

Nutritional Recommendations for Adult Bariatric Surgery Patients: Clinical Practice^{1,2}

Shiri Sherf Dagan,^{3,4,11} Ariela Goldenshluger,^{3,6,11} Inbal Globus,^{3,7} Chaya Schweiger,^{3,8,9} Yafit Kessler,^{3,5} Galit Kowen Sandbank,^{3,7} Tair Ben-Porat,^{3,6,12} and Tali Sinai^{3,10,12*}

³The Israel Dietetic Association, Herzliya, Israel; ⁴Department of Nutrition, and ⁵The Israeli Center for Bariatric Surgery of Assia Medical Group, Assuta Medical Center, Tel Aviv, Israel; ⁶Department of Nutrition, Hadassah-Hebrew University Medical Center, Jerusalem, Israel; ⁷Maccabi Healthcare Services, Tel-Aviv, Israel; ⁸Herzliya Medical Center, Herzliya, Israel; ⁹Nutrition Service, Rabin Medical Center, Petach Tiqva, Israel; and ¹⁰School of Nutritional Sciences, The Hebrew University of Jerusalem, Rehovot, Israel

ABSTRACT

Bariatric surgery is currently the most effective treatment for morbid obesity and its associated metabolic complications. To ensure long-term postoperative success, patients must be prepared to adopt comprehensive lifestyle changes. This review summarizes the current evidence and expert opinions with regard to nutritional care in the perioperative and long-term postoperative periods. A literature search was performed with the use of different lines of searches for narrative reviews. Nutritional recommendations are divided into 3 main sections: 1) presurgery nutritional evaluation and presurgery diet and supplementation; 2) postsurgery diet progression, eating-related behaviors, and nutritional therapy for common gastrointestinal symptoms; and 3) recommendations for lifelong supplementation and advice for nutritional follow-up. We recognize the need for uniform, evidence-based nutritional guidelines for bariatric patients and summarize recommendations with the aim of optimizing long-term success and preventing complications. *Adv Nutr* 2017;8:382–94.

Keywords: obesity, bariatric surgery, nutrition care, eating-related behaviors, dietary supplements

Introduction

Obesity is a major public health burden of pandemic proportions (1). Overall, ~13% of the world's adult population (>600 million people) were categorized as obese in 2014 (2). Bariatric surgery is currently the most effective treatment modality for morbid obesity when compared with nonsurgical interventions (3). The main benefits of this procedure include prolonged weight loss and improved obesity-associated comorbidities and quality of life (4). In 1991, the NIH set eligibility criteria for bariatric surgery, which included a BMI (kg/m^2) ≥ 40 without coexisting medical problems or a BMI ≥ 35 with ≥ 1 severe obesity-related comorbidities, including type 2 diabetes, hypertension, hyperlipidemia, and obstructive sleep apnea (5). Several surgical

procedures are currently available: laparoscopic adjustable gastric banding (LAGB)¹³, laparoscopic sleeve gastrectomy (LSG), laparoscopic Roux-en-Y gastric bypass (RYGB), laparoscopic biliopancreatic diversion with (BPD-DS) or without (BPD) duodenal switch (5), and single-anastomosis gastric bypass (6). Laparoscopic bariatric surgery has been performed since the 1990s and has quickly surpassed open surgery in popularity due to its substantially lower risk of wound infection, incisional hernia (7), venous thromboembolism (8), and pulmonary complications (9). The underlying mechanisms of the beneficial effects of bariatric surgery are complex and include changes in gastrointestinal anatomy and motility (10), changes in diet and behavior, gut hormones [e.g., ghrelin, glucagon-like peptide 1, and peptide YY], bile acid flow, and gut bacteria (11).

In the past several years, there has been a dramatic decrease in the popularity of LAGB due to disappointing long-term outcomes and high reoperation rates secondary to complications (e.g., slippage, pouch dilatation, dysphagia, and erosion). Meanwhile, LSG has gained in popularity (12). The total number of bariatric procedures performed worldwide in 2013 was 468,609; 45% were RYGB surgeries, 37% LSG, and 10% LAGB (1). No other single procedure

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¹¹These authors are co-first authors.

¹²These authors are co-senior authors.

*To whom correspondence should be addressed. E-mail: tali.sinai@mail.huji.ac.il.

¹³Abbreviations used: BPD, laparoscopic biliopancreatic diversion; BPD-DS, laparoscopic biliopancreatic diversion with duodenal switch; DS, dumping syndrome; LAGB, laparoscopic adjustable gastric banding; LSG, laparoscopic sleeve gastrectomy; RYGB, laparoscopic Roux-en-Y gastric bypass; SIBO, small intestinal bacterial overgrowth.

exceeded the threshold of 2.5% (1). In Israel, almost 9000 people with morbid obesity underwent bariatric surgery in 2014 and LSG was the most common procedure (13). Currently, the greatest number of bariatric procedures as a function of total population (0.14%) have been performed in Israel (1).

Dietitians play a vital role in the multidisciplinary team before and after bariatric surgery. Previous studies have shown that adherence to a regular nutritional follow-up contributes to weight reduction postsurgery (14, 15) and prevents weight regain (16). However, this association remains controversial (17, 18). The aim of this narrative review was to summarize the current scientific literature and to present a protocol for nutrition care in bariatric patients to enhance quality of care, set uniform guidelines, and ensure safe practice.

Literature Search

A literature search was performed for the present study on different lines of searches for narrative reviews. The search included 3 electronic databases—PubMed, Google Scholar, and the Cochrane Library—and articles published up to 2016 were selected. Combinations of key words such as “bariatric surgery,” “obesity surgery,” “nutrition care,” “supplements,” and “postoperative follow up” were used. The lists of the articles obtained were manually searched for additional references. The inclusion criteria consisted of all types of articles related only to humans. The exclusion criteria included articles for which the full text was not available or that were not in English or Hebrew. When there were insufficient data to provide definitive recommendations, we based the recommendation, on the unanimous agreement of 15 members of the Israel Dietetic Association who have had ≥ 5 y of experience in the bariatric surgery nutrition field.

Current Status of Knowledge

Presurgery nutritional care

Nutritional evaluation. When a candidate meets the NIH consensus criteria for bariatric surgery, assessment is carried out by a multidisciplinary team with regard to the suitability of the candidate (5). Proper candidate selection, adequate nutritional assessment, and behavioral dietary guidance are essential in preparing for surgery and are key in achieving optimal surgical outcomes (19, 20). To date, there are no evidence-based or uniform protocols for choosing the most appropriate type of bariatric surgery. For the most part, the type of surgery chosen is determined by the patient’s request together with the surgeon’s experience, taking into consideration existing comorbidities (21). Surgeons should take extra caution when recommending the BPD procedure to their patients due to the greater nutritional risks related to the large malabsorptive component (5).

Most nutritional evaluations involve a clinical interview that includes many topics related to the surgery to assess bariatric knowledge, surgery expectations, eating behaviors (e.g., number and types of meals per day, liquid intake), and eating patterns (e.g., grazing, binge eating). Weight-

management history includes the onset of obesity, family history of obesity, previous weight-loss regimens, and physical activity habits. As part of the preoperative preparation, patients are presented with dietary recommendations for the pre- and postsurgery periods (22–24). In addition, psychosocial assessment is conducted to assess mood, social and family support, substance use, cognitive function, psychosocial status, motivation, and willingness to undertake behavioral changes (19, 24). It is advised to determine the patients’ awareness and understanding of the planned operation, potential operational risks, postoperative adverse effects and benefits, and lifestyle changes required to achieve the most favorable outcomes (21).

Weight-loss expectations should be discussed presurgery, and they should be pertinent to the reported average excess weight loss after each procedure (19, 25). Unrealistic expectations of weight loss are prevalent in obese patients and can negatively affect their adherence to dietary and health goals (26). In addition, patients should be encouraged to consider other benefits of the surgery beyond weight loss, including substantial improvement in obesity-related comorbidities and quality of life.

Preoperative weight management. Before bariatric surgery, a supervised weight-management program, including a low-calorie diet, is recommended. However, success in preoperative weight loss should not be a condition for approving surgery (23). Studies have found a positive correlation between preoperative and postoperative weight loss (27–29). A large-scale study based on data from the Scandinavian Obesity Registry showed that weight loss of 9.5% before RYGB was associated with a marked reduction in important postoperative complications, such as anastomotic leakage, deep infection or abscess, and minor wound complications. These findings were even more significant in patients with BMIs >45.8 (30). However, even more modest preoperative weight loss has been associated with surgical advantages, such as shortening the time of the surgery (31). Preoperative weight loss leads to an improved glycemic state before surgery (32). Given the known correlation between preoperative hyperglycemia and postoperative complications, this finding is highly relevant (32). Weight reduction before surgery also provides a protective effect in patients who suffer from nonalcoholic fatty liver disease, who represent 90% of patients with morbid obesity (33). These patients present an enlarged left lobe of the liver that may disturb the visual field of the surgeon and that is particularly susceptible to bleeding (34).

To date, there is no consensus with regard to the recommended duration of preoperative diet and its macronutrient composition (22, 35, 36). When several preoperative diets were compared, a “low-carbohydrate diet” was found to be more effective than a “low-fat diet” with regard to short-term weight loss, improvement in insulin sensitivity, and reduction in lipid concentrations. The former diet showed a positive effect, especially in patients with metabolic syndrome or nonalcoholic fatty liver disease (37–39).

The “very-low-calorie diet,” which includes a total of 450–800 kcal/d was related to a 10% preoperative weight loss, a 9% reduction in BMI, and a 15–20% reduction in liver volume (36). It was also found to be a positive factor for improving cardiovascular risk factors in diabetic patients (32). However, the use of a very-low-calorie diet as a sole method for multiple weeks may induce a catabolic state, which could potentially harm recovery after surgery (40).

According to the American Society for Metabolic and Bariatric Surgery, the maximum length of a preoperative diet is 3 mo in order to maintain high compliance rates among patients. A longer period may decrease motivation. The specific dietary components should be tailored for each patient by the bariatric medical team (35). Recommendations for the duration of the diet range from 2 to 6 wk for the primary aim of reducing liver volume (36, 40–42) but also to reduce visceral adipose tissue before surgery (36). Despite the proven short-term benefits of preoperative weight loss, the evidence on long-term outcomes is still inconclusive (27–29).

Supplementation to prevent nutritional deficiencies. The causes of nutritional deficiencies in obesity are multifactorial and include the following: high intake of calorically dense foods with low nutritional quality (43, 44), limited bioavailability of some nutrients (e.g., vitamin D) (45), chronic inflammation status that affects iron metabolism, and small intestinal bacterial overgrowth (SIBO), which can lead to deficiencies in some vitamins (e.g., thiamin, vitamin B-12, and fat-soluble vitamins) (44). The most common preoperative deficiencies found in studies include vitamin B-12, iron, folic acid, vitamin D, and thiamin (46–52). This evidence supports the need to identify and correct preoperative nutritional deficiencies as part of the comprehensive preoperative evaluation (5). Impaired presurgery nutritional status is found to be related to postoperative nutritional deficiencies as well and is associated with metabolic complications (4, 53). Therefore, daily multivitamin supplementation is recommended during the preoperative diet (23). The management of specific nutritional deficiencies is described in detail in the section entitled “Lifelong vitamin and mineral supplementation” section and in **Table 1**.

Short-term nutritional recommendations

Postsurgery diet progression. Postoperative dietary recommendations are based on gradual progression in food consistency and texture over 1 to 2 mo (54). Patients are instructed to begin with clear liquids at room temperature for 24–48 h postsurgery, increasing the volume gradually to reach ≥ 8 cups/d (~ 2 L). In addition, they should drink liquids in small portions as tolerated, with no more than a half cup per serving. Patients can add liquid foods, such as milk, soy drinks, and plain yogurt, at 3–7 d postsurgery. At 1 to 2 wk postsurgery, patients are advised to progress to a mashed or puréed diet. They are instructed to begin with smooth foods and slowly progress to less homogeneous

mashed foods. During this phase, it is recommended to separate liquids from solids by avoiding drinking beverages 15 min before or 30 min after eating. At 2 wk postsurgery, patients can add soft food to their diet, such as soft meatballs; scrambled or boiled eggs; cooked, peeled vegetables; and soft peeled fruit. They can also add crackers to their diet. One month postsurgery, patients are instructed to add solid foods, including legumes, fresh vegetables, fresh fruit, and bread. At 2 mo postsurgery, patients may consume a regular balanced solid diet (54–58). It is recommended that patients progress to solid foods, because this encourages greater satiety and enhanced nutritional composition. Special attention must be given to patients who hesitate to progress to solid foods postoperatively for fear of gaining weight, pain, nausea, or vomiting (59). Given the high variability among patients with regard to their eating progression, individual consultations with a bariatric dietitian are necessary (57).

Recommended macronutrient composition after surgery.

Protein deficiency (serum albumin < 3.5 mg/dL) remains the most severe macronutrient complication associated with malabsorptive surgical procedures, usually occurring in the first months after malabsorptive procedures (i.e., BPD and distal RYGB), and is generally attributed to the acquired food intolerance for protein-rich foods (60). The clinical manifestations of protein deficiency include hair loss, peripheral edema, poor wound healing, and loss of lean body mass (61). The protein intake requirement after surgery is 60–80 g/d or 1.1–1.5 g/kg of ideal body weight (i.e., BMI = 25) and increases to 90–120 g/d after BPD/BPD-DS (5, 44, 57, 58, 60, 62, 63). To achieve these recommendations, protein-rich foods (e.g., dairy products, eggs, fish, lean meat, soy products, and legumes) should be preferred over foods rich in carbohydrates or fats (61, 64). The quality of the protein source is also very important, particularly with respect to the quantity of leucine, which helps maintain lean tissue (61). The leucine content of foods varies markedly, but some foods are naturally high in leucine, including soy products, eggs, meat, lentils, and hard cheese (65). If a protein supplement is indicated, whey protein is probably the best choice for increasing leucine consumption (61).

Observational studies have shown that macronutrient intake, post-LSG and -RYGB surgeries, ranges from 35% to 48% carbohydrate and 37–42% fat (66–68). The avoidance of simple carbohydrates is recommended and the consumption of foods rich in dietary fibers should be increased. The consumption of simple carbohydrates may lead to dumping syndrome (DS), and fiber-rich foods, such as fruit, vegetables, and whole grains, should be consumed from 1 mo postsurgery to enable adequate weight loss and to enhance healthy eating (44, 58). Recommendations for fat intake after bariatric surgery are similar to those for the general population (62). The role of the dietitian is to estimate the amount of macronutrients consumed, construct a balanced diet, and advise the patient on needed behavioral changes. The dietitian should

TABLE 1 Supplementation for the prevention and treatment of nutritional deficiencies¹

Vitamins and minerals	Routine supplementation for deficiency prevention	Treatment for deficiency
Multivitamin-mineral	Two adult multivitamin-mineral supplements/d (only 1 supplement/d is required after LAGB) containing iron, folic acid, zinc, copper, selenium, and thiamin (200% of the RDA)	—
Calcium citrate	600-mg Ca supplement/d (1200 mg/d after BPD) or more ²	—
Vitamin D	3000 IU/d [as ergocalciferol (vitamin D ₂), or cholecalciferol (vitamin D ₃)]; titration should be done to reach normal concentrations of 30 ng/mL	50,000 IU vitamin D ₂ or D ₃ 1 time/wk for 8 wk, followed by maintenance therapy of 1500–2000 IU/d to achieve normal concentrations
Iron ³	45–60 mg elemental Fe/d from multivitamin and supplements (after LAGB, iron supplementation is necessary if iron intake from food is insufficient)	150–200 mg elemental Fe supplements/d
Vitamin B-12	250–350 µg/d or 1000 µg/wk sublingual, 1000 µg/mo i.m., or 3000 µg every 6 mo i.m. after RYGB and BPD After LSG or LAGB, the use of vitamin B-12 supplements should be considered as needed to maintain vitamin B-12 concentrations and should be included in the multivitamin supplement	1000–2000 µg/d sublingual Intramuscular or subcutaneous vitamin B-12 is necessary when oral therapy does not repair deficiency
Thiamin	DRI for thiamin should be included in the routine multivitamin supplement	500 mg thiamin/d i.v. for 3–5 d, then 250 mg/d for 3–5 d or until the symptoms disappear and then further treatment by oral administration of 100 mg/d as needed
Folic acid	400 µg/d should be included in the routine multivitamin; pregnant women or those planning to conceive should take 800–1000 µg folic acid/d included in a multivitamin supplement or separately	1000 µg folic acid/d
Fat-soluble vitamins (A, K, and E) ⁴	6000 IU vitamin A should be included in the routine multivitamin; for pregnant women or those planning to conceive, the β-carotene form of vitamin A is preferred over retinol After BPD: 10,000 IU vitamin A/d, 300 µg vitamin K/d, and 400 IU vitamin E/d (included in a multivitamin or separately)	Vitamin A deficiency without corneal changes: 10,000–25,000 IU/d orally to achieve clinical improvement When changes in the cornea appear, 50,000–100,000 IU i.m. for 3 d followed by 50,000 IU/d for 2 wk i.m. is recommended Vitamin K deficiency: 10 mg i.m. or submuscular, followed by 1–2 mg/wk parenterally or orally Vitamin E deficiency: 800–1200 IU/d to reach normal serum concentrations
Zinc	The routine daily multivitamin should contain 15 mg/d ≥1 mg Cu per 8–15 mg Zn to prevent copper deficiency is recommended	60 mg Zn 2 times/d
Copper	The routine daily multivitamin should contain 2 mg Cu	Severe deficiency requires 2–4 mg Cu/d i.v. for 6 d
Vitamin C	The routine daily multivitamin should follow the DRI recommendation for vitamin C	100 mg vitamin C 3 times/d or 500 mg/d for 1 mo

¹ Supplements are administered once daily and orally unless stated otherwise. BPD, laparoscopic biliopancreatic diversion; LAGB, laparoscopic adjustable gastric banding; LSG, laparoscopic sleeve gastrectomy; RYGB, laparoscopic Roux-en-Y gastric bypass.

² Daily intake of calcium from food and supplements should reach 1200–1500 mg/d (1800–2400 after BPD). Single doses should not exceed 600 mg and should be separated by ≥2-h intervals from iron supplements or a multivitamin that contains iron.

³ Women of childbearing age or at increased risk of anemia should consume 50–100 mg elemental Fe/d.

⁴ Patients should begin taking fat-soluble vitamin supplements 2–4 wk after surgery.

also indicate if the patient is at risk of developing protein deficiency and provide a tailored list of high-protein foods and/or protein supplementation as needed.

Various favorable eating-related behaviors. Recommended eating behaviors include taking small bites, dividing food intake into 4–6 meals throughout the day, chewing well in a relaxed manner, and ending meals when feeling “comfortably full.” It is advised to eat balanced meals with a high protein content to reach the recommended daily protein intake. Solid foods should be preferred, because this helps provide greater satiety. Instructions should be given to

reduce the consumption of high-calorie–dense foods and beverages (e.g., smoothies, ice cream, milkshakes, juices, chocolate, cream cakes, cookies) and to limit added sugar to avoid DS. Carbonated beverages should also be avoided. Liquids and solids should be separated by drinking 15 min before or 30 min after meals (54, 59, 62, 69, 70). Patients after bariatric surgery are prone to phytobezoar formation due to reduced gastric motility (71), loss of pyloric function, and hypoacidity (72). Currently, case reports of bezoar complications are available only after RYGB and LAGB surgeries (73–79). Nutritional counseling on bezoar formation and the prevention of recurrence after bariatric

surgery should emphasize changing eating habits, including sufficient drinking and chewing (80, 81), as well as avoiding overindulging in foods with a high fiber content (73, 82), especially citrus pith and persimmons (83–86). Finally, daily intakes of vitamin and mineral supplements must be maintained (5) (Table 2). Special attention should be paid to grazing, which is considered an undesirable, negative eating pattern. The term “grazing” is frequently derived from “Western life” circumstances (e.g., eating when stressed or bored, eating while watching television or working on the computer) (59). It is well established that a grazing pattern of eating behavior after surgery reduces the long-term surgical success (59). Eating disorders are another highly important issue to be addressed by a dietitian, because they may emerge or re-emerge postsurgery and compromise surgery outcomes (59, 87, 88). However, this topic is beyond the scope of this review.

Nutritional therapy options for common gastrointestinal symptoms. Gastrointestinal symptoms are very common after bariatric surgery, although most of these can be managed effectively with proper nutritional treatment. Prevention and treatment methods of common gastrointestinal symptoms after bariatric surgery are presented in Table 3.

DS. DS represents a group of early and late gastrointestinal, vasomotor, or hypoglycemic symptoms occurring after sugar-rich or hyperosmotic food consumption in some patients who have undergone gastric surgery. DS develops largely after RYGB, with prevalences ranging from 40% to 76% (58, 89). Early DS is also seen in up to 30% of LSG patients when stimulated with an oral-glucose challenge (58, 89). DS symptoms will usually resolve spontaneously in 18–24 mo postsurgery (58, 90, 91).

Early DS usually occurs 30 to 60 min postprandially, and it can last for 60 min. Early DS occurs as a result of a rapid gastric emptying and the delivery of energy-dense foods to the small bowel followed by a shift of intravascular fluid to the intestinal lumen. This results in cardiovascular symptoms and the release of gastrointestinal and pancreatic hormones (58, 92). Symptoms include abdominal pain, diarrhea, nausea, dizziness, flushing, palpitations, tachycardia, and hypotension (58, 92). Late DS appears 1–3 h after a meal and is related to reactive hypoglycemia.

Symptoms include sweating, tremor, hunger, and confusion up to syncope (21, 58). The first line of treatment is to introduce dietary measures (21, 92). General nutritional recommendations to treat DS include the avoidance of refined carbohydrates (21, 58, 90); increased intakes of protein, fiber, and complex carbohydrates; and separation between liquids and solids for ≥ 30 min (21, 58). Patients who suffer from postprandial hypoglycemia, refractory to the standard nutritional recommendations for DS, should be referred to an endocrinologist. Usually, they are told to consume small amounts of sugar in the first postprandial hour (e.g., half cup of juice, containing 10 g sugar). The use of somatostatin or acarbose to relieve symptoms should also be considered (21, 90).

Diarrhea and flatulence. Diarrhea is reported in up to 40% of patients after bariatric surgery (21). Patients after BPD-DS are especially prone to this adverse event. Symptoms usually involve 2 to 3 soft bowel movements/d, but some patients will have as many as 10–20 daily bowel movements (90). Some patients also suffer from steatorrhea as a result of fat malabsorption, which may lead to deficiencies in fat-soluble vitamins, zinc, copper, and magnesium (23, 58, 90). The nutritional treatment for diarrhea should focus on increased water intake and reduced dietary intake of lactose, fat, and fiber (90). The frequency of flatulence is higher after procedures that lead to malabsorption (93). Supplementation with probiotics, loperamide, and bile chelators (90) or pancreatic enzymes may aid in decreasing flatulence as well (94). Strategies exist to help reduce flatulence postsurgery. These include swallowing and eating slowly, the avoidance of chewing gum, and the elimination of gas-producing foods such as cauliflower and legumes (95).

Risk factors for SIBO include a decrease in gastric acid secretion and a decline in intestinal motility, both of which may occur after bariatric surgery (96), which also is more common after malabsorptive procedures (97). In the case of SIBO, treatment remains empirical and generally broad-spectrum antibiotics are recommended for 2 wk (rifaximin, ciprofloxacin, amoxicillin, etc.) (98). When patients suffer from extremely watery diarrhea, foul flatus, and abdominal cramping, *Clostridium difficile* colitis or antibiotic-associated diarrhea should be ruled out (90). In BPD-DS patients who suffer long term from chronic diarrhea or excessive flatus

TABLE 2 Nutritional recommendations after bariatric surgery

Topics	Recommendations
Eating habits	Plan and arrange frequent small meals throughout the day (4–6 meals/d, according to the postoperational stage) Eat slowly and methodically chew your food Avoid foods that can form phytobezoars, such as persimmons and citrus fruit pith
Fluid intake	Drink sufficient amounts of fluids to maintain adequate hydration (≥ 1.5 L/d) Separate liquids from solids; it is advised to abstain from drinking 15 min before a meal and/or 30 min after the meal Avoid carbonated beverages
Prevent nutritional deficiencies	Eat an adequate amount of protein Make an effort to eat a balanced diet and limit consumption of calorie-dense food and drinks (e.g., milkshakes, ice cream, cakes, and cookies) Take appropriate dietary supplements for life

TABLE 3 Prevention and treatment of common gastrointestinal symptoms after bariatric surgery

Symptom	Guidelines
Early dumping syndrome	Avoid simple sugars and foods that have a high glycemic index Combine complex carbohydrates, protein, and fiber in meals Separate liquids from solid foods; a 30-min interval is recommended
Late dumping syndrome	Add 1 serving sugar/h after meals; one-half cup of fruit juice containing ~10 g sugar is a good option
Diarrhea and flatulence	Prefer low-lactose or lactose-free milk Reduce fat consumption; customize menus Ensure adequate fluid intake In acute cases, consider drug therapy [i.e., Imodium (Janssen Cilag)], and/or probiotics Eat slowly For flatulence, avoid chewing gum and gas-producing foods
Constipation	Increase liquid consumption: hot and cold drinks in a variety of flavors; avoid carbonated and sugar-sweetened beverages Increase consumption of foods rich in fiber, such as fruit, vegetables, and whole grains If there is no improvement, supplements or medications should be considered
Dysphagia	Ensure thorough mastication (chewing ≥ 15 times/bite) and eat slowly (wait a minute between swallows) Avoid hard and dry foods, such as toast or overcooked meat If dysphagia occurs, discontinue eating to prevent regurgitation
Vomiting	Take small bites, chew thoroughly and eat slowly with a meal duration of ≥ 15 min Separate liquids from solids Eat meals at intervals of ≥ 2 –4 h Do not limit foods associated with vomiting; it is worthwhile to reintroduce them over time Thiamin supplements in case of persistent vomiting Monitor hydration and blood electrolytes
Food intolerance	Patient education and raising awareness of the phenomenon Adhere to the nutritional recommendations after surgery In cases of food avoidance, it is important to attempt to provide a balanced menu and, if necessary, use dietary supplements to prevent nutritional deficiencies
Dehydration	Consume ≥ 1.5 L liquids/d Increase fluid intake, when needed, in cases of intense exercise, diarrhea and vomiting, pregnancy, fever, kidney disease, and fasting Encourage liquid consumption by varying beverage temperatures and varying flavors, such as adding herbs, lemon, etc.; avoid carbonated and sugar-sweetened beverages

and do not respond to any of the above treatment options, surgical intervention should be considered (90).

Constipation. Constipation is a common side effect after LAGB, LSG, and RYGB and is rarely seen post-BPD (90). Its prevalence after bariatric procedures ranges between 7% and 39% (99). The etiology includes insufficient fluid intake in the postoperative diet, the use of vitamin and mineral supplements such as calcium and iron, and the use of narcotics as postoperative analgesics (90). Nutritional treatment should focus on higher consumption of water or noncarbonated sugary drinks and dietary fibers found in fruit, vegetables, and whole-grain cereals (90).

Dysphagia. Dysphagia, or difficulty in swallowing, is associated with feeling pressure in the chest or tightness in the throat. It occurs mostly in post-restrictive bariatric surgeries and is related to overeating, rapid eating, and insufficient chewing (90). When dysphagia occurs, patients should be instructed to discontinue eating to prevent regurgitation and vomiting. The nutritional approach should focus on slowing the pace of eating, prolonged chewing (≥ 15 “chews” per bite), and avoiding dry foods such as doughy bread, overcooked steak, and dry chicken breast (90).

LAGB patients should progress gradually with regard to food texture to avoid dysphagia after band adjustment. If symptoms remain, band opening should be considered.

Patients after RYGB who suffer from severe dysphagia 4–6 wk postsurgery should be evaluated for a possible anastomotic stricture (90). Dysphagia post-LSG may be a result of gastric stenosis (100).

Vomiting. Vomiting is reported in 30–60% of patients after bariatric surgeries (58), most of them during the first postoperative months, and is related to inappropriate eating behaviors (58, 101). In the case of vomiting after eating a specific food, it is recommended to reintroduce the food in the future, when the patient has acquired new nutritional skills. Refractory vomiting despite compliance to nutritional recommendations may indicate a surgical complication, such as band slippage, esophageal stricture, bowel obstruction, reflux, and gastric ulcers (101). In the case of LAGB patients, band opening may be helpful (102). When vomiting persists for >2 –3 wk, thiamin supplementation should be taken to prevent neurological side effects (103, 104). Adequate and prolonged hydration maintenance is highly important as well (105).

Food intolerance. Food tolerance is defined as the ability to consume a variety of foods without difficulty, and with minimal regurgitation or vomiting (106). Food intolerance mainly presents in the early postoperative phase (107–109) and tends to improve over time (107, 108). Patients post-LAGB more frequently suffer from food intolerance than

do patients after other bariatric procedures (108, 109). Persistent food intolerance may lead to food avoidance, nutritional deficiencies (90, 107, 109), and maladaptive eating behaviors (59, 109), such as the consumption of soft or semiliquid, and high-calorie–dense foods, which may contribute to surgery failure (106, 108).

To date, there are no official clinical recommendations for treating food intolerance. On the basis of our clinical experience, the dietitian should try to prevent this phenomenon by raising awareness among patients. We suggest providing information with regard to adequate eating and chewing and the ingestion of small quantities at each meal.

Dehydration. One-third of all postoperative bariatric emergency room visits within a 3-mo period postsurgery are related to dehydration (110). Dehydration can occur in the early stages after surgery when patients find it difficult to maintain an adequate fluid intake (23). The main causes of dehydration include vomiting, reduced food intake, mechanical liquid intake limitation (111), and reduction in water intake due to taste changes. Behavioral reasons may also explain this phenomenon, such as the need to separate liquids from solid foods (112), a reduction in sweet drinks, and the avoidance of carbonated beverages. The consumption of 1.5 L liquids/d is recommended to maintain adequate hydration (5). Equally important is to increase awareness of adequate hydration, which is of great importance in cases of exercise, diarrhea, vomiting (113), pregnancy (114), fever, and fasting (115).

Long-term dietary and lifestyle recommendations

Dietary treatment after bariatric surgery covers not only nutritional recommendations but numerous aspects related to promoting a healthy lifestyle such as physical activity, alcohol consumption, smoking, and fasting. In addition, self-monitoring by regular weight checks and food diaries are recommended to prevent weight regain.

Physical activity. Physical activity has an impact on weight loss and long-term weight maintenance (105, 116–118). It can prevent muscle depletion during the drastic weight reduction, help maintain bone mass, increase the metabolism rate, and is related to having a good mood (119). Before beginning to exercise, it is necessary for the patient to receive medical authorization. Bariatric patients should conduct aerobic exercise for 150 min/wk, with a long-term goal of 300 min/wk. It is also recommended to add strength-training 2–3 times/wk (5, 120). Proper hydration is required during exercise (5).

Smoking. Despite the lack of specific evidence with regard to smoking habits and bariatric surgery, there is an indisputable universal recommendation to avoid smoking and tobacco products. This appears to be particularly important in bariatric patients due to an increased risk of delayed surgical wound healing, postoperative marginal ulceration, and

general health (121, 122). Smokers who are bariatric surgery candidates should be advised to stop smoking as early as possible before the surgery (123).

Alcohol consumption. Active alcohol use disorder is considered a contraindication to bariatric surgery (5). It is recommended to avoid or reduce the amount of alcohol consumption after RYGB due to accelerated alcohol absorption (124), higher maximum alcohol concentration (124–126), longer times to eliminate alcohol (125, 126), and an increased risk of the development of alcohol use disorder (127). The data are less clear with regard to altered pharmacokinetics after LSG, and there is no evidence that alcohol absorption is affected by LAGB (127, 128).

Excessive alcohol consumption may affect weight loss as a result of greater caloric intake (129) and cause some nutritional deficiencies, especially of B vitamins (5, 125, 130). Patients who would like to drink alcohol should be advised to eat 15–30 min before alcohol intake. In cases of frequent alcohol consumption, a daily B-complex supplement is recommended (5).

Fasting. Fasting is a tradition that is common in many religions. Complete fasting after bariatric surgery requires special attention due to the risk of dehydration and vomiting and difficulty in proper feeding regulation immediately after the fast (115). Complete fasting should be avoided 12–18 mo after bariatric surgery. After this period, the risk of vomiting decreases. Therefore, healthy patients are allowed to partake in ritual fasting as long as they are properly hydrated before fasting (131).

Pregnancy after bariatric surgery

The optimal timing to conceive after bariatric surgery is inconclusive. The literature in this field is largely based on case-control studies with small sample sizes (132). However, there is a consensus that women should wait 12–18 mo after surgery before getting pregnant (5, 60, 133). Recent studies state that the preferred timing of pregnancy should not be calculated according to the elapsed time from surgery but only after achieving proper nutritional balance (134). Pregnancy after bariatric surgery should be considered as a high-risk pregnancy (132, 133) due to the surgery's associated risk of preterm birth (135), shortened gestation (136), small-for-gestational-age birth (137), and gastrointestinal surgery-related complications such as bowel obstruction, gastric ulcer, and gastric band complications (138, 139). Nutritional deficiencies during pregnancy after bariatric surgery may be caused by the limitation of food intake (140), nausea, and vomiting. The lack of appropriate nutrition can seriously jeopardize pregnancy (138).

Postoperative pregnancy requires follow-up by a multidisciplinary team, including a specialist in bariatric surgery and a dietitian (132, 133). The frequency of nutritional follow-up during pregnancy should be at least once in every trimester (5).

Pregnant women who undergo bariatric surgery should be monitored for appropriate weight gain, nutritional deficiencies, nutritional supplementation, and adequate intakes of protein and fluids. Women who undergo LAGB should have band adjustments as necessary to achieve an appropriate weight gain for fetal health and development (5, 136).

Iron, vitamin A, vitamin K, vitamin B-12, and folic acid deficiencies were found to be related to maternal complications such as severe anemia and to fetal impairments such as neural tube defects, intrauterine growth restriction, SGA, and failure to thrive (133, 137, 141). For these reasons, micronutrient adjustment is crucial during the preconception period and pregnancy. The nutritional assessment should focus especially on folic acid, vitamin B-12, iron, calcium, and fat-soluble vitamins (5). For women of reproductive age, those who are planning to conceive, or those during pregnancy, it is recommended to continue vitamin supplementation as recommended for bariatric patients with some adaptations (Table 1).

Concerns have arisen with regard to breastfeeding in mothers who have undergone bariatric surgery (142). Case reports have been published on severe vitamin B-12 deficiency in exclusively breastfed infants born to mothers who underwent RYGB and who were found to have low vitamin B-12 concentrations (143–145). An additional study reported unchanged or slightly higher calorie density in breast milk in postsurgical mothers compared with nonsurgical mothers. However, further studies on specific micronutrients are required before breastfeeding can safely be advised in postsurgical lactating women (142).

Lifelong vitamin and mineral supplementation

Nutritional deficiencies after bariatric surgery are common (5, 44, 47, 119) and are affected by the type of surgery performed. Deficiencies are more prevalent after malabsorptive surgery (BPD, RYGB, and single-anastomosis gastric bypass) in comparison to restrictive procedures (LSG and LAGB) (58).

Other factors that affect nutritional status are preoperative deficiencies (4, 53), the presence of vomiting or regurgitation, food intolerance, and poor eating patterns (43). In addition, “food urges” or cravings, which are related to weight regain postsurgery, can be exacerbated by nutritional deficiencies, resulting in patients craving essential nutrients (59). Therefore, lifetime supplement intake postsurgery becomes necessary (44) as well as routine vitamin and mineral status screening (64). Supplementation should begin at the time of discharge from the hospital, usually 2–4 d postsurgery (55). Due to changes in absorption capabilities, chewable or suckable pills should be used in the first 3–6 mo. Afterward, oral supplements can be used (5).

Minimal daily nutritional supplementation post-bariatric surgery, according to the procedure, should include 1–2 adult multivitamin-plus-mineral supplements, 1200–2400 mg elemental calcium, ≥ 3000 IU vitamin D (titrated to therapeutic amounts), and 250–350 μg vitamin B-12/d or 1000 μg vitamin B-12/wk (5). Table 1 summarizes general recommendations for routine nutritional supplementation for the prevention

or treatment of deficiencies and also includes specific recommendations for surgery that is malabsorptive in nature (5, 23, 44, 119, 146–149).

Calcium and vitamin D. Calcium absorption is carried out primarily through the proximal jejunum and duodenum and depends on vitamin D concentrations. A comprehensive assessment of calcium status should include monitoring of alkaline phosphates, vitamin D, parathyroid hormone serum concentrations, and urinary calcium. Bariatric patients are at risk of fractures and osteoporosis due to rapid weight loss and absorption changes that occur postoperatively (47) at any time between 8 wk and 32 y after the surgery (150), and the long-term result of calcium or vitamin D deficiency is loss of bone mass and bone metabolism diseases. The accepted adequate vitamin D concentrations are >30 ng/mL (47). Calcium citrate supplements are preferable over calcium carbonate due to their absorption, which is independent of stomach acidity (5, 23).

Thiamin. Thiamin deficiency may appear due to a combination of rapid weight loss, decrease in consumption, and persistent vomiting postoperatively (47). The main risks are neurological, cardiovascular, and metabolic damage (dry beriberi, wet beriberi, and metabolic acidosis) (44). The DRI for thiamin should be included in the routine multivitamin supplementation after surgery for the prevention of deficiency (5). Prophylactic thiamin should be administered to patients with predisposing factors (142).

In cases in which appropriate oral thiamin substitution fails, clinicians should consider the possibility of SIBO (147). In deficiency treatment, glucose should not be given before thiamin repletion due to the risk of deterioration of serum thiamin concentrations (143).

Vitamin B-12. Vitamin B-12 absorption decreases post-bariatric surgery due to changes in hydrochloric acid production and reduced availability of intrinsic factor (47). Neurological symptoms include numbness and tingling of limbs and skin, disrupted coordination, and paralysis in severe cases. Pre- and postsurgical assessment of vitamin B-12 concentrations is required in all bariatric patients (5). Routine vitamin B-12 supplements to prevent deficits are required after RYGB and BPD surgery (44).

Periodic blood tests to identify postoperative deficiencies should be carried out every 6 mo and should be interpreted with caution (58). Deficiencies can occur even when serum concentrations are 300 pmol/L (144). When necessary, additional testing to confirm vitamin B-12 status (i.e., total homocysteine, methylmalonic acid, and holotranscobalamin) may be necessary (144, 145).

Folic acid. Folic acid deficiency may occur due to noncompliance of multivitamin administration, drug interactions, malabsorption, and poor dietary intake (47). It should also be noted that folic acid deficiency is often related to vitamin B-12 deficiency, because the latter plays an important

role in the conversion of inactive methyltetrahydrofolic acid to active tetrahydrofolic acid (44). Folic acid deficiency can cause clinical disorders such as megaloblastic anemia (44). Special attention should be given to pregnant women post-surgery or those planning to conceive due to the relation between this deficiency and growth retardation (44), neural tube defects in the fetus (151), and neurological complications (152).

Vitamin A. Bariatric patients are at risk of vitamin A deficiency, particularly after a BPD procedure, due to limited absorption area, fat malabsorption, and bacterial overgrowth (44, 47). Deficiency may lead to impaired vision, night blindness, corneal dryness, and dry hair (47).

During pregnancy and for those who are planning to conceive, special attention should be given to avoid hypervitaminosis A. Restricting vitamin A intake to 5000 (136) to 10,000 IU/d is advised (153). An excess of retinoic acid was found to be related to an increase in teratogenic risk (136). Therefore, the β -carotene form of vitamin A is preferred over retinol, especially during the first trimester; it is found in several prenatal multivitamins (23).

Vitamins K and E. The absorption of vitamins E and K occurs mainly in the jejunum and ileum. There is not enough evidence to support routine screening for these vitamins post-bariatric surgery (5). Routine supplement intake guidelines for these vitamins have been made specifically for BPD patients due to the risk of malabsorption (119).

Vitamin C. There are limited data with regard to the status of vitamin C in bariatric patients. A daily consumption of ≥ 75 mg for women and 90 mg for men is recommended according to the RDA (5). Vitamin C supplementation should be considered concurrently with iron supplements to improve iron absorption (44, 47).

Trace elements and minerals. Mineral deficiencies have been primarily focused on iron, zinc, and copper, as described below. Selenium is absorbed primarily in the duodenum; therefore, patients after malabsorptive procedures such as RYGB and BPD are at risk of selenium deficiency. The consumption of multivitamin supplements containing a variety of minerals and trace elements such as magnesium, iodine, boron, sulfur, and fluoride is necessary after all bariatric procedures (47).

Iron. Iron deficiency may cause several side effects, including anemia, fatigue, impaired work productivity, and inability to regulate body temperature (23). Iron deficiency anemia is a common long-term problem after bariatric surgeries (23). Iron deficiency may occur due to anatomic changes after surgery, a low tolerance for red meat, reduced acidity in the stomach, the chronic use of drugs to suppress the secretion of gastric acid (47), and (in women) the loss of iron through menstruation (23). The separation of calcium and iron supplements is recommended (47). If iron concentrations

continue to remain low with oral supplementation, intravenous iron is recommended (154).

Zinc. Zinc deficiency induces hair loss, impaired sense of taste, and sexual dysfunction (5). Routine testing for zinc deficiency should be performed after malabsorption procedures (44).

Copper. An increased risk of copper deficiency appears after malabsorptive procedures, as well as in cases of persistent diarrhea (47). In addition, patients who are not concordant with their multivitamins and mineral intake are at risk of developing copper deficiency postsurgery (155). Delays in the diagnosis and treatment of copper deficiency can leave patients with residual neurological disability (155). Routine monitoring is not recommended, and concentrations should be evaluated only in patients with unexplained anemia, neutropenia, myeloneuropathy, or impaired wound healing (5).

The postoperative nutritional follow-up

Long-term weight loss after bariatric surgery requires regular and supportive management by qualified health care professionals (59). Adherence to follow-up is associated with fewer postoperative adverse events, greater excess body weight loss, and fewer comorbidities (156). However, several studies have found that compliance with follow-up after bariatric surgeries is low, with attrition rates ranging from 3% to 63% (156, 157). Digital communication methods, such as social media, telephone consultations, and online educational programs, should be used to increase engagement with patients and to minimize barriers such as time, distance, and cost (59).

It is recommended that the postoperative follow-up be held by a multidisciplinary medical team (13, 59). The follow-ups should include a surgeon, bariatric dietitian, psychologist or social worker (individual or group meetings), and family physician or endocrinologist (13). The recommended schedule for appointments with a bariatric dietitian should include a first meeting 1–2 wk postsurgery, with follow-up visits at 1, 3, 6, 9, and 12 mo postsurgery. After that time, patients should meet with a dietitian ≥ 1 time/y over the long term (5, 64). Weight should be recorded at every appointment (5), and physical activity should be discussed (5, 59, 60, 64). The short-term follow-up visits should focus on the graduated postoperative diet, tailoring of vitamin and mineral supplements (5, 59, 60), and how to deal with common symptoms such as changes in bowel habits, nausea, DS, lactose intolerance, etc. (5, 60).

Blood tests should include complete blood counts, electrolytes, lipid profile, glucose, and liver and kidney functions. Vitamin and mineral status should be assessed every 3 mo in the first postoperative year, every 6 mo in the second year, and then annually (64).

The long-term follow-up visits should include screening for micronutrient deficiencies, bone health, and control of

nutrition-related noncommunicable diseases (5, 13, 60). It is also recommended to reinforce healthy eating habits such as eating slowly, portion control, and meeting protein requirements. Unhealthy habits, such as the consumption of high-calorie liquids, puréed foods, and grazing, should be discouraged (5, 59, 60, 64). In addition, it is important to be aware of the physical side effects, such as maladaptive eating, return of hunger, eating disorders, and excessive skin, which may adversely affect surgery outcomes (59).

Conclusions

The Israel Dietetic Association members recognized the need for bariatric centers to have uniform, evidence-based guidelines and summarized the current scientific literature and expert opinions on the nutritional care of bariatric patients, pre- and postsurgery, in order to optimize long-term success and to prevent nutritional and metabolic complications.

Some important issues after bariatric surgery, such as alcohol consumption, smoking, and bezoar formation, still lack sufficient scientific data. Further research will allow the establishment of specific recommendations with regard to these issues.

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