J Gastric Cancer. 2018 Sep;18(3):230-241
https://doi.org/10.5230/jgc.2018.18.e24
pISSN 2093-582X·eISSN 2093-5641

Journal of Gastric Cancer

Original Article

Check for updates

Enhanced Recovery after Surgery for Gastric Cancer Patients Improves Clinical Outcomes at a US Cancer Center

Jacopo Desiderio[1], Camille L. Stewart[2], Virginia Sun[3], Laleh Melstrom[2], Susanne Warner[2], Byrne Lee[2], Hans F. Schoellhammer[2], Vijay Trisal[2], Benjamin Paz[2], Yuman Fong[2], Yanghee Woo [2]

[1]Department of Digestive Surgery, St. Mary's Hospital, University of Perugia, Terni, Italy
[2]Division of Surgical Oncology, Department of Surgery, City of Hope National Medical Center, Duarte, CA, USA
[3]Division of Nursing Research and Education, Department of Population Sciences, Beckman Research Institute, City of Hope National Medical Center, Duarte, CA, USA

Received: Jun 3, 2018
Revised: Jul 13, 2018
Accepted: Jul 30, 2018

Correspondence to
Yanghee Woo
Division of Surgical Oncology, Department of Surgery, City of Hope National Medical Center, 1500 East Duarte Road, MOB 1002H. Duarte, CA 91010, USA.
E-mail: ywoo@coh.org

ORCID iDs
Yanghee Woo
https://orcid.org/0000-0002-6676-0593

Author Contributions
Conceptualization: D.J., W.Y.; Data curation: D.J., S.C.L., W.Y.; Formal analysis: D.J., S.C.L., W.Y.; Methodology: D.J., S.V., M.L., W.S., L.B., S.H.F., T.V., P.B., F.Y., W.Y.; Writing - original draft: D.J., W.Y.; Writing - review & editing: D.J., S.C.L., S.V., M.L., W.S., L.B., S.H.F., T.V., P.B., F.Y., W.Y.

Conflict of Interest
No potential conflict of interest relevant to this article was reported.

ABSTRACT

Purpose: Enhanced recovery after surgery (ERAS) protocols for gastric cancer patients have shown improved outcomes in Asia. However, data on gastric cancer ERAS (GC-ERAS) programs in the United States are sparse. The purpose of this study was to compare perioperative outcomes before and after implementation of an GC-ERAS protocol at a National Comprehensive Cancer Center in the United States.
Materials and Methods: We reviewed medical records of patients surgically treated for gastric cancer with curative intent from January 2012 to October 2016 and compared the GC-ERAS group (November 1, 2015–October 1, 2016) with the historical control (HC) group (January 1, 2012–October 31, 2015). Propensity score matching was used to adjust for age, sex, number of comorbidities, body mass index, stage of disease, and distal versus total gastrectomy.
Results: Of a total of 95 identified patients, matching analysis resulted in 20 and 40 patients in the GC-ERAS and HC groups, respectively. Lower rates of nasogastric tube (35% vs. 100%, P<0.001) and intraabdominal drain placement (25% vs. 85%, P<0.001), faster advancement of diet (P<0.001), and shorter length of hospital stay (5.5 vs. 7.8 days, P=0.01) were observed in the GC-ERAS group than in the HC group. The GC-ERAS group showed a trend toward increased use of minimally invasive surgery (P=0.06). There were similar complication and 30-day readmission rates between the two groups (P=0.57 and P=0.66, respectively).
Conclusions: The implementation of a GC-ERAS protocol significantly improved perioperative outcomes in a western cancer center. This finding warrants further prospective investigation.

Keywords: Gastrectomy; Gastric cancer; Minimally invasive surgical procedures; Return of function

INTRODUCTION

Enhanced recovery after surgery (ERAS) protocols provide the standardization of pre-, intra-, and postoperative patient care [1]. They were developed to decrease postoperative nausea and pain, promote early return of bowel function, and ultimately decrease the length of hospitalization and enhance functional recovery. The interventions common

Journal of Gastric Cancer

to most protocols include the appropriate application of minimally invasive surgery, early oral nutrition, removal of urinary catheters, and patient mobilization, with the avoidance of nasogastric (NG) tubes and opioid analgesics. Randomized controlled trials of ERAS protocols for patients with colorectal cancer demonstrated that these interventions decreased complications and length of stay without increasing readmission rates [2]. This initial success prompted the development and evaluation of ERAS protocols for patients undergoing other complex cancer surgeries, including gastric, liver, pancreatic, and gynecologic surgeries [3-6].

In 2014, Mortensen et al. published the ERAS Society's consensus guidelines for enhanced recovery after gastrectomy for cancer, which summarized recommendations for 25 protocol components [3]. These were based on literature originating from Asia, where gastric cancer is more common [7-10]. There is, however, a paucity of studies on the feasibility and impact of these programs in the United States, where patients tend to have higher stage at the time of surgery and have a higher body mass index (BMI). For this reason, gastric cancer enhanced recovery after surgery (GC-ERAS) protocols are not often used in the United States. To standardize gastric cancer patient care and determine the feasibility of an ERAS program at our institution, we implemented a GC-ERAS protocol for patients undergoing surgery with curative intent in November 2015. We aimed to compare patients treated with this protocol to a historical control (HC) group, hypothesizing that patients treated with the ERAS protocol would have earlier advancement to a regular diet and earlier discharge from the hospital.

MATERIALS AND METHODS

Patient population

A GC-ERAS protocol was implemented at City of Hope in November 2015 and used for every patient in this study after that time point. The protocol includes a preoperative discussion regarding an exercise regimen and nutritional counseling for all patients. The regimens are then divided for distal or total gastrectomy. Intraabdominal drains are only routinely used for patients who undergo total gastrectomy. Postoperatively, patients receive intravenous non-steroidal anti-inflammatory drugs. Patients who undergo distal gastrectomy have their urinary catheters removed and are started on sips of water on first postoperative day (POD) 1. Patients who undergo total gastrectomy have their urinary catheters removed and start on sips of water on POD 2. The details of these protocols are summarized in **Table 1**.

All members of the patient care team were educated on the protocol, and written guidelines for initial patient consultation and postoperative orders were distributed. In addition, the intraoperative specimen preparation included dissection of the nodal stations before submission to the pathology department. Prior to November 2015, patients were managed without a specific protocol; in this study, they are referred to as the HC group.

One year after implementing the GC-ERAS protocol, we retrospectively identified all patients at our institution with histologically proven gastric adenocarcinoma who underwent gastrectomy with curative intent from January 1, 2012 to October 31, 2016. Patients with gastrointestinal stromal tumors and gastric carcinoids were excluded. Eight different surgeons with expertise in surgical oncology performed these operations. The potential for cure with surgery was defined according to international guidelines [11-13]. Patients were excluded from further analysis if they received combined resections for another cancer

Table 1. Gastric cancer surgery early recovery after surgery protocol at city of hope

Variables	PRE-OP	POD 0	POD 1	POD 2	POD 3	POD 4	POD 5	POD 6-7
DG	· Consider MIS for appropriate cases · Set immediate and long term postoperative expectations · Discuss exercise regimen · Genetic counseling as needed · Provide nutrition counseling	· Start PCA · IV fluids (NS) · IV Antibiotics for 24 hours post · operatively · Mechanical deep venous thrombosis prophylaxis · Monitor labs · NPO	· Add IV ketorolac · Encourage ambulation · Remove urinary catheter · Add chemical DVT prophylaxis · Monitor labs · Sips of water	· Monitor labs · Clear liquids as tolated	· DC PCA · Start oral narcotics, ibuprofen, acetaminophen · Monitor labs · Advance to post-gastrectomy diet	· **Discharge when criteria met**		
TG	· Consider MIS for appropriate cases · Set immediate and long term postoperative expectations · Discuss exercise regimen · Genetic counseling as needed · Provide nutrition counseling	· Start PCA · IV fluids (NS) · IV Antibiotics for 24 hours postoperatively · Mechanical deep venous thrombosis prophylaxis · Monitor labs · Monitor JP drain · NPO	· Add IV ketorolac · Encourage ambulation · Remove urinary catheter · Add chemical DVT prophylaxis · Monitor labs · Continue with JP drain · NPO	· Blue dye test for leak · Remove urinary catheter · Start sips of water if no blue dye in JP drain	· Continue care · Clear liquids as tolerated	· Continue care · Continue clears as tolerated	· DC PCA · Start oral narcotics, ibuprofen, acetamino-phen · Advance to post-gastrectomy diet	· **Discharge when criteria met**

Blue dye test: add 5 drops of blue dye food coloring into 8 ounces of water for patient to drink.
DG = distal gastrectomy; POD = post-operative day; MIS = minimally invasive surgery; PCA = patient controlled anesthesia with IV narcotic; NS = normal saline; labs = complete blood count, comprehensive metabolic panel; NPO = nil per os; IV = intravenous; DVT = deep vein thrombosis; DC = discontinue; TG = total gastrectomy; JP = Jackson Pratt.

Journal of Gastric Cancer

diagnosis, demonstrated distant metastases at the time of surgery, or were being operated on for remnant recurrence.

We queried the electronic medical records for demographic and clinical data including age, sex, race, past medical and surgical history, intraoperative details, postoperative management, and complications graded using the Clavien-Dindo classification system [14]. Propensity score matching between the GC-ERAS and HC groups was then performed to adjust for variables.

Propensity score matching

Propensity score matching analysis, a tool for causal inference in non-randomized studies that allows for conditioning on large sets of covariates, was performed using R version 3.1 (The R Project, Auckland, New Zealand) through the Custom Dialog "PS Matching." Each patient's propensity score was calculated by a multivariable logistic regression model using the covariates of age, sex, number of comorbidities, BMI, type of gastrectomy (distal vs. total), and stage of disease. Patients in the GC-ERAS and HC groups were 1:2 matched by the closest propensity score on the logit scale.

Statistics

SPSS version 23.0 (IBM Corp., Armonk, NY, USA) was used to perform all statistical analyses. The dichotomous variables are expressed as numbers and percentage, while continuous variables are reported as means and standard deviation (SD) or medians and interquartile range (IQR). Student's t-test, Pearson's χ^2 test, or Fisher's exact test were used as appropriate. P-values <0.05 were considered statistically significant.

Institutional approval

This study was approved by the Institutional Review Board of City of Hope National Medical Center and reported in accordance with the Strengthening the Reporting of Observational studies in Epidemiology guidelines and statement [15].

RESULTS

Patient and group characteristics

A total of 95 patients met the inclusion criteria during the study period. Propensity score matching (1:2) yielded a sample of 60 patients (GC-ERAS: n=20, HC: n=40). The groups had similar patient demographics, surgeries performed, and disease stage (**Tables 2-4**). The mean age of the matched cohorts was 62±14 years, and the mean BMI was 24.29±4.01 kg/m^2. While >50% of the patients in both groups had at least one comorbid condition, the majority (75% in the GC-ERAS group and 67% in the HC group) demonstrated good or excellent tolerance to physical activity.

Intraoperative surgical characteristics and outcomes

The details of the surgical procedures performed are shown in **Table 3**. The majority (72%) of patients underwent a distal gastrectomy, which was similar between groups. The method of reconstruction and the frequency of D2 lymphadenectomy were also similar. There was a non-significant trend toward a greater use of minimally invasive surgical procedures in the GC-ERAS group (70%) vs. the HC group (43%, P=0.06). Longer operative times were observed in the GC-ERAS group than in the HC group (356±69 vs. 262±78 minutes, P<0.001).

Table 2. Patient demographics

Variables	GC-ERAS	HC	P-value
Number of patients	20	40	
Age (yr)	61±16	63±14	0.73
Sex			0.39
Female	12	21	
Male	8	19	
Body mass index	24.81±3.76	24.03±4.15	0.48
Race			0.57
Asian	13	21	
Black	0	2	
Hispanic	3	4	
Non-Hispanic White	4	8	
Other	0	5	
Marital status			0.71
Married	14	28	
Single	3	4	
Divorced	0	4	
Widowed	3	4	
Comorbidities			0.80
Present	12	25	
Absent	8	15	
≥2 Present	5	11	
Previous surgery			0.65
Yes	5	11	
No	15	29	
≥2	4	6	
Smoking status			0.21
Current	0	6	
Former	8	13	
Never	12	21	
Smoking within 24 months			0.56
Yes	3	7	
No	17	33	
Alcohol use (drinks monthly)	17±40	9±27	0.39
Activity tolerance			0.61
Excellent	6	9	
Good	9	18	
Moderate	3	10	
Fair	1	3	
Poor	1	0	
Neoadjuvant chemotherapy	4	10	0.76

GC-ERAS = gastric cancer early recovery after surgery; HC = historical control.

Lower estimated blood loss was observed in the GC-ERAS group (58±70 mL) than in the HC group (127±104 mL, P=0.01), but the rates of intraoperative transfusion were similar between both the groups (P=0.41). As expected, lower rates of NG tube placement (35% vs. 100%, P<0.001) and intraabdominal drain placement (25% vs. 85%, P<0.001) were observed in the GC-ERAS group than in the HC group. As per the ERAS protocol, intraabdominal drains were placed in all patients who underwent total gastrectomy but were placed at the discretion of the surgeon in patients who underwent distal gastrectomy when there was concern for injury to the pancreas or lymphatic leak. Prior to using the ERAS protocol, NG tubes were used in all patients. After using the protocol, NG tubes were placed only at the surgeon's discretion in total gastrectomy patients whose esophagojejunostomy raised concerns for leak and for distal gastrectomy patients at risk for gastrointestinal dysmotility such as long-standing gastric outlet obstruction and extensive lysis of small bowel adhesions. There was one intraoperative complication in the entire cohort, which occurred in the HC group.

Table 3. Intra-operative surgical characteristics

Variables	GC-ERAS (%) (n=20)	HC (%) (n=40)	P-value
Type of gastrectomy			0.37
Distal	16 (80)	27 (68)	
Total	4 (20)	13 (33)	
Surgical approach			0.06
Open	6 (30)	23 (58)	
Minimally invasive*	14 (70)	17 (43)	
Reconstruction			0.67
Billroth II	15 (75)	24 (60)	
Roux-en-Y gastrojejunostomy	1 (5)	3 (8)	
Roux-en-Y esophagojejunostomy	4 (20)	13 (33)	
D2 lymphadenectomy	14 (70)	37 (93)	0.07
Combined resection	5 (25)	9 (23)	0.84
Operative time (min)	356±69	262±79	<0.001
EBL (mL)	60±70	127±104	0.01
Drain placement	5 (25)	34 (85)	<0.001
Nasogastric tube placement	7 (35)	40 (100)	<0.001
Intra-operative complications	0 (0)	1 (3)	0.67
Intra-operative transfusions	1 (5)	2 (5)	0.41

GC-ERAS = gastric cancer early recovery after surgery; HC = historical control; EBL = estimated blood loss.
*Laparoscopic or robotic surgery.

Table 4. Pathologic tumor characteristics

Variables	GC – ERAS (%) (n=20)	HC (%) (n=40)	P-value
Location			0.53
Cardia	1 (5)	3 (7.5)	
Body	7 (35)	22 (55)	
Antrum	8 (40)	10 (37.5)	
Other	3 (15)	0 (0)	
Greatest size (cm)	4.36±1.90	4.89±4.53	0.65
Margin status			0.67
Free	20 (100)	39 (97.5)	
Involved	0 (0)	1 (2.5)	
Residual tumor			0.67
R0	20 (100)	39 (97.5)	
R1	0 (0)	1 (2.5)	
Number LN examined	48±25	34±16	0.009
Number LN positive for disease	5±7	6±9	0.92
AJCC 7th Ed pTNM stage			0.11
I	6 (30)	17 (42.5)	
II	4 (20)	5 (12.5)	
III	10 (50)	18 (45)	

CG-ERAS = gastric cancer early recovery after surgery; HC = historical control; LN = lymph nodes; AJCC = American Joint Committee on Cancer.

Tumor characteristics

Table 4 summarizes the tumor characteristics in both groups. The distributions of tumor locations were similar between groups (P=0.53). The mean number of pathologically examined nodes was higher than required for the American Joint Committee on Cancer's TNM pathologic staging in both groups and was significantly higher in the GC-ERAS group (48±25 nodes) than in the HC group (34±16 nodes, P=0.009). The number of lymph nodes positive for metastatic disease, however, was similar between groups (5±7 vs. 6±9, P=0.92). No significant differences were found regarding the rates of R0 resection, margins status, histologic grade, and pathological stage assessment between groups (**Table 4**).

Clinical recovery outcomes

Table 5 summarizes the postoperative outcomes in both groups. Significantly shorter length of hospital stays were observed in the GC-ERAS group (5.5±2.0 days) than in the HC group

https://doi.org/10.5230/jgc.2018.18.e24

Table 5. Post-operative outcomes

Variables	GC – ERAS (%) (n=20)	HC (%) (n=40)	P-value
Length of hospital stay (day)	5.5±2.0	7.8±3.6	0.01
Mobilization (day)	1.1±0.3	1.1±0.3	1.0
Ambulation (hospital day)	1.4±0.7	1.7±0.8	0.12
First flatus (hospital day)	4.0±1.8	4.0±1.1	0.94
Sips of water (hospital day)	1.7±1.0	4.6±3	<0.001
Liquid diet (hospital day)	2.3±1.3	5.5±3.2	<0.001
Post-gastrectomy diet (hospital day)	4.1±1.3	5.8±1.3	<0.001
Post-gastrectomy diet by POD			<0.001
POD ≤3	9 (45)	0 (0)	
POD 4–5	8 (40)	17 (43)	
POD ≥6	3 (15)	15 (38)	
After discharge	0 (0)	8 (20)	
Drain removal			<0.001
Not placed	15 (75)	6 (15)	
POD ≤3	1 (5)	1 (3)	
POD 4–5	1 (5)	8 (20)	
POD ≥6	3 (15)	10 (25)	
After discharge	0 (0)	15 (38)	
NG tube removal			<0.001
Not placed	13 (65)	0 (0)	
POD ≤3	5 (25)	20 (50)	
POD 4–5	2 (10)	14 (35)	
POD ≥6	0 (0)	6 (15)	
ICU stay (day)	0	0.53±1.18	0.05
Transfusion (unit pRBC)	2 (10)	7 (18)	0.70

GC-ERAS = gastric cancer early recovery after surgery; HC = historical control; POD = post-operative day; NG = nasogastric; ICU= intensive care unit; pRBC = packed red blood cells.

(7.8±3.6 days), with a mean difference of 2.3 days (P=0.01). We also observed a significantly shorter time from surgery to first oral intake in the GC-ERAS group, with patients advancing to sips of water on POD 0.7±1.0 vs. 3.6±3.0 in the HC group (P<0.001), a liquid diet on POD 1.3±1.3 vs. 4.5±3.2 in the HC group (P<0.001), and advancing to a post-gastrectomy soft diet on POD 3.1±1.3 vs. 4.8±1.3 in the HC group (P<0.001). Of note, 20% of the HC group were discharged on a liquid diet, whereas all patients in the GC-ERAS group tolerated a post-gastrectomy diet before discharge. All NG tubes and drains were removed before discharge in the GC-ERAS group compared with 37.5% of patients in the HC group who were discharged with a drain (P<0.001). No differences, however, were found regarding the time to patient mobilization, ambulation (P=0.12), or first flatus (P=0.94).

Assessment of complications

Table 6 summarizes the postoperative complications and their associated grades. The overall rate of complications was 18% (11/60), with a low rate of grade III complications or greater (5/60, 8%). The frequencies of complications were similar between the GC-ERAS (1/20, 5%) and HC groups (10/40, 25%, P=0.06), as were the frequencies of complications requiring readmission (1/20, 5% vs. 4/40, 10%; P=0.29). There were no 30-day postoperative mortalities.

DISCUSSION

We present our experience using a GC-ERAs protocol and compare outcomes to a HC cohort immediately before the institution of the protocol. To help eliminate bias in this retrospective study, we used propensity score matching. We demonstrated both the feasibility of a GC-ERAS protocol in a center in the United States and also showed improved outcomes in

Journal of Gastric Cancer

Table 6. Post-operative complications

Variables	GC – ERAS (%) (n=20)	HC (%) (n=40)	P-value
Number of patients with post-operative complications	1 (5)	10 (25)	0.06
Type of complication			0.29
Anastomotic stenosis	1	0	
Arrhythmias	0	1	
Anastomotic leak	0	1	
Intestinal obstruction	0	2	
Prolonged postoperative ileus (>7 days)	0	3	
Wound infection	0	2	
Cardiac	0	1	
Pneumonia	0	3	
Total	1	13	
Clavien-Dindo Grade			0.57
I	0	3	
II	0	6	
IIIa	1	4	
IIIb	0	0	
IVa	0	0	
IVb	0	0	
V (Death)	0	0	
Reoperation	0	0	
Number of patients with 30-day readmissions	1 (5)	4 (10)	0.66
Reason for readmissions/complications			0.29
Bleeding	0	1	
Intra-abdominal fluid collection	0	1	
Anastomotic leak	1	0	
Malnutrition	0	1	
Intestinal obstruction	0	1	
Clavien-Dindo Grade for complicatoin at readmission			0.40
II	0	3	
IIIa	0	1	
IIIb	1	0	
V (Death)	0	0	
Reoperation at readmission	1	0	0.20

GC-ERAS = Gastric cancer early recovery after surgery; HC = historical control.

patients in the GC-ERAS group compared with those in the HC group before adopting a dedicated protocol. This resulted in a decreased use of NG tubes and intraabdominal drains that were once considered routine, earlier advancement of diet, and ultimately shorter length of hospital stay, with no statistical increase in complication or readmission rates. These results mirror those of existing Asian studies, where these protocols originated.

Our GC-ERAS protocol incorporated many of the components recommended by the ERAS Society guidelines [3]. These include: preoperative counseling and meeting with a nutritionist for nutritional optimization (strong recommendation); avoidance of bowel prep (strong recommendation); use of minimally invasive techniques when possible (strong recommendation for early cancer; weak recommendation for advanced cancer); avoidance of NG/jejunal tubes and perianastomotic drains (strong recommendation); use of patient-controlled anesthesia postoperatively (weak recommendation); avoidance of postoperative hyperglycemia (strong recommendation); avoidance of fluid overload (strong recommendation); early removal of urinary catheters (strong recommendation); early postoperative diet advancement (weak recommendation); early mobilization/ambulation (strong recommendation); early nutritional support, if not meeting nutritional needs postoperatively (strong recommendation); and internal auditing for compliance and clinical outcomes (strong recommendation). Additional components of the GC-ERAS protocol

Journal of Gastric Cancer

recommendations were already contained within pre-existing perioperative guidelines in practice at our hospital, including the use of a single dose of preoperative antibiotics, avoidance of perioperative hypothermia, and perioperative deep venous thrombosis prophylaxis.

The results of our study corroborate those of other studies that showed no advantage in the routine use of NG tubes and intraabdominal drains after gastrectomy for cancer. The selective use of NG tubes and intrabdominal drains is not, however, universal to GC-ERAS protocols [8,9]. We chose to incorporate the selective use of these tubes in our GC-ERAS protocol based on data showing that their absence improves patient comfort and facilitates ambulation [16,17] without increasing the risk of anastomotic leakage, number of pulmonary complications, or mortality rate [18-23]. A meta-analysis by Yang et al. [24] also showed that NG tubes were associated with prolonged postoperative ileus and delayed time to first flatus in patients after gastrectomy. As with many elements of ERAS protocols, however, little prospective evidence is available on the examination of prophylactic NG tube and drain placement during upper gastrointestinal surgery in isolation from other protocol directives.

Expediting postoperative bowel function and advancing of diet are also important targets of ERAS protocols and were successfully achieved in GC-ERAS group. In a similar Japanese study with an HC group [8], the first flatus occurred one day earlier and the first bowel movement occurred two days earlier in the GC-ERAS group. This result was further verified in a randomized prospective study by Wang et al. [7], who reported that flatus occurred one day earlier in patients on an ERAS protocol. We did not identify a difference in time to first flatus between groups in our study; however, we also did not rely on the passage of flatus or evidence of bowel function to advance the diet. Early postoperative nutrition reduces postoperative catabolism, accelerates the return of bowel function, and decreases the risk of complications in colorectal surgery [25,26]. Studies specific to early enteral nutrition after gastric surgery have demonstrated the feasibility and safety [7,8,27,28]; however, this also remains controversial due to concerns regarding emesis, aspiration pneumonia, and anastomotic leak. Sugisawa et al. [10] reported no incidences of pneumonia, and one patient had an anastomotic leak using the protocol that included a clear liquid diet on POD 2 and a soft diet on POD 3. In a randomized controlled trial by Tanaka et al., patients were administered a clear liquid diet starting POD 1, with similarly low rates of anastomotic leak (<3%) and pneumonia (1.4%) in the GC-ERAS and control groups [9]. Postoperative nausea and vomiting are not often reported in these studies. Wang et al. did report an increase in nausea/vomiting in the ERAS group [7]. This did not, however, translate into an increased frequency of anastomotic leak, pneumonia, or other complications.

A common goal of all ERAS protocols is earlier discharge, which can serve as a surrogate cumulative measurement for adequate pain control, toleration of enteral nutrition, and decreased frequency of complications. This is only meaningful if the frequency of readmissions does not increase. In our study, patients managed with the GC-ERAS protocol had significantly shorter hospital stays and were discharged on average 2.3 days earlier than patients not managed with the protocol (HC group). The 30-day readmission rate remained low (5%) after the institution of the GC-ERAS protocol and was also unchanged from the HC group (10%, P=0.66). Prior GC-ERAS studies also showed a decreased length of stay by 1–2 days and readmission rates of 0%–1% [7,9,10].

Our study had several limitations, many of which are related to the retrospective nature of the study. We attempted to minimize these limitations with propensity score matching. The GC-

Journal of Gastric Cancer

ERAS protocol was also implemented as a whole; thus, we were unable to examine individual elements to determine which were most important to its success. This is a known limitation of all ERAS protocols and has been the subject of academic discussion [29]. Complicating the interpretation of the study comparison is that although not a statistically significant difference, more patients in the GC-ERAS group underwent minimally invasive surgery than those in the HC group. An emphasis on minimally invasive techniques, however, is a critical component of ERAS protocols for gastric cancer, will continue to play an integral role in the successful application of ERAS protocols, and is strongly recommended by the ERAS Society [3].

We also acknowledge that our ERAS protocol was started primarily as a surgeon-driven program with assistance from affiliated surgical staff. The components of the recommended GC-ERAS protocol that are not currently in place at our institution are generally related to anesthesia. These include preoperative carbohydrate loading (strong recommendation), the use of wound catheters and transversus abdominis plane blocks (weak recommendation), and the use of epidural anesthesia (weak recommendation). Having now demonstrated the feasibility of this protocol within our own department and its positive impact on patient outcomes, we plan to start incorporating these anesthesia-driven aspects into our GC-ERAS protocol.

In conclusion, our results demonstrated that implementing a GC-ERAS protocol is feasible in the United States and that it could positively affect patient outcomes. Based on the study results, we are planning further prospective studies to evaluate the outcomes of using GC-ERAS on patients' inflammatory biomarkers and patients' quality of life metrics and identify factors that inform protocol adherence.

ACKNOWLEDGMENTS

The authors thank Indra M. Newman, PhD, for her manuscript editing assistance.

REFERENCES

1. Carmichael JC, Keller DS, Baldini G, Bordeianou L, Weiss E, Lee L, et al. Clinical practice guideline for enhanced recovery after colon and rectal surgery from the American Society of Colon and Rectal Surgeons (ASCRS) and Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). Surg Endosc 2017;31:3412-3436.
PUBMED | CROSSREF
2. Spanjersberg WR, Reurings J, Keus F, van Laarhoven CJ. Fast track surgery versus conventional recovery strategies for colorectal surgery. Cochrane Database Syst Rev 2011;2:CD007635.
PUBMED
3. Mortensen K, Nilsson M, Slim K, Schafer M, Mariette C, Braga M, et al. Consensus guidelines for enhanced recovery after gastrectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Br J Surg 2014;101:1209-1229.
PUBMED | CROSSREF
4. Melloul E, Hübner M, Scott M, Snowden C, Prentis J, Dejong CH, et al. Guidelines for perioperative care for liver surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. World J Surg 2016;40:2425-2440.
PUBMED | CROSSREF
5. Lassen K, Coolsen MM, Slim K, Carli F, de Aguilar-Nascimento JE, Schäfer M, et al. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Clin Nutr 2012;31:817-830.
PUBMED | CROSSREF

6. Nelson G, Altman AD, Nick A, Meyer LA, Ramirez PT, Achtari C, et al. Guidelines for pre- and intra-operative care in gynecologic/oncology surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations--Part I. Gynecol Oncol 2016;140:313-322.
PUBMED | CROSSREF

7. Wang D, Kong Y, Zhong B, Zhou X, Zhou Y. Fast-track surgery improves postoperative recovery in patients with gastric cancer: a randomized comparison with conventional postoperative care. J Gastrointest Surg 2010;14:620-627.
PUBMED | CROSSREF

8. Yamada T, Hayashi T, Cho H, Yoshikawa T, Taniguchi H, Fukushima R, et al. Usefulness of enhanced recovery after surgery protocol as compared with conventional perioperative care in gastric surgery. Gastric Cancer 2012;15:34-41.
PUBMED | CROSSREF

9. Tanaka R, Lee SW, Kawai M, Tashiro K, Kawashima S, Kagota S, et al. Protocol for enhanced recovery after surgery improves short-term outcomes for patients with gastric cancer: a randomized clinical trial. Gastric Cancer 2017;20:861-871.
PUBMED | CROSSREF

10. Sugisawa N, Tokunaga M, Makuuchi R, Miki Y, Tanizawa Y, Bando E, et al. A phase II study of an enhanced recovery after surgery protocol in gastric cancer surgery. Gastric Cancer 2016;19:961-967.
PUBMED | CROSSREF

11. Japanese Gastric Cancer Association. Japanese gastric cancer treatment guidelines 2010 (ver. 3). Gastric Cancer 2011;14:113-123.
PUBMED | CROSSREF

12. Waddell T, Verheij M, Allum W, Cunningham D, Cervantes A, Arnold D. Gastric cancer: ESMO-ESSO-ESTRO clinical practice guidelines for diagnosis, treatment and follow-up. Eur J Surg Oncol 2014;40:584-591.
PUBMED | CROSSREF

13. Washington K. 7th edition of the AJCC cancer staging manual: stomach. Ann Surg Oncol 2010;17:3077-3079.
PUBMED | CROSSREF

14. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187-196.
PUBMED | CROSSREF

15. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg 2014;12:1495-1499.
PUBMED | CROSSREF

16. Smart NJ, White P, Allison AS, Ockrim JB, Kennedy RH, Francis NK. Deviation and failure of enhanced recovery after surgery following laparoscopic colorectal surgery: early prediction model. Colorectal Dis 2012;14:e727-e734.
PUBMED | CROSSREF

17. Vlug MS, Wind J, Hollmann MW, Ubbink DT, Cense HA, Engel AF, et al. Laparoscopy in combination with fast track multimodal management is the best perioperative strategy in patients undergoing colonic surgery: a randomized clinical trial (LAFA-study). Ann Surg 2011;254:868-875.
PUBMED | CROSSREF

18. Abdikarim I, Cao XY, Li SZ, Zhao YQ, Taupyk Y, Wang Q. Enhanced recovery after surgery with laparoscopic radical gastrectomy for stomach carcinomas. World J Gastroenterol 2015;21:13339-13344.
PUBMED | CROSSREF

19. Carrère N, Seulin P, Julio CH, Bloom E, Gouzi JL, Pradère B. Is nasogastric or nasojejunal decompression necessary after gastrectomy? A prospective randomized trial. World J Surg 2007;31:122-127.
PUBMED | CROSSREF

20. Suehiro T, Matsumata T, Shikada Y, Sugimachi K. Accelerated rehabilitation with early postoperative oral feeding following gastrectomy. Hepatogastroenterology 2004;51:1852-1855.
PUBMED

21. Yoo CH, Son BH, Han WK, Pae WK. Nasogastric decompression is not necessary in operations for gastric cancer: prospective randomised trial. Eur J Surg 2002;168:379-383.
PUBMED | CROSSREF

22. Hirahara N, Matsubara T, Hayashi H, Takai K, Fujii Y, Tajima Y. Significance of prophylactic intra-abdominal drain placement after laparoscopic distal gastrectomy for gastric cancer. World J Surg Oncol 2015;13:181.
PUBMED | CROSSREF

23. Kumar M, Yang SB, Jaiswal VK, Shah JN, Shreshtha M, Gongal R. Is prophylactic placement of drains necessary after subtotal gastrectomy? World J Gastroenterol 2007;13:3738-3741.
PUBMED | CROSSREF

24. Yang Z, Zheng Q, Wang Z. Meta-analysis of the need for nasogastric or nasojejunal decompression after gastrectomy for gastric cancer. Br J Surg 2008;95:809-816.
PUBMED | CROSSREF

25. Han-Geurts IJ, Hop WC, Kok NF, Lim A, Brouwer KJ, Jeekel J. Randomized clinical trial of the impact of early enteral feeding on postoperative ileus and recovery. Br J Surg 2007;94:555-561.
PUBMED | CROSSREF

26. Lewis SJ, Egger M, Sylvester PA, Thomas S. Early enteral feeding versus "nil by mouth" after gastrointestinal surgery: systematic review and meta-analysis of controlled trials. BMJ 2001;323:773-776.
PUBMED | CROSSREF

27. Jo DH, Jeong O, Sun JW, Jeong MR, Ryu SY, Park YK. Feasibility study of early oral intake after gastrectomy for gastric carcinoma. J Gastric Cancer 2011;11:101-108.
PUBMED | CROSSREF

28. Scatizzi M, Kröning KC, Boddi V, De Prizio M, Feroci F. Fast-track surgery after laparoscopic colorectal surgery: is it feasible in a general surgery unit? Surgery 2010;147:219-226.
PUBMED | CROSSREF

29. Abeles A, Kwasnicki RM, Darzi A. Enhanced recovery after surgery: Current research insights and future direction. World J Gastrointest Surg 2017;9:37-45.
PUBMED | CROSSREF