

Complications and Nutrient Deficiencies after Bariatric Surgery: A general review

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Abstract

Obesity is a major public health problem worldwide; approximately 600 million adults over 18 years old are obese. Changes in the lifestyle including diet and physical activity are main causes of overweight and obesity. Use of management methods including diet, physical activity and behavioral modifications has been found to be disappointing in the excessively obese population with weight regain problem.

Hence, surgery, mainly bariatric surgery, is a choice in case of morbid obesity (where BMI is more than 40 or in case of diabetic patients with BMI of 35 or more). However, the substantial weight loss and improvements in co morbid conditions observed after bariatric surgery are not without health and nutritional risks.

Bariatric procedures produce changes in the gastrointestinal anatomy and physiology, leading to changes in the quantity and quality of diet, which may result in nutrient deficiencies. The most common nutritional concerns following bariatric surgery are deficiencies of iron, vitamin B12, folic acid, vitamin D, calcium, and in some patients thiamin, vitamin A, zinc and selenium. In this review nutrient deficiencies after bariatric surgery are discussed.

Keywords: Nutrient Deficiencies, Bariatric Surgery, Macronutrients, Micronutrient, Obesity

Introduction

Obesity is a major public health concern worldwide [1]. The World Health Organization figures indicate that globally approximately more than 1.9 billion adults, 18 years and older, were overweight. Of those over 600 million were obese in 2014. Obesity is an epidemic in many East Mediterranean region countries including Jordan [2, 3].

In Jordan, several studies on obesity have shown that it seems to be a common metabolic disorder. Based on a study conducted by the Ministry of Health in Jordan, the WHO reported in the Non Communicable Disease Country Profile that 21% of Jordanian males and 35.6% of Jordanian females were obese, with a total of 28.1% from both sexes [4,5]. (Table 1) shows the prevalence of overweight and obesity in selected countries of the world.

Changes in the lifestyle such as diet, exercise, and behavioral therapy for weight loss have been disappointing in the excessively obese population, and weight regain is frequent when using these methods of obesity management [6]. Hence, surgery (including bariatric surgery) has grown in popularity to combat this situation [1]. Bariatric surgery is an option for reduced food intake and subsequent weight reduction in patients with clinically severe obesity, and for patients in whom other methods of treatment have failed [7].

Depending on the surgical procedure, patients can expect to lose between 29% and 87% of excess body weight after 1 to 2 years post-surgery [8].

Bariatric procedures produce changes in the gastrointestinal anatomy and physiology. However, the substantial weight loss and improvements in comorbid conditions observed after bariatric surgery, these surgeries are not without nutritional risks [8-10]. As a consequence, there is a change in the quantity and quality of diet, which may result in nutrient deficiencies [7]. The most common nutritional concerns following bariatric surgery are deficiencies of iron, vitamin B12, folic acid, vitamin D, calcium, and in some patients thiamin, vitamin A, zinc and selenium [10,11]. It is, therefore, critical to do a comprehensive nutrition assessment to screen regularly for nutritional deficiencies in obese patients prior- and post bariatric surgery, and encourage adherence to supplementation [9].

Table 1: Overweight and Obesity Comparable estimates of prevalence of overweight and obesity (population aged 18+ years), 2014 [5].

Country	Females	Males
Saudi Arabia	69.2%	67.5%
United Arab Emirates	70.9%	70.5%

Kuwait	72.8%	74.3%
Bahrain	72.1%	69.2%
Qatar	76.6%	76.6%
Oman	64.0%	58.8%
Syria	58.7%	51.5%
Egypt	66.3%	53.8%
Jordan	66.0%	58.9%
Iraq	57.8%	48.7%
Lebanon	67.6%	67.0%
USA	65.3%	74.1%
UK	62.4%	71.1%
Canada	63.4%	72.0%
Mexico	65.0%	61.6%
Japan	22.8%	30.4%
China	33.6%	37.2%
India	23.9%	19.0%

In this paper, the nutritional status of bariatric surgery patients postoperatively is reviewed with focus on protein & micronutrients deficiencies and the impact of nutritional counseling on these deficiencies.

Definition and Background of Bariatric Surgery

The term “Bariatric Surgery” comes from the Greek words baros—meaning weight and iatrea – meaning medical treatment [12]. The history of surgical treatment for obesity started in the 1950s [13].

The Criteria for Bariatric Surgery

According to the National Institute of Health (NIH) consensus and the established criteria for bariatric surgery as expressed by the International Federation of Surgery for Obesity (IFSO), to be eligible for bariatric surgery a candidate must meet the following criteria:

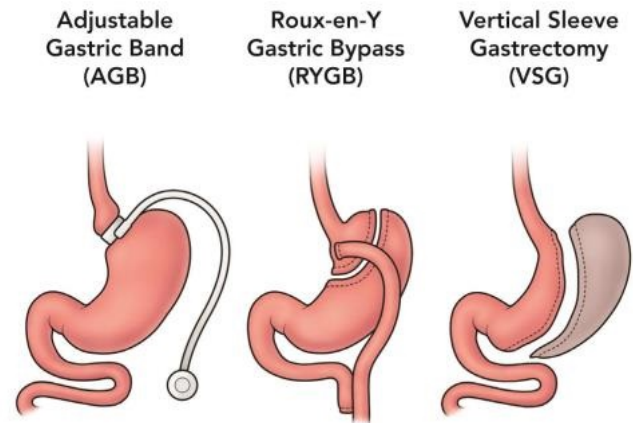
- Patients with a BMI ≥ 40 kg/m²
- Patients with less severe obesity (BMI ≥ 35 kg/m²) if they have high-risk comorbid conditions such as uncontrolled type 2 diabetes mellitus (T2DM) or life threatening cardiopulmonary problems [15-17].

The International Diabetes Federation guidelines state that bariatric surgery should be an accepted option for people who have Type 2 diabetes and BMI of 35 or more, and an alternative treatment option for people with BMI of 30-35 when diabetes cannot be adequately controlled with medical therapies [18,19].

Types of Bariatric Surgery Procedures

Surgical bariatric procedures are traditionally divided into restrictive, malabsorptive, and combined procedures [20, 17].

Restrictive procedures: these procedures simply restrict caloric intake [21]. Weight loss is achieved solely by reduced capability of food intake through limiting the size of the stomach by creating a small gastric pouch with less food intake. Restrictive procedures include: a) Laparoscopic adjustable gastric band (LAGB), b) laparoscopic sleeve gastrectomy (LSG), and c) vertical banded gastroplasty (VBG) [22].



Adapted from an illustration by Walter Pories, MD, FACS

Figure 1: Common types of bariatric surgery [23].

Malabsorptive procedures: in malabsorptive procedures, the effect is induced through bypass of absorptive and secretory areas of the stomach and small intestine [20]. However, this type, which includes: Jejunioileal bypass (JIB), bilio-pancreatic diversion (BPD), and bilio-pancreatic diversion with duodenal switch (BPD-DS), has largely been abandoned due to numerous metabolic and nutritional complications [9, 22]. Calcium deficiency, anemia, protein malnutrition, and thiamine deficiencies are common among patients undergoing these procedures [17].

Combined restrictive and malabsorptive procedures: in these procedures, the size of the stomach is reduced creating a small pouch with a reconfiguration of the anatomy of the small intestines to generate some degree of nutrient malabsorption but to a lesser extent than the BPD [17]. Combined restrictive and malabsorptive procedures include: the roux-en-Y gastric bypass (RYGB).

There are early and late postoperative complications associated with this procedure. Among the early complications that are most frequently reported are dumping syndrome, stomal stenosis, stomal/marginal ulcers, wound infections and/or dehiscence, leaks from the staple/suture anastomosis line, acute gastrointestinal obstruction, acute upper gastrointestinal bleeding, pulmonary embolism and deep venous thrombosis. Among the common late stage postoperative complications are: vitamin and mineral deficiencies, especially vitamin B12, iron, and folate, due to the diversion of food from the stomach and duodenum to the jejunum. To a lesser extent, calcium, potassium, magnesium, thiamine and fat-soluble vitamin deficiencies can occur, but are more frequently seen in a variation of this procedure, known as the long-limb RYGB [17].

Benefits and Risks of Bariatric Surgery

Benefits of Bariatric Surgery

Bariatric surgery is one intervention with proven effectiveness for long term significant weight loss [24]. In addition, results of numerous scientific studies demonstrate that weight loss following bariatric surgery is accompanied by numerous other positive outcomes, including enhancing quality of life, reduction or even reversal of chronic medical conditions such as hypertension, hyperlipidemia,

obstructive sleep apnea, T2DM, and asthma, as well as improvement in physical and/or psychological wellbeing, and lengthening of life span [10, 25].

Bariatric surgery has been shown to reduce mortality in the morbidly obese by 89% and to decrease morbidity associated with cancer and with diseases of the cardiovascular, respiratory, and musculoskeletal systems [26]. Studies show that bariatric surgery increases lifespan, as compared to those who do not have surgery, and resolves obstructive sleep apnea in more than 85% of patients [19]. Patients may lose 30 to 50% of excess weight 6 months after surgery and 77% of excess weight as early as 12 months specially after gastric surgery [19].

Risks or Complications of Bariatric Surgery: Despite clear benefits of bariatric surgery, there is emerging evidence that bariatric surgery is associated with changes in bone metabolism. Vitamin D and calcium malabsorption, secondary hyperparathyroidism, increased bone turnover, and decreased bone mineral density (BMD) have all been reported following bariatric surgery [27]. Other common risks or complications after bariatric surgery are:

Food Intolerance: there is a lower food tolerance in bariatric surgery patients compared to nonsurgical obese patients. All bariatric surgery patients, regardless of procedure, reported problems with food tolerance in the short term (3–6 months), indicating the need for nutrition monitoring and evaluation specially dairy products, bread, rice, pasta, and meat [28].

Nausea and Vomiting: these are most common risks of bariatric surgery, and typically occur due to: eating too much or too fast, drinking too much at one time or drink with meals, not chewing food well and laying down soon after eating [29].

Blockage of the Anastomosis (connection between stomach pouch and small intestine): This may happen due to eating fibrous or tough foods such as dry meat, nuts, seeds, and skins of some fruits and vegetables. This condition can be resolved by sips of water, return to clear fluid for 4 hours and in some times there is need for endoscopy [30].

Dehydration: it can be caused by drinking less fluid (not enough fluids) leading to dark colored urine, little urine output, dry mouth and dry skin. The treatment is by drinking a minimum of 2 liter (8 cups) of fluid daily, sipping the fluid slowly throughout the day, and avoiding diuretics such as tea and coffee [31].

Dumping Syndrome: is caused by rapid release of large dose of sugar into the small intestine. Furthermore, dumping syndrome can occur as a consequence of damage to the vagus nerve [32]. This causes an osmotic shift of fluid into the intestine, which causes a decrease in the blood volume and an increase in heart rate. The symptoms are: nausea, cramps, weakness, diarrhea, abdominal pain, sweating, and fatigue [31]. It may take 30 minutes to 2 hours for symptoms to disappear, and can be prevented by avoiding foods high in sugars, eating protein sources at each meal, avoiding eating large portions, and avoiding drinking with meals [31].

Constipation: is very common after bariatric surgery, and is caused by eating low fiber, and not drinking enough fluids. It can be treated by drinking 2 liters of fluids, doing exercise, and starting slowly

and gradually to increase fiber in diet [33].

Gases: is very common after bariatric surgery, it is a pain or discomfort from gas in the abdomen. To avoid this, spicy and gas-forming foods must be avoided. Also, the patient should eat slowly, chew food well and avoid chewing gum [29].

Hair loss: This is also very common after bariatric surgery and usually occurs after 3-9 months postoperatively. It can be treated by taking enough protein, iron and zinc [29].

Nutrient deficiencies: Post-operatively, bariatric surgery patients are at increased risk of developing nutrient deficiencies because of vomiting, decreased food intake, food intolerance, reduction of gastric secretions, and bypassing of absorption surface areas [34]. Risks of bariatric surgery are most often linked to malabsorptive procedures, but they also can occur after restrictive procedures (those that only reduce the size of the stomach). Risks include macronutrient deficiencies particularly a lack of protein calorie absorption, and micronutrient deficiency especially iron, vitamin B12, folate acid, vitamin D, and calcium [11,24].

Skin necrosis: This includes any skin necrosis even with minimal wound dehiscence. Up to 70% of the patients describe problems with surplus skin. Surplus skin has previously been reported to be located predominantly on the abdomen, thighs, upper arms and breasts, and also on the back, the cheek and over the knees, either in men or in women. In these patients, there is need for body contouring with removal of the redundant skin folds becomes necessary to improve their new quality-of-life expectations [35].

Nutrient Deficiencies after Bariatric Surgery

All types of bariatric surgery lead to an important decrease of ingested calories, ranging from 700 to 900 kcal/day, especially during the first six months after the procedure. Nutrient deficiency is an important complication associated with bariatric surgery with 50% of cases of vitamin deficiency being observed at the end of the first postoperative year, possibly arising from the substantial decrease of food intake, from food intolerance (mainly meat and dairy products), and from nutrient malabsorption (mainly fat and protein) [36,37].

The main nutrients affected by bariatric surgery are protein, vitamin B12, folate, iron and calcium. Such deficiencies might be manifested clinically as anemia due to (iron, vitamin B12 and folic acid) deficiencies, neurological sequelae (vitamin B12, folic acid and thiamin deficiencies) or osteoporosis (calcium and vitamin D deficiencies) [20,36]. So, it is critical to screen for nutritional deficiencies in obese patients prior to bariatric surgery and at regular intervals after bariatric surgery, and encourage adherence to supplementation [38]. However, it should be kept in mind that although micronutrient deficiencies are avoided through adequate supplementation, greater weight loss does not necessarily require higher dosage of multivitamins.

Protein

All types of bariatric surgery lead to very reduced total calorie intake, especially in the first 6 postoperative months, typically ranging from 700 to 900 kcalories per day following RYGB. This can contribute to the decreased intake of all macronutrients, especially protein, as patients may have difficulty achieving recommended protein intakes

severely restricted caloric intake [9].

Although 50% of protein absorption takes place in the duodenum, the remaining proteins are absorbed in the lower parts of the small intestine. Several mechanisms can lead to protein deficiency after bariatric surgery. These include severely restricted caloric intake, dislike for meat, meat intolerance or difficulty to masticate it. In addition, a decrease in enzyme secretions, such as pepsinogen (precursor of pepsin) and the pancreatic enzymes, might also be involved. Also, the time of contact between pepsin or other digestive enzymes, and the reduction in the intestinal absorption surface (due to the exclusion of the duodenum) can all contribute to protein deficiency [34,39].

Although patients are advised to consume at least 1 to 1.5 gm of protein per kg of ideal body weight (a minimum of 60 gm of protein per day), some studies have indicated that protein intake in the first year after surgery may be much lower than recommended, often closer to 0.5 gm/kg [9]. Low protein intake can lead to increased hair loss and contribute to poor wound-healing [9]. Also, Protein deficiency, may lead to hypoalbuminemia, edema, asthenia, fatigue, muscle weakness with loss of muscle mass, and anomalies of the skin, mucosa and nails (alopecia, striated nails, dermatitis, hypopigmentation) [34,38]. protein deficiency is assessed by anthropological measurements of muscle lean mass, as well as biochemical tests such as total protein, albumin and pre-albumin levels [40].

Calcium

Calcium is crucial for bone homeostasis and mineralization. For normal uptake, which occurs maximally in duodenum and proximal jejunum, vitamin D is also needed and calcium and vitamin D deficiencies after bariatric surgery have been extensively documented [20,34]. Low calcium increases release of parathyroid hormone (PTH) with secondary hyperparathyroidism as a consequence which, in turn, increases production of 1,25 dihydroxyvitamin D; the result of this process is increased release of calcium from bone with risk of osteoporosis [36].

The post-surgery calcium deficiency may be due to the limiting of the intake of dairy products due to dietary intolerance, or to bypassing of the primary absorption sites of calcium and vitamin D, namely, the duodenum and proximal jejunum, and the jejunum and ileum, respectively. In gastric bypass patients, incidence of calcium and vitamin D deficiencies were reported to be increased significantly with increased length of the Roux-en-Y limb [10, 20].

High intake of calcium (2g/d) is recommended. In addition, supplementation with calcium citrate (0.5-1.5 g/d) and vitamin D (400-800 I.U./d) should be prescribed. Calcium carbonate is likely to be of less use; the citrate form of calcium is recommended for optimal absorption rather than the commonly prescribed carbonate salts because citrate is better absorbed in the absence of stomach acid, a condition normally found after bariatric surgery [10, 20].

Iron

Iron is absorbed in the proximal small intestine in the duodenum and the proximal jejunum. In order for dietary iron to be absorbed, it needs to be reduced to the ferrous state by acid secretion from the stomach [20]. Iron deficiency is one of the most common and earliest nutritional deficiencies after bariatric surgery. The etiology

of iron deficiency is multifactorial [36]. Iron deficiency is more common after malabsorptive procedures as compared with purely restrictive procedures. The reported incidence of iron deficiency among bariatric surgery patients ranges from 15 to 50% [20].

There are several mechanisms by which bariatric surgery can lead to iron deficiency. First, post-bariatric surgery patients have reduced iron intake secondary to a considerable reduction of their meat intake, due to a low tolerance to red meats. Second, most, if not all of bariatric surgery procedures reduce gastric capacity and consequently hydrochloric acid production and volume. This has important implications in the conversion of ferric form (Fe³⁺) into the more absorbable ferrous form (Fe²⁺), limiting the release of iron from the structural proteins, and also reducing its affinity by its specific co-transporters. Third, these operations result in reduction of the total absorptive surface area. Iron deficiency is especially prevalent in RYGB, precisely due to reduction of gastric capacity, in addition to bypass of the duodenum and proximal jejunum. Lastly, perioperative iron deficiency anemia occurs in approximately 9–16% of bariatric surgery patients, which may account for some of the post-operative deficit [10,41]. Iron deficiency can lead to anemia (typically hypochromic and microcytic), fatigue, muscle weakness, asthenia, dyspnea, hair loss, paleness, and chest discomfort [9].

Routine multi-vitamin supplementation does not appear to be sufficient to prevent iron deficiency after RYGB, and in most cases supplemental iron is necessary [9]. Iron storage depletion is detected by many diagnostic tests such as low serum ferritin, and iron restricted erythropoiesis is indicated by lowered serum iron level, elevated serum transferrin, and total iron binding capacity (TIBC) [39].

Vitamin B12

Vitamin B12 (Cobalamin) is a water-soluble vitamin, which serves as a cofactor in many vital processes and is required for normal nerve cell activity, DNA replication and multiple other functions [20]. Vitamin B12 in food is bound to proteins and first needs to be released by pepsin and hydrochloric acid before it can be bound by intrinsic factor (IF). When the released vitamin B12 in a normal individual enters the duodenum, it is bound to IF released from the parietal cells of the stomach facilitated by pepsin and pancreatic enzymes. In this state, the bound vitamin B12 is eventually absorbed in the terminal ileum [41]. Cobalamin is absorbed by simple diffusion or mass action independent of intrinsic factor [42].

Vitamin B12 deficiency is commonly seen after RYGB (up to one third of patients), but to a lesser extent after restrictive procedures [42]. Its deficiency has been reported in 0-18% of patients having bariatric surgery [32]. In bariatric surgery patients, several factors precipitate deficiency of B12 and these include limited intake of animal proteins due to intolerance, decreased gastric secretions that impair cleavage of the vitamin from the protein, and inadequate secretion and function of intrinsic factor which is essential for vitamin B12 absorption in the lower small bowel that decreases absorption. Vitamin B12 deficiency may also occur due to bacterial overgrowth in the defunctionalized ileal segment due to lack of protective digestive secretions [10,42]. So, serum concentrations should be monitored annually [20]. Symptoms of B12 deficiency might not be prominent, and may include macrocytic anemia, neurological disorders, leukopenia, glossitis, thrombocytopenia, paresthesia, and visual loss [10,20].

Folic Acid

The B vitamins are generally important for neurological and hematological functions. Further, low folate and B12 levels can also be associated with elevated plasma homocysteine levels, which may be a potential independent risk factor for oxidative stress and cardiovascular disease [43]. Folate deficiency is not as common as iron or vitamin B12 deficiency after bariatric surgery, but could be an alternative cause of anemia [20].

Folic acid is present in food as polyglutamates and must be hydrolyzed to monoglutamates by the intestinal brush border. Folic acid absorption predominantly takes place in the upper third of the small intestine but can be absorbed to lower extent throughout the small intestine [20,36]. Absorption is pH dependent and therefore partially facilitated by hydrochloric acid. Additionally, vitamin B12 acts as a coenzyme in converting folic acid to its active form thus a vitamin B12 deficiency may result in a folate deficiency [44]. In addition, the maintenance of normal folate status may be due to increased bacterial folate synthesis in the upper small bowel under achlorhydric conditions after gastric bypass surgery [15].

Prevalence of folate deficiency is variable from one study to another; in about 20% of patients it happens at the end of 1 year on average. Deficits in folates are explained primarily by a deficiency of dietary intake of folate (fruits and vegetables, the main source of folate) [38]. Deficiency symptoms include megaloblastic anemia, thrombocytopenia, leucopenia, glossitis, and elevated homocysteine levels [10]. Unlike iron deficiency, folate deficiency is preventable and promptly corrected by multivitamin supplementation (1mg/day) [20,36].

Zinc

Zinc is involved in over 200 enzyme systems; its functions can be summed up as having 3 basic functions: catalytic, structural and regulatory. It plays a role in cell division, cell growth, wound healing and immunity [45]. Zinc is absorbed in the duodenum and proximal jejunum, as being dependent on fat absorption. It has been reported to be deficient after malabsorptive bariatric procedures [45].

Low serum zinc levels have been reported in both pre-operative (up to 28%) and post-operative bariatric patients (36–51%) [9]. Also, Low serum levels of zinc were described after gastroplasty as a consequence of reduced dietary intake [38,45,46]. Deficiency symptoms include dermatitis, alopecia, glossitis, angular cheilitis and diarrhea [45]. In practice, moderate hair loss is frequently observed among women between 3 and 6 months after the bariatric surgery [39].

Conclusions

In order to achieve weight loss and maintain good health, it is important to develop and maintain proper eating habits before and after surgery. Failure to modify eating habits will result in weight regain and complications such as dumping syndrome and its consequences. The role of the dietitians and nutrition experts is to minimize the risks of surgery and avoid the consequent deficiencies. Patients need to understand the importance of good nutrition and lifestyle modifications, as well as the potential short-term and long-term nutritional complications.

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Conflict of Interest

The authors have no Conflict of interests among them.

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