

# Enhanced Recovery Protocol Versus Conventional Perioperative Management For Three-Dimensional Laparoscopy-Assisted Gastrectomy: A Prospective Cohort Study

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## Research

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# Abstract

**Background:** It remains unclear whether patients undergoing three-dimensional (3D) laparoscopy-assisted gastrectomy could benefit from enhanced recovery protocol. The aim of present study is to compare enhanced recovery protocol and the conventional perioperative management after 3D laparoscopy-assisted gastrectomy in gastric cancer.

**Methods:** A prospective cohort of patients received 3D laparoscopy-assisted gastrectomy were enrolled between 2017 and 2018. A hospital-based enhanced recovery protocol was established and implemented. Patient's clinic-pathological characteristics and perioperative outcomes were compared between enhanced recovery group (ERG) and conventional group (CG). ER protocol compliance rate was calculated for patients in ERG. Univariate and multivariate binary logistic regression analysis were performed to investigate influential factors for delayed discharge and for postoperative complications.

**Results:** One hundred and eighty-seven patients received 3D laparoscopy-assisted gastrectomy in ERG and 111 patients in CG were enrolled in the final analysis. Patients had comparable baseline characteristic between groups. However, patients in ERG had shorter time to oral feeding, reduced postoperative hospital stay and less medical cost (all  $P < 0.05$ ). The postoperative complication rate were 10.7% for ERG and 10.8% for CG respectively. Regarding individual items in enhanced recovery protocols, prevention of postoperative nausea and vomiting had the highest compliance of 100% (187/187) while ambulation on postoperative day one had the lowest compliance of 32.1% (60/187). Univariate logistic regression analysis revealed operation time ( $P < 0.001$ ), blood loss ( $P = 0.007$ ), intraoperative transfusion ( $P = 0.003$ ) and compliance ( $P < 0.001$ ) were correlated with delayed discharge, while multivariate analysis demonstrated that only compliance [odds ratio (OR), 0.939;  $P < 0.001$ ] and operation time (OR, 1.010;  $P = 0.048$ ) were statistically significant. Additionally, univariate analysis showed blood loss (OR, 1.002;  $P = 0.028$ ) and compliance (OR, 0.978;  $P = 0.030$ ) were associated with postoperative complications, but multivariate analysis showed neither was statistically significant. Spearman correlation analysis revealed compliance was negatively correlated with postoperative hospital stay (Spearman  $r = -0.64$ ,  $P < 0.001$ ) and with medical cost (Spearman  $r = -0.26$ ,  $P < 0.001$ ).

**Conclusion:** The present prospective cohort study suggests it is safe and feasible to incorporate 3D laparoscopic gastrectomy into enhanced recovery settings. Furthermore, improving compliance with enhanced recovery protocol may shorten hospital stay and promote postoperative recovery.

## Background

By identifying factors that delay postoperative recovery, Kehlet [1] from Denmark combined a series of perioperative interventions to reduce surgical stress and organ dysfunction. These evidence-based measures aimed to optimize the patient's perioperative physiological status (insulin resistance, nutritional risk, pain relief, etc.) and enhance recovery after surgery. In 2001, a study group was organized during the European Society of Clinical Nutrition and Metabolism (ESPEN) and used the termed "enhanced recovery

after surgery (ERAS)” for the first time at the 2002 ESPEN meeting. The ERAS group announced the first consensus guideline for colorectal surgery in 2009 [2]. Afterwards, ERAS guidelines for colon surgery, pelvic surgery, and pancreaticoduodenectomy were published in 2012 [3–5], and a perioperative care protocol for gastrectomy was also published in 2014. The ERAS concept was initially accepted in Europe and became popular globally in recent years.

The enhanced recovery after surgery (ERAS) protocol constitutes preoperative, intraoperative, and postoperative interventions. It is not enough to establish a ERAS protocol, and it is more important to put the protocol into practice [6]. There is increasing evidence that the ERAS guidelines are difficult to adopt, as implementation of the ERAS protocol in clinical settings necessitates multidisciplinary cooperation among surgeons, anesthetists, and other medical team members [7]. Any barriers came from patient-related factors, staff-related factors, practice-related issues and resources could compromise the adherence to ERAS protocol [8]. Due to different accessible resources across different hospitals, there may not be one-size-fit-all ERAS protocols. Additionally, for gastric cancer, between the Western countries and Eastern countries, there may be huge differences in patient characteristics, extent of nodal dissection, quality of surgery, and even perioperative care before ERAS [9]. Therefore, it would be practical to establish hospital-based tailored ERAS protocol to improve adherence [6].

Minimally invasive surgery has been increasingly adopted in clinical settings since the 1990s [10]. For treatment of gastric cancer, laparoscopy-assisted distal gastrectomy has been recommended as an alternative approach for clinical stage I tumors [11]. Performance of lymph node dissection and vascular division in the three-dimensional (3D) abdominal cavity under a traditional two-dimensional (2D) laparoscopic view is technically demanding for surgeons, especially for less experienced surgeons. In simulated settings, 3D vision has advantages over 2D vision in terms of precision of depth judgements, technical performance and perceived workload [12]. For gastric cancer, documents revealed that 3D laparoscopic gastrectomy could shorten operation time and reduce intraoperative blood loss, especially during difficult procedures such as lymphadenectomy around the celiac artery and hand-sew reconstruction in a narrow space [13–15]. Hence, 3D laparoscopy could be of great benefit both for surgeons and for patients, and could be seemed as the “future” of laparoscopy [16].

Currently, no publication investigates the role of ERAS pathway in 3D laparoscopic gastrectomy. In the present study, we established a tailored ERAS strategy to improve compliance in our hospital. Then, we compared enhanced recovery protocol and the conventional perioperative management after 3D laparoscopy-assisted gastrectomy in gastric cancer. The aim of the study was to clarify the safety and feasibility of this ERAS protocol in 3D laparoscopy-assisted gastrectomy.

## Methods

### Patients

This study was reviewed and approved by the Chinese People’s Liberation Army General Hospital Research Ethics Committee. From January 2017 to December 2018, consecutive patients in ERAS

settings and those in conventional perioperative management who underwent 3D laparoscopy-assisted gastrectomy performed by L.C. and C.L were enrolled. All patients provided written informed consent. The patients' data were recorded in a prospectively maintained database.

## **ERAS protocol**

A tailored ERAS protocol was established based on knowledge-to-action cycle [6]. The ERAS development team consisted of surgeons, anesthesiologists, nurses, dietitians, and administrator. Each provided their unique expertise and perspective regarding various points in the patients' care. The ERAS protocol is summarized in Table 1. Before admission, the patients received orally presented preoperative education and counseling at the outpatient clinic. Abdominal computed tomography, chest radiography, gastroscopy, electrocardiography, blood testing, and respiratory function testing were performed for diagnosis and preoperative assessment. The patients were encouraged to quit smoking for >2 weeks. Frail and deconditioned patients underwent a prehabilitation program that addressed their physical, metabolic, nutritional, and mental status to increase their functional reserve. On the day of admission, the preoperative education was further enhanced by written material. The patients were informed of the approximate length of stay (generally 5–7 days after gastrectomy), preoperative fasting time, surgical strategy, pain control, and time of catheter removal. Their nutritional status was evaluated according to the Nutrition Risk Screening 2002. Mechanical bowel preparation was not performed, and the patients were fasted up to 6 h before surgery. No preanesthetic medication was administered.

On the day of surgery, the patients underwent anesthetic induction with propofol and a short-acting opioid in the operating room. A short-acting non-depolarizing muscle relaxant was used to facilitate intubation and ventilation. Full monitoring and internal jugular vein access were established. Short-acting anesthetic drugs were used for maintenance of anesthesia, and short-acting muscle relaxants were used for surgical exposure during the laparoscopic procedures. The depth of anesthesia was controlled by maintaining the bispectral index (BIS) at 40 to 60 or the end-tidal concentration at 0.7 to 1.3 using monitored anesthesia care, and too-deep anesthesia (BIS of <45) was avoided in patients of advanced age. A nasogastric tube and urinary catheter were inserted after anesthesia. Antibiotics were administered within 1 h before skin incision, and a further dose was administered when the operative time lasted more than 3 h. The air conditioner in the operating room was set at 25°C to 28°C. A Bair Hugger Warming Unit (3M, Maplewood, MN, USA) was used to keep the patients' temperature at >36°C when necessary. During the surgery, an individualized goal-directed fluid management strategy and protective-ventilation strategy were adopted. To relieve postoperative pain, ropivacaine (0.5%) was administered regionally near the abdominal incision and flurbiprofen axetil (50 mg) was administered intravenously when suturing the abdominal skin. Patient-controlled analgesia was utilized. Ondansetron (4 mg) was administered to prevent postoperative nausea and vomiting. Upon completion of the surgery, the nasogastric tube was removed; an abdominal drainage tube was not placed.

On postoperative day (POD) 1 and 2, the patients were encouraged to walk around the ward with increasing frequency, and oral intake began with water and clear nutritional liquid (six spoonfuls of

Ensure<sup>®</sup> Powder in 200 ml of water three times daily; 750 kcal/d). The urinary catheter was removed. Ondansetron (4 mg) was intravenously administered each day as needed for nausea and vomiting. On POD 3 to 5, a liquid diet was started if tolerated. On POD 5 to 7, a soft blended meal was started if tolerated. Discharge to perioperative surgical home was encouraged if the patients had normal laboratory test results and no discomfort.

### **Conventional perioperative care**

Patients in the conventional group received primary nursing care. A solid diet was allowed until the day before surgery and clear fluid was allowed until 22:00. Bowel preparation (polyethylene glycol electrolyte) was administered on the day before surgery. During surgery, drainage tubes were regularly placed. After surgery, additional analgesics were administered when the patient reported pain. Nasogastric tube was removed on POD 1 or POD 2. Clear fluid was allowed when patients had a flatus, and soft blended food was allowed after two-to-three days of clear fluid without abnormality. Removal of urinary tube was generally on POD 1 if patients had no difficulty in urination. Abdominal drainage was removed when drainage fluid was clear and was less than 20 ml. Patients were usually discharged on POD 8 to 14 if the blood test was normal and patients had no complaint.

### **Surgical procedure**

Based on the preoperative examination and intraoperative exploration, the patients underwent either total or subtotal 3D laparoscopy-assisted gastrectomy (Aesculap EinsteinVision<sup>®</sup> 3D camera system; B. Braun, Melsungen, Germany). Gastrectomy and lymph node dissection were performed to the extent previously described [17-19]. Digestive reconstruction was performed extracorporeally. Gastroduodenostomy, gastrojejunostomy, Roux-en-Y anastomosis, or esophagogastric anastomosis was performed according to the intraoperative exploration findings and surgeon's preference.

### **Perioperative data**

The patients' clinic-pathological data were collected, including sex, age, comorbidities, nutritional risk, operative time, intraoperative blood loss, pathological stage, and other variables. Postoperative complications were recorded according to the Clavien–Dindo grading system [20]. Postoperative mortality and readmission rate within 30 days was documented. The following items were documented to calculate protocol compliance: no placement of nasogastric tube postoperatively, removal of urinary catheter on POD 1 to 2, no placement of abdominal drainage tube, ambulation on POD 1, oral intake of clear nutritional liquid on POD 1, oral intake of a liquid diet on POD 3 to 5, postoperative analgesia, and prevention of postoperative nausea and vomiting.

### **Statistical analysis**

Continuous variables are presented as mean  $\pm$  standard deviation or median with interquartile range (IQR). The Mann–Whitney test or independent-samples *t* test was used to compare continuous variables,

and the  $\chi^2$  test was used to compare categorical variables. Univariate and multivariate logistic regression were performed to investigate the factors influencing delayed discharge [postoperative hospital stay (PHS) of >7 days]. Pearson's correlation analysis was applied to investigate the relationship between the compliance rate and PHS. SPSS software version 17.0 (SPSS, Inc., Chicago, IL, USA) was used for the statistical analysis. A two-sided P value of <0.05 was considered statistically significant.

## Results

### Baseline characteristics

From January 2017 to December 2018, 187 patients received 3D laparoscopy-assisted gastrectomy in enhanced recovery group (ERG) and 111 patients in conventional group (CG) were enrolled. The baseline characteristics of the enrolled patients are shown in Table 2. The mean age was  $60.0 \pm 11.3$  for patients in ERG and  $60.7 \pm 10.8$  for those in CG ( $P = 0.600$ ). Patients characteristics were well balanced between groups in terms of body mass index ( $P = 0.241$ ), gender ( $P = 0.309$ ), blood type ( $P = 0.057$ ), nutritional risk score ( $P = 0.591$ ) and comorbidity ( $P = 0.803$ ).

### Intraoperative outcomes

The intraoperative outcomes are shown in Table 3. The operation time was  $238 \pm 51$  min for ERG and  $244 \pm 55$  min for CG respectively ( $P = 0.341$ ). There was no statistically significant regarding blood loss ( $P = 0.881$ ). In terms of the resection extent in ERG, 82 patients underwent total gastrectomy, 101 patients underwent partial gastrectomy (89 distal and 12 proximal), and four patients underwent combined resection (two distal gastrectomy with gallbladder resection, one distal gastrectomy with partial hepatectomy, and one distal gastrectomy with transverse colon resection). As for resection extent in CG, 49 patients received total gastrectomy and 62 patients received partial gastrectomy. Five patients (2.7%) in ERG underwent conversion to open surgery (to facilitate combined resection in two patients and because of abdominal adhesions in two patients) and one patient (0.9%) in CG was converted to open surgery due to abdominal adhesions ( $P = 0.292$ ). There was not significant difference between groups with regard to lymphadenectomy ( $P = 0.147$ ) and digestive reconstruction ( $P = 0.232$ ).

### Postoperative outcomes

The postoperative outcomes are shown in Table 4. The number of lymph nodes retrieved was  $32 \pm 13$  for ERG and  $29 \pm 14$  for CG ( $P = 0.062$ ). Patients in ERG started oral feeding earlier than those in CG ( $2.8 \pm 1.7$  versus  $4.7 \pm 2.8$ ,  $P < 0.001$ ). Notably, there was comparable postoperative morbidity (Clavien-Dindo  $\geq$  II) between groups ( $P = 0.780$ ). In the ERG, 10 patients developed hypoalbuminemia requiring albumin infusion, 2 patients developed anemia requiring blood transfusion, and one patients developed pneumonia requiring pharmaceutical therapy (grade II). Four patients developed complications requiring surgical or endoscopic intervention, including two with duodenal stump fistula, one with anastomotic bleeding, and one with anastomotic fistula (grade III). Three patients developed postoperative complications transferred to intensive care unit (grade IV). In the CG, 2 patients developed postoperative

thrombocytopenia requiring platelet infusion and 5 patients developed hypoalbuminemia requiring albumin transfusion (grade II). Two patients had complications requiring surgical intervention including one with anastomotic fistula and one with anastomotic stenosis (grade III). Three patients were transferred to intensive care unit (grade IV). None mortality was observed in both group, and 30-day readmission rates were comparable ( $P = 0.515$ ). Patients in ERG had shorter PHS than those in CG ( $7.3 \pm 3.9$  versus  $10.5 \pm 5.4$ ,  $P < 0.001$ ). There was also reduced medical cost in ERG ( $P = 0.002$ ).

### **ERAS protocol compliance**

The ERAS protocol compliance is shown in Table 5. The median overall compliance rate was 0.75 (IQR, 0.55–0.88). Specifically, prevention of postoperative nausea and vomiting had the highest compliance rate (100%), and ambulation on POD 1 had the lowest compliance rate (32.1%). We investigated factors influencing delayed discharge, and the univariate analysis showed that intraoperative blood transfusion, operation time and blood loss were positively correlated with delayed discharge while the compliance was negatively correlated with delayed discharge (Table 6). Interestingly, the multivariate analysis indicated that only the compliance [odds ratio (OR), 0.939;  $P = 0.001$ ] and operation time (OR, 1.010;  $P = 0.048$ ) were correlated with delayed discharge. Additionally, univariate analysis showed blood loss (OR, 1.002;  $P = 0.028$ ) and compliance (OR, 0.978;  $P = 0.030$ ) were associated with postoperative complications, but multivariate analysis showed neither was statistically significant (Table 7). The correlation analysis demonstrated that ERAS compliance was negatively correlated with the PHS (Spearman  $r = -0.64$ ,  $P < 0.001$ ) and with the medical cost (Spearman  $r = -0.26$ ,  $P < 0.001$ ) (Figure 1).

## **Discussion**

More minimally invasive gastrectomy procedures began to be performed when the first Da Vinci robot surgical system was introduced in our center in 2006 [19, 21]. Our previous study showed that the ERAS protocol combined with laparoscopic surgery promoted faster postoperative recovery, improved patients' early postoperative nutritional status, and more effectively reduced postoperative stress reactions in older patients with gastric cancer [22]. Three-dimensional laparoscopy was recently introduced in our center and has demonstrated potential advantages over traditional 2D laparoscopy with respect to the depth of visualization and performance of lymphadenectomy in complex anatomic sites. To the best of our knowledge, no study has evaluated the safety and feasibility of the ERAS protocol in 3D laparoscopic surgery, especially for gastric cancer.

The present prospective cohort study has shown that it is safe to incorporate the ERAS protocol into perioperative care for patients undergoing 3D laparoscopic gastrectomy. ERAS protocols vary among previous studies. Most of the ERAS protocols in previous studies focused on surgery-related items, including no use of abdominal drainage, early removal of the urinary catheter, early ambulation, and similar measures. However, because ERAS emphasizes the perioperative cooperation of a multidisciplinary team, it is necessary also consider anesthesia-related items such as a multimodal analgesia strategy and protective-ventilation strategy. Unlike previous studies, we organized a multi-

disciplinary discussion and integrated surgery- and anesthesia-related items into the tailored ERAS protocol to provide patients with optimal care. Because the ultimate goal of ERAS is to achieve a “pain- and risk-free operation” [23], anesthesia indeed plays a pivotal role in promoting recovery. In our study, BIS-guided anesthetic methods were adopted with the aim of not only preventing awareness but also minimizing anesthetic adverse effects and facilitating rapid awakening and recovery. During the operation, we used the protective-ventilation strategy (ventilation with low tidal volumes of 6–8 ml/kg) to decrease pulmonary complications and shorten the hospital stay [24]. Goal-directed fluid management was used to maintain homeostasis and avoid fluid overload. Postoperative pain affects patients’ recovery. We used multimodal analgesic regimens, including ropivacaine and flurbiprofen axetil, to achieve optimal analgesia with minimal adverse effects and to facilitate early ambulation and oral intake.

An ERAS protocol was not enough, and improving implementation of the ERAS protocol should be stressed. Our results demonstrated that higher compliance was correlated with a shorter hospital stay and lower medical cost, indicating potentially fast recovery. These findings are inconsistent with those from an international registry study [25]. In that study, ERAS compliance had an inverse effect on the length of hospital stay and a negative relationship with complications [25]. To improve compliance, it would be useful to identify barriers and facilitate ERAS protocol implementation first. Using the knowledge-to-action cycle, McLeod et al. [6] developed a tailored implementation strategy to improve compliance, while Pearsall et al. [7] conducted semi-structured interviews to identify barriers and enablers in implementing ERAS protocols. Our experience revealed three main types of factors affecting implementation of ERAS protocols: administration-related, doctor-related, and patient-related factors. Because ERAS protocols necessitate the cooperation of a multidisciplinary team, we built an ERAS College for Gastrointestinal Surgery to integrate participation among surgeons, anesthesiologists, nurses, and nutritional clinicians. We also established administrative easy admission access for ERAS patients. With respect to doctor-related problems, the major barrier was doctors’ unwillingness to change their regular practice. Continuous medical education for the medical staff is one method that may solve this problem. Patients’ expectations were another obstacle. Video education, education booklets, and verbal education were provided to the patients throughout their entire hospitalization experience.

By establishing an ERAS protocol and improving compliance, we achieved an average discharge time of 7.3 days and a morbidity rate of 10.7% for patients underwent 3D laparoscopy-assisted gastrectomy. Liu et al. [26] investigated the efficacy of fast-track and minimally invasive surgery for gastric cancer. In their study, the median PHS and morbidity rate for patients undergoing 2D laparoscopy-assisted gastrectomy were 6 days and 8.1%, respectively [26]. In a phase II ERAS clinical trial from Japan, the median PHS and morbidity rate were 8 days and 10.7%, respectively [27]. A study performed by an Italian research group revealed that the median PHS and morbidity rate in ERAS settings were 8 days and 11.1%, respectively [28]. Our results are comparable with these findings. Unlike these previous publications, however, the present study is the first to incorporate 3D laparoscopy into ERAS settings. Compared with traditional laparoscopy, 3D laparoscopy was able to accelerate surgeons’ proficiency [29]. Specifically, the 3D display is useful because it helps to improve surgical skill during difficult procedures such as

lymphadenectomy around the celiac artery [15]. Compared with patients in CG, patients in ERG had similar oncological safety but a shorter PHS and less medical cost, indicating the potential benefit of the ERAS program.

In present study, we found that the ERAS compliance was negatively correlated with delayed discharge but was not significantly correlated with postoperative complications. There was also comparable 30-day readmission rate between groups. Similar to our study, recent population-based prospective multicenter study from Western countries reported that it could be possible to gain a 10% reduction in hospital stay for every 10% increase in ERAS compliance [30]. Correlation between morbidity and ERAS compliance rate was also observed [30]. Postoperative complications could be divided into “surgical” and “medical” [31]. The ERAS protocol could optimize patient’s perioperative physiological performance to minimize “medical” complication. Surgical quality by experienced surgeons could prevent “surgical” complication. From our experience, intraoperative surgical quality including dissection, stanch and digestive anastomosis, should be ensured in ERAS settings.

Some limitations should be considered when interpreting these results. First, the findings needed to be verified in a larger cohort in our ongoing trial. Second, we are still collecting data regarding the patients’ long-term quality of life. Third, the feasibility of the ERAS protocol for older patients with a poor performance status and high nutritional risk remains unclear. It may be better to provide these vulnerable patients with individualized ERAS items to accelerate recovery.

In conclusion, our study suggests that incorporating an ERAS program into 3D laparoscopy-assisted gastrectomy can promote patient rehabilitation. Higher compliance with this ERAS protocol could shorten the hospital stay and decrease medical cost.

## **Declarations**

### **Ethics approval and consent to participate**

This study was reviewed and approved by the Chinese People’s Liberation Army General Hospital Research Ethics Committee. Each participant provided written informed consent, and our study conformed to the Declaration of Helsinki.

### **Consent for publication**

Not applicable

### **Availability of data and materials**

The raw data are available upon reasonable request to the corresponding author.

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### **Author's contributions**

Study design and concept: KCZ, CRL, JXC. Data acquisition: KCZ, CRL, JXC. Data analysis and interpretation: CRL, JXC, ZQ, LC. Collection of clinical data and sample disposal: ZQ, LC. Manuscript preparation: KCZ. Manuscript review: ZQ, LC. All authors read and approved the final manuscript.

### **Competing interests**

Drs. Kecheng Zhang, Canrong Lu, Jianxin Cui, Zhi Qiao and Lin Chen have no conflicts of interest or financial ties to disclose.

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None

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## Tables

Table 1. Perioperative ERAS items in gastric cancer surgery

Before admission	Preoperative education and counseling at outpatient clinic
	Cardiac and pulmonary management
Day before surgery	Nutritional assessment
	No mechanical bowel preparation
	Fasting up to 6 h before surgery
Day of surgery	Antimicrobial prophylaxis before skin incision and every 3h
	Fluid restriction (Keep vein catheter)
	Insert of nasogastric tube (remove after surgery)
	Temperature management
	Insert of urinary catheter
	Goal-directed fluid management (crystal solution preferred)
	Protective-ventilation strategy ( ventilation with low tidal volumes, 6-8mL/kg)
	Bispectral-index-guided (40-60) anesthetic management
	No abdominal drainage
Day after surgery	
POD 1-2	Removal of urinary catheter
	Sip of water with nutritional powder
	Ambulation
	Patient-controlled analgesia
	Prevention of PONV
POD 3-5	Liquid diet
	Ambulation
	Laboratory test
POD 5-7	Soft blended meal
	Ambulation
	Removal of vein catheter
	Check discharge criteria
	Discharge to perioperative surgical home

POD, postoperative day; PONV, postoperative nausea and vomiting;

Table 2. Baseline characteristics of enrolled patients

Variables	ERG (n=187)	CG (n=111)	P value
Age, yrs	60.0±11.3	60.7±10.8	0.600
BMI, kg/m <sup>2</sup>	23.8±3.4	24.3±3.8	0.241
Gender, M/F	144 (77%)/43(23%)	91 (82%)/ 20 (18%)	0.309
Blood type			0.057
A	62 (33.2%)	27 (24.3%)	
AB	21 (11.2%)	10 (9.0%)	
B	45 (24.1%)	43 (38.7%)	
O	59 (31.6%)	31 (27.9%)	
Nutritional risk score <sup>S</sup>			0.591
0	98 (52.4%)	61 (55.0%)	
1	47 (25.1%)	24 (21.6%)	
2	19 (10.2%)	11 (9.9%)	
3	13 (7.0%)	12 (10.8%)	
4	10 (5.3%)	3 (2.7%)	
Numbers of comorbidity			0.803
0	125 (66.8%)	73 (65.8%)	
1	33 (17.6%)	17 (15.3%)	
2	16 (8.6%)	14 (12.6%)	
3	7 (3.7%)	3 (2.7%)	
4	6 (3.2%)	4 (3.6%)	
Type of comorbidity			0.197
Anemia	21 (11.2%)	6 (5.4%)	
Coronary disease	25 (13.3%)	20 (18.0%)	
Diabetes	18 (9.6%)	15 (13.5%)	
Hepatobiliary disease	23 (12.3%)	12 (10.8%)	
Hypertension	20 (10.7%)	17 (15.3%)	

Others <sup>¶</sup>	3 (1.6%)	0 (0.0%)
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*IQR*: interquartile range

§Nutrition Risk Screening 2002 scale

¶one in reflux esophagitis, one in pancreatic cyst and one in duodenal polyps

Table 3. Intraoperative outcomes

Variables	ERG (n=187)	CG (n=111)	P value
ASA			0.499
I	4 (2.1%)	2 (1.8%)	
II	161 (86.1%)	92 (82.9%)	
III	22 (11.8%)	17 (15.3%)	
Operation time, min	238±51	244±55	0.341
Blood loss, ml	167±333	172±139	0.881
Extent of resection			0.388
Distal gastrectomy	89 (47.6%)	57 (51.4%)	
Total gastrectomy	82 (43.9%)	49 (44.1%)	
Proximal gastrectomy	12 (6.4%)	5 (4.5%)	
Combined resection <sup>§</sup>	4 (2.1%)	0 (0.0%)	
Blood transfusion, Y/N	13(7.0%)/174(93.0%)	10 (9.0%)/101 (91.0%)	0.520
Conversion to open surgery	5 (2.7%)	1 (0.9%)	0.292
Lymph node resection, D2/D1 plus	186(99.5%)/1(0.5%)	108 (97.3%)/3 (2.7%)	0.147
Reconstruction			0.232
Billroth I	31 (16.6%)	20 (18.0%)	
Billroth II	14 (7.5%)	16 (14.4%)	
Roux-en-Y	130 (69.5%)	70 (63.1%)	
Esophagogastrostomy	12 (6.4%)	5 (4.5%)	

*IQR*: interquartile range

§two distal gastrectomy with gallbladder resection, one distal gastrectomy with partial hepatectomy, one distal gastrectomy with transverse colon resection

Table 4. Postoperative outcomes

Variables	ERG (n=187)	CG (n=111)	P value
Tumor size, cm	3.9±2.3	4.2±2.5	0.293
Tumor differentiation			0.630
Well-Moderately	9 (4.8%)	5 (4.5%)	
Moderately	28 (15.0%)	18 (16.2%)	
Moderately-Poorly	68 (36.4%)	39 (35.1%)	
Poorly	78 (41.7%)	49 (44.1%)	
Signet-ring cell	4 (2.1%)	0 (0.0%)	
pT stage			0.690
T1	41 (21.9%)	24 (21.6%)	
T2	30 (16.0%)	21 (18.9%)	
T3	91 (48.7%)	43 (38.7%)	
T4	25 (13.4%)	13 (11.7%)	
Lymph node retrieval	32±13	29±14	0.062
pN stage			0.735
N0	81 (43.3%)	50 (45.0%)	
N1	30 (16.0%)	13 (11.7%)	
N2	30 (16.0%)	17 (15.3%)	
N3	46 (24.6%)	31 (27.9%)	
pTNM stage			0.868
I	57 (30.5%)	33 (29.7%)	
II	53 (28.3%)	29 (26.1%)	
III	77 (41.2%)	49 (44.1%)	
Oral feeding, days	2.8±1.7	4.7±2.8	<b>&lt;0.001</b>
Morbidity (Clavien-Dindo classification)			0.780
II	13 (7.0%)	7 (6.3%)	
III	4 (2.1%)	2 (1.8%)	
IV	3 (1.6%)	3 (2.7%)	
Mortality	0 (0.0%)	0 (0.0%)	-

PHS, days	7.3±3.9	10.5±5.4	<b>&lt;0.001</b>
30-day readmission	10 (5.3%)	8 (7.2%)	0.515
Cost, ¥, × 10 <sup>3</sup>	86.9±20.7	94.9±23.3	<b>0.002</b>

*IQR*: interquartile range

Table 5. ERAS protocol compliance

Items	Compliance (N=187)
None nasogastric tube postoperatively	116 (62.0%)
Removal of urinary catheter on POD 1-2	127 (67.9%)
None abdominal drainage postoperatively	105 (56.1%)
Ambulation on POD 1	60 (32.1%)
Oral intake of clear nutritional liquid on POD 1-2	95 (50.8%)
Oral intake of liquid diet on POD 3-5	116 (62.0%)
Postoperative analgesia	184 (98.4%)
Prevention of PONV	187 (100.0%)

*PONV*: postoperative nausea and vomiting

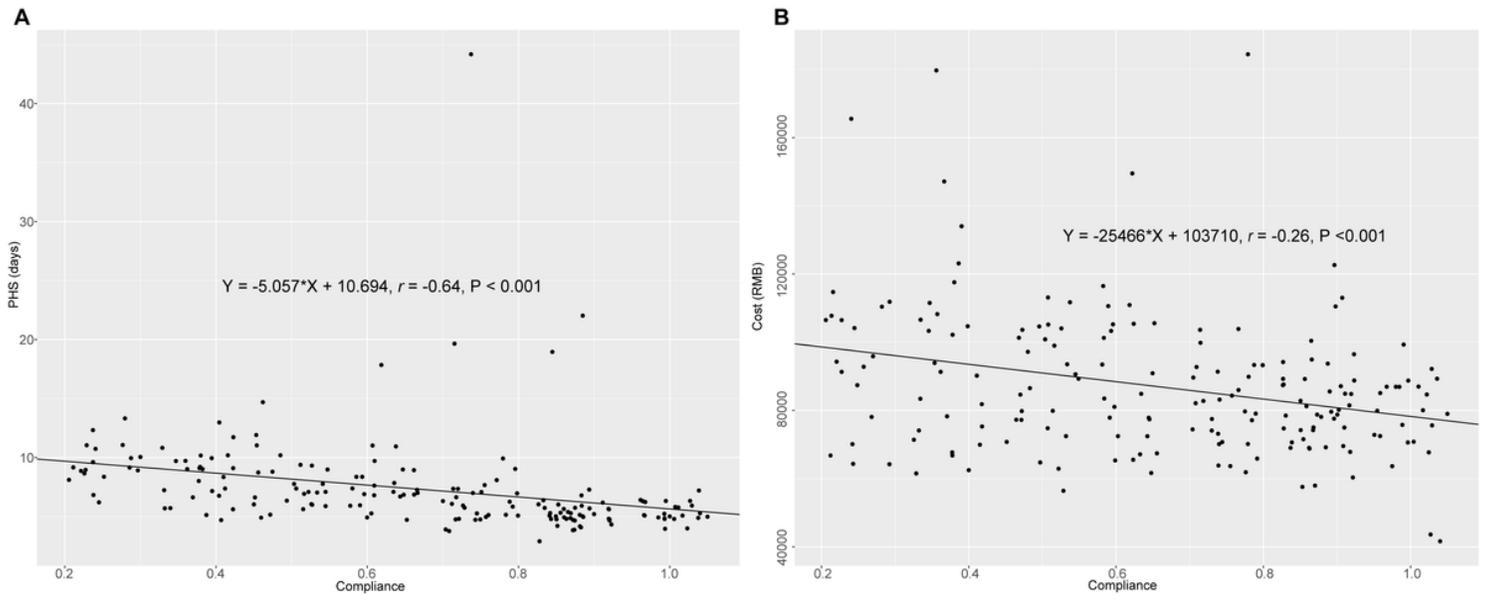
Table 6. Univariate and multivariate logistic regression for delayed discharge

Variables	Univariate analysis		Multivariate analysis	
	Odds ratio	P value	Odds ratio	P value
Gender, F vs. M	1.039 (0.508-2.124)	0.917		
Age, >60 vs. ≤60	1.262 (0.685-2.328)	0.456		
Comorbidity, ≥1 vs. < 1	1.342 (0.712-2.531)	0.363		
Nutritional score, ≥3 vs. <3	0.365 (0.119-1.123)	0.079		
<b>Transfusion, Y vs. N</b>	<b>7.407 (1.960-27.996)</b>	<b>0.003</b>	<b>1.409 (0.254-7.817)</b>	<b>0.695</b>
<b>Operation time</b>	<b>1.019 (1.012-1.027)</b>	<b>&lt;0.001</b>	<b>1.010 (1.000-1.020)</b>	<b>0.048</b>
<b>Blood loss</b>	<b>1.004 (1.001-1.006)</b>	<b>0.007</b>	<b>1.001 (0.998-1.003)</b>	<b>0.633</b>
Partial vs. total gastrectomy	0.830 (0.452-1.524)	0.548		
<b>Compliance (%), per 10%</b>	<b>0.931 (0.913-0.950)</b>	<b>&lt;0.001</b>	<b>0.939 (0.920-0.958)</b>	<b>&lt;0.001</b>

Table 7. Univariate and multivariate logistic regression for postoperative complications

Variables	Univariate analysis		Multivariate analysis	
	Odds ratio	P value	Odds ratio	P value
Gender, F vs. M	0.560 (0.156-2.011)	0.374		
Age, >60 vs. ≤60	0.777 (0.307-1.965)	0.593		
Comorbidity, ≥1 vs. < 1	1.760 (0.688-4.502)	0.238		
Nutritional score, ≥3 vs. <3	1.297 (0.349-4.823)	0.698		
Transfusion, Y vs. N	1.576 (0.323-7.678)	0.574		
Operation time	1.002 (0.994-1.011)	0.590		
<b>Blood loss</b>	<b>1.002 (1.000-1.004)</b>	<b>0.028</b>	<b>1.002 (0.999-1.004)</b>	<b>0.070</b>
Partial vs. total gastrectomy	0.949 (0.374-2.412)	0.913		
<b>Compliance(%), per 10%</b>	<b>0.978 (0.959-0.998)</b>	<b>0.030</b>	<b>0.985 (0.964-1.006)</b>	<b>0.148</b>

## Figures



**Figure 1**

Linear correlation between compliance and PHS, and medical cost