

NUTRITIONAL DEFICIENCIES ASSOCIATED TO BARIATRIC SURGERY

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Abstract

Obesity is an epidemic disease, increasingly addressed through surgical options for weight loss. Benefits of these surgical procedures, such as weight loss and improvement of obesity-related co-morbidities, are well established. However, postoperative complications do occur. Deficiencies in micronutrients, which include water and fat-soluble vitamins and minerals, are common after bariatric surgery. Recognition of the clinical signs and symptoms of micronutrient deficiencies is important to minimize long-term adverse effects.

key words: bariatric surgery, nutritional deficiencies, weight loss.

Background and Aims

Obesity is a growing worldwide epidemic. Thus, approximately 312 million people are obese and 1.7 billion are overweight [1,2]. Obesity is a disease associated with an increased mortality risk [3] and is also associated with higher health costs [4]. Non-surgical interventions have failed to achieve long-lasting weight loss. Only bariatric surgery leads to permanent weight loss and reduction in obesity-related comorbidities, such as type 2 diabetes, hyperlipemia, hypertension, coronary artery disease, in the majority of morbidly obese patients [5-11].

However, after bariatric surgery an important number of patients present mineral and vitamin deficiencies, although they are receiving a routine supplementation [12].

Lifestyle intervention therapies, that include changes in diet and increased physical activity, often produce insufficient weight loss and inadequate weight loss maintenance. Bariatric surgery is currently regarded as the most effective treatment option for severe obesity in adults [8,13,14]. Bariatric surgery has medical as well as economic advantages [10,14]. Large studies have shown a significant reduction in long-term total mortality (including deaths from diabetes

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mellitus), cardiovascular-related events and cancer following gastric bypass surgery [14,15]. Bariatric surgery is feasible and safe, when carried out in specialized medical institutions with a multidisciplinary setting [16]. This type of surgery is divided into three categories: restrictive, malabsorptive and hybrid procedures, the later combining gastric restriction and malabsorption. For example, the sleeve gastrectomy (SG), a restrictive procedure, a small tube is created by resecting the majority of the stomach, as shown in

[Figure 1](#). Roux-en-Y bypass surgery (RYGB) is a hybrid procedure, which involves the creation of a small (15-30 ml) gastric pouch by transecting the stomach and then draining the pouch via a Roux limb. The Roux limb (75-150 cm) is the segment of bowel between then small gastric pouch and the jejunojunctionostomy.

The SG and RYGB were the most common bariatric approaches in Europe and North-America, respectively [13].

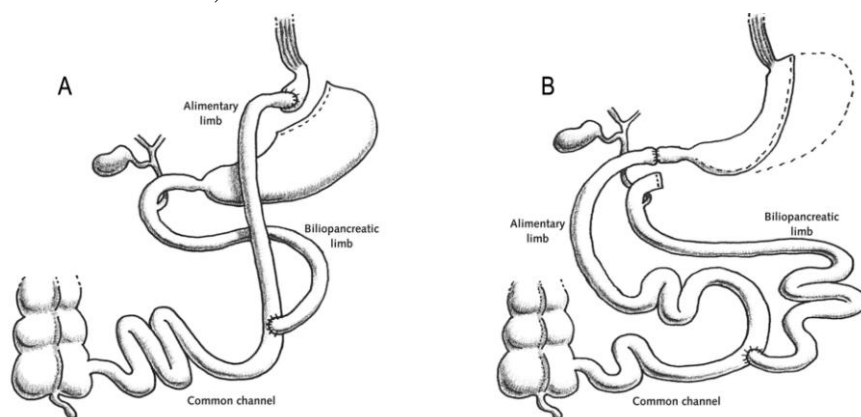


Figure 1. Type of bariatric surgical procedures: A. Roux-en-Y gastric bypass, B. Sleeve gastrectomy.

Despite routine supplementation of minerals and vitamins, different bariatric surgery procedures frequently cause a variety of nutritional and metabolic complications [12,17]. Purely restrictive intervention, such as SG, tends to cause fewer deficiencies than do malabsorptive procedures, such as RYGB and biliopancreatic diversion (BPD) [12,18,19]. The nutrient deficiencies are related to reduction in food intake as well as the physiological impact of surgically induced anatomical changes in the gastrointestinal tract.

The aim of this review was to summarize the current knowledge on nutritional deficiencies following bariatric surgery.

Micronutrient deficiencies in bariatric surgery patients

Minimal information exists regarding micronutrient requirement after bariatric surgery. Micronutrients are essential factors that are required by humans in microgram or milligram quantities, being involved in various metabolic pathways. Micronutrients include trace elements (such as chromium, selenium, zinc), water soluble vitamins (such as thiamine-vitamin B1, riboflavin-vitamin B2, niacin-vitamin B3, folic acid, pyridoxine-vitamin B6, biotin, cobalamin-vitamin B12, vitamin-C, etc.), fat soluble vitamins (vitamin A, D, E, and K) and essential minerals (including iron, calcium and iodine).

Because vitamin and mineral deficiencies are common after bariatric surgery, many bariatric programmers recommend taking one comprehensive tablet that contains multivitamins and minerals, as well as daily calcium supplementation after surgery [20]. These deficiencies are associated with a decrease in food intake and with the physiological influence of the anatomical changes performed in the gastrointestinal tract [12,21]. It is important to note that some patients already present nutrient deficiencies before surgery (secondary to various alimentary disorders), with a higher prevalence of abnormalities within one year after surgery [17].

Deficiency of fat soluble vitamins

Vitamin D

Calcium and vitamin D deficiencies are a significant problem in the bariatric surgery patient, with resultant osteoporosis or osteomalacia and associated fractures [22,23]. In normal state, vitamin D is absorbed in the ileum or produced in the skin in response to ultraviolet B radiation [24]. Moreover, vitamin D obtained from the diet or cutaneous synthesis is taken up by the adipose tissue, which stores vitamin D for subsequent release and metabolism at time when production is reduced [17,25]. Adipose tissue mass appears to inversely correlate with vitamin D status. Deficiency of vitamin D after bariatric surgery exacerbates calcium malabsorption, thereby causing secondary hyperparathyroidism, and thus calcium is reabsorbed from the bones and urinary calcium secretion is decreased [26]. The prevalence of secondary hyperparathyroidism can reach 58% in patients after gastric bypass [27]. Clinically,

hypocalcaemia or osteomalacia may cause generalized bone pain, muscular weakness, tetany, and chronic musculoskeletal pain [24]. In a 1-year sleeve gastrectomy study [28], 39% of patients were vitamin D deficient despite daily multivitamin supplementation. RYBG remains a higher risk procedure for nutrient deficiencies [21], therefore patients undergoing RYGB need to be closely monitored postoperatively for abnormal bone metabolism. Epidemiological evidence supports an association between hypovitaminosis D and increased risk of mortality due to cardiovascular disease, stroke, hypertension and diabetes mellitus [29].

In conclusion, it is important to check that calcium and vitamin D levels are sufficient prior surgery and prior to starting any treatment with bisphosphonate. The standard recommendation for the patients diagnosed with vitamin D deficiency, through low serum levels of total 25-hydroxivitamin D, is 50.000 International Units (IU) oral vitamin D once weekly. Vitamin D2 (ergocalciferol) or D3 (cholecalciferol) can be used for supplementation [30]. Some patients may require large regular doses of vitamin D after bariatric surgery. The initial dose for the treatment of osteomalacia is 600.000 IU of vitamin D2, given as 50.000 IU doses once weekly. Some researchers have suggested switching patients to supplementation with 1000-2000 IU vitamin D3, taken with meals once or twice daily, after repletion has been confirmed [31,32]. In severe malabsorption phototherapy may be necessary [30].

Vitamin K

Vitamin K can be 40-70% absorbed from the ileum and jejunum [33]. Biosynthesis of

vitamin K by the intestinal flora also provides humans with this vitamin [34]. The turnover of vitamin K is rapid; thereby whole-pool of vitamin K is small.

The occurrence of vitamin K deficiency after bariatric surgery is likely to be rare. However, subclinical vitamin K deficiency might be present after RYGB [35]. This vitamin deficiency can be treated with either oral vitamin K 2.5-25 mg daily or parenteral vitamin K 5-15 mg intramuscularly or subcutaneously.

Vitamin A

Vitamin A deficiencies induce decreased vision, poor night vision (nyctalopia), purities and dry hair [36]. Vitamin A deficiency has been identified in patients with BPD or extended RYGB [36], because fat soluble vitamin absorption require micelle formation with bile acids. Some factors contribute to a high risk of this deficiency in gastric bypass surgery patients including: insufficient intake of lipids and food sources of vitamin A, lipid malabsorption, oxidative stress and presence of nonalcoholic fatty liver disease [37].

For the treatment of this deficiency oral vitamin A supplementation with 10.000 IU daily is necessary.

Deficiency of water soluble vitamins

Peripheral neuropathy can develop secondary to several water soluble vitamin deficiencies, especially vitamin B12, thiamine and folic acid.

Thiamine (vitamin B1)

Thiamine is a coenzyme for the essential enzymes involved in the early stages of the tricarboxylic acid cycle and in the pentose phosphate pathway in humans [38]. Thiamine deficiency after RYGB is quite common [39], and is associated with small intestinal bacterial

overgrowth. Antibiotic therapy may be required to correct this deficiency. Thiamine deficiency, manifesting as Wernicke's encephalopathy or as acute psychosis, is particularly important in the postoperative patients with excessive vomiting, inadequate dietary intake or rapid weight loss, and can occur within 1 month post-surgery. Oral thiamine, 100 mg twice daily, is a standard therapy for this deficiency, but for patients with severe symptoms a minimum 250 mg of thiamine daily for at least 3-5 days is necessary [40].

Cyancobalamin (vitamin B12)

Vitamin B12 is a cofactor in the biosynthesis of succinyl-coenzyme A and methionine, and thus is important for the functioning of neural cells [41].

The mechanisms for vitamin B12 deficiency are likely to be multifactorial in origin. Patients who have RYGB or BPD lose the physiological function of parietal cells in the antrum. Parietal cells are the source of the hydrochloric gastric acid and the gastric intrinsic factor glycoprotein [41]. Gastric intrinsic factor forms a complex with vitamin B12 that is normally absorbed through a specific receptor in the distal ileum.

Vitamin B12 deficiency can become clinically relevant only several years after bariatric surgery. Vitamin B12 deficient patients may develop symptoms of neurological abnormalities and macrocytic anemia [42,43]. Manifestations of vitamin B12 deficiency may also include leucopenia, glossitis, and thrombocytopenia. The diagnosis of vitamin B12 deficiency is supported by an increased serum level of methylmalonic acid since vitamin B12 is

required for the metabolism of this compound [41].

Correct and effective treatments for vitamin B12 deficiency include oral doses of 500-2000 mg per day, intramuscular 1000 µg monthly, nasal 500 µg once weekly or sublingual 500 µg once daily vitamin B12 [41].

Folic acid

Folate deficiency, although not widely reported, can occur in bariatric surgery patients. The frequent causes cited in literature include decreased food intake [44,45], deficiency of vitamin B12 and surgical bypass of the site of absorption.

Symptoms of deficiency include megaloblastic anemia, leukopenia, thrombocytopenia, glossitis and increased homocysteine plasmatic levels [45,46]. Daily intake of 800 µg to 1 mg has been found to prevent the deficiency [47,48].

Deficiency of trace minerals

Iron (Fe)

Iron deficiency affects 6-33% of bariatric surgery patients after 1 year [22], and is a major cause of anemia among this patient population. Iron is predominantly absorbed in the duodenum and proximal jejunum, which are bypassed post-surgery. Moreover, hypochlorhydria after RYGB prevents conversion of ferric to the absorbable ferrous iron and further decreases its absorption [49].

Treatment with iron is recommended for all these patients; additional supplementation is required for menstruating women [22]. Iron deficiency can be initially treated with 150-200 mg per day of oral elemental iron (ferrous sulfate, gluconate or fumarate) or a ferrous salt-vitamin C combination [50].

Parenteral iron, in the form of iron-dextran or iron-sucrose, is occasionally needed in patients who have a poor response or intolerance to oral iron therapy [49,50].

Zinc (Zn)

Zinc is absorbed in the duodenum and proximal jejunum and is a major cofactor in cytosolic copper-zinc superoxide dismutase [51] and thus it has an antioxidant effect. Symptoms of zinc deficiency include diarrhea, emotional disorders, skin eruption (bullous-pustular dermatitis), glossitis, alopecia; nail dystrophy and hypogonadism in males [52,53].

Zinc deficiency can be treated with oral zinc sulfate in doses of 220 mg every other day or zinc-gluconate in doses of 30-50 mg every other day [53].

Selenium (Se)

Selenium is important in the activity of glutathione peroxidase, an enzyme which catalyzes the reaction of reduced glutathione with hydrogen peroxidase. Selenium deficiency induces cardiomyopathy (Keshan disease), myositis, weakness and muscle cramps [54]. This deficiency has been cited in 14-22% of bariatric surgery patients [55,56]. For treatment of selenium deficiency, 100 µg oral sodium selenite daily is necessary.

Cooper (Cu)

Cooper is essential for the production of red blood cells and for the maintenance of the structure and functioning of the nervous system [57]. Cooper is absorbed in the stomach and proximal duodenum. Thus, Cu deficiency has been documented in patients who have undergone gastric surgery [57]. The clinical and neuro-imaging findings in these patients are similar to those of patients with vitamin B12 deficiency [57,58].

Treatment of copper deficiency presumes copper gluconate 2-4 mg taken orally daily or every other day [59].

Conclusion

Bariatric surgery has proven to be an effective weight loss treatment for obesity and its comorbidities. Considering the serious consequences of nutritional deficiencies associated with weight loss, it is important that early identification, specific treatment and

routine prophylactic micronutrient supplementation are recognized as a key component in the successful management of the bariatric surgery patients. Physicians who treat patients after bariatric surgery need to have standardized approaches to micronutrient supplementation and postoperative evaluation. Further studies are needed to evaluate if the standardized measurements of micronutrient blood levels are adequate for the assessment of clinically relevant nutritional deficiencies.

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