



The Optimal Nutritional Programme for Bariatric and Metabolic Surgery

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Abstract

Purpose of Review Bariatric surgery is the most effective treatment for severe and complex obesity; however, the risk of developing nutrient deficiencies varies based upon the type of surgery, degree of malabsorption, and level of nutrition intervention. There are numerous factors that can impact the nutrition status of a patient during their pre- and postoperative journey. We review the critical components and considerations needed in order to provide optimal nutrition care for patients with bariatric surgery.

Recent Findings A dietitian, specializing in bariatric surgery, is the best equipped healthcare provider to prepare and support patients in achieving and maintaining optimal nutrition status. We present best practices for both the pre- and postoperative nutrition-related phases of a patient’s journey.

Summary The dietitian specialist is integral in the assessment and ongoing nutrition care of patients with bariatric surgery. Further consideration should be given to enable access for lifelong follow-up and monitoring.

Keywords Nutritional management · Micronutrients and macronutrients · Bariatric surgery · Malabsorption · Vitamins and minerals · Perioperative nutrition

Introduction

Obesity is a pervasive worldwide disease and continues to be the leading cause of chronic co-morbidities, decreasing quality of life and increasing mortality. While bariatric and metabolic surgery is recognized as the most effective treatment to ameliorate obesity and improve associated diseases, the patient’s success is greatly influenced by a patient-centred

approach involving a comprehensive and interdisciplinary team of healthcare specialists including registered dietitians (RD).

All bariatric procedures can potentially pose a nutritional risk if the patient is not properly assessed and subsequently educated on the nutritional requirements postoperatively. Contributors to this nutritional risk include the health status of the bariatric surgical candidate prior to surgery, the status of obesity as a disease that presents with many micronutrient deficiencies, and the restricting and/or malabsorptive nature of the bariatric procedure itself. While the morbidity and mortality rate of bariatric surgery is low, nutritional challenges co-exist with the surgery and may manifest as protein-calorie malnutrition and vitamin and mineral deficiencies, particularly thiamine (B1), vitamin B12, vitamin D, and iron [1–3]. Such deficiencies can lead to more serious conditions of anaemia, metabolic bone disease and neuropathies [4]. Other postoperative challenges with bariatric surgery include nausea, vomiting, diarrhoea, constipation, bezoar, and bacterial overgrowth [4].

The role of the RD is paramount and begins with the pre-assessment and evaluation of the surgical candidate. Research shows that obesity is a form of malnutrition with vitamin and

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mineral deficiencies including vitamin B1, vitamin B12, folate, vitamin A, vitamin D, and iron [5, 6]. These are the very same nutrient deficiencies that may be exacerbated postoperatively. The RD, through medical nutrition therapy, evaluates the patient and corrects deficiencies preoperatively (pre-op). The RD also assesses the patient's readiness to make lifestyle changes; educates on the importance of physical activity and proper eating mechanics; makes dietary recommendations including supplementation and diet progression; and shows patients cooking techniques, appropriate products, and how to prepare their kitchens for after surgery. Postoperatively, the RD plays a pivotal role to facilitate and support the patient through their journey. The RD assists patients as they advance their diet and gives strategies and solutions that help patients navigate through their dietary needs. Most importantly, the RD can identify potential nutritional deficiencies through nutrition assessment and nutrition-focused physical examination and mitigate these challenges through sound nutrition counselling and guidance. Research also shows that having an RD on the interdisciplinary team shows fewer readmissions related to dietary issues, improved nutritional biochemistries, greater resolution of co-morbidities, less nutritional complications, and greater weight loss [4, 7–11].

Research shows patients consider access and interaction with RDs as a vital role in their success with RDs being one of the most valuable clinicians to continue a relationship with postoperatively [12]. Current clinical practice guidelines for bariatric surgery recognize and support that the RD, on the team, is an indispensable specialty to a sound bariatric programme [2–4, 13–15].

Pre-op Diet: Optimizing Nutrition Status

In order to optimize nutrition status after bariatric surgery, all patients should meet with an experienced RD for a comprehensive nutritional assessment. The RD should review, with the patient, standard assessment components (i.e. medical comorbidities, weight history, basic nutrition knowledge, laboratory values, diet, and supplement intake) and other issues that could affect nutrient status, such as unrealistic expectations for weight loss after bariatric surgery, disordered eating, economic constraints, and the patient's ability to be physically active [2, 3, 16–18].

Nutritional deficiencies identified preoperatively should be corrected as clinically indicated prior to surgery [2, 3, 16–19]. In larger or more systematized programmes, this may take place as part of a multidisciplinary treatment team or in smaller programmes; the RD may be responsible for many, if not all, aspects of the nutrition evaluation: assessment and intervention (treatment). For the procedures which create more malabsorption, such as the biliopancreatic diversion/duodenal switch (BPD/DS) or single anastomosis duodeno-

ileal bypass with sleeve gastrectomy (SADIs), additional evaluation for bone mineral density, such as baseline DEXA scans, should also be considered [2, 17].

Prevalence of Pre-op Nutrient Deficiencies

Pre-op screening is recommended for vitamins D, B1, B6, and B12; calcium; iron; zinc; and copper and in some cases selenium and vitamins A, E, and K for the malabsorptive procedures [3, 16]. Since it has been reported that patients presenting for bariatric surgery have at least one vitamin or mineral deficiency prior to surgery and the prevalence of nutrient deficiencies (vitamins B1, B12, and D; folate; iron; zinc; and copper) has been reported as ranging from 29 to 90%, it would seem wise to assess for these nutrients before proceeding with bariatric surgery [3••]. If a deficiency is noted before surgery, then there may be time to correct this deficiency, particularly when many insurance providers such as in the USA or national health services as in the UK require patients to complete several months of medical weight management before approving bariatric surgery. Moreover, once a patient has a nutrient deficiency pre-op, the deficiency is compounded after surgery and will not normalize with basic or preventative supplementation [3, 19]. In fact, increased amounts of repletion doses will be needed to correct pre-op deficiencies. Since many nutritional blood tests are not checked until 3 months or even 1 year after surgery, these deficiencies continue to worsen and provide ample opportunity for new deficiencies to develop [19]. Pre- and post-op screening for nutrient deficiencies is similar in terms of signs and symptoms, specific laboratory assays, and recommendations for deficiency. Insurance companies may not pay for certain blood tests unless there is a diagnosis tied to the request. This presents a quandary for some of the more expensive laboratory assays. There is no guarantee that the cost of the laboratory test will be covered by insurance in the USA and other countries. However, it is important to note that the nutrient with the highest prevalence of deficiency may not necessarily equal the nutrient with the greatest risk of irreversible and permanent damage to the patient. For example, vitamin D deficiency is reported as the highest prevalence (90%) in patients seeking bariatric surgery, but the nutrient with the greatest risk of irreversible and permanent damage to the patient is thiamine (vitamin B1) with less than 30% reported prevalence [3••]. In the USA, vitamin D tends to be a covered laboratory cost prior to bariatric surgery, but not vitamin B1. It could be worthwhile prioritizing additional laboratory tests to screen for deficiencies, based on prevalence, geography, time frame that damage can occur, and harm to the patient.

Even though screening for all patients and all nutrients is recommended preoperatively, each practice will need to consider their specific patient population, as well as ramifications

of adverse outcomes, including nutrients with severe and potentially irreversible harms, when applying guidelines to a specific protocol development [3••].

Pre-op Preparation

Many programmes require a very low-calorie diet (VLCD \leq 800 kcal) or low-calorie diet (LCD \leq 1000 kcal) “prep for surgery”. These reduced calorie diets vary widely (all liquid, solid foods and liquids, pre-packaged meals, etc.). It is difficult, if not impossible, to meet the recommended daily amounts of vitamins and mineral through these restricted diets [20]. It will be important to incorporate the recommendation of a generic “complete” multivitamin and mineral supplement which contains vitamin B1 but no added herbs or potential blood thinners. Additionally, patients could begin taking a calcium supplement with Vitamin D while avoiding taking calcium with iron-containing products.

Early Post-op

Bariatric surgeries reduce stomach capacity and may include bypassing portions of the small intestine to produce further metabolic changes. Currently, American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for Surgery of Obesity and Metabolic Disorders (IFSO) recognize the following surgeries for weight loss: adjustable gastric band (AGB), sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), BPD/DS, and more recently one anastomosis gastric bypass (OAGB) and SADIS (Fig. 1) [21, 22]. These procedures change gastric anatomy and physiology, thus changing chemical and mechanical digestion. After bariatric surgery, patients will no longer have the same ability as before surgery to digest certain foods and extract specific nutrients from foods. Typically, the procedures which leave a greater amount of common channel, the contents of the small intestine’s digestive path that mixes with bile from the biliopancreatic loop before emptying into the large intestine, produce less malabsorption [23, 24]. Since patients are unable to ingest the variety and quantity of food needed to provide nutrients for normal nutrition status, patients must take vitamins and minerals lifelong [25, 26].

Diet Progression: from Liquid to Solids

In the early post-op time span (the first 6 weeks after surgery), patients need to follow a diet progression (liquids to solids) in order to adjust to the reduced stomach capacity and keep well hydrated, minimize potential nausea and vomiting, and allow the patient to become familiar with changes in “satisfied/full”.

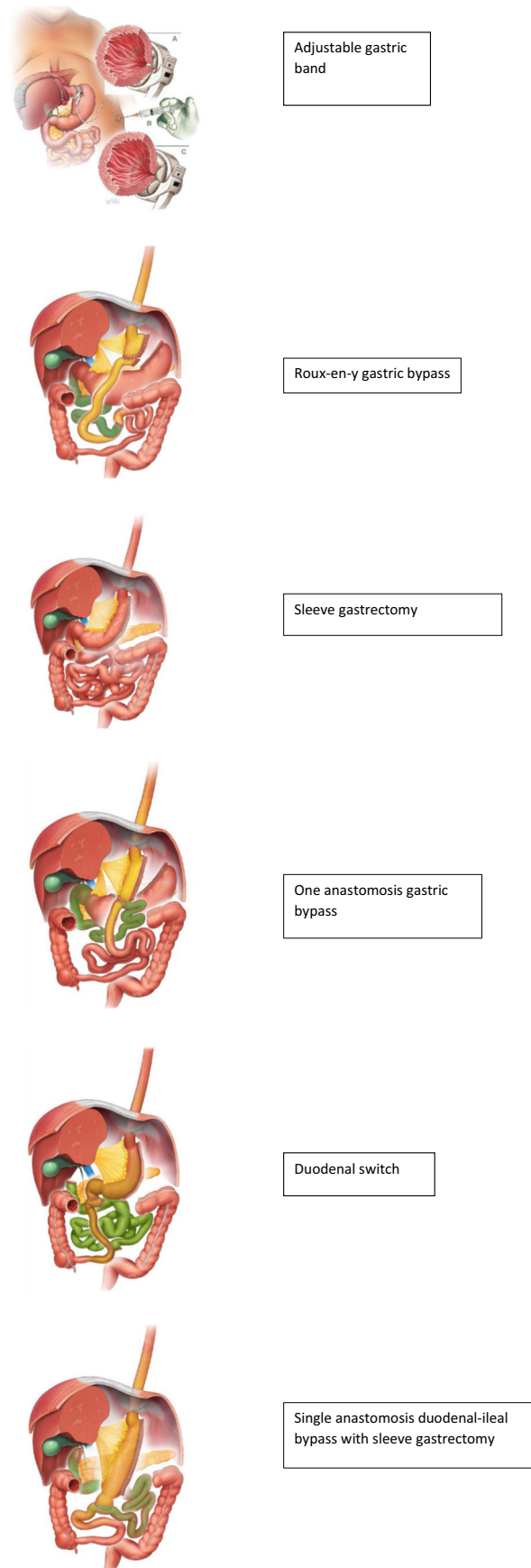


Fig. 1 Bariatric surgery procedures “© Dr Levent Efe, courtesy of IFSO”

RDs with expertise in bariatric surgery are the best equipped clinicians to provide education and counselling for achieving optimal nutrition status after bariatric surgery. Within the first 30 days after surgery, hydration and abdominal pain are two major reasons for hospital readmission and/or visits to the emergency department. Patients need to be taught how to sip fluids immediately after surgery and when to begin taking vitamins, minerals, and supplemental protein and appropriate behavioural changes with dietary intake to promote optimal nutritional status. As the patient's diet progresses into more solid foods and more difficult to digest animal protein, behavioural changes become even more critical: taking small bites of low sugar foods, chewing thoroughly, and preparing animal sources of proteins to be moist and not dry. Additionally, drinking while eating can interfere with solid food intake, so patients are instructed to avoid drinking 30 min before and during a meal and to wait 30 min after the meal before drinking fluids. After the 1st 6 weeks to 3 months, patients should be able to drink up until they eat a meal but continue to avoid drinking fluid during the meal and up to 30 min afterwards to decrease the possibility of rapid food emptying, decreased satiety, and possible dumping [27, 28]. Education should include instructions regarding how to obtain adequate fluids and protein and any additional patient concerns specific to the surgical procedure and patient's medical and nutrition history [2, 3, 16–18].

Current clinical practice recommendations for protein intake after bariatric surgery vary by type of surgery. Typically, 60–80 g/day total protein intake or 1.0–1.5 g/kg ideal body weight (IBW) is recommended for procedures, except for BPD/DS for which 90 g/day protein is recommended [16]. Early post-op, this may be difficult to achieve through food alone. For example, a pouch or sleeve capacity can vary from as little as 10 to 90 ml which leaves little room for foods other than protein. This creates a very unbalanced diet, thus making recommended protein, vitamin, and mineral supplements critical to a patient's nutrition status. After BPD/DS and other malabsorptive procedures, the amount of protein should be increased by approximately 30% or to 90 g/day to accommodate for malabsorption. Liquid protein supplements can help to provide protein and calories to preserve lean muscle mass when dietary intake is most limited. It is important to work with an RD who can evaluate the quality of the protein supplement since all proteins are not of the same quality. Aills et al. provide a detailed section discussing protein, including the importance of assessing the quality of protein in various dietary supplements [16].

Physical activity is a critical component of postoperative healing, ideal weight loss, and maintenance. Walking is recommended as the primary activity during a patient's recovery phase. Patients should progress to

moderate-intensity physical activity with a minimum of 150-min aerobic activity per week, and once recovery is complete, incorporate additional strength training at least 2 times per week. Aerobic activity could be performed in bouts of at least 10-min duration and consist of activities such as brisk walking, dancing, or household chores [29].

Common Problems During Early Post-op (1st 6 Weeks After Surgery)

Patients may find it difficult to consume the amount and frequency of fluids needed after surgery, thus being at risk for dehydration. Food intolerances may be a consequence of not following recommended behaviours for eating and drinking early post-op, including:

- Sipping small amounts of liquids slowly
- Taking small bites and chewing thoroughly
- Avoiding drinking fluids while eating
- Progressing slowly through diet phases from liquids to solid foods
- Avoiding foods that are problematic, such as pasta, rice and doughy breads, tough to digest animal proteins, and some raw fruits and vegetables

Persistent nausea, vomiting, or diarrhoea may not be due to behavioural factors and should be evaluated further by the multidisciplinary team including the RD and surgeon [30]. Moreover, increased unintended fluid output (vomiting, diarrhoea, and excessive sweating) will cause increased excretion of water-soluble vitamins. With decreased intake of essential vitamins and nutrients, vitamin B1 deficiency can occur in as little as 2 weeks. Thiamine must be replaced daily, and with increased excretion, the patient can deteriorate quickly. Repletion should follow current clinical practice guidelines [3, 16, 17, 30]. It is important to note that patients with dehydration should not be rehydrated with dextrose containing IV solutions without the concurrent administration of vitamin B1 and for patients at risk for refeeding syndrome, the simultaneous administration of magnesium, potassium, and phosphorus [2, 3, 16–18].

Prevalence of Post-op Nutrient Deficiencies

It is critical to understand that the severity of deficiencies increases with bariatric surgery. In fact, all nutrient deficiencies reviewed by Parrott et al. increased in severity postoperatively [3•]. In particular, thiamine deficiency is reported in up to 50% patients (< 30% pre-op) and vitamin D deficiency

in 100% (90% pre-op) [3••]. Patients who have a nutrient deficiency that is not corrected prior to surgery are more likely to continue with that same deficiency and develop additional deficiencies compared to patients who have no deficiencies or deficiencies that are corrected prior to surgery [19]. This may be due to nutrient-nutrient interaction, reduced intake, or lack of appropriate vitamin and mineral supplementation.

Types of Bariatric Surgery and Prevalence of Deficiencies

Procedure-specific factors determine which nutrient deficiencies may occur:

- Amount and location of removed/bypassed stomach
- Shortening or bypassing portions of the small intestine
- Length of the common limb channel
- A shorter common channel means more malabsorption: DS > SADIs > OAGB > RYGB
- Bile production and availability to mix with nutrients [31]. See Table 1.

Summary

Pre-op Recommendations

- Multivitamin and mineral supplement, containing thiamine 12–50 mg.
- Calcium with vitamin D.
- Choose a dietary approach that is consistent among providers and patients.

Early Post-op Recommendations

- Supplement daily with a complete multivitamin and mineral supplement (containing recommended amounts of thiamine, iron, selenium, zinc, and copper) after all bariatric procedures. It is important to note that some multivitamin supplements that are routinely available may not contain sufficient amounts of certain vitamins and minerals in the recommended doses (in particular, thiamine). So, it may be necessary to take 2 multivitamins and/or take a separate B vitamin or use a multivitamin prepared specifically for patients with bariatric surgery.
- Supplement daily with calcium citrate or carbonate (with meals) 1200 mg to 1500 mg or more in BPD/DS and SADIs in divided doses. Avoid taking with iron-containing products.
- Supplement daily with a total of 3000 IU vitamin D from all vitamins.
- Know the prevalence and risk factors for developing post-operative nutrient deficiencies
- Identify nutrient deficiencies—use a combination of signs and symptoms and laboratory values [2, 3, 16–18].

Postoperative Nutrition and Care

Continued contact and support with the RD during the first 2 years is important to maximize outcomes, as generally the greatest weight loss (WL) occurs during the first year with the focus changing to weight maintenance in the second year. Outcomes include achieving adequate WL while preserving lean body mass, developing healthy nutritional habits, preventing possible nutritional deficiencies, and avoiding

Table 1 Nutrients potentially affected by procedure [3, 17, 32, 33]

	Sleeve gastrectomy	Roux-en-y gastric bypass	One anastomosis gastric bypass	Duodenal switch	Single anastomosis duodenal-ileal bypass with sleeve gastrectomy
Thiamine	Yes	Yes	Yes	Yes	Yes
Vitamin B12	Yes	Yes	Yes	Yes	Yes
Folate	Yes	Yes	Yes	Yes	Yes
Iron	Yes	Yes	Yes	Yes	Yes
Vitamin D and calcium	Yes	Yes	Yes	Yes	Yes
Vitamins A, E, and K	No	Potentially vitamin A	Yes	Yes (high risk)	Yes (high risk)
Zinc	Yes	Yes	Yes	Yes (high risk)	Yes (high risk)
Copper	Yes (low risk)	Yes	Yes	Yes (high risk)	Yes (high risk)
Selenium	Yes	Yes	Yes	Yes (high risk)	Yes (high risk)
Lipids	No	No	Yes	Yes (high risk)	Yes (high risk)
Protein	No	No	Yes	Yes (high risk)	Yes (high risk)

possible complications, such as dumping syndrome, hypoglycemia, and sarcopenia [5, 34]. Patients ought not to compare their WL, as rates vary greatly among patients [34]. They need a way to assess their progress toward 20–30% weight loss at the end of the 1st year and to achieve the best quality of life possible.

Patients should have regular appointments with their RD, at least every 3 months in the first postoperative year and twice in the second year, coupled with recommended nutritional blood tests (Table 2). Research shows that patients who adopt healthier eating habits and behaviours such as stopping eating when feeling full, stopping grazing, and starting to self-weigh lost the most weight at 3 years [35]. Other positive behaviour changes include planning meals and snacks and eating mindfully and slowly, avoiding distractions, avoiding liquids during meals, reducing sugar and fat content of the diet, and avoiding alcohol [34–36]. While the composition of the optimal post-surgery diet is not known, a greater WL was seen in patients who reduced the relative proportion of energy from fat in favour of protein or carbohydrates [37]. Protein intake may help with satiety and preservation of lean body mass [38, 39].

With WL, fertility improves among post-op women, and oral contraceptives may be less effective. Women are recommended to postpone conception until a stable weight is reached, usually 12 to 18 months after bariatric surgery. Thus, they should wait at least 12 months before conceiving. Maternal malnutrition may increase the risk of small for gestational age, preterm birth, and congenital abnormalities, so closer nutritional monitoring is recommended [40].

During the patient consultation, the RD has an important role in nutrition assessment, diagnosis, intervention, and monitoring. Nutritional deficiencies can be managed with recommended dietary intake and the use of multivitamin and mineral supplements. Adherence may be an issue for some patients, so continued monitoring is essential [41].

Table 2, based on Parrott et al., summarizes nutritional monitoring, vitamin, and mineral supplements and treatment of deficiencies [3]. Iron deficiency is highly prevalent in patients postoperatively (8–55% incidence [3]). Higher risk patients include fertile and pregnant women and those who have had RYGB, BPD/DS, OAGB, and SADIs [3, 32, 33, 42]. At least 18 mg iron is recommended in patients who have the SG and who do not have a prior iron deficiency or have heavy menses. Recommendations for all other patients consist of 45–60 mg elemental iron daily. However, iron deficiency anaemia may still occur requiring higher dosages or intravenous iron infusions.

Factors increasing risk of thiamine deficiency have been discussed earlier. Parrott et al. recommend patients to take at least 12 mg thiamine with preferred dose of 50 mg daily and outline treatments for suspected or diagnosed thiamine deficiency [3].

Vitamin B12 deficiency has severe consequences leading to megaloblastic anaemia; however, prior to this, patients usually present with neurological symptoms such as ataxia, optic atrophy, memory loss, mental status change, and myeloneuropathy, and these may be irreversible. Folic acid supplementation may mask vitamin B12 deficiency.

Vitamin D deficiency is prevalent, and high doses are required to maintain levels. For further details of monitoring and treatment of vitamin and mineral deficiencies, please see Table 2.

Frequent complications in the first 2 years, besides nutritional deficiencies, include hair loss (telogen effluvium), dumping syndrome, reactive hypoglycemia, and sarcopenia.

Hair Loss (Telogen Effluvium)

Hair loss is common after the 3rd and 6th month post-op, mainly related to decreased energy, protein and iron intake. It can occur after a very low-calorie diet and/or excessive weight loss [43]. It usually improves after 6 months.

Dumping Syndrome Reactive Hypoglycaemia

Dumping syndrome is a group of symptoms that are more likely to occur after RYGB than SG surgeries due to the lack of the pyloric sphincter. This varies, ranging from 10 to 75% among patients after RYGB and 33% after SG. Dumping syndrome results from the rapid emptying of food from the stomach into the jejunum, probably causing neural activation in the proximal alimentary limb (occurring sometimes early (within 1 h) or late (1–3 h) after eating carbohydrate-rich foods [44]. The most common symptoms are tachycardia, abdominal pain, diaphoresis, nausea, diarrhoea, and sometimes hypoglycemia.

Late dumping syndrome, also known as reactive hypoglycaemia, relates to exaggerated insulin release leading to rebound hypoglycemia. Symptoms include feeling shaky, sweaty, weak, and extremely fatigued and in extreme cases, loss of consciousness. Dietary modification is the first treatment. Three meals a day and three in-between meal snacks containing low glycaemic index carbohydrates and avoidance of sugar-rich food and liquids are recommended. If there is no improvement, onward referral to an endocrinologist should be considered [45].

Sarcopenia

In addition to reduction of excess fat mass, fat-free mass (FFM) is inevitably lost in the process. There are reports of

Table 2 Postoperative nutritional supplementation and monitoring for patients who have bariatric surgery, based on Parrott et al. [3]

Vitamins and minerals	Routine preventive supplementation	Deficiency treatment	Monitor
Thiamine	12 mg/day (d)	Repletion may be by: oral therapy—100 mg 2–3 times/day iv therapy—200 mg 3 times/day IM therapy—250 mg once daily for 3 to 5 days 1000 µg/day IM to achieve normal levels	Treat immediately if the patient has prolonged episode of dysphagia, vomiting, poor dietary intake, or fast weight loss. Do not wait for confirmation of deficiency by laboratory tests
Vitamin B12	350–500 µg/day or 1000 µg intramuscularly monthly (IM)		Screen every 3 months in first year post surgery and then at least annually or as clinically indicated. Treat immediately if deficiency detected
Folic acid	400–800 µg/day	1000 µg/day Check for vitamin 12 deficiency first	Screen within 3 months of surgery, then every 3 to 6 months until 12 months and then annually. Give attention to female patients of childbearing age
Iron	Males: 18 mg/day Fertile females: 45–60 mg/day	150–300 mg (2–3 times)/day Use IV supplementation if does not resolve	Screen within 3 months of surgery, then every 3 to 6 months until 12 months and then annually
Vitamin D	3000 IU/day To maintain 25(OH) vit D > 30 ng/mL	6000 IU/day or 50,000 IU 1 to 3 times/week	Screen within 3 months of surgery, then every 3 to 6 months until 12 months and then annually
Calcium	BPD/DS: 1800–2400 mg/day AGB/SG/RYG/GB: 1200–1500 mg/day	Check PTH (<30 ng/dL) and vitamin D (>30 ng/dL)	Monitor PTH at baseline to exclude primary hyperparathyroidism
Vitamin A	RYGB/SG: 5000–10,000 IU/day BPD/DS: 10,000 IU/day	10,000–25,000 IU/day until clinical improvement (1–2 weeks). IM injections may be needed if no improvement	Screen in first year following RYGB and OAGB. Screen within 3 months of surgery, then every 3 to 6 months until 12 months and then annually following BPD/DS and SADIs
Vitamin E	15 m/day	100–400 IU/day	Screen at least annually in BPD/DS and SADIs. Screen in unexplained anaemia or neuropathy
Vitamin K	AGB: 90–120 µg/day SG/RYGB: 90–120 µg/day BPD/DS: 300 µg/day	10 mg parenterally in acute malabsorption 1–2 mg/day orally or 1–2 mg/week parenterally in chronic malabsorption	Screen at least annually in BPD/DS and SADIs or where there is established fat soluble vitamin deficiency
Zinc	AGB/SG: 8–11 mg/day RYGB: 8–22 mg/day BPD/DS: 16–22 mg/day	No recommended amount for treatment of deficiency. Monitor copper to avoid zinc induced copper deficiency. Supplementation with 1 mg copper is recommended for every 8–15 mg of elemental zinc to prevent copper deficiency	Screen at least annually especially in RYGB, BPD/DS, OAGB, and SADIs
Copper	AGB/SG: 1 mg/day RYGB/BPD/DS: 2 mg/day	3–8 mg/day oral copper gluconate or sulphate. Monitor zinc	Screen at least annually especially in RYGB, BPD/DS, OAGB, and SADIs

These recommendations are based on ASMBS guidelines. Please note that recommendations vary between different national guidelines

AGB, adjustable gastric band; SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; OAGB, one anastomosis gastric bypass; SADIs, single anastomosis duodenal-ileal bypass with sleeve gastrectomy; PTH, parathyroid Hormone

For OAGB and SADIs, follow recommendations for BPD/DS

16–23% of FFM loss in the first-year post-surgery [46, 47]. Excessive muscle mass losses are related to sarcopenia, i.e. the presence of both low muscle mass and low muscle strength or performance [48]. Muscle mass contributes to increased resting metabolic rate (RMR). So, increased muscle mass losses are related to decreased RMR and higher risk of weight regain. To prevent excessive FFM losses, patients are advised to increase high quality protein intake (1.0–1.2 g/kg IBW/day) in separate doses [39]. Recent studies advise that 60–75 min of resistance exercises 3 times a week helps to preserve muscle mass after surgery [49].

Long-Term Follow-Up Care

Patients, post-bariatric surgery, require access to long-term follow-up. Weight regain, nutritional issues, and post prandial hypoglycaemia may present over time, so patients must have access to ongoing support from healthcare professionals as part of chronic disease management [2, 3, 14, 18, 50, 51]. Annual reviews should include nutritional monitoring and the opportunity to refer back to the bariatric surgery centre or obesity physician if there are any concerns [14, 50, 51].

Insurance policies may determine access to follow-up, whereas public healthcare may commission 2-year follow-up only [14, 44, 51, 52]. This may leave patients vulnerable as often their local general practitioners receive no training in this area. In the UK, guidelines proposed that patients should be offered at least annual review, including monitoring of nutritional status and vitamin and mineral supplementation, as part of a shared care model of chronic disease management [14, 51, 52]. The dietetic led annual review is a key component. Experienced bariatric dietitians are skilled in nutritional management, able to identify issues related to bariatric surgery, and advise when patients should be referred back to the bariatric surgery centre/obesity physician. The challenge remains as to how long-term follow-up care will be delivered or funded.

Aftercare of patients undergoing malabsorptive procedures, such as BPD/DS, OAGB, and SADIS, may need to remain with the specialist centre lifelong [14, 53]. These procedures have a greater incidence of severe nutritional deficiencies, such as protein malnutrition and fat-soluble vitamin deficiencies, which are difficult for non-specialist healthcare professionals to manage [14, 32, 33, 42, 53–55].

General practitioners and patients should be made aware that there are a number of symptoms that may require further investigation and/or referral back to the specialist centre. This include dysphagia and/or vomiting, diarrhoea, abdominal pain, reflux, oedema, neurological symptoms, and post-prandial hypoglycaemia [14, 18].

Nutritional Issues and Access to Psychology and Exercise Physiologist/Physiotherapist

Patients may find it difficult to adhere to the postoperative dietary guidelines, resulting in regurgitation and food choices of less nutritional value [56, 57, 58]. Some patients may experience anorexia or restrict their intake because of fear of weight regain. Many patients with severe and complex obesity have depression, and this or other psycho-social issues, including finances, may affect intake and affordability of life-long multivitamin and mineral supplements. Although in many cases, the dietitian and patient can work together to address these, at times, onward referral to psychology may be required for on-going disordered eating, alcohol misuse, self-harm, or trauma affecting eating [58, 59]. Dietitians and psychologists often work closely together in the management of patients.

Physical activity plays an important role in improving physical fitness, mental well-being and weight maintenance; however, many patients may not meet the recommended minimum of at least 150 min of physical activity per week [60]. Patients need support to help address the barriers to being more active. Ideally, access to a physiotherapist/exercise physiologist is needed.

Weight Maintenance/Regain

Approximately 20–30% patients who have bariatric surgery have inadequate weight loss. Most patients lose 20–30% initial weight following bariatric surgery. In the Swedish obese subjects (SOS) intervention study, the average weight loss at 1 year was 25.3%; however, there was some weight regain by 6 years resulting in average weight loss of 16.9% at 6 years and 16% at 10 years [61]. The amount of weight loss differs among surgical interventions, with RYGB and BPD/DS typically producing greater and more rapid average weight loss than SG and AGB [34, 62]. Significant weight regain (WR) occurs in 20–35% of patients, depending on the procedure and time since surgery [61, 62]. In a recent study, King et al. suggested that the best way of expressing WR is by quantifying it as a percentage of maximum weight lost which is more closely associated with most clinical outcomes [62].

A systematic review classified the aetiology of WR in 5 domains: nutritional non-adherence, mental health issues, endocrine or metabolic imbalance, physical inactivity, and anatomical surgical factors [63].

Treatment depends on the quantity of weight regained. Dietary and lifestyle changes may help patients lose 5 to 10% of the weight regained. Increased protein intake may facilitate satiety and weight maintenance [38, 64, 65]. Self-monitoring and weight checks that are key components are successful weight maintenance [35, 65, 66]. Regular

follow-up visits with RD may have a role in preventing WR following bariatric surgery [7].

For patients who need to lose more than 10% of their eight, a concomitant use of anti-obesity medications can be prescribed as part of chronic disease management [67–69]. A comprehensive evaluation should occur when significant weight regain or failure to lose weight occurs. Interventions should first include dietary assessment and counselling, including physical activity and behavioural modification with frequent follow-up and then if appropriate, pharmacological therapy and/or surgical revision [30].

Patient Support Groups

Bariatric surgery is not without challenges. Attrition rates for clinic attendances are shown to be up to 3%–63%, and failure to return for follow-up visits has been associated with increased postoperative complications, lower percentage of weight loss, weight regain, higher degree of nutritional deficiencies, poorer dietary compliance, and higher rates of surgery-related morbidity [70–73]. Research shows that dietary and lifestyle non-adherence occur as early as at 6–18 months and includes excessive snacking, inadequate protein and fluid intake, poor vitamin and mineral intake, inactivity, and eating mechanics and behaviours not conducive to long-term weight loss success [74–76].

An important component of interdisciplinary bariatric programmes, enabling patient follow-up and compliance, is the offering of support groups. These provide a sense of inclusion and community in a safe, nurturing, and unbiased environment [77–79]. Support groups help to build healthy relationships between providers and patients and patients with other patients who share common goals and challenges. They provide invaluable information by having the venue to share the lived experiences of patients with bariatric surgery.

Interdisciplinary topics that may be of interest to patients include those that encompass medical, emotional, psycho-social, exercise, and nutrition. Goals include preventing the onset of recurrence and relapse toward unhealthy eating habits, reinforcing dietary guidelines, eating patterns and mechanics, and increasing the patient's knowledge and understanding. Support groups are typically facilitated by licenced healthcare specialists and patient peers and mentors.

Historic and current research shows a positive relationship between support groups and patient outcomes [78, 80–86]. Systematic reviews show a positive association between attending support groups and WL compared to those who do not [85, 86]. In addition, the number of attended support groups appears to influence greater WL [86]. Hameed et al. showed that motivators to attend a support group are not influenced by the patient's perception of weight regain, surgical type, or postoperative complications; however, body image, concerns

with loose skin, or concerns with difficulties to resume work could influence attendance [87]. When patients attend, they desire the support group to be delivered by experts about obesity, nutrition, exercise, and bariatric surgery; look for moral support from others who had experienced a similar journey; and want to be able to stay connected with professionals specializing in obesity treatment [87]. Encouraging patients to attend support groups preoperatively may encourage postoperative attendance. Continued reinforcement regarding importance of attending support groups should be disseminated by all team members. The stronger the recommendation, the greater the participation [88]. The support group facilitator should be skilled and enthusiastic and set a positive tone to stimulate good group dynamics, keeping patients engaged and wanting to attend.

The use of the internet for social support can be beneficial. Research shows that online support groups, including social media, can provide a solution for those patients who cannot travel to attend live support group sessions or have concerns for confidentiality. Research shows that patients who attend online support groups have a greater sense of positive disinhibition, personal empowerment, and an increased sense of control and self-confidence and develop social relationships that assist with making appropriate decisions [89].

Conclusion

Bariatric surgery is the most effective treatment for severe and complex obesity. Patients with obesity have a high prevalence of nutritional deficiencies which may increase following bariatric surgery. Research shows that patients with obesity have many nutrient deficiencies; if not treated and corrected preoperatively, these deficiencies will increase in severity and may cause additional deficiencies after surgery. Postoperatively, patients need support with food and texture reintroduction and advice on appropriate vitamin and mineral supplementation. The dietitian, specializing in bariatric surgery, has a critical and integral role in assessing, monitoring, and supporting patients pre- and postoperatively. The skilled dietitian supports patients with behavioural and lifestyle changes necessary for optimal results and facilitating weight maintenance. After the first 2 years, lifelong annual dietetic and nutritional reviews are recommended, but the challenge remains as to how these will be delivered or funded.

Compliance with Ethical Standards

Conflict of Interest Lillian Craggs-Dino is on Scientific Advisory Board for Bariatric Fusion, LCC.

Julie Parrott declares that she has no conflict of interest.

Silvia Leite Faria declares that she has no conflict of interest.

Mary O'Kane declares that she has no conflict of interest.

Human and Animal Rights All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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- Of importance
- Of major importance

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