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SCIENTIFIC REVIEW

Guidelines for Perioperative Care in Bariatric Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations

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Abstract

Background During the last two decades, an increasing number of bariatric surgical procedures have been performed worldwide. There is no consensus regarding optimal perioperative care in bariatric surgery. This review aims to present such a consensus and to provide graded recommendations for elements in an evidence-based "enhanced" perioperative protocol.

Methods The English-language literature between January 1966 and January 2015 was searched, with particular attention paid to meta-analyses, randomised controlled trials and large prospective cohort studies. Selected studies were examined, reviewed and graded. After critical appraisal of these studies, the group of authors reached a consensus recommendation.

Results Although for some elements, recommendations are extrapolated from non-bariatric settings (mainly colorectal), most recommendations are based on good-quality trials or meta-analyses of good-quality trials.

Conclusions A comprehensive evidence-based consensus was reached and is presented in this review by the enhanced recovery after surgery (ERAS) Society. The guidelines were endorsed by the International Association for Surgical Metabolism and Nutrition (IASMEN) and based on the evidence available in the literature for each of the elements of the multimodal perioperative care pathway for patients undergoing bariatric surgery.

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Introduction

Bariatric surgery is the most effective treatment for morbid obesity, resulting in sustained weight loss as well as pronounced effects on obesity-related comorbidities. The number of procedures performed worldwide increased from 146,000 to 340,000 between 2003 and 2011, with Roux-en-Y gastric bypass and sleeve gastrectomy accounting for approximately 75 % of all procedures [1]. In the 2013 Scandinavian Registry for Obesity Surgery (SOReg) annual report which included >8000 procedures "any complication" and "severe complication" (Clavien grade >3a) [2] within 30 days were reported to be 7 and 3 %, respectively [3]. Similar figures were reported from the United Kingdom in 2014 [4].

Enhanced recovery after surgery (ERAS) pathways involve a series of perioperative evidence-based interventions that were developed initially for elective colorectal surgery [5]. ERAS pathways aim to maintain physiological function, enhance mobilisation, reduce pain and facilitate early oral nutrition postoperatively by reducing perioperative surgical stress. The adoption of ERAS pathways has resulted in improved outcome in terms of reduced morbidity, faster recovery and reduced length of hospital stay in dedicated centres [6–11]. Although several of the individual ERAS components have been introduced in the setting of bariatric surgery, there are few reports in the literature on the effects resulting from adoption of complete ERAS pathways.

This article represents an initiative by the ERAS Society (www.erassociety.org) to present a consensus review of optimal perioperative care for bariatric surgery based on best evidence available currently. The guidelines were endorsed by the International Association for Surgical Metabolism and Nutrition (IASMEN; www.iasmen.org) after review of the final version of the manuscript.

Methods

Literature search

The authors corresponded by email during the fall of 2013 and the various topics for inclusion were agreed and allocated. The literature search utilised the Medline, Embase and Cochrane databases to identify relevant contributions published between January 1966 and January 2015. Medical Subject Heading (MeSH) terms were used, as were accompanying entry terms for the patient group, interventions and outcomes. Key words included "obesity", "obese", "bariatric", "gastric bypass", "sleeve gastrectomy", "fast track" and "enhanced recovery". Reference lists of all eligible articles were checked for other relevant studies.

Study selection

Titles and abstracts were screened by individual authors to identify potentially relevant articles. Discrepancies in judgment were resolved by the first and senior authors and through correspondence within the writing group. Particular emphasis was placed on recent publications of good quality (moderate- and high-quality RCTs and large high-quality cohort studies as well as systematic reviews and meta-analyses) which were considered for each topic. Retrospective series were included if data of better quality were lacking. Conference proceedings were excluded.

Quality assessment and data analysis

The methodological quality of the studies was assessed using the Delphi checklist [12]. The strength of evidence and conclusions were assessed and agreed by all authors. Quality of evidence and recommendations were evaluated according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system [13]. Quoting from the GRADE guidelines, the recommendations are given as follows: "Strong recommendations indicate that the panel is confident that the desirable effects of adherence to a recommendation outweigh the undesirable effects". "Weak recommendations indicate that the desirable effects of adherence to a recommendation probably outweigh the undesirable effects, but the panel is less confident". Recommendations are based not only on quality of evidence ("high", "moderate", "low" and "very low") but also on the balance between desirable and undesirable effects and on values and preferences [13]. The latter implies that, in some cases, strong recommendations may be reached from low-quality data and vice versa.

Results: evidence base and recommendations

The recommendations, evidence and grade of recommendation are summarised in Table 1.

Preoperative interventions

Preoperative information, education and counselling

There is little evidence available on the impact of information, education or counselling prior to bariatric surgery. Preoperative information and/or a visit to the ward has been shown to reduce anxiety and improve compliance

Table 1 ERAS recommendations for (a) preoperative, (b) intraoperative and (c) postoperative care in bariatric surgery

Element	Recommendation	Level of evidence	Recommendation grade
(a)			
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 gastro-oesophageal 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
(b)			
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

Table 1 continued

Element	Recommendation	Level of evidence	Recommendation grade
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
(c)			
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
		Positioning in the postoperative period: High	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	High (14 RCTs and 1 meta-analysis)	Strong

Table 1 continued

Element	Recommendation	Level of evidence	Recommendation grade
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

with postoperative instructions, postoperative recovery, length of stay and long-term outcomes [14–20]. A preoperative psychological intervention has also been shown to reduce fatigue and stress and improve wound healing postoperatively [21, 22]. Two systematic reviews of patient education [23, 24] evaluated outcomes including biophysical, functional, experiential, cognitive, social, ethical and financial parameters. They identified variable impact of education on outcome but positive results were in a minority. A subsequent RCT of preoperative education in knee arthroplasty has shown a reduction in length of stay [25]. Specific guidelines have recommended preoperative information [26–28].

Prehabilitation and exercise

Prehabilitation comprises preoperative physical conditioning to improve functional and physiological capacity to enable patients to recover sooner after surgical stress [29, 30]. Improved preoperative physiological status results in an improved postoperative physiological status and faster recovery, decreased postoperative complications and length of stay.

A systematic review evaluated the effects of preoperative exercise therapy on postoperative complications and length of stay in surgery of all types [31]. In patients undergoing cardiac and abdominal surgery, meta-analysis indicated that prehabilitation led to reduced complication rates and length of stay. The applicability of these studies to patients undergoing bariatric surgery is questionable.

A more recent systematic review looked at 8 RCTs investigating the effect of preoperative exercise on cardiorespiratory function and recovery after multiple types of surgery [32] and concluded that there was limited evidence demonstrating physiological improvement with prehabilitation. In addition, there was little correlation between improvement in physiological status and clinical outcomes.

A reanalysis [33] of the data from an original RCT of two prehabilitation methods showed that those who completed prehabilitation prior to colectomy but whose fitness still deteriorated were more likely to suffer complications requiring reoperation or intensive care. A further RCT incorporated 'trimodal prehabilitation' which included nutritional counselling with protein supplementation, anxiety reduction and a moderate exercise program [34] showed no difference in complication rates or length of stay but better functional recovery at 4 and 8 weeks.

Despite prehabilitation being attractive and logical, there is sparse evidence linking improvement of physiological function with preoperative exercise and decreased postoperative complications.

Smoking and alcohol cessation

In many centres, as well as in most guidelines, drug or alcohol abuse during the preceding 2 years is considered contraindications for bariatric surgery [35].

Tobacco smoking is associated with increased risk of postoperative morbidity and mortality [36], attributed mainly to reduced tissue oxygenation (and consequent wound infections) [37], pulmonary complications [38] and thromboembolism [38]. Several controlled trials have demonstrated that cessation of smoking is associated with marked reductions in postoperative complications [39–42]. The duration of smoking cessation seems to be equally important, with a systematic review and meta-analysis reporting that the treatment effect was significantly larger in trials with smoking cessation of at least 4 weeks [36]. Although not studied specifically in patients undergoing bariatric surgery, there are no data to suggest that either the increased risk associated with smoking or the effect of smoking cessation should be different in this category of patients.

Hazardous drinking, defined as intake of three alcohol equivalents (12 g ethanol each) or more per day, has long been identified as a risk factor for postoperative complications [43–45]. A large retrospective study comprising >300 000 patients undergoing elective surgery (including bariatric surgery) reported that consumption of >2 alcohol equivalents/day within 2 weeks of surgery was an independent predictor of pneumonia, sepsis, wound infection/disruption and length of hospital stay [44]. Alcohol abstinence for one month has been associated with better outcome after colorectal surgery [46]. ERAS guidelines for colonic surgery, therefore, recommend alcohol cessation 4 weeks prior to surgery. However, due to the need for behavioural changes associated with bariatric surgery in combination with the increased risk of alcohol dependence after gastric bypass surgery [47], 1–2 years of alcohol abstinence is usually considered mandatory in patients with earlier overconsumption. The evidence for this recommendation is, however, still to be established.

Preoperative weight loss

A preoperative low-calorie diet (LCD, 1000–1200 kcal/d) or very low-calorie diet (VLCD approx. 800 kcal/d) for 2-4 weeks is usually recommended in bariatric centres. This has been shown to reduce liver volume by 16–20 % [48, 49] and the surgeon's perceived complexity of the procedure [50]. In a systematic review of 11 non-randomised studies, preoperative weight loss was associated with a reduction in postoperative complications (18.8 ± 10.6 vs. 21.4 ± 13.1 %, $p = 0.02$) [51]. This finding was also confirmed in a multicentre RCT (5.8 vs. 13.2 %, $p = 0.04$) [50] as well as in a study comprising over 22,000 patients from the Scandinavian Obesity Registry [52]. There are no data from studies evaluating differences between patients with or without diabetes in terms of effect of preoperative weight loss on postoperative complications.

Recent systematic reviews reported mandatory weight loss prior to surgery to be the only factor associated positively with postoperative weight loss [51, 53]. In a recent registry study including >9000 patients undergoing laparoscopic gastric bypass, preoperative weight reduction was associated with improved weight loss after 2 years. Moreover, this effect was more pronounced in patients with high BMI (>45.7 kg/m^2) [54].

In patients with type 2 diabetes on glucose-lowering drugs, low-caloric intake in combination with unchanged medication may induce hypoglycaemia. Evidence-based guidelines for these situations are lacking, but some recommendations are available [55].

Glucocorticoids

Glucocorticoids have anti-inflammatory properties and have therefore been used in elective surgery to reduce the stress response [56, 57]. They have also been used to reduce postoperative nausea and vomiting (PONV) [58]. In a recent systematic review and meta-analysis [59] of 11 RCTs of moderate quality addressing the effect of glucocorticoids on postoperative outcome, they were found to decrease complication rates and LOS. No effect was found for overall complications or anastomotic leakage in colorectal surgery [59]. A minimum dose of 2.5–5 mg dexamethasone given 90 min prior to induction of anaesthesia is necessary to achieve the effect on PONV [60–62].

Data from studies including patients undergoing bariatric surgery are relatively sparse. In one retrospective analysis of 2000 consecutive patients undergoing outpatient laparoscopic gastric bypass, a steroid bolus was identified as a predictor of successful discharge within 24 h [63].

In two meta-analyses, no adverse effects were identified with the use of a single dose of glucocorticoids [59, 64]. As glucocorticoids can cause hyperglycaemia, which is associated with increased postoperative, especially infective, complications [65], blood glucose should be monitored intra- and postoperatively in patients undergoing bariatric surgery, particularly if glucocorticoids are administered.

Preoperative fasting

Recent studies have demonstrated no differences in residual gastric fluid volume (RGFV), pH [66, 67] or gastric emptying rates following semi-solid meals [68, 69] or drinks [70] in obese and lean patients. No differences were found in RGFV and pH in a randomised study of morbidly obese patients who drank 300 ml of clear fluid 2 h before induction of anaesthesia, compared with those who fasted from midnight [71, 72]. RGFV and pH were also similar following an overnight fast in obese diabetic patients (with and without autonomic neuropathy) and non-diabetic controls [72–74]. Presently, anaesthesia societies recommend intake of clear fluids up to 2 h and solids 6 h before induction of anaesthesia in healthy [75, 76] and obese [76] patients.

Carbohydrate loading

Preoperative carbohydrate conditioning, using iso-osmolar drinks ingested 2–3 h before induction of anaesthesia, attenuated development of postoperative insulin resistance, reduced postoperative nitrogen and protein losses and maintained lean body mass [77]. Recent meta-analyses [78, 79] demonstrated preoperative conditioning using carbohydrate drinks to be associated with significant reduction in length of hospital stay by about 1 day in patients undergoing major abdominal surgery. When 'preoperative' carbohydrate conditioning drinks were administered to patients with type II diabetes (mean BMI 28.6 kg/m^2), no differences were noted in gastric emptying times compared with healthy subjects [80]. However, postprandial glucose concentrations reached a higher peak and were elevated for longer in patients with diabetes, returning to baseline after 180 min [80]. In addition, preoperative carbohydrate ingestion did not lead to an increase in aspiration-related complications in patients undergoing laparoscopic gastric bypass [81]. Two further studies have used these drinks in bariatric surgery within an enhanced recovery pathway [82, 83]. In the only randomised study comparing enhanced recovery versus standard care in bariatric patients (laparoscopic sleeve gastrectomy), no differences in overall complications were noted between the groups [82]. However, it was of note that compliance with preoperative carbohydrate conditioning was only 15 % in the enhanced recovery group [82].

Intraoperative interventions

Perioperative fluid management

Perioperative fluid management and accurate assessment of volume status in morbidly obese patients are a challenge. Reasons for this include physiological differences, the presence of multiple comorbidities (and associated polypharmacy), inaccuracies associated with use of non-invasive monitoring and higher incidence of rhabdomyolysis (RML) postoperatively [84]. Additionally, liver-shrinking diets, employed for 2–3 weeks preoperatively, may result in acute nutritional, electrolyte and fluid deficits [85]. While *total* blood volume is increased in obese patients, obese have a reduced blood volume on a volume/weight basis compared with non-obese patients (50 ml/kg compared with 75 ml/kg) [86].

In bariatric surgery, RML rates of 5–77 % were reported (defined by elevation of serum creatine kinase (CK) of ≥1000 IU/L) (although 65 % of these procedures were performed by laparotomy) [84]. Of those with RML, the overall incidence of renal failure was 14 % and mortality 3 %. Risk factors for RML identified in a meta-analysis were male sex, BMI >52 kg/m^2 and operation time >4 h [84]. Overall, postoperative Acute Renal Failure (ARF, defined by the study authors [87] as a rise in serum creatinine >1.4 mg/dL (>124 μmol/l) at any time during the inpatient stay, with an increase of serum creatinine of >0.3 mg/dL (>26 μmol/l) from the baseline value during the first postoperative week) has been reported in 2 % of patients undergoing laparoscopic bariatric surgery [87]. Occurrence of intraoperative hypotension was amongst nine predisposing risk factors identified on multivariate analysis. Presence of preoperative renal insufficiency placed patients at greatest risk for postoperative ARF [87].

Few data from RCTs allow guiding perioperative fluid therapy in morbidly obese patients. Present fluid management paradigms are based on studies of liberal *versus* restrictive strategies in non-obese patients whereby fluid excess or 'imbalance' resulted in worsened outcomes than maintaining 'fluid balance' [88, 89]. In morbidly obese patients, data from non-randomised studies [90–93] support 'liberal' fluid regimens which were associated with reduced occurrence of RML (up to 4–5 L crystalloid during a 2–3 h operation [90]), reduced postoperative nausea and vomiting (25 ml/kg which in this study equated to a mean ±SD 3209 ± 1123 versus 2737 ± 828 ml administered intraoperatively) [92], postoperative ARF (4-5L crystalloid for a 2 h operation [93]) and shortened hospital stay (7 ml/kg/h which in this study equated to >1750 ml administered intraoperatively) [94]. In more conservative intraoperative fluid regimens (15 ml/kg), there were no differences in postoperative RML following laparoscopic bariatric surgery compared to more liberal strategies (40 ml/kg) [95]. No differences in intraoperative urine output were noted when morbidly obese patients were randomised to intraoperative low (4 ml/kg/h) *vs* high (10 ml/kg/h) volumes of Ringer's lactate [96]. Functional parameters, such as stroke volume variation (SVV)-guided intraoperative fluid therapy, enabled maintenance of haemodynamic parameters with lower infusion volumes in patients undergoing laparoscopic bariatric surgery [97]. The enteral route for fluid and nutrition should be used preferentially and numerous bariatric series have demonstrated that this is possible on the first postoperative day [63, 98].

Anaesthesia

In this section, information is focused on details of particular relevance in the bariatric setting. For general anaesthetic considerations in gastrointestinal surgery within an ERAS pathway, see Ref. [99].

Postoperative nausea and vomiting prophylaxis Bariatric patients are frequently <50 years of age, female and non-smokers undergoing laparoscopic procedures of more than one hour in duration, and receive postoperative opioid analgesia, all of which are risk factors for PONV [100]. Additionally, a history of PONV or motion sickness, as well as the use of volatile anaesthetic increases the risk of PONV [100].

Recent guidelines for the management of PONV recommend a multimodal approach by reducing the baseline risk with the use of antiemetics according to patient risk factors [101]. Recommended strategies include Propofol for induction and maintenance of anaesthesia, avoidance of volatile anaesthetics, minimisation of intra- and postoperative opioids and avoidance of fluid overload [101]. A recent RCT comparing opioid-free TIVA with volatile-opioid anaesthesia in bariatric surgery, reported a significantly lower rate and severity of PONV in the opioid-free TIVA group [102]. In addition to this baseline risk reduction, the recommended antiemetics for PONV prophylaxis are 5-hydroxytryptamine receptor antagonists, corticosteroids, butyrophenones, neurokinin-1 receptor antagonists, antihistamines and anticholinergics. The use of a combination of antiemetics in bariatric surgery is supported by a randomised trial demonstrating the superiority of triple combination of haloperidol, dexamethasone and ondansetron over a single or double combination in laparoscopic sleeve gastrectomy [103].

Anaesthetic maintenance Various volatile agents have been compared in the bariatric population. The results are inconsistent, but in general favour the use of shorter acting, lower absorption agents that may offer small advantages in emergence and functional recovery times [104–107].

No prospective comparisons of intravenous versus volatile anaesthetic technique were identified in bariatric surgery. A consistent finding is that early PONV is increased with volatile agents compared to Propofol target controlled infusion. This effect is particularly marked in patients at high risk of PONV [108].

Utilisation of short-acting agents and opioid minimisation within a wider ERAS regimen appears to reduce costs, complication rates and length of stay in other specialities [28]. The current evidence does not allow recommendation of specific anaesthetic agents or techniques in bariatric surgery.

Airway management The airway of bariatric patients can present specific challenges. Bag and mask ventilation has been demonstrated to be difficult in up to 15 % of patients with higher BMI [109, 110].

Endotracheal intubation remains the reference standard in obese patients. Correct sizing of endotracheal tube may have impact on micro-aspiration and postoperative complications. Little literature currently exists to recommend routine adoption of supraglottic devices [111].

A Cochrane review was unable to differentiate between the efficacy of direct and indirect fibre-optic mechanisms of tracheal tube placement [112]. However, adoption of a specific ramped position for direct laryngoscopy in the population with high BMI can reduce the incidence of difficulty [113].

Ventilation strategies The effects of intraoperative intermittent positive pressure ventilation (IPPV) regimens on physiological variables are reported in bariatric patients [114–118]. Currently, the translation of these data into effects on postoperative pulmonary complications and outcomes is lacking for the bariatric population.

A 2012 systematic review and meta-analysis on ventilation in bariatric patients did not identify any benefit between volume control and pressure control modes of mandatory ventilation [119]. Concurrent use of positive end expiratory pressure (PEEP) and recruitment improved intraoperative oxygenation and pulmonary mechanics. In a wider surgical population, adoption of the other elements of lung protective ventilation (LPV) was associated with significant reduction in postoperative complications [120].

Patient positioning affects pulmonary function perioperatively [121]. The “beach chair” and “leg flexion position” have been demonstrated to be superior to straight, supine position regardless of Trendelenburg angle. These pulmonary effects are most marked in the absence of the intraoperative pneumoperitoneum [122]. However, they may have negative influence on surgical access with consequent need of increased insufflation pressures [123].

Neuromuscular blockade Deep Block: Higher pressure pneumoperitoneum, to facilitate laparoscopic surgery, can have deleterious cardiovascular effects and increased depth of neuromuscular blockade may improve surgical conditions, without the need to increase insufflation pressure.

Data from small trials in non-bariatric surgery suggest that deep blockade may facilitate manoeuvrability during laparoscopic procedures [124, 125]. Although this may be extrapolated to bariatric procedures, results from prospective trials have yet to be reported [126].

Residual Blockade: The effect of the extent of residual depth of neuromuscular blockade in the recovery period has been studied extensively [127–129], although not specific in bariatric surgery. However, many of the physiological findings may have increased relevance to the bariatric population, e.g. diminished airway/pharyngeal tone, airway diameter, dysfunctional swallow and aspiration defenses.

There is evidence to suggest that a nerve-stimulated train of four (TOF) ratio of 0.9 translates into recovery benefits [130, 131]. Trials in different healthcare settings have shown an association between residual blockade and post anaesthesia care unit (PACU) pulmonary complications [132, 133]. Reductions in PACU discharge time associated with TOF ratio >0.9 have been demonstrated [134]. A higher level of neuromuscular function was also associated with patient perceived satisfaction with the quality of recovery [135].

An early systematic review comparing recovery of neuromuscular function with acetylcholine esterase inhibition versus selective cyclodextrin binding (sugammadex) suggested an equivalent side effect profile [136]. The use of binding agents is supported in bariatric surgery [137–140] where predictability of complete neuromuscular recovery within short time is important.

Laparoscopy

Laparoscopic bariatric surgery has rapidly superseded open surgery [141]. Three RCTs including more than 50 patients, compared open with laparoscopic gastric bypass [142–144]. The main findings were significantly shorter hospital stay [142–144] as well as reduced rate of incisional hernia [142, 143] favouring laparoscopy. Further beneficial effects like reduction in intraoperative blood loss [143], diminution of postoperative pain [144] and earlier recovery [143] were also shown. None of these studies found any difference in terms of weight loss. However, due to decreased postoperative adhesions, laparoscopic approach may be associated with increased rates of internal herniation [145, 146].

Higher costs of laparoscopic surgery are compensated for by fewer postoperative complications and shorter hospitalisation time [147]. The use of robotic surgery has also been described in bariatric surgery. A recently published systematic review included results from 2 557 patients found similar overall major and minor complications between robotic and laparoscopic groups, but the costs for robotic gastric bypass were higher [148].

Nasogastric tube

A Cochrane meta-analysis concluded that routine nasogastric intubation following open abdominal surgery should be abandoned in favour of selective use [149]. A subgroup analysis of 9 RCTs including 1085 patients that underwent gastro-duodenal surgery found increased pulmonary complication associated with routine use of postoperative nasogastric tube.

The role of nasogastric tubes in bariatric surgery was specifically addressed in a retrospective cohort study of 1067 gastric bypass patients [150]. There was no difference in complication rates between patients with or without postoperative nasogastric tube. In a meta-analysis of patients with gastrectomy for gastric cancer, time to oral diet was significantly shorter in patients without nasogastric/jejunal decompression [151]. The rate of anastomotic leakage and the number of pulmonary complications were similar.

As routine postoperative nasogastric intubation has not been proven to protect against complications like leakage, and even increases pulmonary infection risk and time to recovery, nasogastric tubes placed during surgery should be removed before reversal of anaesthesia.

Abdominal drainage

In a systematic review on the role of drainage after Roux-en-Y gastric bypass, the sensitivity of drainage in detecting postoperative leakage varied between 0 and 94 %, and the efficacy of drainage for the non-operative treatment of leakage was between 12.5 and 100 % [152]. Only one study reported data about non-operative treatment of leakage without drainage, which was pursued in one out of three patients [153]. However, there are no RCTs evaluating the role and efficacy of prophylactic abdominal drainage following bariatric surgery. A recent retrospective study on laparoscopic Roux-en-Y gastric bypass compared an historical group of 272 patients with routine drain and 483 without [153]. The leakage and reoperation rates were similar.

In one RCT including both subtotal and total gastrectomy with D2 lymph node dissection for gastric cancer, there was no significant difference between the groups with or without drainage in the incidence of intra-abdominal abscess, wound infection or pneumonia [154].

Despite lack of evidence in bariatric surgery, systematic use of abdominal drainage might be unnecessary, as demonstrated in other various types of gastrointestinal surgery [155].

Postoperative interventions

Postoperative analgesia

Respiratory function is compromised after bariatric surgery: obesity induces severe restrictive syndrome and lying flat can induce atelectasis. Sedative drugs used during and after anaesthesia promote obstruction of the upper airways which might induce postoperative hypoxaemia [156]. Thus, postoperative analgesia in bariatric surgery is based on two strategies.

Multimodal systemic analgesia Multimodal pain management strategies should be used when possible to reduce the consumption of narcotics [157]. Non-opioid analgesics, such as intravenous acetaminophen (paracetamol) and non-steroidal anti-inflammatory drugs (NSAIDs) should be used systematically [158]. Dosage should be adapted according to ideal body weight [157]. Other drugs, like pregabalin, have been studied but evidence for its efficacy is still awaited [159]. Current results on the use of dexmedetomidine do not allow recommending its routine use [160]. If opioids become necessary, patient-controlled analgesia with increased refractory period between boluses rather than continuous infusion is recommended, in particular for patients with obstructive sleep apnoea (OSA) [161]. For opioids, the enteral route should be used as early as possible. Surveillance must continue in the postoperative phase [162].

Nerve block and infiltration Wound infiltration with local anaesthetics has been used with success in laparoscopic surgery, particularly in cholecystectomy, colorectal and gynaecological surgery, but there are no specific studies in bariatric surgery [163]. RCTs and meta-analyses have demonstrated the safety of local anaesthetic aerosolisation techniques in laparoscopic surgery [164]. It may be combined with pre-incision infiltration [165]. Efficacy of its use has also been demonstrated in bariatric surgery [166] and ropivacaine or levobupivacaine seem to be more effective than short-acting agents, like lidocaine [167]. Recently, it was reported that ultrasound-guided transversus abdominal plane block is feasible and safe in bariatric surgery [168] but data from RCTs comparing this technique with local anaesthetic infiltration are lacking.

Thoracic epidural analgesia (TEA) improves lung function and hastens recovery of spirometric values in obese patients following laparotomy [169] but there is no consensus for laparoscopic surgery. A recent study in laparoscopic colorectal surgery suggested that the use of TEA did not improve outcome or respiratory function, compared with patient-controlled analgesia [170]. A retrospective study in open gastric bypass patients concluded that intravenous morphine was an acceptable strategy for postoperative analgesia, and did not result in more adverse events or poor outcome compared with TEA [171]. Moreover, application of TEA may be complicated in obese patients. Surprisingly, TEA was reported to be associated with a four-fold higher risk of wound infection in patients undergoing open gastric bypass.

Thromboprophylaxis

In many studies, thromboembolic complications represent the main cause of morbidity and 50 % of mortality after bariatric surgery [172–174]. Risk factors, in addition to obesity itself, include history of venous thromboembolism, increased age, smoking, varicose veins, heart or respiratory failure, OSA, thrombophilia and oestrogen oral contraception [175].

Although not shown to reduce the incidence of fatal pulmonary embolism [176], mechanical methods such as intermittent pneumatic compression or graduated compression stockings should be used. Moreover, early mobilisation and the use of calf-length compression stockings were associated, with a low incidence of deep venous thromboembolism in a study of 280 bariatric patients [177].

Bariatric surgery patients are at least at moderate risk of thromboembolism and, therefore, mechanical methods should be combined with pharmacological prophylaxis. Many studies [172, 178] also in bariatric surgery [179] have compared low molecular weight heparins (LMWH) with unfractionated heparin (UFH), without demonstrating any difference in efficiency or adverse events.

However, LMWH has a number of advantages over UFH, including a more predictable dose response, increased bioavailability and longer plasma half-life after subcutaneous injection, allowing once-daily dosing. LMWH also reduces the risk of heparin-related side effects, such as thrombocytopenia and osteoporosis, with long-term use [180].

The first injection should be administered 8–12 h after surgery [181]. There are no data supporting an injection twice a day for prophylaxis. However, an increased dose adjusted to BMI (i.e. 6000 u of enoxaparin for BMI >30 kg/m^2, 8000 u for BMI >40 kg/m^2, 10,000 u for BMI >50 kg/m^2) has been shown to be safe without increased risk of bleeding [182–184]. Finally, many studies indicate prolonged risk of thrombotic events, not least due to unpredictable food intake in some patients, encouraging recommendation of 3–4 weeks treatment [185, 186]. There are no data suggesting that the use of fondaparinux or other new oral anticoagulants should be recommended.

Treatment with vitamin K antagonists should be stopped 5 days before and resumed 12–24 h after surgery in combination with “bridging” LMWH [178].

For patients who cannot receive anticoagulant treatment, the use of retrievable vena cava filters has been evaluated. Many adverse events have been reported and since convincing evidence for its efficacy is lacking [187–189], the use of such devices in current practice is not recommended.

Postoperative nutrition

Prior to bariatric surgery, all patients should undergo an appropriate nutritional evaluation, including selective micronutrient measurements. In comparison with purely restrictive procedures, more extensive perioperative nutritional evaluations are required for gastric bypass and even more “aggressive” malabsorptive procedures such as biliopancreatic diversion [190].

Early postoperative nutritional care Nutritional and meal planning guidance should be provided to patient and family before bariatric surgery and during the postoperative hospital course and reinforced at subsequent outpatient visits. A clear liquid meal regimen can usually be initiated a couple of hours postoperatively. A consultation should be provided with a dietician and a protocol-derived staged meal progression, based on the type of surgical procedure, should be adhered to.

Patients should adhere to a plan of multiple small meals each day, chewing their food thoroughly without drinking beverages at the same time.

The balanced meal plan should include more than five servings of fruits and vegetables daily for optimal fibre consumption, colonic function and phytochemical intake.

Protein malnutrition causes an annual hospitalisation rate of 1 % per year after malabsorptive procedures and leads to significant morbidity [191]. Protein intake should average 60–120 g daily. Concentrated sweets should be avoided after any bariatric procedure to reduce caloric intake and in particular after gastric bypass to minimise symptoms of dumping.

Minimal nutritional supplementation includes 1–2 adult multivitamin-mineral supplements containing iron, 1200–1500 mg/d of calcium and vitamin B12 preparation [192].

Fluids should be consumed slowly and in sufficient amounts to maintain adequate hydration (more than 1.5 L daily) [193]. Clinical and biochemical monitoring is recommended for micro- and macro-nutritional deficiencies, particularly for iron, vitamin B12, calcium and folic acids deficiencies [194].

Management of diabetes mellitus and lipids Postoperative glycaemic control should aim at achieving HbA1c of 62 mmol/mol or less with fasting blood glucose ≤110 mg/dl (6.1 mmol/l) and postprandial glucose ≤180 mg/dl (10 mmol/l) [195]. Although this is higher compared with usual recommendations by, for example, The American Diabetes Association in non-morbidly obese patients, this degree of glucose control has been shown to be realistic and achievable after bariatric surgery [195]. Physicians and ward nurses should be familiar with glycaemic targets and insulin protocols as well as the use of dextrose-free IV fluids and low-sugar liquid supplements [196]. Obese patients with type 1 diabetes should receive scheduled insulin therapy during their hospital stay. Cessation of insulin treatment is often possible early after bariatric surgery, while liberal continuation of treatment with metformin is usually recommended [197]. Lipid abnormalities should be treated according to the National Cholesterol Educational Program (NCEP) guidelines [198]. Any existing lipid-lowering therapy for LDL-cholesterol and triglyceride values should be continued after surgery if levels remain above desired goals [199, 200].

Postoperative oxygenation

a) Obese patients without obstructive sleep apnoea (OSA)

Obesity is associated with increased gastric and oesophageal pressures (promoting aspiration), along with reduced FRC and ERV, that increases the work of breathing [201]. After surgery, atelectasis has been found to persist for a longer time in morbidly obese compared with normal weight patients [202]; thus, all obese patients should be considered as high risk irrespective in the presence of OSA.

A Cochrane review evaluated preoperative incentive spirometry and failed to show any benefit in preventing postoperative pulmonary complications [203]. Therefore, routine perioperative use of incentive spirometry for improving oxygenation is not recommended. In open surgery, use of congruent epidural analgesia (epidural insertion site corresponding to dermatomes of surgical incision) with local anaesthetics has been shown to improve postoperative oxygenation [204].

Despite normal pulse oximetry values, immediate postoperative tissue oxygen saturation has been shown to be lower in obese patients [205]. Although tissue oxygen saturation and pulmonary function have been reported to return to normal within the first 24 h after surgery, there is not enough evidence to recommend a minimum duration of oxygen supplementation. Thus, the use and the duration of postoperative oxygen supplementation need to be individualised. Postoperative positioning in head-elevated, semi-sitting or prone position (if feasible) further prevents pulmonary atelectasis [202]. Any postoperative sign of insufficient ventilation such as arterial desaturation, tachypnoea, unexplained tachycardia or hypercarbia should prompt the use of positive pressure ventilation.

b) Obese patients with OSA

There is strong evidence to support a high predictive value of the STOP-BANG questionnaire for preoperative screening of OSA [206]. Patients with moderate to high risk should be considered for positive airway pressure support postoperatively. High vigilance for the need of postoperative positive pressure support is recommended in these patients, in addition to routine oxygen supplementation. These patients should have at least continuous pulse oximetry [207] and respiratory rate monitoring. A meta-analysis concluded that oxygen therapy improves oxygen saturation significantly in patients with OSA [208]. However, it may also increase the duration of apnoea-hypopnoea events and should, therefore, be used carefully. The American Academy of Sleep Medicine recommends careful attention during the first 24 h after surgery in patients with presumed OSA and also suggests that opioid based patient-controlled analgesia should be avoided [209]. Patients should be discharged from PACU when clinical evaluation is satisfactory and they are fully conscious/oriented with adequate respiratory rate and depth.

Non-invasive positive pressure ventilation

Non-invasive positive pressure (NIPP) support includes continuous positive airway pressure (CPAP), non-invasive ventilation and bi-level positive airway pressure (BiPAP). Patients with OSA often benefit more from positive pressure support compared with oxygen therapy alone [210].

Data from two recent meta-analyses demonstrate that higher FiO_2s might actually increase the risk of apnoea/hypopnoea in morbidly obese patients postoperatively [211]. It is, therefore, recommended that CPAP (beginning from 5 to 7.5 cm of water) should be used in preference to oxygen therapy alone, in particular in patients with OSA and signs of respiratory deterioration.

Several retrospective analyses evaluating prophylactic CPAP use have not demonstrated a clear benefit in oxygenation [212, 213]. "Super obese" patients (BMI >60 kg/m^2), with complications requiring reoperation may be considered for prophylactic CPAP as these patients often need prolonged respiratory support [214]. There is a lack of available evidence to support the use of BiPAP over CPAP in patients without Obesity Hypoventilation Syndrome (OHS, see below) or patients with elevated pCO_2 levels. The need of CPAP has been shown to be reduced after laparoscopic compared with open procedures [215].

In terms of requirement for postoperative CPAP/NIV, obese patients can be divided into the following subsets:

a) Obese patients without diagnosed OSA.

These patients benefit from oxygen therapy (via face-mask or nasal cannula), upright positioning and early ambulation. Retrospective analyses have shown that a diagnosis of OSA is often missed in many bariatric surgical patients [216] and this subset of patients is at high risk to develop postoperative complications [217]. In patients with BMI >35 kg/m^2 the use of nasal CPAP postoperatively might be an alternative due to higher tolerance/compliance, however its therapeutic efficacy may be limited by oral air leaks [218].

b) Patients with OSA-not using preoperative CPAP therapy.

Two subgroups of patients are included in this category: patients with diagnosed OSA without prescribed CPAP, and patients with prescribed CPAP but who do not use it regularly (poor compliance). The severity of OSA could be expected to be worse in the latter group who are candidates needing CPAP in the immediate postoperative period. However, in both groups intraoperative anaesthetic and surgical factors play the most important role for the need for positive pressure ventilatory support due to worsening of OSA. Regional anaesthesia and short-acting anaesthetic drugs should be used [219]. Patient-related factors indicating increased need for NIPP use include moderate to severe OSA [211], male gender, age >50 years, BMI >60 kg/m^2 [220], pulmonary co-morbidity, open surgery [221] and the need for reoperation [214]. An oxygen saturation below 90 % in the immediate postoperative period is usually defined as hypoxia and indicates need for NIPP [217]. Liberal use of NIPP therapy should, therefore, be adhered to according to the above criteria as well as in the presence of tachypnoea or hypercarbia.

c) Obese patients with OSA on home CPAP therapy.

Compliance with CPAP has been reported to be poor, ranging from 50 to 80 % [222]. However, patients prescribed CPAP habitually should continue their treatment in the postoperative period since it decreases complication rates [223]. Based on data from retrospective studies, slightly higher CPAP values than prescribed for home use may be needed in the postoperative period, due to respiratory inhibitory effects of perioperative narcotics and muscle relaxants [224].

d) Patients with Obesity Hypoventilation Syndrome (OHS) ("Pickwickian syndrome")

OHS is defined as severely obese patients with baseline awake hypoxia and hypercarbia along with raised serum bicarbonate (>27 mmol/l). Patients with OHS are at high risk of perioperative complications [225]. OHS patients are highly sensitive to opioids irrespective of route of administration (intravenous/central neuraxial) and might present with sustained and life threatening respiratory depression in the postoperative period [226]. Opioid-free anaesthesia with a preference of regional anaesthesia (using local anaesthetics) and the use of minimally invasive procedures is recommended. Prophylactic nasal BiPAP/NIV for 24–48 h postoperatively has been shown to reduce risk of respiratory complications [227]. At least, prophylactic initiation of BiPAP in sitting/semi-sitting position along with intensive monitoring for first 24 h is recommended in these patients.

Summary and conclusion

ERAS versus traditional care in bariatric surgery: clinical outcomes

For bariatric surgery, the literature supporting the use of ERAS is comparatively sparse. Although not defined as a regular ERAS program, McCarty and collaborators reported improved postoperative recovery in 2000 consecutive patients undergoing laparoscopic RYGB with a standardised multimodal program aimed to modify perioperative care [63]. So far, there is one single RCT published in which the use of a standardised ERAS programme in patients undergoing laparoscopic sleeve gastrectomy was compared with "standard care". The authors reported shorter hospital stay with ERAS but no differences in readmission rates, postoperative complications or fatigue scores [82]. In general, most data reporting beneficial effects associated with ERAS are generated from studies involving elderly, sometimes medically frail patients, whereas individuals submitted to bariatric surgery are typically younger and more physically fit. Therefore, results from previous studies may not be immediately applicable to bariatric surgery. Morbidity and mortality rates in association with bariatric surgery are relatively low with 3 and 0.04 % for severe complications and mortality, respectively, within 30 days as reported in the Scandinavian Obesity Registry (SOReg) [3], and further reductions in these may be difficult to achieve.

It could be assumed that for some ERAS elements, such as early mobilisation and oral intake, adherence is relatively high in most centres, whereas there may be room for improvement for others, such as postoperative oxygenation and non-invasive positive pressure ventilation. Since the recommendation grade for the use of most of the included ERAS elements for obese individuals undergoing surgery in general is strong, the use of systematic ERAS pathway may have the potential to improve outcomes after bariatric surgery.

Future perspectives and validation

Data from studies evaluating the effects of ERAS pathways and health costs in patients undergoing bariatric surgery are sparse. Some studies in colorectal [228] and pancreatic [229] surgery reported reduced costs with ERAS, whereas others could not identify any difference [230]. For bariatric surgery and ERAS, reports on quality of life (QOL) are still due and the very few studies reporting data in colorectal surgery have failed to demonstrate any difference [230, 231]. Possible explanations for this might be difficulties associated with randomisation between ERAS and conventional care and/or lack of instruments with sufficient sensitivity to detect any possible improvements in patients' perceived QOL. Nevertheless, QOL and cost will be key elements in evaluating the success of ERAS in the bariatric setting in the future. Implementation and validation of guidelines like the present one are also important factors for improvement of outcome. Therefore, the teams involved in these guidelines will include the recommendations into a web-based ERAS® database for continuous audit and analysis, which will help validate the guidelines in clinical practice.

Comment

These guidelines represent an effort to provide all caregivers involved in the management of patients undergoing bariatric surgery with an overview of the current literature. Surgical and anaesthesiological practice is continuously developing, which means that recommendations need to be challenged and updated, probably within 3- to 5-years interval. It might seem to the reader that the level of evidence for many of the elements is surprisingly low. However, it should be acknowledged that this reflects the current situation in most areas of modern medicine in general and not least within surgical practice.

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Compliance with Ethical Standards

Conflict of Interests AT and MV have no conflicts of interest to declare. ADM has no direct conflicts of interest to declare. He has received speakers' honoraria from Covidien. DR has no direct conflict of interest to declare. SA has no direct conflicts of interest to declare. He has received speakers' honoraria and consultation fees from Fischer & Paykel Healthcare, Merck Sharp & Dohme and BBraun; unrestricted educational grants from Fresenius Kabi, Nestle Nutrition, Covidien, Ethicon EndoSurgery, Merck Sharp & Dohme, Fischer & Paykel Healthcare, GORE and BBraun. He has also completed a bariatric fellowship funded via an educational grant from Ethicon EndoSurgery (paid to the institution). ND has no direct conflicts of interest to declare. He has received unrestricted grants and speakers' honoraria from Johnson & Johnson, Nestlé and from MSD. DNL has no direct conflicts of interest to declare. He has received unrestricted grants and speakers' honoraria from Fresenius Kabi, BBraun, Nutricia and Baxter Healthcare.

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