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ORIGINAL CONTRIBUTIONS

Enhanced Recovery in Bariatric Surgery: A Study of Short-Term Outcomes and Compliance

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Abstract

Introduction The implementation of Enhanced Recovery After Surgery (ERAS) guidelines has been widely studied among various surgical specialties. We aimed at comparing the perioperative outcomes and compliance with ERAS protocol in bariatric surgery at our center.

Methods An observational review of a prospectively maintained database was performed. Patients who underwent primary bariatric surgery (gastric bypass or sleeve gastrectomy) between January 2011 and June 2018 were included. Patients were divided into pre- and post-ERAS groups. Data including basic demographic information, length of hospital stay, 30-day perioperative complications, and readmission rates were collected. Compliance with elements of ERAS was assessed using a combination of chart review and a prospectively implemented checklist. $P < 0.05$ was chosen to be statistically significant.

Results A total of 435 patients were included: 239 patients in the pre-ERAS group and 196 patients in the post-ERAS group. There were no statistical differences in baseline demographics and major comorbidities between the 2 groups. The post-ERAS group had shorter length of hospital stay (2.23 vs 1.23, $p < 0.001$) and lower rates of 30-day postoperative morbidity (8.7 vs 4%, $p = .04$).

There was no significant difference between the 2 groups with respect to readmissions rates. There was no mortality in either group. Overall compliance rates with ERAS elements were 85%; compliance increased significantly with the implementation of a checklist ($p < 0.001$).

Conclusions Implementation of ERAS program for bariatric surgery is safe and feasible. It reduces hospital stay and postoperative morbidity. Easy to implement strategies such as checklists should be encouraged in bariatric programs to aid in implementation and compliance with ERAS elements for perioperative care.

Keywords Bariatric · Perioperative care · Enhanced recovery · Outcomes · Compliance

Introduction

Bariatric surgery remains the most effective treatment for obesity as studies demonstrate long-term weight loss and decreased incidence of obesity-related complications [1]. It is an ever-evolving field, and the increase in popularity of surgery as a treatment for obesity has led to a recognition of specific challenges healthcare providers face in the care of bariatric surgery candidates. The number of bariatric procedures performed per year has been increasing worldwide [2]. With increased practice, improved surgeon expertise, standardized preoperative care, and meticulous selection of surgical candidates, outcomes have improved in bariatric surgery; reported complication rates are low with earnest perioperative care and follow-up [3]. With the introduction of minimally invasive techniques, bariatric surgery has undergone a major overhaul. The next logical step is to seek strategies to optimize bariatric perioperative care to handle the growing volume of potential surgical candidates.

The Enhanced Recovery After Surgery (ERAS) program is a multifaceted approach to the perioperative care of the

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surgical patient. After the introduction of the protocol for colorectal surgery patients in 2001, these guidelines have been widely studied among various surgical specialties including thoracic, orthopedic, and urological surgery and their implementation has demonstrated reduced length of stay, faster recovery, and favorable surgical outcomes [4–7]. The ERAS society published the recommendations for bariatric surgery in 2016. ERAS for bariatric surgery consists of multimodal recommendations that introduced preoperative, intraoperative, and postoperative measures of care for surgical candidates. The aim of these guidelines is to optimize operative stress, reduce postoperative pain, and enhance early mobilization [8].

Obesity is still considered a stigma [9]; the number of obese patients who qualify for bariatric surgery as compared to those who undergo surgery is low [10]; it is therefore of utmost importance to take every step possible for improving safety, efficiency, and outcomes. ERAS society recommendations for perioperative care are an evidence-based approach towards homogenizing protocols to achieve these goals. Recent meta-analyses have concluded that ERAS implementation in bariatrics leads to a reduction in hospital stay while maintaining no negative influence on overall morbidity [11–13]. In their meta-analyses, Małczak et al. and Ahmed et al. comment on the scarcity of reporting compliance rates in ERAS-related studies and a lack of homogenization across various ERAS protocols. Extensive evidence is also deficient about the implementation ERAS protocols and their safety [8]. In this study, we aimed to compare the perioperative outcomes in bariatric surgery before and after implementation of a homogenous ERAS protocol in our bariatric program. We also report compliance with the protocol elements.

Methods

An observational study of a prospectively maintained database was performed. Patients who underwent primary bariatric surgery (gastric bypass or sleeve gastrectomy) between January 2011 and June 2018 at a single academic medical center were included. Revision bariatric surgery procedures were excluded from this review. The enhanced recovery protocol (Table 1), adopted from the Awad et al.'s and ERAS society recommendations [8, 14], were implemented in January 2016 (Table 1). Readers are encouraged to review ERAS society recommendations for detail on components of ERAS protocol as we chiefly focus on outcomes and compliance while very briefly summarizing the ERAS protocol in Table 1. Study subjects were categorized as pre-ERAS group (January 2011–December 2015) and post-ERAS group (January 2016–June 2018). Compliance rates were tracked by retrospective chart review for patients between January 2016 and December 2017 and a prospectively collected checklist based on our protocol for patients between January 2018 and June 2018. For retrospectively reviewed data, missing data points in charts were assumed as non-implementation of an element of the ERAS protocol.

Demographic information, comorbidities, operative data, length of hospital stay, 30-day perioperative complications, and readmissions were recorded and reviewed. Primary outcomes of interest were length of hospital stay and 30-day morbidity. Length of hospital stay was defined as the number of nights spent in the hospital after surgery. Postoperative 30-day morbidity was recorded in a system-based approach and included cardiovascular, respiratory, hematological, nervous system, renal and electrolyte abnormalities requiring supplementation, gastrointestinal, wound, and dehydration-related complications. Complications within 30-days of the operation were then described using Clavien-Dindo classification system of surgical complications [15]. Secondary outcome of interest was 30-day postoperative readmission rates and compliance rates with each of the elements of ERAS protocol.

Patient characteristics, operative, and postoperative data were summarized with descriptive statistics, and continuous data were compared between the pre- and post-implementation groups with *t* test for normally distributed data and Mann–Whitney *U* test for skewed data. Chi-square analysis or Fisher's exact test were used for categorical variables where appropriate. Analysis was done using Microsoft Excel® program and SPSS v.24 (Armonk. NY). A p value of less than 0.05 using a two-tailed analysis was considered statistically significant.

Results

We identified a total of 435 patients who underwent primary bariatric surgery at our center; 239 prior to implementation of ERAS program and 196 afterwards. The pertinent patient characteristics and anthropometric measurements prior to surgery are outlined in Table 2. There was no statically significant difference between the two groups with respect to gender, preoperative body mass index (BMI), and concomitant presence of hypertension, diabetes mellitus, or hyperlipidemia. Patients in the post-ERAS group had a low prevalence of gastroesophageal reflux disease (GERD) when compared to patients in the pre-ERAS group ($p = 0.01$). In the pre-ERAS group, 59.32% of the total operations performed were laparoscopic and 40.16% were robotic-assisted. In the post-ERAS group, 58% operations were done via a laparoscopic approach whereas 42% were done via a robotic assistance. In the pre-ERAS cohort, sleeve gastrostomies accounted for 66.5% operations whereas 33.5% operations were gastric bypasses. In the post-ERAS group, 79% of the procedures were sleeve gastrostomies whereas 21% were gastric bypasses.

Table 1 Enhanced recovery after bariatric surgery protocol and compliance

Preoperative interventions		% Compliance (without a checklist) $n = 149$	% Compliance (with a checklist) $n = 47$
	Preoperative information, education, and counseling	100	100
	Smoking and alcohol cessation	100	100
	Preoperative weight loss *	87	92
	Reduced fasting times. Liquids up to 2 h before surgery	93	97
	Acetaminophen 1000 mg PO given preoperatively	63	78
Intraoperative interventions	Positioning and airway management: reverse Trendelenburg or sitting up for extubation	74	93
Optimize ventilation strategies	Fraction of inspired oxygen (FiO_2) < 40% to decrease absorption atelectasis	64	97
	Positive end-expiratory pressure (PEEP) of 6–15 cm H_2O, recruitment maneuvers (30–40 cm $H_20 \times 30$–40 s)	84	96
	Permissive hypercapnia during CO_2-insufflation	67	95
Intraoperative fluid management	Fluid management (0.5–1.5 L)	89	94
	Avoid colloids	93	96
	Treat hypotension with vasopressors	NA	NA
	Avoid vasodilation from anesthetic overdose (≤ 0.5 minimum alveolar concentration (MAC), age adjusted; propofol ≤ 100 mcg/kg (adjusted body weight)/min)	92	98
Medications	Dexamethasone 8 mg IV at induction	82	94
	Ondansetron 4 mg IV	92	96
	Metocloperamide 10 mg	57	63
	Scopolamine: transdermal 1.5 mg	56	73
Postoperative interventions	Minimize use of long acting opioids above doses typically needed postoperatively	45	67
Multimodal analgesia	Wound infiltration with local anesthetic	94	98
	Ketorolac 15–30 mg IV given at conclusion of surgery or in PACU	78	91
	Ketamine 0.5 mg/kg (adjusted body weight) loading dose, 0.15 mg/kg/h as bolus, or infusion until 45 min before emergence	76	81
Thromboprophylaxis	Pneumatic compression in combination with low molecular weight heparin (LMWH)	91	100
	Early ambulation	90	98
	Early nutrition and early water trial	76	82
	Protein intake monitored. Supplementation of iron, vitamin B12, and calcium	100	100

*Patients were encouraged to lose 10% of their baseline weight; however, surgery was not delayed if this goal was not attained

The mean length of stay was 1.23 days in the post-ERAS group as compared to 2.23 in the conventional care group ($p < 0.001$). Seventy-four percent of the patients were discharged on postoperative day 1 with ERAS as compared to a meager 1% patients with traditional care. Chronological trends of day 1 discharge rates after implementation of ERAS are outlined in the Fig. 1. There was a statistically significant reduction in 30-day all-cause postoperative complication rates (8.7% in pre-ERAS and 4% post-ERAS, $p = 0.045$) (Table 3). There was no mortality in either group.

Mean compliance rate with all elements of ERAS was 85.87 ± 14. However, with the implementation of a checklist based on the protocol, compliance increased significantly ($p < 0.001$) from 80.94 ± 15.44 ($n = 147$) to 91.97 ± 10.81 ($n = 47$) (Table 1). We did not find a statistically significant difference between the two groups with regard to readmission within 30 days of the bariatric surgery ($p > 0.05$). Four out of the total 239 patients in the pre-ERAS group were readmitted within 30 days of the procedure. One patient had an intraperitoneal abscess requiring laparoscopic drain placement, one patient required inpatient treatment of UTI, one patient had abdominal wall cellulitis, and one patient underwent diagnostic laparoscopy for small bowel obstruction on postoperative day 11. The latter patient also underwent CT guided drainage of a pelvic abscess on postoperative day 23. In the post-ERAS group, we had 3 readmissions within 30 days of the bariatric procedure; one patient was readmitted for melena with hypotension (diagnostic upper endoscopy was normal), one patient had strangulation of small bowel in a pre-existing incisional hernia and underwent laparoscopic resection of small bowel

Table 2 Baseline characteristics and anthropometric data

	Pre-ERAS group $N = 239$	Post-ERAS group $N = 196$	p value
Age Mean ± SD	42.94 ± 11.06	43.84 ± 8.63	0.35
Female (%)	191 (79%)	133 (78.6%)	0.76
Weight (in kg): Mean ± SD	129.08 ± 29.98	125.65 ± 24.12	0.19
BMI (m^2/kg) Mean ± SD	47.12 ± 8.97	45.84 ± 8.62	0.13
Comorbidities: *n* (%)			
Diabetes	101 (42%)	90 (46%)	0.39
Hypertension	128 (53%)	115 (59%)	0.20
Hyperlipidemia	98 (41%)	74 (38%)	0. 52
GERD	142 (59%)	92 (47%)	0.01

and repair of incisional hernia with mesh, and one patient was admitted for nausea and vomiting, elevated lipase, alkaline phosphate, and total bilirubin. The abdominal ultrasound was normal. Patient was kept *nil* per os overnight, lipase trended down the next day, and patient was discharged on clear liquid diet in stable condition.

Discussion

Our study utilizes a homogenous, evidence-based protocol for ERAS and reports compliance with the ERAS elements; characteristics which have been missing from previous ERAS-related studies according to recent meta-analyses [11, 12]. Implementation of the ERAS program at our academic medical center resulted in a statistically significant decrease in length of hospital stay and short-term postoperative morbidity ($p < 0.05$). While the reduction in length of stay is consistent with the current evidence in favor of *effectiveness* of ERAS in bariatric surgery, reduction in postoperative morbidity in both groups also justifies the case for *safety* of ERAS protocols. This decrease in complication rates after post-ERAS implementation group (8.7 vs 4%) is clinically relevant. For instance, the decrease in dehydration events postoperatively is pertinent evidence for ERAS-guided fluid management (Table 3). Moreover, Clavien category IV complications dropped from 2.1 to 0% in our implementation of ERAS protocol; no patients experienced thromboembolic events with ERAS protocol which most likely stems from the optimal utilization of early ambulation and ERAS-guided thromboprophylaxis.

Majority of the patients were safely discharged on postoperative day 1 after the implementation of ERAS guidelines. ERAS protocol in our setting emphasized on early ambulation, early feeding, and an anticipation of early recovery, which contributed to a faster return to function. This demonstrates the feasibility of shift in expedited perioperative care of the bariatric surgery patients. The increase in postoperative day 1 discharge rates over time (Table 2) indicates that experience with enhanced

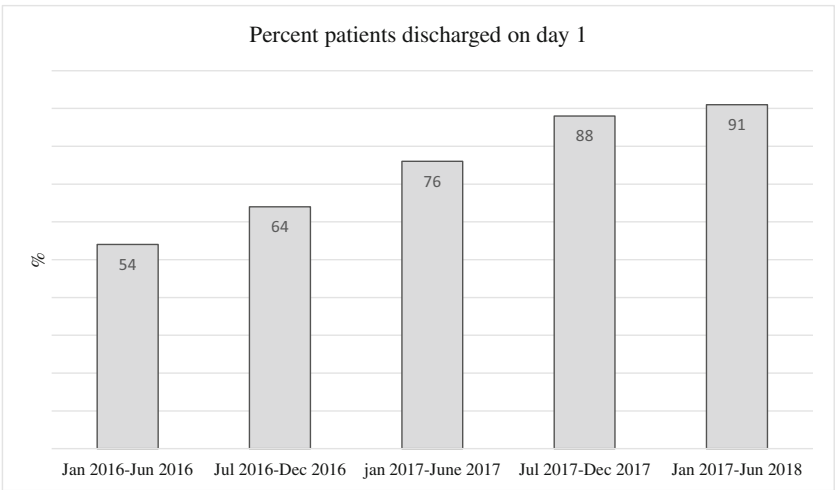

Fig. 1 Semi-annual trends in day 1 discharge rates

Table 3 Reported complications categorized according to Clavien-Dindo classification

Clavien-Dindo grade	Pre-ERAS group		Post-ERAS group	
	Complications type reported	No. of complications	Complication type reported	No. of complications
I	Abdominal pain controlled with analgesics	3	Supratherapeutic INR	1
	Dehydration	4	Dehydration	1
	Fecal impaction	1	Palpitations.	1
	Hyperkalemia	2	Hypokalemia	1
II	Atrial fibrillation with rapid ventricular response	1	Constipation treated with medication	1
	Hypoxemia requiring supplemental oxygen	1	UTI	1
	Urinary tract infection (UTI)	1		
III	Infra-mesocolic intraperitoneal abscess	1	Strangulated pre-existing incisional hernia	1
	Leak from posterior wall of gastric pouch	1	Numbness in fingers, blurry vision right eye, and confusion. MRI normal	1
	Small bowel obstruction	1		
IV	Acute renal failure	2		0
	Diabetic ketoacidosis	1		
	Venous thrombosis	1		
	Guillian-Barre syndrome	1		
V		0		0

recovery guidelines facilitates their effective implementation without compromising on safety. An interesting study by Sheaffer et al. has shown that a simple education system involving patients and healthcare providers regarding the ERAS guidelines reduced the length of stay significantly [16]; reducing the length of stay is relevant considering the high costs of bariatric surgery [17].

Małczak et al. concluded that widespread utilization of these guidelines has been frustrating, mainly due to a lack of standardization and prevalent heterogeneity of ERAS protocols [13]. We addressed this issue by following a homogenous protocol based on guidelines from ERAS society and Awad et al. [8, 14]. However, we concur that ERAS protocols do not take into account the high-risk status of some patients, which creates challenges while selecting patients for enhanced recovery. High-risk patients with multiple comorbidities such as chronic kidney disease (CKD) and advanced congestive heart failure (CHF) on transplant lists are often referred for bariatric surgery as an effective weight loss measure to become eligible for future transplantation. Such patients have comorbidities that may require close perioperative monitoring or management such as dialysis. A safe clinical judgment in such high-risk patients dictates observation instead of an expedited discharge. An inclination for close postoperative observation in patients with multiple comorbidities contributed to delay in discharge for 28% who were discharged after day 1 versus 72% patients who were discharged on day 1 at our hospital. Although not selected as outcomes of interest for this study, the most common causes that contributed to delay in discharge included nausea and medical stabilization in CKD and CHF patients. A study by Jonsson et al. [18] has ventured into such barriers to implementation of ERAS and factors that prolong the length of stay. CKD and CHF were both statistically significant predictors for late discharge after bariatric surgery in this setting. This underscores a need for stratification of guidelines that make provisions for perioperative risk status of a patient.

Our overall mean compliance rates were 85%; among the 25 components, 19 were implemented in more than 75% of the cases. High compliance rates with ERAS protocols have been shown to correlate with better outcomes in colorectal and bariatric programs [19, 20]. However, the challenge with ERAS-based care has been its "labor intensive nature" which needs collaboration between "multiple hospital personnel" [11]. We found a significant increase in compliance with a checklist based on the ERAS protocol; this suggests that simple solutions can be initiated to improve compliance and outcomes in bariatric programs. Use of checklists, flow sheets, or other innovative yet easy to implement tools is especially important to reduce the inertia for ERAS implementation. There is a steady increase in number of bariatric operations per year in the USA, with 228,000 procedures performed in 2017 [21].

Yet, remarkably, we only found one study at the US-based health system which attempted to implement, evaluate, and assess compliance with ERAS-based care delivery for Roux-en-Y gastric bypass [22]. Therefore, research should attempt to seek out strategies such as checklists, workflow sheets, or order sets to homogenize and ensure compliance with ERAS-guided perioperative care.

Data regarding long-term efficacy and safety of bariatric surgery for the treatment of obesity, diabetes, and other obesity-related complications are emerging with consistently positive outcomes reported in multiple recent prospective studies [23–25]. It is reasonable to expect a growth in volume of bariatric procedures [2], necessitating the need for widespread optimized care. As implementation of ERAS program gains popularity in bariatric programs, randomized trials aimed at patient selection and risk stratification for ERAS need to be carried out. Moreover, with a myriad of interventions that constitute the ERAS protocol, such studies can provide best evidence for identifying interventions from the ERAS protocol which have the most significant effect on patient outcomes.

Our study is subject to the intrinsic limitations of an observational study. Moreover, our data comes from a bariatric center of excellence, which allowed for structured implementation of guidelines. Trends in discharge rates may be subject to bias originating from the fact that SG was performed relatively more often than RYGB after ERAS implementation as compared to before ERAS. The transition to SG as the most common procedure is reflective of national trends with regard to bariatric procedure types [21]. To examine the effect of this confounding, we compared length of stay between RYGB patients and SG patients, both before and after ERAS implementation. We did not find a statistically significant difference ($p > 0.05$) between length of stay for sleeve and bypass patients in our program. A low rate of complications may also be subject to bias resulting from improving surgeon expertise and a low morbidity risk after bariatric surgery. However, we believe that strategies aimed at previously described challenges to ERAS implementation, to educate healthcare providers and ancillary staff, can provide a practical avenue to address guideline compliance and improve outcomes [26]. Since ERAS is a multimodal approach involving surgeons, anesthesiologists, dieticians, and nursing teams, the assessment of the extent to which the protocols are followed will need multidisciplinary approaches such as checklists and audits. We believe that streamlining existing perioperative care with programs such as ERAS is the way forward in bariatric perioperative care. Bariatric surgery candidates are a great fit for ERAS protocols as they undergo a diligent selection and preoperative preparation process; bariatric programs can safely implement ERAS protocols and improve outcomes.

Conclusion

Our study demonstrated that implementation of ERAS program is feasible and resulted in a statistically significant reduction in length of stay and short-term complications after primary bariatric surgery. The use of ERAS guidelines should be encouraged as a standard of care in bariatric surgery programs. To ensure homogenization of protocols and compliance, we recommend the use of a checklist for ERAS-based perioperative care in bariatric surgery.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of Animal and Human Rights All procedures performed in studies 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.

Disclosure Information None of the authors have any financial conflicts to disclose. The study is based on the analysis from a bariatric database mandated by University of Arizona Institutional Review Board (IRB approval number 10-0744-01). No funding was provided for the study.

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