Review Article

Enhanced recovery after surgery in bariatric and metabolic surgery

Recep Aktimur

Department of General Surgery, Samsun LIV Hospital, Samsun, Turkey

Correspondence to: Recep Aktimur. Department of General Surgery, Samsun LIV Hospital, Samsun, Turkey. Email: recepaktimur@gmail.com.

Abstract: Enhanced recovery after surgery (ERAS) protocol is an extensive, evidence based, multimodal and multidisciplinary protocol for surgery. ERAS aims to enhance pre-intra and postoperative physiology and optimization of recovery after surgery. The concept of this approach showed us, multidisciplinary instrument integrating several perioperative elements, with the use of minimally invasive surgery, could be adopted various surgical procedures. Recently, principles of these protocols and their advantages are extended into bariatric and metabolic surgery. In this review, we summarize the components of ERAS protocols for bariatric and metabolic surgery according to ERAS Society guidelines and present the evidence on the emerging role of ERAS principles in obese patients. Many recent trials have evaluated ERAS protocols for bariatric surgery. Studies demonstrate that using ERAS protocols requires evidence-based modifications in all perioperative phase. The benefits of ERAS in this group of patients, including decreased length of hospital stay, rapid patient turnover, shorter operating room times and lower healthcare costs have been well demonstrated repeatedly. Despite the role of ERAS protocols in bariatric surgery is in its early phase, literature supports its role in improving perioperative outcomes compared with conventional care. Evidence-based protocols and multidisciplinary teamwork seem to be the key factors for success in ERAS.

Keywords: Enhanced recovery after surgery (ERAS); bariatric; metabolic; surgery; enhanced recovery after bariatric surgery (ERABS)

Received: 03 December 2019; Accepted: 23 June 2020; Published: 20 October 2021.

doi: 10.21037/ales-19-254

View this article at: http://dx.doi.org/10.21037/ales-19-254

Introduction

Enhanced recovery after surgery (ERAS) protocol is an extensive, evidence based, multimodal and multidisciplinary protocol for surgery. ERAS aims to enhance pre-intra and postoperative physiology and optimization of recovery after surgery. The concept of ERAS and to provide shortened length of stay (LOS) with more physiological recovery initiated with Khelet in the late 1990s (1). Khelet *et al.* designed a multimodal programme in colorectal surgery and have been shown reduced complications and shortened LOS. The benefits of ERAS programme has been shown and documented several meta-analyses comprising other surgical disciplines (2-4). Subsequently, this idea against conservative approach and the surgical dogmas evolved into a multidisciplinary instrument integrating several perioperative elements, and with the use of minimally invasive surgery it has been adapted bariatric surgery. Today, number of official ERAS Society Guidelines for Perioperative Care in Bariatric Surgery is accepted worldwide and now it is recognized as enhanced recovery after bariatric surgery (ERABS). Unlike the "fast track surgery", ERAS actually encompasses whole perioperative phases ad provide not only accelerated discharge but focused primarily on the quality of recovery. Scientific evidence suggests that implementation of ERAS programme boosts patient satisfaction, reduced morbidity, decrease recovery times and hospital costs in dedicated centres (5-7).

This article aims to increase understanding of ERABS based on the best evidence available. ERAS Society guidelines on bariatric surgery and other specialties are accessible on www.erassociety.org.

Table 1 ERAS recommendation for preperative care in bariatric surgery

Element	Recommendation	Level of evidence	Recommendation grade
Preoperative information, education and counselling	Patients should receive preoperative counselling	Moderate	Strong
Prehabilitation and exercise	Although prehabilitation may improve functional recovery, there are insufficient data in the literature to recommend prehabilitation before bariatric surgery for the reduction of complications or length of stay	Low	Weak
Smoking and alcohol cessation	Tobacco smoking should be stopped at least 4 weeks before surgery. For patients with a history of alcohol abuse, abstinence should be strictly adhered to for at least 2 years. Moreover, the risk of relapse (or new onset in patients without earlier abuse) after gastric bypass should be acknowledged.	Smoking: high Alcohol: low (only one high-quality RCT)	Strong
Preoperative weight loss	Preoperative weight loss should be recommended prior to bariatric surgery Patients on glucose-lowering drugs should be aware of the risk of hypoglycaemia	Postoperative complications: high Postoperative weight loss: low (inconsistency, low quality)	Strong
Glucocorticoids	Eight mg dexamethasone should be administered i.v., preferably 90 min prior to induction of anaesthesia for reduction of PONV as well as inflammatory response	Low (no RCTs in bariatric surgery)	Strong
Preoperative fasting	Obese patients may have clear fluids up to 2 h and solids up to 6 h prior to induction of anaesthesia. Further data are necessary in diabetic patients with autonomic neuropathy due to potential risk of aspiration.	Non-diabetic obese patients: high Diabetic patients without autonomic neuropathy: moderate Diabetic patients with autonomic neuropathy: low	Strong Weak Weak
Carbohydrate loading	While preoperative oral carbohydrate conditioning in patients undergoing major abdominal elective surgery has been associated with metabolic and clinical benefits, further data are required in morbidly obese patients. Similarly, further data are needed on preoperative carbohydrate conditioning in patients with gastrooesophageal reflux who may be at increased risk of aspiration during anaesthetic induction.	Shortened preoperative fasting (non-diabetic obese patients): low Diabetic patients without autonomic neuropathy: moderate Diabetic patients with autonomic neuropathy: low Preoperative carbohydrate loading in obese patients: low	Strong

Evidence based recommendations from Bariatric ERAS guideline (8)

Preoperative interventions (Table 1)

Preoperative information, education and counselling

Althought, preoperative information has been found to decrease anxiety and increase compliance to postoperative planned course, recovery, LOS and outcomes there is little evidence (9,10). A systematic review identified the impact of preoperative information on surgical outcomes but confirmed results were in minority (11).

Prehabilitation and exercise

Despite all of the logical basis of prehabilitation and exercise before surgery, the evidence is sparse and the generalisation of current studies to bariatric and metabolic surgery patients is questionable. In an analysis of recent systematic review, eight RCTs assessing the impact of preoperative exercise on cardiovascular and respiratory function and recovery after surgery was concluded that the evidence which shows

physiological improvement with prehabilitation was limited (12).

Smoking and alcohol cessation

Tobacco smoking increases morbidity and mortality after surgery with decreased tissue oxygenation, pulmonary complication and thromboembolism (13). Marked reduction in postoperative complications with smoking cessation has been shown, also at least 4 weeks of smoking cessation was found to be more effective (13,14).

Daily intake of 36 g ethanol or more has been found to increase postoperative complications (15). Retrospectively studied wide population of patients who undergoing elective (including bariatric) surgery shown that, consumption of >24 gr ethanol per day within 2 weeks of surgery was an independent factor for development of pneumonia, sepsis, wound infection and hospital stay (15). Alcohol cessation of at least 4 weeks before surgery is recommended current ERAS guidelines for colorectal surgery.

Preoperative weight loss

Preoperative weight loss is found to reduce liver volume by 16–20%, surgeon's perceived complexity of the procedure and postoperative complications (16,17). The positive effect of preoperative weight loss on postoperative complications has not been confirmed in diabetic patients. On the other hand, it was shown that, weight loss prior to surgery is the only positively associated factor for postoperative weight loss (16,18).

Glucocorticoids

Anti-inflammatory effects of glucocorticoids have long been used in a variety of elective surgery to decrease surgical stress, postoperative nausea and vomiting (PONV) (19,20). Althought it was not found to be associated with overall complication rate and the safety of anastomosis in colorectal surgery, they were shown to reduce complication rates and LOS in a recent meta-analysis (21). To achieve effect on PONV, >2.5–5 mg dexamethasone must be given 90 minutes before anaesthesia induction (22). Meta analyses show that, a single dose glucocorticoids usage has no adverse effect, but due to the hyperglycaemia effect of glucocorticoids and associated increase on postoperative infective complications, blood glucose should be monitored preoperatively (21,23). In bariatric surgery patients, one retrospective study has shown that, to achieve a successful discharge within 24 hours, a steroid bolus was useful (24).

Preoperative fasting

Opposite to the surgical dogmas, in a recent study on bariatric patients who included a program which was consist of drinking 300 mL of clear fluid 2 hours before anaesthesia induction, no differences was found in residual gastric fluid volume (RGFV) and gastric pH compared with nil-per-os (25-27). Similar findings were found in diabetic bariatric patients (with/without autonomic neuropathy) (28). Now, clear fluids and solids intake 2 and 6 hours before the surgery is recommended in anaesthesia guidelines in healthy and obese patients (29,30).

Carbohydrate loading

Preoperative carbohydrate loading with iso-osmolar beverages ingested 2–3 hours before anaesthesia induction, decreased postoperative insulin resistance, regulated postoperative nitrogen and protein balance and LOS (31-33). In patients with type II diabetes (mean BMI 28.6 kg/m^2), gastric emptying times with preoperative carbohydrate loading were similar like healthy subjects (34). In bariatric patients preoperative carbohydrate loading has not showed an association with an increase in aspiration-related outcomes, and in a RCT (laparoscopic sleeve gastrectomy) no differences was found between the groups (35,36).

Intraoperative interventions (Table 2)

Perioperative fluid management

Sharp and correct assessment of volume status and therefore perioperative fluid management in morbidly obese patients are challenging. Because, they have physiological differences, comorbidities, poly-pharmacy, preoperative diets-driven deficits (37). Notedly, while obese patients have increased total blood volume, volume/weight rate is reduced when compared with non-obese patients (50 mL/kg compared with 75 mL/kg) (38). Despite decreased rate of rhabdomyolysis (RML) with laparoscopy (2%) than laparotomy (5–77%), predisposing factors like >4 hours operation time and intraoperative hypotension must be avoided (39,40).

Althougt, in bariatric patients, "liberal" fluid regimens (40 mL/kg, found to be associated with reduced RML, PONV, postoperative acute renal failure and LOS) is supported in non-randomised studies, more conservative approach (15 mL/kg) reported no differences in terms of postoperative RML (41-44).

PONV

Recent guidelines recommend a multimodal approach include Propofol for anaesthesia induction and maintenance,

Table 2 ERAS recommendation for intraperative care in bariatric surgery

Element	Recommendation	Level of evidence	Recommendation grade
Perioperative fluid management	Excessive intraoperative fluids are not needed to prevent rhabdomyolysis and maintain urine output. Functional parameters, such as stroke volume variation facilitate goal-directed fluid therapy and avoid intraoperative hypotension and excessive fluid administration. Postoperative fluid infusions should be discontinued as soon as practicable with preference given to use of the enteral route	Maintenance as opposed to liberal fluid regimens: moderate Reduce stress response: moderate Open surgery: high Laparoscopic surgery: moderate	Maintenance fluid regimens: strong
PONV	A multimodal approach to PONV prophylaxis should be adopted in all patients	Low	Strong
Standardised anaesthetic protocol	The current evidence does not allow recommendation of specific anaesthetic agents or techniques	Low	Weak
Airway management	Anaesthetists should be aware of the specific difficulties in managing bariatric airway	Moderate	Strong
	Tracheal intubation remains the reference for airway management	Moderate	Strong
Ventilation strategies	Lung protective ventilation should be adopted for elective bariatric surgery	Moderate	Strong
	Patient positioning in an anti-Trendelenburg, flexed hip, anti- or beach chair positioning, particularly in the absence of pneumoperitoneum improves pulmonary mechanics and gas exchange	Low	Weak
Neuromuscular block	Deep neuromuscular block improves surgical performance	Low	Weak
	Ensuring full reversal of neuromuscular blockade improves patient recovery	Moderate	Strong
	Objective qualitative monitoring of neuromuscular blockade improves patient recovery	Moderate	Strong
Monitoring of anaesthetic depth	BIS monitoring of anaesthetic depth should be considered where ETAG monitoring is not employed	High	Strong
Laparoscopy	Laparoscopic surgery for bariatric surgery is recommended whenever expertise is available	High	Strong
Nasogastric tube	Routine use of nasogastric tube is not recommended postoperatively	Low	Strong
Abdominal drainage	There is insufficient evidence to recommend routine use of abdominal drainage	Low	Weak

minimalisation of volatile anaesthetics, avoidance of intra-postoperative opioids and avoidance of fluid overload (45). In a randomised trial assessing laparoscopic sleeve gastrectomy patients, a triple combination of haloperidol, dexamethazone and ondansetron found to demonstrate better than a single or double combination of them (46).

Anaesthetic maintenance

In other specialties, usage of short-acting agents and opioid avoidance within a ERAS programme appears to decrease cost, complications and LOS. In bariatric surgery, there are no verified evidence and recommendations about anaesthetic regimen (47).

Airway management

Correct sizing endotracheal intubation is especially important in obese patients.

Ventilation strategies

In a systematic review on ventilation strategies in obese patients has not been demonstrate any superiority on ventilation modes, volume control or pressure control (48). On the other hand, lung protective ventilation (LPV) strategies were found to be associated with important reduction in complication rates (49).

Althougt, the "beach chair" and "leg flexion" positions have been shown to be better from straight, supine position regardless of Trendelenburg angle in the absence of the intraoperative pneumoperitoneum they are not confirmed in laparoscopic surgery of obese patients (50).

Neuromuscular blockade

Deep block; may improve surgical maneuverability with lesser pressure insufflation intraoperatively (51). But, this effect on bariatric procedures have yet to be reported.

Residual blockade; remaining neuromuscular blockade depth in the recovery period, which called residual depth, seems obese population have increased relevance may have deleterious effects on this population. Returning high level of neuromuscular function is related with patient perceived satisfaction with increased recovery quality (52).

Laparoscopy

With laparoscopy, significantly shorter hospital stay, reduced rate of incisional hernia and decreased intraoperative blood loss, reduced postoperative pain and easier recovery were reported in RCTs (53,54). But, in terms of weight loss, there are no scientific data in comparison of open and laparoscopic surgery. On the other hand, robotic surgery in bariatric patients have similar overall major and minor complications but costs for robotic surgery were higher (55).

Nasogastric tube

In a wide retrospective cohort study, the assessment of the use of postoperative nasogastric tube has not been showed any difference between with or without the tube usage in 1067 gastric bypass patients, in terms of complication rates (56). In the gastric cancer patients who underwent gastrectomy, without nasogastric/nasojejunal tube while the number of respiratory complications and anastomotic leakage were similar, time to oral diet was significantly shorter (57). And when, there are need to apply nasogastric tubes during surgery, it should be removed before the end of the operation.

Abdominal drainage

detecting postoperative leakage with abdominal drainage is controversial, the sensitivity rate is varied between 0 and 94%, and the efficacy rate of non-operative treatment of leakage in Roux-n-y gastric bypass patients with only drainage is between 12.5% and 100% (58). On the other hand, non-operative leakage treatment with abdominal drainage was reported in one out of three patients in one study (59). And, the efficacy of prophylactic drainage use in bariatric and metabolic surgery has not been evaluated in any RCTs. In a recent study, similar leakage and reoperation rates showed between routine drain and without, retrospectively (59). Althought, the evidence is limited in obesity surgery, routine use of abdominal drains adds any benefits as known in other types of gastrointestinal surgery (60).

Postoperative interventions (Table 3)

Postoperative analgesia

Obesity, itself induces restrictive syndrome and this patient population prone to development of atelectasia. Sedative drugs lead the upper airway obstruction and postoperative hypoxemia (61). Thus, effective analgesia in obese population after surgery is critically important and currently it should be based on two strategies.

Multimodal systemic analgesia

Non-opioid analgesic agents like intravenous acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDs) must be used systemically and the dosage must be adopted to ideal weight (62,63). If opioid use is necessary, patient-controlled analgesia regimens with as possible as increased period between i.v. drug boluses should be preferred rather than continuous i.v. infusion, especially in obese patients with obstructive sleep apnoea (OSA) (64).

Nerve block and infiltration

Althought, there are no specific study on bariatric surgery, wound or periton infiltration with long-acting local anaesthetics has been used extensively with success in variety of laparoscopic procedures. Efficacy of the use of local anaesthetic aerosolisation techniques and pre-incisional infiltration has been shown and long-acting agents like ropivacaine or levobupivacaine seems to be more effective than lidocaine (short-acting agents) (65,66). Also, ultrason-guided transversus abdominus plane block was reported with effective and safe results in bariatric and

Table 3 ERAS recommendation for postoperative care in bariatric surgery

Element	Recommendation	Level of evidence	Recommendation grade
Postoperative analgesia	Multimodal systemic medication and local anaesthetic infiltration techniques should be combined. Thoracic epidural analgesia should be considered in laparotomy.	Multimodal intravenous medication, local anaesthetic infiltration: high	Multimodal intravenous medication, local anaesthetic infiltration: strong
		Epidural analgesia: very low	Epidural analgesia: weak
Thromboprophylaxis	Thromboprophylaxis should involve mechanical and pharmacological measures with LMWH. Dosage and duration of treatment should be individualised.	Mechanical measures in combination with LMWH: high	Strong
		Dosage of LMWH: low	Weak
Early postoperative nutrition	Protein intake should be monitored. Iron, vitamin B12 and calcium supplementation is mandatory	Nutritional supplementation: moderate	Strong
	Postoperative glycaemic and lipid control has to be strict in patients with diabetes	Glycaemic control: high	Strong
Postoperative oxygenation	Obese patients without OSA, should be supplemented with oxygen prophylactically in head-elevated or semi-sitting position in the immediate postoperative period	Prophylactic oxygen supplementation: low (only retrospective data)	Strong
	Uncomplicated patients with OSA should receive oxygen supplementation in a semi-sitting position. Monitoring for possible increasing frequency of apnoeic episodes should be diligent. A low threshold for initiation of positive pressure support must be maintained in the presence of signs of respiratory distress.	Positioning in the postoperative period: high	Strong
		High (14 RCTs and 1 meta-analysis)	Strong
Non-invasive positive pressure ventilation	Prophylactic routine postoperative CPAP is not recommended in obese patients without diagnosed OSA	Moderate (only retrospective data)	Avoiding routine use of CPAP: weak
	CPAP therapy should be considered in patients with BMI >50 kg/m^2, severe OSA or oxygen saturation ≤90% on oxygen supplementation	Low	Strong
	Obese patients with OSA on home CPAP therapy should use their equipment in the immediate postoperative period	Moderate (only retrospective data)	Strong
	Patients with Obesity Hypoventilation Syndrome (OHS) should receive postoperative BiPAP/NIV prophylactically along with intensive care level monitoring	Low (only retrospective data)	Strong

metabolic surgery, but the optimal technique from RCTs are limited.

Thoracic epidural analgesia (TEA) related recovery advantage has been reported in laparotomy but the data for usage in laparoscopic surgery is limited, even the application of TEA may lead complication in obese patients (67).

Thromboprophylaxis

Obese patients prone to thromboembolic complications and morbidity and 50% mortality after bariatric surgery is related with thromboembolic events (68). Other risk factors known as; venous thromboembolism history, older age, tobacco smoking, having varicose veins, cardiorespiratory failure, OSA, thrombophilia and the usage of oestrogen oral contraception (69).

Mechanical methods such as intermittent pneumatic compression or graduated compression stockings are not found to be effective to avoid the development of mortal pulmonary embolism, it should be used. Early postoperative mobilisation and calf-length compression stocking were decreased deep venous thromboembolism in bariatric patients (70).

As obesity surgery population have moderate risk of thromboembolic events, pharmacological prophylaxis and mechanical methods should be combined. Comparison of low molecular weight heparins (LMWH) and unfractionated heparin (UFH) were showed similar efficiency or adverse events in bariatric surgery (71). A more predictable and easier dose response, better bioavailability and longer effect on plasma after subcutaneous application with once-daily dosing, reduced thrombocytopenia and osteoporosis in longer usage, LMWH has a number of advantages over UFH (72). Twice dose usage of LMWH is not supported in studies, recommended first injection should be applied 8–12 hours after surgery (73). BMI adjusted increased dose regimen (i.e., for BMI >30 kg/m^2 6,000 U of enoxaparin, for BMI >40 kg/m^2 8,000 U, for BMI >50 kg/m^2 10,000 U) has been found to be safe without increased risk in terms of bleeding, and 3–4 weeks of treatment recommended (74,75).

Bridging LMWH; to achieve effective bridging, vitamin K antagonists agents should be stopped 5 days before surgery and resumed 12–24 h after with combination (76).

Vena cava filters use in current practice is not recommended due to many adverse events and lacking evidence for its efficacy (77).

Postoperative nutrition

All patients should undergo an appropriate nutritional evaluation before bariatric surgery, it is particularly important for malabsorptive procedures.

Early postoperative nutritional care

Before and after bariatric and metabolic surgery, nutritional counselling must be provided to patients and their family. Clear liquids could be initiated a couple of hours after surgery and protocol-derived staged progression should be adhered with the help of dietician. For optimal fibre consumption fruits and vegetables intake recommended. Especially after malabsorptive procedures, protein malnutrition causes 1% hospitalisation and results with morbidity (78). Average protein intake should be 60–120 g daily, and should be avoided from concentrated sweets for calori reduction and minimise symptoms of dumping after gastric bypass surgery. Minimal recommended nutritional supplementation should include 1–2 servings of multi vitamin-mineral supplements containing iron, calcium (1,200–1,500 mg/d) and vitamin B12 (79). To maintain adequate hydration fluids should be consumed in sufficient amount (more than 1.5 L per day) with slowly.

Management of diabetes mellitus and lipids

To achieve goals on postoperative glycaemic control fasting blood glucose and postprandial glucose should remain ≤110 mg/dL and ≤180 mg/dL, and the team (physician and ward nurses) should be trained for glycaemic targets (80). Scheduled insulin therapy should be use in obese patients with type I diabetes, in type II diabetes patients insulin requirement may be ended early after bariatric and metabolic surgery, but the metformin continuation is usually recommended (80). Any existing anti-lipid therapy for triglyceride and LDL-cholesterol should be continued until the goals of desired levels are reached (81).

Postoperative oxygenation

Obese patients without obstructive sleep apnoea (OSA)

Compared with normal weight patients, obese patients are prone to aspiration and atelectasis; thus, irrespective from the presence of OSA all obese patients should be accepted as high risk for respiratory complications (82,83). To prevent postoperative respiratory complications preoperative incentive spirometry assessed but showed no benefit, so routine use is not recommended (84). Postoperative tissue oxygenation has been found to be lower in obese patients, despite normal oxygen saturation on pulse oximetry (85). On the other hand, tissue oxygenation and respiratory function have been shown to return to normal within the first 24 h after surgery. But there is not enough data to recommend a optimum duration of oxygen support, so it should be individualised according to patients pulmonary compliance. To prevent pulmonary atelectasis, semisitting or head-elevated postoperative positioning or prone position (if feasible) recommended (82). If there are any sign of insufficient oxygenation such as decreased arterial saturation, tachypnoea, unexpected tachycardia or hypercarbia, positive pressure ventilation should be used.

Obese patients with OSA

For preoperative screening of OSA, STOP-BANG questionnaire should be used in preoperative assessment, and determined patients with moderate to high risk, should be evaluated for positive airway pressure support postoperatively, and close monitorisation of pulmonary function must be done (86). In patients with OSA, oxygen therapy should be used carefully, because while it improves oxygen saturation it can lead to increase the duration of apnoea-hypopnea events. American Academy of Sleep Medicine recommends the avoidance of opioid based patient-controlled analgesia in this group of patients (87).

Non-invasive positive pressure ventilation (NIPP)

Continuous positive airway pressure (CPAP), non-invasive ventilation and bi-level positive airway pressure (BiPAP) are called as NIPP support.

Generally oxygen therapy alone is not sufficient for patients with OSA (88). Recent meta-analyses showed that higher FiO_2s levels might increase the risk of apnoea/hypopnea events in bariatric patients postoperatively (89). Therefore, when a patient with OSA have signs of respiratory deterioration CPAP should be used in preference to oxygen therapy alone.

Prophylactic use of CPAP has been showed no clear benefit in oxygenation (90), but in BMI >60 kg/m^2 patients, with need of reoperation for complications it may be considered (91).

Postoperative CPAP/NIV requirement of obese patients can be divided into following subgroups

Obese patients without diagnosed OSA

Routine oxygen therapy (via nasal cannula or face-mask), upright postoperative positioning and early mobilisation is generally sufficient fort his group of patients.

Patients with OSA-not using preoperative CPAP therapy

In this group of patients, regional anaesthesia regimen and short-acting anaesthetic agents recommended (92). Patient related risk factors, which lead to increased need for NIPP use include OSA (moderate to severe), male gender, BMI >60 kg/m^2, age >50 years, pulmoner comorbidity, open surgery and the need for reoperation. In the immediate postoperative period, oxygen saturation below 90%, tachypnoea or hypercarbia indicates need for NIPP.

Obese patients with OSA on home CPAP therapy

Patients using CPAP on home, must continue preoperative CPAP treatment postoperatively, because it decreases complications (93).

Patients with obesity hypoventilation syndrome (OHS) ("Pickwickian syndrome")

Baseline awake decreased oxygenation and hypercarbia with raised serum bicarbonate (27 mmol/L) are defined as OHS in severely obese patients. OHS patients are prone to postoperative pulmonary complication, irrespective of the route of administration (intravenous/central neuraxial) they are highly sensitive to opioid agents and the use of them might lead sustained and life threatening pulmonary depression in the postoperative period (94). Therefore, opioid-free anaesthesia regimen with a preference of local anaesthetics using regional anaesthesia and prophylactic nasal BiPAP/NIV for postoperative 24–48 h are recommended (95).

The clinical results of ERAS in bariatric and metabolic surgery patients

Mostly performed bariatric and metabolic operations are all studied with ERAS protocol, and some of them were compared. In a cohort of 1,967 patients, a significant decrease of procedural times and LOS were shown after implementation of ERAS (96). Dogan *et al.* showed that an ERAS programme after laparoscopic Roux-n-y gastric bypass improves patients recovery and reduce the use of resources, with no significant differences in terms of surgical outcome (97). Additionally, recovery cost advantage was found with ERAS protocol in another study (98).

Despite the reported advantage of ERAS in abdominal surgery, some surgeons are still concerned about reducing hospital stay because of the consideration about increased complication rate, readmissions of ER and repeated hospitalisation, and the unnecessary utilization of the resources. Despite, the data on successful and safe discharge within 24 hours of surgery without meaningful increase in mortality, morbidity, and readmission rates in bariatric surgery patients (99-101), it was shown that LOS of ≤1 day for LRYGB patients was associated with a significantly increased risk of early mortality and early serious complications (102). On the other hand, cost saving approach shifts daily practice from he inpatient to outpatient. Similar findings were reported in a recent matched-cohort study of ERAS in one anastomosis gastric bypass (OAGB) by Aktimur *et al.*, they concluded that the ERAS programme on morbidly obese patients undergoing OAGB significantly reduces the LOS and the number of 30-D ER visits (103).

Conclusions

Current evidences and years spend with using ERAS elements in variety of surgical procedures shows that the use of systematic ERAS pathway according to structured ERAS guidelines on bariatric surgery may have the potential to improve outcomes after bariatric and metabolic surgery.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Mehmet Mahir Ozmen) for the series "Bariatric and Metabolic Surgery" published in *Annals of Laparoscopic and Endoscopic Surgery*. The article has undergone external peer review.

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/ales-19-254). The series "Bariatric and Metabolic Surgery" was commissioned by the editorial office without any funding or sponsorship. The author has no other conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth 1997;78:606-17.
2. Coolsen MM, van Dam RM, van der Wilt AA, et al. Systematic review and meta-analysis of enhanced recovery after pancreatic surgery with particular emphasis on pancreaticoduodenectomies. World J Surg 2013;37:1909-18.
3. Ni TG, Yang HT, Zhang H, et al. Enhanced recovery after surgery programs in patients undergoing hepatectomy: A meta-analysis. World J Gastroenterol 2015;21:9209-16.
4. Ni X, Jia D, Chen Y, et al. Is the Enhanced Recovery After Surgery (ERAS) Program Effective and Safe in Laparoscopic Colorectal Cancer Surgery? A Meta-Analysis of Randomized Controlled Trials. J Gastrointest Surg 2019;23:1502-12.
5. Basse L, Hjort Jakobsen D, Billesbolle P, et al. A clinical pathway to accelerate recovery after colonic resection. Ann Surg 2000;232:51-7.
6. Basse L, Raskov HH, Hjort Jakobsen D, et al. Accelerated postoperative recovery programme after colonic resection improves physical performance, pulmonary function and body composition. Br J Surg 2002;89:446-53.
7. Wind J, Hofland J, Preckel B, et al. Perioperative strategy in colonic surgery; LAparoscopy and/or FAst track multimodal management versus standard care (LAFA trial). BMC Surg 2006;6:16.
8. Thorell A, MacCormick AD, Awad S, et al. Guidelines for Perioperative Care in Bariatric Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. World J Surg 2016;40:2065-83.
9. Halaszynski TM, Juda R, Silverman DG. Optimizing postoperative outcomes with efficient preoperative assessment and management. Crit Care Med 2004;32:S76-86.
10. Hathaway D. Effect of preoperative instruction on postoperative outcomes: a meta-analysis. Nurs Res 1986;35:269-75.
11. Ronco M, Iona L, Fabbro C, et al. Patient education outcomes in surgery: a systematic review from 2004 to 2010. Int J Evid Based Healthc 2012;10:309-23.
12. Lemanu DP, Singh PP, MacCormick AD, et al. Effect of preoperative exercise on cardiorespiratory function and recovery after surgery: a systematic review. World J Surg 2013;37:711-20.
13. Mills E, Eyawo O, Lockhart I, et al. Smoking cessation reduces postoperative complications: a systematic review and meta-analysis. Am J Med 2011;124:144-54.e8.
14. Møller AM, Villebro N, Pedersen T, et al. Effect of preoperative smoking intervention on postoperative complications: a randomised clinical trial. Lancet 2002;359:114-7.
15. Nath B, Li Y, Carroll JE, et al. Alcohol exposure as a risk factor for adverse outcomes in elective surgery. J Gastrointest Surg 2010;14:1732-41.
16. Cassie S, Menezes C, Birch DW, et al. Effect of preoperative weight loss in bariatric surgical patients: a systematic review. Surg Obes Relat Dis 2011;7:760-7; discussion 767.
17. Edholm D, Kullberg J, Haenni A, et al. Preoperative 4-week low-calorie diet reduces liver volume and

intrahepatic fat, and facilitates laparoscopic gastric bypass in morbidly obese. Obes Surg 2011;21:345-50.
18. Livhits M, Mercado C, Yermilov I, et al. Does weight loss immediately before bariatric surgery improve outcomes: a systematic review. Surg Obes Relat Dis 2009;5:713-21.
19. Henzi I, Walder B, Tramer MR. Dexamethasone for the prevention of postoperative nausea and vomiting: a quantitative systematic review. Anesth Analg 2000;90:186-94.
20. Sapolsky RM, Romero LM, Munck AU. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocr Rev 2000;21:55-89.
21. Srinivasa S, Kahokehr AA, Yu TC, et al. Preoperative glucocorticoid use in major abdominal surgery: systematic review and meta-analysis of randomized trials. Ann Surg 2011;254:183-91.
22. Wang JJ, Ho ST, Wong CS, et al. Dexamethasone prophylaxis of nausea and vomiting after epidural morphine for post-Cesarean analgesia. Can J Anaesth 2001;48:185-90.
23. Sauerland S, Nagelschmidt M, Mallmann P, et al. Risks and benefits of preoperative high dose methylprednisolone in surgical patients: a systematic review. Drug Saf 2000;23:449-61.
24. McCarty TM, Arnold DT, Lamont JP, et al. Optimizing outcomes in bariatric surgery: outpatient laparoscopic gastric bypass. Ann Surg 2005;242:494-8; discussion 498-501.
25. Buchholz V, Berkenstadt H, Goitein D, et al. Gastric emptying is not prolonged in obese patients. Surg Obes Relat Dis 2013;9:714-7.
26. Cardoso-Júnior A, Coelho LG, Savassi-Rocha PR, et al. Gastric emptying of solids and semi-solids in morbidly obese and non-obese subjects: an assessment using the 13C-octanoic acid and 13C-acetic acid breath tests. Obes Surg 2007;17:236-41.
27. Maltby JR, Pytka S, Watson NC, et al. Drinking 300 mL of clear fluid two hours before surgery has no effect on gastric fluid volume and pH in fasting and non-fasting obese patients. Can J Anaesth 2004;51:111-5.
28. Ishihara H, Singh H, Giesecke AH. Relationship between diabetic autonomic neuropathy and gastric contents. Anesth Analg 1994;78:943-7.
29. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: a report by the American Society of Anesthesiologist Task Force on Preoperative Fasting. Anesthesiology 1999;90:896-905.
30. Smith I, Kranke P, Murat I, et al. Perioperative fasting in adults and children: guidelines from the European Society of Anaesthesiology. Eur J Anaesthesiol 2011;28:556-69.
31. Awad S, Varadhan KK, Ljungqvist O, et al. A meta-analysis of randomised controlled trials on preoperative oral carbohydrate treatment in elective surgery. Clin Nutr 2013;32:34-44.
32. Ljungqvist O. Jonathan E. Rhoads lecture 2011: Insulin resistance and enhanced recovery after surgery. JPEN J Parenter Enteral Nutr 2012;36:389-98.
33. Smith MD, McCall J, Plank L, et al. Preoperative carbohydrate treatment for enhancing recovery after elective surgery. Cochrane Database Syst Rev 2014;(8):CD009161.
34. Gustafsson UO, Nygren J, Thorell A, et al. Pre-operative carbohydrate loading may be used in type 2 diabetes patients. Acta Anaesthesiol Scand 2008;52:946-51.
35. Azagury DE, Ris F, Pichard C, et al. Does perioperative nutrition and oral carbohydrate load sustainably preserve muscle mass after bariatric surgery? A randomized control trial. Surg Obes Relat Dis 2015;11:920-6.
36. Lemanu DP, Singh PP, Berridge K, et al. Randomized clinical trial of enhanced recovery versus standard care after laparoscopic sleeve gastrectomy. Br J Surg 2013;100:482-9.
37. Pösö T, Kesek D, Aroch R, et al. Morbid obesity and optimization of preoperative fluid therapy. Obes Surg 2013;23:1799-805.
38. Adams JP, Murphy PG. Obesity in anaesthesia and intensive care. Br J Anaesth 2000;85:91-108.
39. Chakravartty S, Sarma DR, Patel AG. Rhabdomyolysis in bariatric surgery: a systematic review. Obes Surg 2013;23:1333-40.
40. Sharma SK, McCauley J, Cottam D, et al. Acute changes in renal function after laparoscopic gastric surgery for morbid obesity. Surg Obes Relat Dis 2006;2:389-92.
41. de Menezes Ettinger JE, dos Santos Filho PV, Azaro E, et al. Prevention of rhabdomyolysis in bariatric surgery. Obes Surg 2005;15:874-9.
42. Domi R, Laho H. Anesthetic challenges in the obese patient. J Anesth 2012;26:758-65.
43. Schuster R, Alami RS, Curet MJ, et al. Intra-operative fluid volume influences postoperative nausea and vomiting after laparoscopic gastric bypass surgery. Obes Surg 2006;16:848-51.
44. Wool DB, Lemmens HJ, Brodsky JB, et al. Intraoperative fluid replacement and postoperative creatine

phosphokinase levels in laparoscopic bariatric patients. Obes Surg 2010;20:698-701.
45. Gan TJ, Diemunsch P, Habib AS, et al. Consensus guidelines for the management of postoperative nausea and vomiting. Anesth Analg 2014;118:85-113.
46. Benevides ML, Oliveira SS, de Aguilar-Nascimento JE. The combination of haloperidol, dexamethasone, and ondansetron for prevention of postoperative nausea and vomiting in laparoscopic sleeve gastrectomy: a randomized double-blind trial. Obes Surg 2013;23:1389-96.
47. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS(R)) Society recommendations. Clin Nutr 2012;31:783-800.
48. Aldenkortt M, Lysakowski C, Elia N, et al. Ventilation strategies in obese patients undergoing surgery: a quantitative systematic review and meta-analysis. Br J Anaesth 2012;109:493-502.
49. Futier E, Constantin JM, Paugam-Burtz C, et al. A trial of intraoperative low-tidal-volume ventilation in abdominal surgery. N Engl J Med 2013;369:428-37.
50. Dixon BJ, Dixon JB, Carden JR, et al. Preoxygenation is more effective in the 25 degrees head-up position than in the supine position in severely obese patients: a randomized controlled study. Anesthesiology 2005;102:1110-5; discussion 1115A.
51. Carron M, Gasparetto M, Vindigni V, et al. Laparoscopic surgery in a morbidly obese, high-risk cardiac patient: the benefits of deep neuromuscular block and sugammadex. Br J Anaesth 2014;113:186-7.
52. Murphy GS, Szokol JW, Avram MJ, et al. Intraoperative acceleromyography monitoring reduces symptoms of muscle weakness and improves quality of recovery in the early postoperative period. Anesthesiology 2011;115:946-54.
53. Luján JA, Frutos MD, Hernandez Q, et al. Laparoscopic versus open gastric bypass in the treatment of morbid obesity: a randomized prospective study. Ann Surg 2004;239:433-7.
54. Nguyen NT, Goldman C, Rosenquist CJ, et al. Laparoscopic versus open gastric bypass: a randomized study of outcomes, quality of life, and costs. Ann Surg 2001;234:279-89; discussion 89-91.
55. Bailey JG, Hayden JA, Davis PJ, et al. Robotic versus laparoscopic Roux-en-Y gastric bypass (RYGB) in obese adults ages 18 to 65 years: a systematic review and economic analysis. Surg Endosc 2014;28:414-26.
56. Huerta S, Arteaga JR, Sawicki MP, et al. Assessment of routine elimination of postoperative nasogastric decompression after Roux-en-Y gastric bypass. Surgery 2002;132:844-8.
57. 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;95:809-16.
58. Liscia G, Scaringi S, Facchiano E, et al. The role of drainage after Roux-en-Y gastric bypass for morbid obesity: a systematic review. Surg Obes Relat Dis 2014;10:171-6.
59. Kavuturu S, Rogers AM, Haluck RS. Routine drain placement in Roux-en-Y gastric bypass: an expanded retrospective comparative study of 755 patients and review of the literature. Obes Surg 2012;22:177-81.
60. Petrowsky H, Demartines N, Rousson V, et al. Evidence-based value of prophylactic drainage in gastrointestinal surgery: a systematic review and meta-analyses. Ann Surg 2004;240:1074-84; discussion 1084-5.
61. Siyam M, Benhamou D. Anaesthetic management of adult patients with obstructive sleep apnea syndrome. Ann Fr Anesth Reanim 2007;26:39-52.
62. Maund E, McDaid C, Rice S, et al. Paracetamol and selective and non-selective non-steroidal anti-inflammatory drugs for the reduction in morphine-related side-effects after major surgery: a systematic review. Br J Anaesth 2011;106:292-7.
63. Ziemann-Gimmel P, Hensel P, Koppman J, et al. Multimodal analgesia reduces narcotic requirements and antiemetic rescue medication in laparoscopic Roux-en-Y gastric bypass surgery. Surg Obes Relat Dis 2013;9:975-80.
64. Graves DA, Batenhorst RL, Bennett RL, et al. Morphine requirements using patient-controlled analgesia: influence of diurnal variation and morbid obesity. Clin Pharm 1983;2:49-53.
65. Alkhamesi NA, Kane JM, Guske PJ, et al. Intraperitoneal aerosolization of bupivacaine is a safe and effective method in controlling postoperative pain in laparoscopic Roux-en-Y gastric bypass. J Pain Res 2008;1:9-13.
66. Hilvering B, Draaisma WA, van der Bilt JD, et al. Randomized clinical trial of combined preincisional infiltration and intraperitoneal instillation of levobupivacaine for postoperative pain after laparoscopic cholecystectomy. Br J Surg 2011;98:784-9.
67. von Ungern-Sternberg BS, Regli A, Reber A, et al. Effect of obesity and thoracic epidural analgesia on perioperative spirometry. Br J Anaesth 2005;94:121-7.
68. Overby DW, Kohn GP, Cahan MA, et al. Prevalence of thrombophilias in patients presenting for bariatric surgery. Obes Surg 2009;19:1278-85.

69. Samama MM. An epidemiologic study of risk factors for deep vein thrombosis in medical outpatients: the Sirius study. Arch Intern Med 2000;160:3415-20.
70. Gonzalez QH, Tishler DS, Plata-Munoz JJ, et al. Incidence of clinically evident deep venous thrombosis after laparoscopic Roux-en-Y gastric bypass. Surg Endosc 2004;18:1082-4.
71. Shepherd MF, Rosborough TK, Schwartz ML. Heparin thromboprophylaxis in gastric bypass surgery. Obes Surg 2003;13:249-53.
72. Hirsh J, Raschke R. Heparin and low-molecular-weight heparin: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. Chest 2004;126:188S-203S.
73. ASMBS updated position statement on prophylactic measures to reduce the risk of venous thromboembolism in bariatric surgery patients. Surg Obes Relat Dis 2013;9:493-7.
74. Hull RD, Pineo GF, Stein PD, et al. Extended out-of-hospital low-molecular-weight heparin prophylaxis against deep venous thrombosis in patients after elective hip arthroplasty: a systematic review. Ann Intern Med 2001;135:858-69.
75. Simone EP, Madan AK, Tichansky DS, et al. Comparison of two low-molecular-weight heparin dosing regimens for patients undergoing laparoscopic bariatric surgery. Surg Endosc 2008;22:2392-5.
76. Guyatt GH, Akl EA, Crowther M, et al. Executive summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest 2012;141:7S-47S.
77. Kaufman JA, Kinney TB, Streiff MB, et al. Guidelines for the use of retrievable and convertible vena cava filters: report from the Society of Interventional Radiology multidisciplinary consensus conference. Surg Obes Relat Dis 2006;2:200-12.
78. Crowley LV, Seay J, Mullin G. Late effects of gastric bypass for obesity. Am J Gastroenterol 1984;79:850-60.
79. Kushner R. Managing the obese patient after bariatric surgery: a case report of severe malnutrition and review of the literature. JPEN J Parenter Enteral Nutr 2000;24:126-32.
80. Khanna V, Kashyap SR. Clinical Management of Type 2 Diabetes Mellitus after Bariatric Surgery. Curr Atheroscler Rep 2015;17:59.
81. Dhatariya K, Levy N, Kilvert A, et al. NHS Diabetes guideline for the perioperative management of the adult patient with diabetes. Diabet Med 2012;29:420-33.
82. Eichenberger A, Proietti S, Wicky S, et al. Morbid obesity and postoperative pulmonary atelectasis: an underestimated problem. Anesth Analg 2002;95:1788-92.
83. Robinson PD. Obesity and its impact on the respiratory system. Paediatr Respir Rev 2014;15:219-26.
84. Guimarães MM, El Dib R, Smith AF, et al. Incentive spirometry for prevention of postoperative pulmonary complications in upper abdominal surgery. Cochrane Database Syst Rev 2009;(3):CD006058.
85. Fleischmann E, Kurz A, Niedermayr M, et al. Tissue oxygenation in obese and non-obese patients during laparoscopy. Obes Surg 2005;15:813-9.
86. Chung F, Subramanyam R, Liao P, et al. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. Br J Anaesth 2012;108:768-75.
87. Meoli AL, Rosen CL, Kristo D, et al. Upper airway management of the adult patient with obstructive sleep apnea in the perioperative period--avoiding complications. Sleep 2003;26:1060-5.
88. Wong DT, Adly E, Ip HY, et al. A comparison between the Boussignac continuous positive airway pressure mask and the venturi mask in terms of improvement in the PaO2/F(I)O2 ratio in morbidly obese patients undergoing bariatric surgery: a randomized controlled trial. Can J Anaesth 2011;58:532-9.
89. Giles TL, Lasserson TJ, Smith BH, et al. Continuous positive airways pressure for obstructive sleep apnoea in adults. Cochrane Database Syst Rev 2006;(1):CD001106.
90. Neligan PJ, Malhotra G, Fraser M, et al. Continuous positive airway pressure via the Boussignac system immediately after extubation improves lung function in morbidly obese patients with obstructive sleep apnea undergoing laparoscopic bariatric surgery. Anesthesiology 2009;110:878-84.
91. Helling TS, Willoughby TL, Maxfield DM, et al. Determinants of the need for intensive care and prolonged mechanical ventilation in patients undergoing bariatric surgery. Obes Surg 2004;14:1036-41.
92. Komatsu R, Turan AM, Orhan-Sungur M, et al. Remifentanil for general anaesthesia: a systematic review. Anaesthesia 2007;62:1266-80.
93. Liao P, Yegneswaran B, Vairavanathan S, et al. Postoperative complications in patients with obstructive sleep apnea: a retrospective matched cohort study. Can J Anaesth 2009;56:819-28.
94. Macintyre PE, Loadsman JA, Scott DA. Opioids, ventilation and acute pain management. Anaesth Intensive

Care 2011;39:545-58.
95. Rennotte MT, Baele P, Aubert G, et al. Nasal continuous positive airway pressure in the perioperative management of patients with obstructive sleep apnea submitted to surgery. Chest 1995;107:367-74.
96. Mannaerts GH, van Mil SR, Stepaniak PS, et al. Results of Implementing an Enhanced Recovery After Bariatric Surgery (ERABS) Protocol. Obes Surg 2016;26:303-12.
97. Dogan K, Kraaij L, Aarts EO, et al. Fast-track bariatric surgery improves perioperative care and logistics compared to conventional care. Obes Surg 2015;25:28-35.
98. Simonelli V, Goergen M, Orlando GG, et al. Fast-Track in Bariatric and Metabolic Surgery: Feasibility and Cost Analysis Through a Matched-Cohort Study in a Single Centre. Obes Surg 2016;26:1970-7.
99. Barreca M, Renzi C, Tankel J, et al. Is there a role for enhanced recovery after laparoscopic bariatric surgery? Preliminary results from a specialist obesity treatment center. Surg Obes Relat Dis 2016;12:119-26.
100. Khorgami Z, Petrosky JA, Andalib A, et al. Fast track bariatric surgery: safety of discharge on the first postoperative day after bariatric surgery. Surg Obes Relat Dis 2017;13:273-80.
101. Rickey J, Gersin K, Yang W, et al. Early discharge in the bariatric population does not increase post-discharge resource utilization. Surg Endosc 2017;31:618-24.
102. Morton JM, Winegar D, Blackstone R, et al. Is ambulatory laparoscopic Roux-en-Y gastric bypass associated with higher adverse events? Ann Surg 2014;259:286-92.
103. Aktimur R, Kirkil C, Yildirim K, et al. Enhanced recovery after surgery (ERAS) in one-anastomosis gastric bypass surgery: a matched-cohort study. Surg Obes Relat Dis 2018;14:1850-6.

doi: 10.21037/ales-19-254
Cite this article as: Aktimur R. Enhanced recovery after surgery in bariatric and metabolic surgery. Ann Laparosc Endosc Surg 2021;6:48.

