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Original Article

Efficacy and safety of enhanced recovery after surgery for patients undergoing laparoscopic bariatric surgery

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Abstract: *Background:* Enhanced recovery after surgery (ERAS) is widely used in general surgery, cardiac surgery, obstetrics, gynecology, and other multi-disciplinary fields but rarely in laparoscopic bariatric surgery. This present study aimed to investigate the efficacy and safety of ERAS for patients undergoing laparoscopic bariatric surgery. *Methods:* According to the implementation of a ERAS strategy during the perioperative period, 46 patients undergoing laparoscopic bariatric surgery were divided into an ERAS group (24 cases) and non-ERAS group (control, 22 cases). Overall surgical outcome, clinical indicators, preoperative and postoperative inflammatory markers, postoperative pain, postoperative complications, hospital stay length, hospitalization cost, and satisfaction degree of patients to nursing in the two groups were observed and compared. *Results:* Laparoscopic bariatric surgery was successfully performed in all patients without conversion to open surgery. The time before anal exhaust, time before taking food, time before ambulation, time before bowel recovery, and time of intravenous infusion in the ERAS group were significantly shorter than those in the control group, respectively ($P < 0.05$). At 24 hours after surgery, the C-reactive protein and interleukin-6 levels in ERAS group were significantly lower than those in the control group ($P < 0.05$). The postoperative pain degree in ERAS group was significantly lighter than that in the control group ($P < 0.05$). Incidence of postoperative nausea/vomiting in ERAS group was significantly lower than that in the control group ($P < 0.05$). The hospital stay length in ERAS group was significantly shorter than that in the control group ($P < 0.05$), and hospitalization cost in ERAS group was significantly less than that in the control group ($P < 0.05$). The satisfaction rate of patients to nursing in ERAS group was significantly higher than that in the control group ($P < 0.05$). *Conclusion:* ERAS is safe and effective in laparoscopic bariatric surgery and can be further clinically popularized.

Keywords: Enhanced recovery after surgery, laparoscopic bariatric surgery, efficacy, safety

Introduction

Enhanced recovery after surgery (ERAS) was first proposed by Kehlet and Wilmore [1] at the beginning of this decade by applying clinically mature theories and methods to reduce stimulation and stress reaction of surgical trauma, especially negative reaction, for accelerating the recovery of patients after surgery [2]. The ERAS concept has made a revolutionary change to traditional perioperative management principles and is supported by evidence-based medicine. It will be the future development of perioperative management [3]. Presently, ERAS is widely used in general surgery, cardiac surgery, obstetrics, gynecology, and other multi-disciplinary fields. Being overweight has become a global epidemic and surgical treatment is an important tool for long-term and stable weight loss in severely obese patients [4]. Laparoscopic bariatric surgery has extensively acquired development in recent years due to its minimal invasion, low incidence of postoperative complications, and significant curative effects [5]. It is commonly used in treatment of obesity and metabolic disease [6, 7]. Our study investigated the efficacy and safety of ERAS in patients undergoing laparoscopic bariatric surgery. The objective was to provide a reference for its further clinical application.

Subjects and methods

Subjects

Forty-six patients undergoing laparoscopic bariatric surgery in the Second People's Hospital of Qujing City (Qujing, China) from February 2014 to September 2016 were enrolled in this study. There were 19 males and 27 females. The age of patients was 37-69 years with mean of 4.14±7.56 years. Body mass index (BMI) of

patients was 34.66-38.32 kg/m^2 with mean of 36.34±5.72 kg/m^2. According to whether ERAS strategy was implemented during the perioperative period, the patients were divided into an ERAS group (24 cases) and non-ERAS group (control group, 22 cases). Detailed treatment and diagnosis plans had been formulated by a multi-disciplinary team through discussion before surgery for patients. In obesity patients with type 2 diabetes mellitus (T2DM), blood sugar was strictly controlled before surgery. For severely obese patients complicated with cardiopulmonary dysfunction, appropriate diuresis dehydration and pulmonary hypertension reduction treatments were given. This study was approved by the Ethics Committee of the Second People's Hospital of Qujing City. Written informed consent was obtained from all participants.

Inclusion criteria

According to indication standards of Guidelines for Surgical Treatment of Obesity and Type 2 Diabetes in China (2014) [8], the inclusion criteria were as follows: 1) the patients were confirmed with obesity-related metabolic disorders and the obesity could be treated effectively; 2) waist circumference: male ≥ 90 cm; female ≥ 85 cm; 3) BMI ≥ 32.5 kg/m^2 or 27.5 ≤ BMI ≤ 32.5 kg/m^2 with T2DM for ≤ 15 years; islet cells had certain insulin secretion functions and fasting serum C-peptide ≥ half of the normal lower limit; 4) age: 16-65 years; 5) no alcohol or drug dependence, no serious mental or intelligence disorders; 6) patients understood and accepted the bariatric surgery method and the potential risk of complications; patients comprehended the importance of postoperative recovery by changing eating habits and life style and could actively cooperate with the postoperative follow up.

Exclusion criteria

The exclusion criteria were as follows: 1) patients had secondary obesity caused by a variety of reasons; 2) patients had gastric and duodenal malignant lesions and gastroesophageal reflux disease [9]; 3) the functions of heart, lungs, and other important organs could not tolerate surgery.

Treatment in ERAS group

The ERAS group adopted the ERAS strategy during the perioperative period. 1) Preoperative preparation: From 1 month before surgery, low-fat and high-dietary fiber dieting and proper aerobic exercise were adopted to achieve the purpose of weight loss, liver volume reduction, and avoiding liver injury due to frequent intraoperative liver lifting. On the day of admission, excepting routine publicity and education, the treatment procedure of ERAS and recovery goals achieved at various stages during the perioperative period were explained in detail in order to reduce patient fear and tension. Preoperative intestinal preparation was not performed. Normal eating was taken in 1 day before surgery with fasting 6 hours before surgery. At 2 hours before surgery, 150 mL of water containing 5% glucose was taken orally followed by liquid fasting. The nasogastric tube was not used before surgery. A urinary catheter was not used before laparoscopic sleeve gastrectomy (LSG) surgery. In laparoscopic Roux-en-Y gastric bypass (LRYGB) surgery, it was placed during anesthesia and was removed on the next day. Antibacterial agents were prophylactically used at 1 hour before surgery and were stopped within 24 hours after surgery. 2) Anesthesia and operation: As soon as patients entered the operating room, the one-time intravenous indwelling needle puncturing was performed. General anesthesia combined with epidural block anesthesia was adopted. Short-acting anesthetic inducers were used and the anesthetic was sprayed on the endotracheal tube surface before anesthesia. Low volume ventilation (5-8 mL/kg) was taken during surgery to avoid complications such as hypocarbia, barotraumas, and circulation dysfunction caused by hyperventilation. The temperature in the operating room was adjusted at 26°C. The abdominal cavity was flushed with 40°C normal saline to avoid hypothermia. The two legs of patients were wrapped using elastic bandages in order to prevent deep vein thrombosis. The patients were in supine position, with higher head and lower feet at 30°. The left side was elevated at 15°. Four-port technique was used in laparoscopic sleeve gastrectomy and the five-port technique was used in laparoscopic gastric bypass. The gastric volume regulating band was placed through the mouth. Part of the stomach was removed the by cutting it into a tube-shaped block or making it into a gastric pouch under a Harmonic Ace device (Ethicon Inc., OH, USA). The abdominal cavity drainage tube was selectively placed to exhaust pneumoperitoneum based on observing the surgical

wound bleeding. 3) Postoperative management: After surgery, 100-200 mL of warm water was taken on the first day. A liquid diet was taken from the next day with a semi-liquid diet taken from the third day. Early ambulation was adopted from the second day after surgery and ambulation distance was increased day by day. For patients with postoperative nausea, vomiting, and hiccups metoclopramide and Ondansetron were prescribed along with acupuncture treatment. Parenteral nutrition was not used after surgery. The daily fluid amount was maintained at 2000-2500 mL. The analgesia pump was placed for continued epidural analgesia. Non-opioid drugs were used in case of poor analgesic pump effect [10].

Treatment in control group

The control group adopted conventional treatment during the perioperative period. 1) Preoperative preparation: Before surgery, no weight-loss exercise was required and routine publicity and education were performed on the day after admission. Three days before surgery, metronidazole was taken for bowel preparation and liquid dieting began. Fasting was conducted 1 day before surgery. Intravenous dripping of glucose was performed to supplement energy after catheterization by subclavian vein or internal jugular vein puncture. A urinary catheter was used during the surgery and was removed 3 days after surgery. No prophylactic antibacterial agent was used before surgery. 2) Anesthesia and operation: General anesthesia was adopted and the anesthesia drugs were the same as with the ERAS group. Low-volume ventilation (10-15 mL/kg) was used during surgery. There was not a special setting for air temperature (generally 22-24°C) in the operating room. The abdominal cavity was flushed using normal saline. Elastic bandages were used to wrap the two legs in order to prevent deep vein thrombosis. Surgery was performed by the same responsible surgeon as with the ERAS group and the two groups took the same surgical method. An abdominal cavity drainage tube was used to observe the volume of drainage after surgery. 3) Postoperative management: After surgery, continued fasting was performed until 2 days after exhaust. The average fasting time was 3-5 days and afterwards the liquid diet was gradually transited to ordinary diet. During the fasting period, the daily fluid amount was the same as with normal gastrointestinal surgery. Daily fluid infusion through the central vein was maintained at 3500-4000 mL, according to weight. Electrolytes were monitored and potassium, sodium, and calcium were timely supplemented. Bucinnazine hydrochloride or pethidine hydrochloride were used to relieve postoperative pain. The patients were encouraged to perform early ambulation after surgery according to their wishes. After surgery, antimicrobial agents were chosen according to blood routine, calcitonin, C-reactive protein levels, and presence of persistent fever.

Observation indexes

During the perioperative period, clinical indicators included time before anal exhaust, time before taking food, time before ambulation, time before bowel recovery, and time of intravenous infusion. Preoperative and postoperative inflammatory markers including C-reactive protein (CRP) and interleukin-6 (IL-6), postoperative pain [11], postoperative complications, hospital stay length, and hospitalization cost in the two groups were observed. In addition, the satisfaction degree of patients to nursing was evaluated based on the nursing attitude, nursing level, and ward environment: very satisfied, 5 points; satisfied, 4 points; dissatisfied, ≤ points. Satisfaction rate = ($number_{very\ satisfied}$ + $number_{satisfied}$)/total number * 100%.

Statistical analysis

Statistical analysis was carried out using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). Enumeration data were presented as number and were compared using X^2 test. Measurement data were presented as mean ± SD and were compared using *t* test. $P < 0.05$ was considered statistically significant.

Results

General data of patients

General data of patients in the two groups are shown in **Table 1**. There was no significant difference of age, gender, BMI, surgical approach, hypertension, T2DM, or obstructive sleep apnea syndrome (SAS) between ERAS and control group ($P > 0.05$).

Overall surgical outcome

The laparoscopic bariatric surgeries were successfully performed in 46 patients without con-

Table 1. General data of patients in the two groups

Group	ERAS	Control	t/X^2	P
n	24	22		
Age (years)	35.44±6.16	32.81±8.31	1.226	0.227
Gender (n)			0.003	0.958
Male	10	14		
Female	9	13		
BMI (kg/m^2)	37.24±6.51	35.45±4.89	1.047	0.301
Surgical approach (n)				
LSG	19	5	0.262	0.609
LRYGB	16	6		
Hypertension (n)	6	4	0.314	0.575
T2DM (n)	4	2	0.581	0.446
Moderate-severe SAS (n)	7	5	0.247	0.619

ERAS, enhanced recovery after surgery; BMI, body mass index; LSG, laparoscopic sleeve gastrectomy; LRYGB laparoscopic Roux-en-Y gastric bypass; T2DM, type 2 diabetes mellitus; OSAS, obstructive sleep apnea syndrome.

version to open surgery. In ERAS group, 1 patient was transferred to the Intensive Care Unit after surgery due to severe OSAS and returned to ordinary ward on the next day. The remaining 45 patients safely returned to ordinary ward after surgery.

Comparison of perioperative clinical indicators between the two groups

As shown in **Table 2**, time before anal exhaust, time before taking food, time before ambulation, time before bowel recovery, and time of intravenous infusion in ERAS group were significantly shorter than those in the control group, respectively ($P < 0.05$).

Comparison of preoperative and postoperative inflammatory markers between the two groups

Before surgery, there was no significant difference of serum CRP or IL-6 level between ERAS group and control group ($P > 0.05$). At 24 hours after surgery, CRP and IL-6 levels in each group were significantly higher than those before surgery, respectively ($P < 0.05$), and those in the ERAS group were significantly lower than those in the control group, respectively ($P < 0.05$) (**Table 3**).

Comparison of postoperative pain between the two groups

In ERAS group, there were 24, 4, and 0 cases with postoperative grade I, II, and III pain, respectively. In control group, there were 11, 9, and 2 cases with postoperative grade I, II, and III pain, respectively. There was significant difference between the two groups ($P < 0.05$, **Table 4**).

Comparison of complications between the two groups

During the surgery, no gastric leakage, anastomotic leakage, gastrointestinal bleeding, or deep vein thrombosis occurred in either group. There were 8 and 15 cases of nausea/vomiting in ERAS group and control group, respectively, with significant difference between them ($\chi^2 = 5.576$; $P = 0.018$). In addition, there were 2 cases of other postoperative complication in ERAS group. In one case, incomplete ileus appeared on the third day after surgery and recovered after conservative treatment. In the other case, acute urinary retention occurred after removal of ureter on the second day after surgery. After resetting, the urine tube was removed on the third day after surgery. In the control group, navel incision infection appeared in 1 patient on the 5th day after surgery but it healed after positive dressing and half-month infrared incision exposure. There was no significant difference between the two groups ($P > 0.05$). There was no re-admission after discharge or unplanned reoperation in either group.

Comparison of hospital stay length and hospitalization cost between the two groups

As shown in **Table 5**, the hospital stay length in ERAS group was significantly shorter than in the control group ($P < 0.05$) and hospitalization cost in ERAS group was significantly less than that in the control group ($P < 0.05$).

Comparison of nursing satisfaction degree between the two groups

In the ERAS group, there were 19, 3, and 2 cases scored as very satisfied, satisfied, and dissatisfied with nursing during the perioperative period, respectively. In the control group, there were 12, 5, and 5 cases scored as very satisfied, satisfied, and dissatisfied with nursing during the perioperative period, respectively. The satisfaction rate in ERAS group was significantly higher than that in the control group ($P < 0.05$, **Table 6**).

Table 2. Comparison of perioperative clinical indicators between the two groups (days)

Group	n	Time before anal exhaust	Time before taking food	Time before ambulation	Time before bowel recovery	Time of intravenous infusion
ERAS	24	2.63±0.83	1.33±0.31	2.24±0.21	1.21±0.39	3.36±0.52
Control	22	3.21±0.96	4.65±0.42	2.89±0.38	2.26±0.45	4.91±0.73
t		-2.197	-30.679	-7.261	-8.476	-8.348
P		0.033	< 0.001	< 0.001	< 0.001	< 0.001

ERAS, enhanced recovery after surgery.

Table 3. Comparison of preoperative and postoperative inflammatory markers between the two groups

	Group	n	Before surgery	24 h after surgery
CRP (mg/L)	ERAS	24	4.63±0.65	10.17±2.04*
	Control	22	5.12±1.25	87.52±12.56*
	t		-1.689	-29.774
	P		0.098	< 0.001
IL-6 (pg/ml)	ERAS	24	4.98±1.12	8.21±1.31*
	Control	22	5.63±1.33	12.78±2.12*
	t		-1.798	-8.877
	P		0.079	< 0.001

*P < 0.05 compared with before surgery. ERAS, enhanced recovery after surgery; CRP, C-reactive protein; IL-6, interleukin-6.

Table 4. Comparison of postoperative pain between the two groups

Group	n	Pain grade		
		I	II	III
ERAS	24	20	4	0
Control	22	11	9	2
χ^2			6.461	
P			0.040	

ERAS, enhanced recovery after surgery.

Table 5. Comparison of hospital stay length and cost between the two groups

Group	n	Hospital stay length (days)	Hospitalization cost (million yuan)
ERAS	24	5.22±1.04	5.13±0.52
Control	22	7.58±1.42	5.56±0.42
t		-6.469	-3.068
P		< 0.001	0.004

ERAS, enhanced recovery after surgery.

Discussion

ERAS refers to the complete process of smooth and rapid recovery of patients during perioperative period. It cannot simply be interpreted as fast surgery. In ERAS, detailed perioperative period diagnosis and treatment strategies are required to reduce the body stress reaction, especially the negative effects. This can promote rapid recovery of patients shortening the length of hospital stay, reducing patient pain, and saving hospitalization cost [12]. At the same time, ERAS does not increase the risk of surgical complications or the readmission rate [7]. The completion of ERAS needs the efforts of specialized doctors, ward nurses, anesthesiologists, operating room nurses, and the patients themselves.

Laparoscopic surgery has been carried out for 25 years in China. Compared with conventional gastrointestinal surgery, laparoscopic gastrointestinal surgery is better received and favored by the vast number of patients and medical workers due to its earlier off-bed time, faster aeration time, lower surgical incision infection rate, less postoperative pain, and hospitalization days [13]. Weight-loss metabolic surgery has been an emerging discipline in recent years in which a variety of surgical approaches have been successively applied through its development. Currently accepted standard surgical methods in laparoscopic bariatric surgery include LRYGB and LSG. Compared with LRYGB, LSG has a more simple operation and similar achievement in treatment of obesity and T2DM. It has gradually promoted and been favored by metabolic surgeons [14]. Because obese patients are different from ordinary patients in the aspects of breathing, circulation, and metabolism perioperative ERAS is a new issue to anesthesiologists and surgeons. ERAS-related articles mainly appear in retrospective reports of European and American countries [15] in which the scholars pay more attention to the details in ERAS including a strict low-calorie diet list based on patient BMI and gender within 2-4 weeks before surgery, playing video of weight-loss surgery, and adding heat and humidity to

Table 6. Comparison of nursing satisfaction degree between the two groups

Group	n	Very satisfied	Satisfied	Dissatisfied	Satisfaction rate
ERAS	24	19	4	1	95.83%
Control	22	12	4	6	72.72%
χ^2					4.750
P					0.029

ERAS, enhanced recovery after surgery.

carbon dioxide before blowing in the abdominal cavity. These measures can alleviate postoperative pain and improve surgery outcome.

Epidural block anesthesia can prevent afferent nerve stimulation, inhibit the stress reaction caused by surgery, reduce sympathetic nerve and adrenal cortical reaction, and improve the body's glucose tolerance [16]. In this study, in the ERAS group, intraoperative general anesthesia combined with epidural block anesthesia can not only reduce the use of general anesthesia drugs and the effects of anesthesia drugs on hemodynamics and cardiovascular burden but also be used as continuous epidural injection drugs to ease pain and promote offbed activity and cough phlegm, achieving the purpose of reduction of respiratory tract infection and prevention of deep vein thrombosis. The cases of postoperative nausea/vomiting in the ERAS group were significantly less than those in the control group. This may be related to early ambulation and use of non-opioid analgesics. In addition, early dieting can shorten the paralytic ileus after surgery so as to accelerate intestinal function recovery [17].

In conclusion, ERAS is safe and effective in laparoscopic bariatric surgery. It can obviously improve surgery outcome, reduce inflammatory reaction and complications, shorten postoperative hospitalization days, and reduce costs. It can be further clinically popularized. This study still had some limitations. Due to a relatively small sample size, no severe postoperative complications were found. In future studies, a larger sample size will make the results more convincing.

Disclosure of conflict of interest

None.

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