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A Review on the Management of Nutritional and Metabolic Problems Following Bariatric Surgery

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ABSTRACT:

In individuals with extreme obesity, bariatric surgery (BS) is now the most effective treatment for causing long-term weight reduction as well as lowering mortality and comorbidity load. However, BS may also lead to additional clinical issues, difficulties, and side effects, particularly in the area of nutrition. As a result, managing bariatric patients' dietary needs requires specialized nutritional knowledge. Again, final therapy will be much more challenging if any of these persistent issues are not handled quickly. Severe and permanent issues may develop if these disorders go undetected. The typical and more recent issues that patients who have had bariatric surgery are now experiencing will be covered in this article. Bariatric surgery patients need to be monitored medically for various factors, which are often influenced by the kind of surgery done. Nutritional counselling is advised after surgery to make it easier for patients to adjust their eating behaviours to their new gastrointestinal physiology. Nutritional deficiencies may develop depending on the kind of bariatric treatment; they should be avoided, identified, and remedied. This review provides the management of nutritional and metabolic problems following bariatric surgery.

1. Introduction

Especially in the western world, obesity is a complex illness with a growing frequency. Therefore, obesity is a health issue with considerable medical, socio-psychological, and economic repercussions, especially when combined with its co-morbidities of hypertension, type 2 diabetes, dyslipidemia, joint diseases, and significant decline in health-related quality of life. Primary treatments for obesity should involve dietary and lifestyle modifications, behavioral change, and pharmaceutical intervention. Unfortunately, using such conservative treatment approaches often leads to disappointing patient outcomes. According to a growing body of evidence, bariatric surgery is the only method of treating obesity that has been shown to have long-lasting impacts on both the condition of obesity and its related diseases. Furthermore, bariatric surgery was related to a considerable decrease (about 30%) in mortality compared to controls typically treated in primary healthcare in large matched-control research with more than 4000 subjects. The benefits to one's health from having bariatric surgery should be compared against the hazards involved [1].

When it comes to new patient conditions and complications that could arise from obesity-related disease control, pharmacokinetic modifications, problems with pregnant women, mental obstacles in adapting to substantial alterations in eating behavior patterns and self-image, and weight regaining, BS may not be the best option [2]. Due to this, multidisciplinary long-term follow-up is advised following BS, and bariatric centers are required to provide a suitable follow-up program [3]. The dietary management of the bariatric patient is one of the most crucial components of medical treatment. The dietary state should be assessed before BS, and preoperative weight reduction may be tried. Nutritional counseling is crucial after surgery to help patients adjust their eating patterns to their new gastrointestinal physiology. Depending on the kind of bariatric treatment, nutritional deficiencies may develop; they should be avoided and ultimately remedied [4]. Last but not least, particular nutritional issues like reactive Hypoglycemia and dumping syndrome might happen and should primarily be treated with dietary management. This study will briefly discuss the dietary care of bariatric patients, progressing from the preoperative to the postoperative phases.

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2. Therapeutic Approach to Metabolic Syndrome

A sedentary lifestyle and the easy availability of cheap meals, among other things, help to explain why MetS (metabolic syndrome) are so common today. Its therapy aims to lower the risks of T2DM and CVD. The first and most crucial stage is to adopt a new lifestyle that includes dietary and exercise modifications and the development of better behaviors. Individual MetS components may be improved by weight reduction and way of life adjustments. Individuals find it simpler to implement and sustain these adjustments in their routines thanks to behavioral treatments. Most intervention trials' major objective was weight loss. All MetS metrics have significantly improved as a result of it. Blood pressure, triglyceride, glucose, and total cholesterol concentrations were significantly decreased with even modest weight loss (about 7%) [5]. Additionally, adipokines and inflammatory indicators, including adiponectin and tumor necrosis factor-alpha, are improved by weight loss [6].

For obese individuals, a weight reduction of around 10% of baseline weight in six months is an acceptable starting objective. Even a small weight reduction of between 5 and 10 percent increases insulin sensitivity by 30 and 60 percent, having a higher impact than insulin-sensitizing medications [7]. Because most people with this disease are obese and sedentary, calorie restriction is a successful strategy when all treatment alternatives are considered. Changes in physical activity are a constant component of MetS lifestyle therapies, and the most recent research on the subject supports the use of exercise as a successful therapy for the condition. Along with dietary modifications, a program of consistent physical exercise lowers the risk of CVD and insulin resistance [8].

3. Macronutrient Deficiencies

Due to decreased protein and fat absorption after pure malabsorptive treatments, macronutrient deficits are most often seen. Nevertheless, all bariatric surgeries have reportedly sometimes been known to cause protein deficiency due to decreased consumption.

3.1 Protein-calorie malnutrition

Protein calorie malnutrition was often seen in the early days of bariatric surgery following jejuno-ileal bypass, a treatment that is all but abandoned because of significant malabsorption. This nutritional shortage is seldom seen after restricted surgeries or RYGP with roux limbs [9].

3.2 Fat malabsorptive

Severe fat malabsorption is mostly seen after more intensive surgical treatments, such as BPD and BPD-DS, similar to protein-calorie malnutrition. Although a certain amount of fat malabsorption is intended with these operations, an excessive loss of fat absorption might cause deficits in fat-soluble vitamins and important fatty acids in very rare circumstances [10].

4. Deficiency of Micronutrients

After bariatric surgery, micronutrient shortages are not unusual to occur. The most common nutritional deficits are calcium, folic acid, iron, and vitamin B12. Clinical symptoms of these deficiencies include osteoporosis, anemia (iron, vitamin B12, and folic acid), and neurological side effects (calcium, vitamin D).

4.1 Vitamins and calcium

For the mineralization and homeostasis of bones, calcium is essential. Vitamin D is required for proper uptake, which is greatest in the duodenum and proximal jejunum. A lack of vitamin D has also been associated with cancer, rheumatoid arthritis, hypertension, diabetes, and peripheral vascular disease [11]. In addition, vitamin D is crucial for several metabolic activities. The jejunum and ileum are where most uptake happens. Low calcium raises parathyroid hormone (PTH) secretion with secondary hyperparathyroidism, which raises 1,25-hydroxyvitamin D3 hydroxylation to the active form. Increased calcium absorption from the bones due to this mechanism increases the risk of osteoporosis.

Wernicke's encephalopathy (clinical picture of vitamin B1 deficiency) with ophthalmoplegia, nystagmus, ataxia and encephalopathy [12] is the worst-case scenario and may manifest as beriberi or [13] in worst instances, cerebral thiamine deficit.

In these situations, prompt detection is necessary to prevent long-term brain injury. So-called dry beriberi, also known as isolated peripheral neuropathy, presents a less serious clinical condition [14]. Burning paresthesia, lower extremity weakness, and sensory deficits are possible symptoms. In most situations, multivitamin supplement helps in avoiding vitamin B1 deficiency.

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Vitamin B12, also known as cobalamin, is a water-soluble vitamin necessary for proper nerve cell functioning, DNA replication, and many other activities. In consumed nutrition, vitamin B12 is protein-bound and must be released by stomach acid. Additionally, intestinal absorption requires binding to intrinsic factor, which is secreted from the stomach. Up to one-third of patients with RYGB may experience vitamin B12 insufficiency, although this is less prevalent with restrictive surgeries [15].

5. Nutritional Management Before BS

5.1 Nutritional assessment before BS

Before surgery, candidates for BS should have their nutritional state evaluated. This assessment is crucial for post-surgical treatment. In the last several years, several studies have shown that compared to controls with normal weight, people with extreme obesity often have micronutrient deficiencies (MDs). Asheim et al. examined the vitamin status of 110 individuals with extreme obesity in 2008 and found that they had considerably lower levels of vitamins A, B6, C, 25-hydroxyvitamin D, and lipid-standardized vitamin E than 58 participants with normal weight [16]. Similar to this, Van Rutte et al. found that among 200 individuals with extreme obesity, 38% had low blood iron, 24% had low serum folate, 11% had low serum vitamin B12, and 81% had hypovitaminosis D (with 55% having severe deficiency with a level below 30 nmol/l) [17]. Finally, Peterson et al. found that 71.4 percent and 36.2 percent of 58 BS candidates had a frank iron deficit (35 ug/dL for females and 50 ug/dL for males) and vitamin D insufficiency (20 ng/mL) [18].

A low-quality, monotonous, high-fat and high-calorie diet may cause MDs in individuals with extreme obesity. For instance, consuming too much simple sugar, dairy products, or fats may result in a vitamin B1 deficiency [19]. Increasing hepcidin expression and activation in the fatty tissue may affect iron levels [20]. There may also be a link between higher amounts of lipophilic substances like vitamin D stored in the adipose tissue of obese persons and the variation in 25(OH)D levels among those with and without overweight [21]. Before the treatment, BS candidates' nutritional state should be evaluated and corrected. This will help avoid post-bariatric MDs. After BS, patients who received preoperative MDs corrections did not develop new deficiencies during the first year, while all patients who were not given pre - operative MDs corrections were still lacking in one or even more micronutrients, despite methodical post - operative diets supplemented with these nutrients [22].

5.2 Debates about preoperative weight loss

Weight reduction before surgery is still up for discussion. Most current relevant recommendations do not indicate preoperative weight reduction [23]. Patients must undergo a period of recognizable medical management before BS and that it is also important to evaluate the patient's motivation and willingness to adhere to follow-up programs, but neither the indication for BS nor the preoperative evaluation ever mentions a preoperative weight loss [24].

Patients were randomly assigned to a 2-week preoperative VLCD regimen or no preoperative dietary restriction in Van Nieuwenhove et al. study's [25]; in Kalarchian et al., study [26]; and in Coffin et al., study's [27] they were compared to patients receiving a 6-month behavioral lifestyle intervention.

In a cohort of 127 treated patients with a regular 6-month medical weight-loss regimen and a 2-week preoperative diet with meal replacements before SG [28], McNickle & Bonomo found no link between preoperative weight loss and 1-year outcomes.

The proportion of excess BMI reduction one year following sleeve gastrectomy (SG) was not significantly different between those who lost weight and those who gained weight before surgery, according to Sherman WE et al., analyses of a cohort of 141 patients who had SG [29].

In a retrospective study involving 548 patients, Giordano & Victorzon compared patients who lost different amounts of weight before surgery (5%, > 5 to 10%, and > 10%). Postoperative weight loss was higher in patients who lost > 10% of their body weight at 12 months, with no significant differences found at 24 months [30].

6. Nutritional Strategy After BS

6.1 Bariatric surgery characteristics and dietary effects

According to the architecture and the main mode of action, bariatric surgeries have traditionally been classified as restrictive, mixed, or malabsorptive. In a

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time when the metabolic mechanisms of action of BS gained significantly more attention than the anatomical or functional ones, this classification has recently come under fire. However, from a nutritional perspective, this categorization is still accurate since the effects of BS on nutritional status are mostly related to the decrease in stomach volume and the decreased absorption of nutrients. Figure 1 provides a visual illustration of the anatomical characteristics of the most popular bariatric operations.

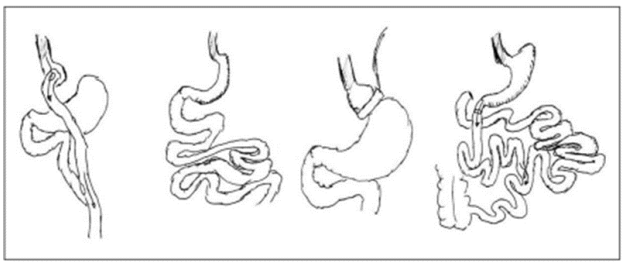

Fig. 1. Anatomical characteristics of the main widely used bariatric operations are shown graphically. The procedures from left to right include sleeve gastrectomy, Roux-en-Y gastric bypass, adjustable gastric banding, and biliopancreatic diversion with a duodenal switch [31].

6.2 Protein Consumption and Supplementation

Rapid weight reduction over the first few months after BS may accompany a substantial unexpected loss of muscle and fat-free mass [32]. Protein intake is frequently and significantly decreased after BS, especially in the first months following the procedure, primarily due to gastric intolerance to protein-rich foods [16]. Rapid weight loss is supposed to be protected against lean mass loss by consuming enough protein. A minimum of 60 grams of protein per day and up to 1.5 grams per kilogram of ideal body weight per day are recommended by current recommendations, although larger protein intakes—up to 2.1 grams per kilogram per day—might be necessary for certain circumstances [23]. The consumption of liquefied protein shakes (30 g/d) in the initial months following BS is suggested because of the difficulties in obtaining these high targets simply through natural diets [32].

A small, randomized experiment recently called into doubt the efficacy of protein supplements in reducing the loss of lean body tissues. Oppert et al., [33] randomly allocated 76 patients in the experiment to receive standard treatment following BS, standard care plus extra whey protein supplementation (48 g/day), standard care and protein supplementation and supervised strength training (1 h three times per week). Lean body mass loss was similar across all groups, but only the protein plus exercise group showed a gain in muscular strength. The findings of this small study highlighted the value of integrating strength training among the sorts of physical activity advised following BS [23], even if they are unlikely to change earlier wise recommendations.

7. Lifelong Nutritional Management: Early and Late

Because of the small quantity and postoperative stomach edema, eating solid foods is difficult or impossible in the first few days following surgery. For this reason, most postoperative dietary plans recommend starting off on a liquid or extremely soft diet and gradually building up to solid foods during the first few weeks following surgery to minimize or avoid regurgitation and vomiting [34]. Within 24 hours following surgery, a low-sugar clear liquid diet is often started. Patients are then directed to gradually transition from clear liquids to soft or creamy meals and finally to solid chewable items over two to four weeks [34].

For the first four months after surgery, Sarwer et al., randomly assigned 84 patients treated with BS to dietary counseling or conventional treatment. In the dietary counseling group, weight loss was somewhat higher but not substantially so. However, patients who received nutritional counseling reported substantial improvements in several eating habits that were thought to be crucial for long-term weight management success [35]. According to Rudolph & Hilbert's meta-analysis of five randomized controlled studies, patients who received behavioral lifestyle interventions lost more weight than those in control groups [36], despite constraints brought on by the small and varied samples of studies.

8. Deficiencies In Micronutrients And Their Supplementation

After BS, vitamin and mineral shortages are rather typical. The different procedures' modes of action and anatomical features determine their frequency and severity. Nutritional deficits are more frequent after surgical procedures that cause some degree of malabsorption than they are following solely gastric

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restrictive treatments that do not affect intestinal continuity or normal digestive processes [23]. Cornerstones of long-term follow-up following BS include prevention, identification, and treatment of vitamin and mineral deficiencies. Depending on the surgery and current recommendations, daily vitamin and mineral supplements should be recommended to every patient following BS [37, 38].

Table 1. Some randomized control studies compared patients who lost a considerable amount of weight before surgery with those who did not show particular results.

Sample size	**Operating time**	**Intraoperative complications**	**Surgeons perceived difficulty**	**30- days postoperative complications**	**Postoperative WL**	**references**
273	**NS**	**NS***	Higher in the control group vs. WL	Higher in the control group vs. WL	/	Van Nieuwenhove Y et al., [39].
143	NS	/	/	**NS**	**NS**	Kalarchian MA et al., [40].
141	NS	/	/	**NS**	BMI loss	Sherman WE et al., [41].
76	48 g/day (1 h three times per week)	/	/	/	BMI loss	Oppert et al., [42].
115	NS	/	/	/	**NS**	Coffin B et al., [27].

W L = weight loss, *NS stands for no major difference between the control group and the weight loss group

9. Dietary Macronutrient's Effect on MetS

We evaluate the current state of knowledge on each macronutrient's contributions to MetS. The role of each macronutrient present in the diet in developing and managing this syndrome has been widely investigated.

9.1. Proteins

Proteins are linked to greater satiety and the retention of lean body mass during weight reduction, although it is unclear how they should be included in the diets of people with MetS. According to recommendations, adults should consume a minimum of 0.8 g/kg body weight of digestible protein per day, or a range of 10 to 35 percent of their total calorie consumption. According to ADA policy statements, people with diabetes and healthy kidneys should get between 15 and 20 percent of their calories from protein. However, they acknowledge that there is currently insufficient data to propose a specific protein intake level to either reduce CVD risk factors or glycemic management [43].

Due to the satiety factor of proteins, some studies [44] suggest hyper protein diets in treating MetS. The maintenance of lean mass is another benefit of these diets. However, these diets are not universally recognized and may increase urinary calcium excretion and bone remodeling [45]. These worries are, on the whole, a bit exaggerated. In pre-existing metabolic, renal impairment cases, high-protein diets do not seem to cause calcium bone loss or harm the kidney.

9.2. Lipids

Carbohydrates and fats make up the majority of the energy consumed by humans. Lipids, however, also have functional properties and are crucial in the pathophysiology of atherosclerosis. In contrast to carbs, the recommended range of fat calories in the diet is relatively wide. As a result, low-lipid and low-carbohydrate diets have drastically different total lipid contents. The appropriate macronutrient distribution of total fat is 20–35% of total caloric intake for all people [46]. Only when fat consumption exceeds 35 to 40 percent of total caloric intake may it affect insulin sensitivity and the risk of developing type 2 diabetes [47]. Regardless of how it affects weight, a diet high in fat (20–40%) does not alter insulin sensitivity [48].

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For a while, the American Diabetic Association (ADA) advised that 60–70% of the total energy in the diet should come from a combination of carbs and monounsaturated fatty acids. However, since the ADA 2014 policy statement, there hasn't been a "first-line" strategy for determining the ideal amount of carbohydrates in a diet since the research is still conflicting [49]. On the other hand, when weight loss is the aim, low-fat diets are comparable to but not superior to other weight-reduction diets in overweight or obese people [50].

According to European recommendations, foods high in trans or saturated fats (such as hard margarine, tropical oils, fatty or processed meat, desserts, cream, butter, and regular cheese) should be swapped out for monounsaturated fats (such as extra virgin olive oil) and polyunsaturated fats (such as avocado) (non-tropical vegetable oils). Thus, it is expected that trans fats will make up only 1% of total calories and saturated fat 10% (or just 7% in cases when high plasma cholesterol levels are present) [51].

9.3. Carbohydrates

Carbohydrates control blood glucose and insulin levels after oral delivery, absorption, gastrointestinal and pancreatic hormone production, liver metabolism, and visceral and muscle uptake. They shouldn't be seen as a uniform part of the cuisine. Overall, there are three basic kinds of carbs: fiber, starch or complex carbohydrates, and sugars or simple carbohydrates, each of which affects the glycemic response differently.

A simple carbohydrate that merits special attention is fructose. When absorbed, it does not affect insulin or leptin secretion. Long-term daily intake promotes the development of MetS and type 2 diabetes in children and adults by increasing weight and decreasing insulin sensitivity [52]. Soft drinks increase the intake of simple carbohydrates in the diet by containing significant quantities of high-fructose corn syrup (HFCS) and sucrose [53]. It was said that 100 g/day of fructose has no impact on body weight and that moderate fructose intake of up to 50 g/day, or 10% of calories, has no negative effects on lipid and glucose regulation. However, a larger intake is not advised, and consumption of drinks with added sugar should be restricted or avoided [54].

Diets with low carbohydrate content or ketogenic diets have gained popularity during the last 20 years. Because it was believed that the higher lipid content would raise the risk of CVD, they were first deemed invalid. However, compared to traditional low-fat hypocaloric diets, numerous groundbreaking research revealed higher weight reduction over the first six months of follow-up [55]. After a year of follow-up, no statistically significant differences in weight reduction were discovered. Interestingly, these ketogenic diets enhance triglyceride levels, HDL cholesterol levels, insulin sensitivity, and glycosylated hemoglobin (HbA1c). When HbA1c levels are high, carbohydrate restriction has a larger impact on lowering them than protein or fat restriction [56].

10. Particular dietary issues after bariatric surgery (Dumping syndrome and Hypoglycemia)

Although BS has had several positive health effects like the remission of diabetes, it is also linked to a relatively underappreciated condition called postprandial reactive Hypoglycemia. Despite a recent publication indicating a high percentage of reactive Hypoglycemia one year after SG, Hypoglycemia (reactive) is usually thought to be more prevalent after RYGB than SG [57]. A 1-year randomized investigation evaluating SG and RYGB found no difference in hypoglycemic episodes (29 vs. 14%) [58].

GLP-1 affects insulin secretion solely in individuals who have had RYGB surgery, regardless of whether they have Hypoglycemia or are asymptomatic symptoms. GLP-1 levels were 10 times greater after meals in RYGB patients, and symptomatic patients had a faster rate of glucose manifestation in their blood than asymptomatic individuals [59]. As a result of their gradual adjustment to Hypoglycemia, patients of RYGB often are unconscious of low glucose levels. Additionally, it was mentioned that RYGB lessens the hormonal and symptoms reactions associated with hypoglycemia [60].

Early and late symptoms of dumping are categorized according to when they appear after eating and are brought on by the discharge of hormones (gut) and the fast entrance of water into the lumen of the intestine. The most prevalent kind is early dumping, which accounts for 40% of cases following RYGB and SG [61], whereas late dumping is only seen in 25% of patients [62]. The Sigstad's score and the Arts' dumping questionnaire are

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two questionnaires that have been developed to identify the dumping syndrome [63, 64]. If the preceding criteria are met, and all other hypoglycemic reasons have been ruled out, postprandial Hypoglycemia can be recognized, according to a recent proposal by Salehi et al., in patients who had RYGB. (1) Post - prandial neuroglycopenia in BS patients 6-12 months before symptoms, (2) documented Hypoglycemia (venous glucose, 54 mg/dL) at the time of neuroglycopenic symptoms, with symptom resolution following treatment to raise glucose, and (3) no hypoglycemia following a prolonged fast of at least 12 hours [65]. This shows that whereas Hypoglycemia and dumping syndrome may share the same fundamental process (rapid nutrition transfer from the gastric pouches to the gut), both display distinct dysfunctional gut physiology characteristics. Dietary changes, pharmaceutical therapies, and, in rare cases, continuous tube feeding, or surgical re-intervention are all forms of treatment for post-bariatric low blood pressure and dumping disease. Smaller, more frequent meals are advised from a nutritional standpoint (about six per day), and fluid consumption should be postponed for at least 30 minutes following meals [62].

11. Recommendation for postoperative Supplementation

Deficits in micronutrients (vitamins and minerals) are particularly easy to develop after BMS due to lower dietary intake (gastric restriction and change of gut hormones). Different operations may affect how well nutrients are absorbed; the most nutritionally problematic surgery is often the malabsorptive biliopancreatic diversion/duodenal switch technique. There are also differences between people. Therefore, standardized nutritional supplements are often advised, but they should be tailored to the person based on the results of follow-up laboratory tests [66]. Micronutrient deficiencies that often occur include those in vitamin B1, B12, folic acid, A, D, E, and K, as well as iron, calcium, copper, zinc, and selenium. All sleeve gastrectomy (SG) and bypass patients should be given a multivitamin and mineral pill, according to the ASMBS recommendation [67]. In individuals at higher risk, additional iron, vitamin B12, or calcium supplementation with vitamin D should be considered (e.g., existing osteoporosis and heavy menstruation).

The following ingredients should be included in the daily multivitamin and mineral tablets:

- **Thiamin:** To maintain blood levels of thiamin and avoid thiamine insufficiency, take 12 mg of thiamin daily and, ideally, a 50 mg dosage of thiamin from a B-complex supplement or multivitamin once or twice daily.
- 350–500 mcg of vitamin B12 per day or 1,000 mcg each parent per month is advised.400–800 mcg of oral folate (vitamin B9) should be taken daily from a multivitamin. Fertile women should consume 800-1,000 mg of oral folate per day.
- **Iron:** Post-BMS patients at low risk of post-WLS iron shortage (men and patients without a history of anemia) should take a multivitamin containing at least 18 mg of iron daily. Women who are on their period and those who have had RYGB, SG, or BPD/DS should take at least 45–60 mg of elemental iron every day (cumulatively, including iron from all vitamin and mineral supplements). Oral supplements, drugs that lower acid levels and foods strong in phytates or polyphenols should all be given in staggered dosages apart from calcium supplements.
- **Calcium:** After bariatric surgery, elemental calcium dosages of 1,200–2,000 mg per day are advised, and they often also include vitamin D. All patients who underwent BMS should supplement their diets with 1,200–1,500 mg of calcium daily.
- A, D, E, and K are fat-soluble vitamins. The recommended daily doses for vitamin A are 5,000–10,000 IU, for vitamin K, 90–120 ug, and vitamin E, 15 mg. For mal-absorptive procedures, BPD, or DS, additional vitamin A (10,000 IU/d) and vitamin K (300 g/d) Supplementation is advised. It is advised to take 3,000 IU of vitamin D3 every day until blood levels of 25(OH)D are larger than required (30 ng/mL).
- **Zinc:** Depending on the surgery, all post-BMS patients should take zinc at 100–200% of the usual intake (8–22 mg/day). The supplementation strategy is advised to include a ratio of 8–15 mg of supplementary zinc for every 1 mg of copper to reduce the risk of copper deficit in post–BMS patients.

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- **Copper:** depending on the surgery, all post-BMS patients should take 1-2 mg/day of copper as part of their regular multivitamin and mineral prescription [68].

12. Changes in food preferences and food intolerance

Studies found that following BS, there were significant decreases in appetite and an increase in postprandial fullness, leading to smaller meals without a corresponding rise in frequency [69]. The decrease in hunger and energy consumption has been linked to several causes. Neurological and physiological alterations impacting hypothalamic signaling and gut hormones are brought on by changes in gastrointestinal structure [70]. Additionally, BS alters dietary preferences, such as enhanced sharpness to sweet taste and reduced hedonic appraisal of sweet and fatty meals [71], in addition to increasing satiety.

After RYGB, it was shown that smaller, solid-textured meals were more easily accepted and caused less Hypoglycemia than larger, liquid meals [72]. Faulconbridge et al., showed that 6 months following RYGB and SG, the brain response to high-calorie diets considerably reduced and remained steady in the control group [73]. The "conditioned taste avoidance" [74] theory, which describes a deliberate adjustment to food that is still pleasant but has unfavorable effects when ingested in higher amounts, may help to explain food intolerance following BS. Early dumping, as previously mentioned, may encourage postprandial pain and cause a conditioned aversion shift in eating habits following SG, particularly concerning sweets [75].

Nielsen et al., found no differences in dietary preferences between before and after BS, although overall calorie intake reduced 6 and 18 months after BS. Additionally, the preference for low-fat savory meals at 6 months post-BS compared to before surgery may suggest in which patients were more conscious of the dietary guidelines in the initial postoperative phase and that this knowledge decreased with time [76].

13. Conclusion

The effects of BS alter eating patterns and nutrition in important and lasting ways. To accommodate the morphological and functional changes to the gastrointestinal tract caused by BS, patients' eating habits must constantly be adjusted to the new gastrointestinal physiology, and unique nutritional issues and symptoms may arise. The preoperative period is another crucial time to ensure proper dietary control. Every year, over 100,000 bariatric procedures are carried out, with gastric bypass being the most popular. Compliance with long-term follow-up is vital, as nutritional and metabolic problems can be easily treated or avoided. Physicians other than the primary surgeon need to be engaged in the follow-up of such patients as the number of patients receiving bariatric surgery rises. Bariatric patients' diets need the expertise of nutritionists and dieticians.

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