail of the pancreas during splenectomy, may lead to a higher risk of pancreatic fistula, resulting in abdominal infection or abscess if not well-drained. In addition, bleeding sites around the spleen and pancreatic vascular bed were also a common cause of reoperation [6-8]. Combined colectomy may increase the risk of intra-abdominal infection because of the greater probability of exposure to pathogens. Given the high risk of postoperative morbidity and unplanned reoperation, combined multi-organ resection should be cautiously considered. However, precise identification of T4b disease can be difficult by preoperative CT, endoscopic ultrasound or intraoperative assessments [22-23]. Thus, improved methods for preoperative and intraoperative assessment of disease extension to adjacent organs should be investigated. In recent years in our department, intraoperative rapid frozen pathological examinations have been performed more and more commonly in patients with suspected tumor invasion; some cases were identified as only inflammation adhesion instead of true invasion. As a result, the percentage of patients requiring combined multi-organ resection decreased in our department over time. On the other hand, although there was a patient who underwent reoperation because of iatrogenic common bile duct injury in the process of cholecystectomy for gallstone, patients who underwent simultaneous additional resection of other organs for benign diseases was not an independent risk for reoperation according to multivariate analysis in this study. A possible explanation is that patients who underwent cholecystectomy, oophorocystectomy or liver cyst fenestration had markedly lower levels of complications because of the simple nature of these procedures.

Although the difference was perhaps marginally significant (P = 0.056), patients with longer operation times ($\geq$ 240 min) seemed to have a higher incidence of reoperation. Oh et al [6] also proposed a decrease in the operation time to reduce the incidence of intestinal adhesions, leading to a reduction in the requirement for reoperation. On the other hand, surgical experience and case volume greatly influenced the operation time and postoperative complications [24]. In the present study, the average operation time decreased from 220 $\pm$ 41 min to 170 $\pm$ 43 min through the first 400 cases to the last 348 cases (P < 0.001), with the incidence of reoperation apparently decreased from 2.0% to 0.3%, but the difference was not statistically significant (P = 0.09). A possible measure to reduce the operation time is the use of energy devices, such as ultrasonically activated coagulating shears. Several studies have shown that the use of ultrasonically activated coagulating shears reduces the operative time, and even major postoperative complications compared to conventional monopolar electrosurgery [25].

The present study has several limitations. First, it was a retrospective study from a single institution. Secondly, there has not been a uniform standard for determining when reoperation should occur; the indication and timing for reoperation may differ in different surgical centers. In addition, the incidence of reoperation for each complication was extremely low, thus we enrolled all the cases requiring reoperation into the study group to explore their risk factors, but in fact the risk factors for each cause should be different. A prospectively registered high-volume sample database that collects and stores detailed data would minimize the impact of confounding factors and improve the credibility of the conclusions. Nevertheless, the present study identified specific factors associated with reoperation following gastrectomy for gastric cancer in a large cohort of patients.

In conclusion, reoperation usually aims to manage some severe or life threatening postoperative complications, but in term, may also leads to serious complications, even death. Combined multi-organ resection is identified as the only independent risk factor for reoperation in patients undergoing initial gastrectomy for gastric cancer. Thus, meticulous surgical procedures and close observation need to be performed on patients underwent combined multi-organ resection for gastric cancer.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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