



# An ERAS protocol for bariatric surgery: is it safe to discharge on post-operative day 1?

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## Abstract

**Background** Laparoscopic sleeve gastrectomy is the most commonly performed bariatric surgery in the world. Enhanced recovery after surgery (ERAS) protocols have been shown to reduce complications and decrease length of stay for various types of surgeries. In this study, we propose an ERAS protocol for laparoscopic sleeve gastrectomy and compare the clinical outcomes with patients who received standard care.

**Methods** We performed a single-institution retrospective analysis in patients who underwent laparoscopic sleeve gastrectomy from February 2015 to December 2017. Patients were stratified into standard care and ERAS protocol groups. The ERAS protocol consisted of goal-directed patient education, specific pre- and post-op multi-modal medication regimen, early ambulation, and early oral intake. Patients were discharged on their first post-operative day if they met appropriate post-surgical milestones. The primary outcomes were length of stay, 7- and 30-day readmission rates, and complication rates. Secondary outcomes included anti-emetic and pain medication utilization, post-operative emesis episodes per day, post-operative pain scores, and mortality.

**Results** We included 214 consecutive patients who underwent sleeve gastrectomy, 130 were in the ERAS group and 84 were in the standard care group. Median hospital stay was significantly shorter in the ERAS group compared to the standard care group (1 vs. 2 days;  $p < 0.001$ ). There were no differences in 7- or 30-day readmission rates (1.5 vs. 1.2%;  $p = 0.838$ , 2.3 vs. 2.4%;  $p = 0.966$ ) or post-operative complications (6.2 vs. 3.6%;  $p = 0.410$ ). The ERAS group also had decreased median intra-operative opioid consumption and self-reported pain scores on post-operative day 1 (27.5 MME vs. 27.4 MME;  $p = 0.044$ , 3.3 vs. 3.9;  $p = 0.046$ ). Mortality rate was 0% overall.

**Conclusion** A cost-effective ERAS protocol for laparoscopic sleeve gastrectomy results in shorter length of stay, without increase in peri-operative morbidity or readmission rates.

**Keywords** ERAS protocol · Enhanced recovery after surgery · Bariatric surgery · Sleeve gastrectomy

Laparoscopic sleeve gastrectomy (LSG) was initially developed as the first stage of biliopancreatic diversion with duodenal switch for super obese patients, but was then found to be effective as a single stage operation in the treatment of obesity and related comorbidities [1–4]. LSG has since become the most commonly performed bariatric surgery

in the United States, with 125,318 cases performed in 2016, which was an 18.8% increase from 2015 [5]. LSG has become a popular choice for bariatric surgery due to the ease of the procedure with proven long-term results in weight loss and improvement of obesity-related comorbidities [6–8]. Although LSG has been proven to be safe and effective, there is short-term morbidity associated with the procedure [9].

First introduced in 1999, enhanced recovery after surgery (ERAS) protocols involve several peri-operative interventions that aim to shorten recovery time, while also improving patient satisfaction, peri-operative morbidity, mobilization, pain control, and early oral intake [10]. ERAS protocols have been shown to reduce complications and decrease

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length of stay in various surgical disciplines [11–15]. Guidelines have been published regarding recommendations for ERAS components in bariatric surgery, but it is unclear if all components are necessary for a successful ERAS pathway [16]. Several barriers to ERAS implementation have been identified; these include cost, resistance to change, lack of communication, and teamwork [17, 18]. It has been estimated that although ERAS can be cost-effective in the long run, initial implementation costs can be prohibitive [19]. These obstacles were considered during the design phase of our ERAS protocol. Our aim in this study was to evaluate the feasibility of implementing a low-cost, simplified ERAS protocol for laparoscopic sleeve gastrectomy that utilizes basic and essential practice changes with minimal institutional costs.

## Materials and methods

### Study design

We performed a single-institution retrospective analysis of patients who underwent laparoscopic sleeve gastrectomy from February 2015 to December 2017. This study was approved by our institutional review board (IRB) and was Health Insurance Portability and Accountability Act (HIPAA) compliant. Two board-certified minimally invasive surgeons performed all surgeries.

Patients were stratified into standard protocol and ERAS protocol groups. The timeframes analyzed were 18 months

before and after the implementation of the ERAS protocol. The standard group included consecutive LSG performed from February 2015 to June 2016. The ERAS group included consecutive LSG performed from July 2016 to December 2017. Patient demographics, including age, gender, body mass index (BMI), and American Society of Anesthesiologist (ASA) grade were collected. The presence of any obesity-related comorbidities, e.g., hypertension, diabetes mellitus II, dyslipidemia, obstructive sleep apnea, were also collected. Information relative to implementation of our ERAS protocol, e.g., history of post-operative nausea and vomiting and chronic pain medication usage were noted. Exclusion criteria included revisional surgeries and patients that were pre-admitted prior to surgery for unrelated reasons.

The ERAS protocol involved interventions in all stages of a patient's clinical pathway including pre-admission, pre-operative, intra-operative, post-operative, and after-discharge phases (Table 1). The components of the ERAS protocol were established by reviewing current suggestions in ERAS literature and guidelines [16, 20]. Prior to implementation of the protocol, patients were only provided with risks and benefits of surgery as designated in the surgical consent. In the ERAS group, pre-admission phase patients were provided with direct and clear counseling regarding expectations and goals for surgery. Additionally, both standard and ERAS protocol groups received counseling regarding smoking cessation. Active smokers were not eligible for surgery. In the pre-operative ERAS patients were provided multi-modal anti-emetic therapy. Both groups received pre-operative and post-operative thromboprophylaxis. Patients

**Table 1** ERAS protocol compared to standard care

Phase of care	Group	
	ERAS	Standard care
Pre-admission		
Education	Clear directive counselling of expectations and goals	Routine surgical consent
Peri-operative		
Intra-op maintenance	Intra-op maintenance of euglycemia, euolemia and normothermia	Standard anesthesia care
Medications		
Scheduled	Enoxaparin, PPI, aprepitant, scopolamine patch	Enoxaparin, PPI
Post-operative		
Scheduled	PPI, ketorolac, IV acetaminophen	PPI
PRN	Lorazepam, ondansetron, metoclopramide, prochlorperazine, promethazine, hyoscyamine, hydrocodone/acetaminophen	Single anti-emetic therapy Single analgesic therapy with IV narcotic until the start of oral intake on POD 1
Discharge		
Scheduled	PPI, docusate	PPI
PRN	Hydrocodone/acetaminophen, ondansetron	Hydrocodone
Patient care	No Foley catheter, early mobility, head of the bed elevated 45 degrees, avoidance of fluid overloading, rigorous early ambulation	Foley catheter removed POD 1, liberal use of IVF
Diet	Start clear liquids POD 0 30 ml every 15 min	Start clear liquids POD 1 30 ml every 15 min

with a BMI > 50 kg/m<sup>2</sup> were given thromboprophylaxis for 2 weeks post-operatively. For the intra-operative phase, concerted efforts with anesthesia were focused on maintaining normothermia, euglycemia, and euvoemia. Routine Foley catheter placement was discontinued. Post-operatively, patients were treated with multi-modal analgesia, anti-emetic regimens, and an anxiolytic as needed. Oral intake was initiated in the post-anesthesia care unit, with 30 ml of clear liquid being consumed every 15 min. A rigorous early mobility plan was also employed, which required the patient to ambulate with assistance within 30 min of arriving to the ward, repeating this process at least every 2 h until bedtime. Nurses trained in the ERAS protocol implemented these patient care activities. Patients were discharged on their first post-operative day if they met appropriate post-surgical milestones. These included the ability to tolerate an oral diet, the ability to ambulate independently, and adequate pain control. Patients in both groups were maintained on a 3-month course of proton pump inhibitor for post-surgical stress. The details listed here are not inclusive for the full surgical course for LSG but instead highlight differences and between this protocol and previous standard of care.

The primary outcomes were length of stay, 7- and 30-day readmission rates, and complication rates. Secondary outcomes measures included anti-emetic and pain medication utilization, post-operative emesis episodes per day, post-operative pain scores, and mortality. Thirty-day post-operative complications were recorded and graded according the Clavien–Dindo classification (C–D). C–D < II were considered minor complications and C–D > IIIa were considered major complications. Minor complications were considered any deviation of the post-operative course including those requiring any non-standard pharmacological treatment. Major complications were events that required surgical, endoscopic or radiological intervention, life-threatening events, or death [21]. Pre-operative, intra-operative and post-operative anti-emetic and pain medication utilization was recorded to assess compliance with the protocol and characterize drug utilization in the standard care group. Narcotic pain medication usage was reported as median opioid consumption intra-operatively and post-operatively in morphine milligram equivalents (MME). Pain was assessed using the patient-reported Numerical Rating Scale 0–10, on which “0” represents no pain and “10” represents the worst pain possible.

### Statistical analysis

All statistical analyses were performed using SPSS, version 24 (IBM SPSS Statistics for Macintosh, Version 24.0. Armonk, NY: IBM Corp). Groups were compared using Chi-Square test for categorical variables and expressed in percentages. Independent samples t-test was used for

normally distributed continuous variables and expressed as mean with standard deviation. Kruskal–Wallis test was used to assess non-parametric continuous data, with post hoc analysis by means of the Mann–Whitney *U* test and expressed with median and interquartile range. Results were considered statistically significant when  $p < 0.05$ . All data were analyzed on an intention-to-treat basis (Fig. 1).

### Results

We included 214 patients who underwent sleeve gastrectomy, of which 130 were in the ERAS group and 84 were in the standard care group. Relevant patient characteristics are shown in Table 2. There was no statistically significant difference in gender, age, body mass index, or ASA classification. Two surgeons performed all of the surgeries included in this study. In the standard care group 73.8% of surgeries were performed by surgeon 1 compared to 51.5% in the ERAS group. Median hospital stay was significantly shorter in the ERAS group compared to the standard care group (1 vs. 2 days;  $p < 0.001$ ), (Table 3). 83.1% of patients in the ERAS group were successfully discharged on post-operative (POD) 1. There were no differences in 7 or 30-day readmission rates (1.5 vs. 1.2%;  $p = 0.838$ , 2.3 vs. 2.4%;  $p = 0.966$ ). There were no differences in overall post-operative complications (6.2 vs. 3.6%;  $p = 0.410$ ) or major complications (0.77 vs. 1.2%;  $p = 0.754$ ). Major complications included 1 case of post-operative bleeding in the standard care group that required reoperation. There were no instances of post-operative bleed in the ERAS group. There were no anastomotic leaks, deep vein thrombosis, or pulmonary embolisms in either group. 100% of patients in each group received chemical and mechanical DVT prophylaxis in the peri-operative period. Results of medication utilization, post-operative nausea episodes, and pain scores are shown in Table 4. Preoperatively, a higher percentage of patients in

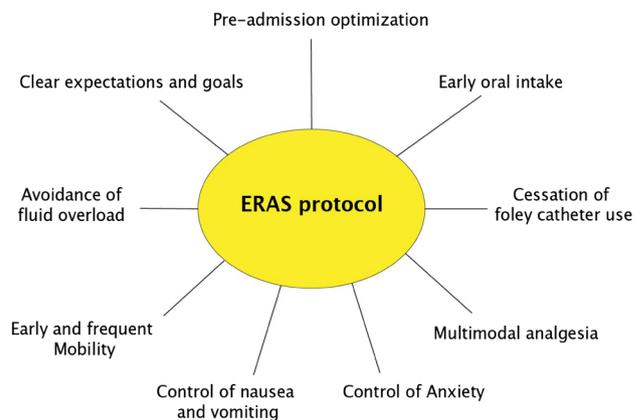


Fig. 1 Diagram of the key factors of the ERAS protocol

**Table 2** Baseline characteristics

Variables	Standard care (n = 84)	ERAS (n = 130)	p value
Female gender	61 (72.6%)	109 (83.8%)	0.063
Age (years)	42.7 ( $\pm$ 10.1) <sup>a</sup>	41.9 ( $\pm$ 10.8) <sup>a</sup>	0.696
ASA grade			
I	1 (1.2%)	1 (0.8%)	0.299
II	25 (29.8%)	49 (37.7%)	
III	58 (69.0%)	76 (58.5%)	
IV	0 (0.0%)	4 (3.1%)	
BMI (kg/m <sup>2</sup> )	42.4 (30.5–73.7) <sup>b</sup>	44.7 (33.7–72.8) <sup>b</sup>	0.069
Comorbidities			
Hypertension	47 (56.0%)	61 (46.9%)	0.217
Dyslipidemia	50 (59.5%)	72 (55.4%)	0.583
Diabetes mellitus II	25 (29.8%)	50 (38.5%)	0.207
OSA	60 (71.4%)	77 (59.2%)	0.076
PONV	9 (10.7%)	22 (16.9%)	0.208
Chronic pain	21 (25.0%)	28 (21.4%)	0.536

<sup>a</sup>Values are mean ( $\pm$  standard deviation)

<sup>b</sup>Values are median (interquartile range)

**Table 3** Comparison of length of stay, complication, and readmission rates between standard care and ERAS groups

Variables	Standard care (n = 84)	ERAS (n = 130)	p value
Length of Stay (days)	2 (2–6) <sup>a</sup>	1 (1–6) <sup>a</sup>	<0.0001*
7-day readmission	1 (1.2%)	2 (1.5%)	0.838
30-day readmission	2 (2.4%)	3 (2.3%)	0.966
Complications	3 (3.6%)	8 (6.2%)	0.410
Minor	2 (2.4%)	7 (5.4%)	0.400
Major	1 (1.2%)	1 (0.77%)	0.754

\*Represents statistical significance

<sup>a</sup>Values are median (interquartile range)

the ERAS group received scopolamine and aprepitant. Intra-operatively, a higher percentage of patients in the ERAS group received dexamethasone. Post-operatively a higher percentage of patients in the ERAS group received scheduled ketorolac, scheduled acetaminophen, scopolamine, and prochlorperazine. Overall intra-operative opioid consumption was decreased in the ERAS group, but there was no difference in the post-operative phase. The median number of total anti-emetics given to patients in the ERAS group was higher compared to the standard care group (3 agents vs. 1 agent;  $p < 0.001$ ). However, there was no difference in the median number of emesis episodes per day of hospitalization (0 vs. 0;  $p = 0.179$ ). Mean self-reported pain scores were similar in both groups on POD 0 but were decreased in the

ERAS group on POD 1 (3.3 vs. 3.9;  $p = 0.046$ ). Mortality rate was 0% overall.

## Discussion

Our study found that implementation of an ERAS protocol for bariatric surgery resulted in a significant decrease in length of hospital stay without increasing post-operative morbidity. Although other surgical disciplines have found that implementation of an ERAS protocol decreases complication rates, we did not find that in our study. However, our results are consistent with other bariatric ERAS studies that yielded similar results [16, 22]. This is likely due to the fact that LSG is an elective surgery with low complication rates and is therefore requires a highly powered study to show a significant decrease. We attribute part of the success of this protocol to the increased usage of non-opioid pain medication, which likely contributed to the decrease in POD 1 pain scores. Another contributing factor was setting clear expectations of the ERAS protocol-guided hospital course. Peri-operative education is a mainstay of bariatric surgery, however, in during our ERAS-specific education, patients were counseled on unique expectations that were not included in the standard care group. These expectations included early ambulation starting on POD 0, early oral intake starting in the post-op recovery unit, utilization of multi-modal analgesia and anti-emetic therapy to decrease post-operative pain and nausea and vomiting, and possibly most importantly anticipating a POD 1 discharge. This education outlined unambiguous goals and expectations of patients' hospital stay, which was imperative to the success of our ERAS protocol. Although we were able to confirm that patients in the ERAS group received multi-modal anti-emetic therapy, we did not observe a decrease in emesis episodes. This may be due to the fact that the incidence of vomiting was extremely low in both groups. This may reflect a limitation in the power of our study to show a difference in post-operative emesis between the two groups.

There have been several studies published regarding optimal ERAS protocol components. These include standard practice guidelines for decreasing morbidity for a particular surgery but also guidelines regarding how to implement an optimal ERAS program. This involves hiring a program manager that coordinates a team of physicians, nurses and other administrative personnel to meet several times a month. This multidisciplinary team is endowed with dedicated blocks of time and salary equivalents to facilitate these obligations. Compliance monitoring is also indicated to show that each component of the ERAS protocol is being followed appropriately, which may require a dedicated audit system (i.e., ERAS interactive audit system) [23]. Stone et al. found that initiation of an effective ERAS protocol

**Table 4** Medication usage, incidence of post-operative emesis, and post-operative pain scores

Variables	Standard care (n = 84)	ERAS (n = 130)	p value
Pre/intra-operative non-opioid medication usage			
Scopolamine	25 (19.1%)	106 (80.9%)	<0.001*
Aprepitant	0 (0.0%)	56 (43.4%)	<0.001*
Dexamethasone	56 (66.7%)	105 (80.2)	0.026*
Post-operative non-opioid medication usage			
Ketorolac	37 (44.0%)	89 (67.9%)	<0.001*
Acetaminophen	27 (32.1%)	87 (66.4%)	<0.001*
Scopolamine	2 (2.4%)	117 (89.3%)	<0.001*
Promethazine	22 (26.2%)	25 (19.1%)	0.219
Prochlorperazine	4 (4.8%)	19 (14.5%)	0.024*
Metoclopramide	12 (14.3%)	23 (17.6%)	0.526
Hyoscyamine	2 (2.4%)	5 (3.8%)	0.563
Lorazepam	5 (6.0%)	10 (7.6%)	0.637
Total anti-emetic medication count	1 (0–4) <sup>a</sup>	3 (0–6) <sup>a</sup>	<0.001*
Intra-operative opioid consumption (MME)	27.5 (7.5–58.0) <sup>a</sup>	27.4 (4.8–50.0) <sup>a</sup>	0.044*
Post-operative opioid consumption (MME)	24.2 (4.8–182.8) <sup>a</sup>	24.3 (0–140.0) <sup>a</sup>	0.445
Emesis episodes	0 (0–2.50) <sup>a</sup>	0 (0–7.0) <sup>a</sup>	0.179
Pain scores			
POD 0	4.8 (± 2.0) <sup>b</sup>	4.3 (± 1.9) <sup>b</sup>	0.493
POD 1	3.9 (± 1.8) <sup>b</sup>	3.3 (± 2.3) <sup>b</sup>	0.046*

\*Represents statistical significance

<sup>a</sup>Values are median (interquartile range)<sup>b</sup>Values are mean (± standard deviation)

at a quaternary hospital cost USD \$552,783, but did have an eventual net savings of USD \$ 395,717 in the first year [19]. Although it may be true that this is an optimal way to enforce an ERAS protocol, striving to adhere to these standards should not deter an institution from implementing an ERAS protocol. For our ERAS program, no additional staff or compliance software was utilized. Implementation consisted of establishing a protocol and educating the faculty, fellows, house staff and nursing staff on the details of the protocol. Using open communication and teamwork amongst the established staff, we were able to implement a successful program without increasing overhead cost. This low buy-in ERAS model promotes accessibility to facilities like small community hospitals that may not have the resources to implement a robust ERAS protocol. We did not perform a formal cost-analysis in this study, but it has been well established in the literature that implementation of an ERAS protocol with a decreased length of stay can be cost-effective. Although some studies factor decreased complication rate into the cost, it has also been shown to be cost-effective in bariatric ERAS protocols where no decrease in complication rate was identified [20, 24].

There are several limitations of this study. First, there is the consideration of control selection bias, as our standard of care group had significant variation in care as a consequence of regularly changing housestaff. Another related bias is one

of time. Since the groups in our study were stratified sequentially there may have been an inherent difference in the operations performed, i.e., performance that improves with experience. Also, change in attending surgeons' caseload contribution overtime may be an underlying confounding variable in our results. Another limitation is that although we performed an audit of medication utilization, compliance of post-operative patient care activities (i.e., early ambulation) were not monitored, making it difficult to establish if our simple ERAS protocol was followed. However, even without performing a full audit to assess compliance with the protocol, we were able to show significant decrease in LOS, without increase in morbidity. Another limitation was due to the retrospective nature of this study; nausea scores were not collected, which prevented us from reporting true post-operative nausea and vomiting incidence.

In future studies, we will assess quality measures in our patients to see if there are further changes we can make to improve our protocol. Due to the success of our ERAS protocol for sleeve gastrectomy, we have adopted this protocol for all of our bariatric patients. Although there are studies that report success with same day discharge for sleeve gastrectomy, there are also conflicting studies that suggest that these patients may be at an increased risk of mortality [25, 26]. We have not transitioned to this practice as we monitor our patients for at least 24 h to ensure adequate control of

pain and nausea and vomiting before discharge. However, this is an option that we may be open to in the future.

In conclusion, implementation of a simplified and inexpensive ERAS protocol may be low risk, cost-effective, and clinically beneficial. Further research is needed to delineate the specific value of ERAS when applied to bariatric surgery.

## Compliance with ethical standards

**Disclosures** Bryan J. Sandler reports Consulting Fee for ValenTx, Inc, and Honoraria for Gore and Bard-Davol; Garth R. Jacobsen reports Honoraria for Gore, Bard-Davol, and Ethicon. Santiago Horgan reports Consulting Fee for Fortimedix, Stryker and ValenTx, Inc. and Speaker for Ethicon. Authors Jenny Lam, Toshiaki Suzuki, Carlos Maeda, Beiqun Zhao, David Bernstein, and Thach Pham have no conflicts of interest or financial ties to disclose.

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