DERLEME / *Review*

Nutrition in Bariatric Surgery and Postoperative Nutrition Problems

Bariyatrik Cerrahide Beslenme ve Postoperatif Beslenme Sorunları

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ABSTRACT

Obesity is a common disease characterized by excessive fat accumulation and has adverse health effects. When adequate weight loss cannot be achieved, bariatric surgery has become the gold standard of treatment in recent years. It can be performed in individuals with a Body mass index (BMI) over 40 kg/m² or in the presence of a BMI of 35 kg/m² and an accompanying comorbidity. Pre- and postoperative nutritional monitoring is very important for the success of the operation and prevention of complications. Postoperative nutrition requires adequate energy and nutrient intake for tissue healing and maintenance of lean body mass. Nutrient deficiencies, intolerances and protein malnutrition may occur when the dietary phases recommended by the guidelines are not followed. Supplements may be recommended to ensure the necessary protein intake. Long-term (multidisciplinary) follow-up of patients is necessary to ensure that micro and macronutrient deficiencies that may develop are met and optimum weight loss is achieved. Decreased oxidative stress in the postoperative period contributes to the reduction of inflammation and oxidative damage by increasing antioxidant defense and enzyme levels.

Keywords: *Bariatric surgery, preoperative nutrition, postoperative nutrition, macronutrients and micronutrients, nutrient deficiencies*

ÖZ

Obezite, aşırı yağ birikimi ile tanımlanan ve sağlık üzerinde olumsuz etkileri olan yaygın bir hastalıktır. Yeterli ağırlık kaybı sağlanamadığında, bariatrik cerrahi son yıllarda altın standart haline gelen bir tedavi yöntemi olarak kabul edilmektedir. Beden kütle indeksi (BKİ) 40 kg/m² üzerinde olan bireylerde veya BKİ 35 kg/m² ve eşlik eden bir komorbidite varlığında uygulanabilir. Pre ve postoperatif beslenme takibi, operasyon başarısı ve komplikasyonların önlenmesi açısından çok önemlidir. Postoperatif beslenme, doku iyileşmesi ve yağsız vücut kütlesinin korunması için yeterli enerji ve besin ögesi alımını zorunlu kılmaktadır. Kılavuzlarca önerilen diyet aşamaları uygulanmadığında besin ögesi yetersizlikleri, intoleranslar ve protein malnütrisyonu gibi sorunlar ortaya çıkabilmektedir. Gerekli protein alımının sağlanması için takviyeler önerilebilmektedir. Gelişebilecek mikro ve makro besin eksikliklerinin karşılanması ve optimum ağırlık kaybının sağlanabilmesi için hastaların uzun dönem (multidisipliner) takibi gereklidir. Postoperatif dönemde oksidatif stresin azalması, antioksidan savunmanın ve enzim seviyelerinin artmasıyla inflamasyonun ve oksidatif hasarın azalmasına katkı sağlamaktadır.

Anahtar Kelimeler: *Bariatrik cerrahi, preoperatif beslenme, postoperatif beslenme, makro ve mikro besin ögeleri, besin yetersizlikleri*

1 Introduction

According to the definition of the World Health Organization, obesity is a condition of excessive fat accumulation in the body to the extent that health and well-being are negatively affected. When an individual is obese, body fat exceeds physiological values. The normal amount of body fat, which shows high variability among individuals, depends on age and gender. Body fat percentage increases slowly with age in adulthood in both men and women. It is unknown whether these age-related increases are a normal physiological effect in adulthood or whether they are due to overeating and a sedentary lifestyle (1). The etiology of obesity is multifaceted. The three main factors that form the basis of the etiology of obesity are dietary choices, metabolic factors, and inactivity, which are also influenced by genetic factors (2). Given the chronic and recurrent nature of obesity, the goal should be to achieve lasting success with a long-term treatment procedure for all contributing factors, especially diet and lifestyle changes (3).

According to current studies, bariatric surgery is considered the gold standard in the treatment of

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Gönderim Tarihi:08.12.2024 - Kabul Tarihi: 02.07.2025

morbid obesity and weight-related comorbidities and is much more effective than non-surgical interventions (4). Bariatric surgery, which is categorized as malabsorptive and restrictive, also includes combined methods that both cause malabsorption and restrict food intake (5). Achieving maximum weight loss through healthy nutrition while preventing micronutrient deficiency and loss of lean body mass is one of the primary goals of bariatric surgery. Since obesity is a risk factor for malnutrition and micronutrient deficiencies, all bariatric surgery patients should receive monitoring and treatment for nutritional deficiencies preoperatively and postoperatively (6).

The members of the bariatric multidisciplinary team should include an obesity specialist, surgeon, nutrition and diet specialist, psychologist, and anesthesiologist, although this may vary depending on the specific situation (7). Modifiable patient behaviors are of great importance to the outcomes of surgery. American Association of Clinical Endocrinology/The Obesity Society/ American Society for Metabolic and Bariatric Surgery (AACE/TOS/ASMBS) Clinical Practice Guidelines recommend performing nutritional, psychosocial, and behavioral assessments during the preoperative period and throughout the postoperative follow-up process, which includes dietary changes, physical activity, and behavioral modifications managed by a multidisciplinary team (8).

It is essential to evaluate the nutritional status, nutrient deficiencies, nutritional knowledge, habits, physical activity, biochemical findings, anthropometric measurements, and psychosocial status of the patients in the preoperative period to organize the nutritional program and manage postoperative weight loss. Acquiring new eating habits through nutrition education during the preoperative period is essential (9). Postoperative nutrition therapy, which varies according to the type of surgery performed, should meet adequate energy and nutrient requirements to promote tissue healing and prevent lean tissue loss. Nutrient adjustments should promote early satiety, avoid syndrome dumping, facilitate weight loss, and prevent weight regain (10).

In this study, we aim to provide information on 'how nutrition should be in the preoperative and postoperative periods, what nutrient deficiencies may occur in the postoperative period, and the methods of intervention for these deficiencies, as well as how antioxidant capacity changes in the postoperative period,' by providing examples from various studies regarding indications, contraindications, and types of surgical interventions.

2 Nutrition in Bariatric Surgery

2.1 Nutrition in the Preoperative Period

Preoperative nutritional assessment is crucial for patients undergoing bariatric surgery (11). According to the 2022 guidelines from the American Society for Metabolic and Bariatric Surgery, a detailed nutritional assessment should be the first step in the preoperative period (12). Preoperative nutrition affects physiological responses to surgery, intestinal hormones, and malabsorption processes in the postoperative period. Therefore, personalized preoperative nutrition is critical for postoperative health (13). Since some patients may have preoperative micronutrient deficiencies (Thiamine, B_{12}, B_6, A, D, K vitamins, Folate, Iron, Calcium, Magnesium) (14), micronutrient status should be monitored before surgery (15). In addition to these biochemical analyses, dietary assessment, and nutrition-focused physical examination, identifying preoperative nutritional deficiencies is essential to determine the underlying causes of these inadequacies (13).

In the preoperative period, low-calorie (800-1200 kcal/day) and very low-calorie (500-800 kcal/day) diets are commonly recommended to achieve weight loss and liver volume reduction before surgery. These diets should be moderate in carbohydrates, containing at least 20% protein and less than 30-35% fat (12). In bariatric surgery, a 5-10% weight loss is aimed through a tolerable diet to reduce the risk of complications and facilitate the surgical process. As a result of the low and very low-calorie diets applied in

the preoperative period, significant reductions in body weight and waist circumference have been observed without issues in kidney, liver, and metabolic functions (16). In addition, screening should be performed in the preoperative period to detect deficiencies in essential nutrients such as iron, folic acid, and vitamins of B_{12}, A, D, and E, with recommendations for necessary supplements based on the results (17).

2.2 Nutrition in the Postoperative Period / Diet Stages

Postoperative nutritional intervention aims to minimize the dietary effects that may occur in the short and long term due to anatomical, physiological, and primarily changes in intestinal and brain hormones resulting from the procedure and to initiate the preoperative diet early. To adapt to the changing anatomical structure and improve any gastric edema, a personalized diet that gradually transitions from liquid to solid should be implemented according to the surgical technique (18).

2.2.1 Clear Liquid Diet (Phase One)

This phase occurs in the first 24-48 hours postoperatively and consists of administering 120-180 mL of clear liquids to the patient every hour, including foods that do not require digestion, are close to body temperature, and contain no fiber, to ensure bowel movements and manage gastric edema (19). Sugar-free, carbohydrate-free, calorie-free, and caffeine-free beverages and diluted fruit juices can be consumed in the first 48 hours of the postoperative period, depending on the patient's tolerance. Non-particulate soups made with skim milk or yogurt, clear broth (20), powdered protein supplements, and plain or diluted fat-free buttermilk/yogurt are also allowed during this period. Daily fluid consumption should reach 1500-1800 mL during this period (21).

2.2.2 Full Liquid Diet (Phase Two)

Foods that stimulate the gastrointestinal tract are preferred, starting after the first 24-48 hours postoperatively. This phase lasts 10-14 days but can be shortened or extended based on the patient's tolerance (5,9). In the diet on days 2-3, patients are expected to consume carbohydrate-free and sugar-free liquids every 15 minutes. Caffeine consumption should be limited, and all fluids should be consumed slowly. Fruit juice should be diluted half and half with water. Since using straws may cause problems such as swallowing air and difficulty controlling the amount of fluid, daily fluid consumption should be limited to 1500-1800 mL during this period. This stage introduces milk, dairy products, and dietary protein sources (19). Protein intake should be limited to 25-30 grams per serving. Carbonated, caffeinated, and sugary drinks should not be consumed, and the consumption of salty liquids should be moderated. In addition to adding at least 4 cups of water compared to previous days, using straws should also be limited (22).

2.2.3 Puree Diet (Phase Three)

This dietary phase can extend from the 3rd to the 6th postoperative week. The aim is to ensure adequate food intake and prevent dehydration due to decreased fluid consumption. To prevent common nutritional problems during this period, liquids should be sipped slowly, and bites should be small and chewed thoroughly. To obtain the necessary nutrients, liquids should be avoided during meals, and a gradual progression from liquids to solids should be followed (23). In addition to a complete liquid diet, protein-rich foods such as eggs, red meat, chicken, fish (minced), whole wheat, rye, oat flour, fruits, and vegetables that do not cause gas or bloating can be consumed. If adequate protein cannot be obtained from food, protein powder may be used in liquids during this period (24).

2.2.4 Soft Food Diet (Phase Four)

The soft diet is introduced at 6-8 weeks to transition to a normal solid diet. Energy needs are determined by height, body weight, and age. In this phase, low-carbohydrate cereals, pasta, oatmeal, rice pilaf, mashed potatoes, toast, freshly cooked vegetables, and peeled soft, low-sugar fruits can be added to the puree diet (5). Patients are expected to consume high-protein foods on

their plates first, followed by vegetables, grains, and fruits. Avoid foods with a high carbohydrate content, such as rice and pasta, unless an average of 60 g of protein is consumed daily (9). Precise fluid intake should be increased to 1440-1920 mL in this stage. Patients should be served 3-6 meals. Fluid consumption should be avoided during meals. Patients should wait 30 minutes after the meal to resume fluid intake (6). Introducing new foods should be tried slowly, especially those with a viscous consistency (rice, bread), which may be difficult to tolerate. During this period, multivitamins, calcium, and iron should be started in chewable or liquid forms, and when tolerated, tablets and capsules should be introduced (18).

2.2.5 Solid Food Diet (Phase Five)

It includes a dietary regimen modified and improved daily according to the patient's tolerance (25). It is necessary to consume at least 1500 ml of water per day (18). Each new food should be consumed separately and repeatedly to understand the tolerability of the food. Water consumption should be limited during or immediately after a meal to increase food consumption compared to the previous stages (26). During this phase of gradual, controlled trials of new foods, carbohydrates such as rice, bread, and pasta should be limited until the patient can tolerate protein-rich foods comfortably. As hunger increases in the following weeks, food intake should be increased gradually, in line with the recommended calorie intake. A slow chewing rate and an adequate number of chews are the most critical parameters to prevent obstruction (22). The aim should be to ensure sufficient and balanced nutrition in this dietary phase, where nutritional habits must be changed, and nutrition education is essential (21).

2.2.6 Protein Consumption and Its Importance in the Postoperative Period

The bariatric surgical procedures Roux-en-Y Gastric Bypass (RYGB) and Sleeve Gastrectomy (SG) alter the anatomy and physiology of the gastrointestinal tract, affecting the intake, digestion, and absorption of many nutrients, especially amino acids, and often leading to nutritional deficiencies. Reduced gastric capacity, hydrochloric acid in gastric secretion, and reorganization of the small intestine with a decrease in digestive enzymes are the main factors limiting the digestion and absorption of nutrients (27). In this process, a protein-rich diet provides satiety and helps control body weight by reducing energy intake. Protein supplements are essential for maintaining muscle mass and promoting body fat loss (28,29). The American Association of Clinical Endocrinologists also recommends individualized protein intake according to age, gender, and weight and recommends a daily protein intake of 60-120 grams or 1.5 grams/kg/day in the postoperative period (30,31).

Since many patients cannot tolerate solid and protein-rich foods in the postoperative period, it is recommended to supplement protein intake with liquid protein supplements. Studies have shown that protein supplements positively affect body composition, metabolic rate, and functional outcomes, reduce body fat percentage and mass, and prevent lean tissue loss in bariatric surgery patients (28,29). For example, a significant relationship was found between protein intake and lean mass loss after RYGB and SG procedures. However, if protein intake was insufficient, lean mass loss increased, and total energy expenditure decreased, especially in the first months (32,33). Since bariatric surgery complicates dietary protein intake, digestion and absorption are unaffected, and protein supplements or enrichment are critical for adequate protein intake (31).

2.3 Fluid Consumption in the Postoperative Period

One of the complications seen in the postoperative period is dehydration; adequate fluid intake plays a critical role in preventing this. Although it varies according to the individual needs of patients, daily fluid consumption of 15-2 liters is recommended to avoid digestive system complications and optimize fluid intake (34). Preventing dehydration caused by vomiting, excessive sweating, and diarrhea, seen in the postoperative period, is essential to avoid unwanted fluid outflows (23). In addition to adequate fluid intake, when and

how the fluid is taken is also very important. Postoperative patients are advised not to drink fluids during meals and to wait 30 minutes after the meal to consume fluids. The most important reason for this is to prevent liquid consumption with meals from accelerating the gastric emptying time and causing dumping syndrome (35). After all bariatric surgery procedures, care should be taken to ensure that the beverages consumed are caffeine-free, alcohol-free, gas-free, and sugar-free, except for the recommended protein-source drinks (36).

2.4 Nutrient Deficiencies in the Postoperative Period

Although the goal of bariatric surgery is to reduce caloric intake for weight loss, these procedures can cause significant nutritional deficiencies that can lead to serious complications such as anemia, metabolic bone disease, and neurological/ocular disorders. Studies show reduced levels of almost all vitamins and minerals in the bariatric population, including vitamins A, B_6, B_{12}, C, D, E, Thiamine, Folate, Iron, Zinc, and Selenium (37).

2.4.1 Macronutrient Deficiencies

The risk of protein deficiency is high, especially in bariatric surgery patients undergoing malabsorptive procedures. Restrictive procedures can also affect digestion, leading to similar problems. Inadequate protein intake is influenced by factors such as intolerance to protein-containing foods, anorexia, prolonged vomiting, diarrhea, depression, fear of weight gain, alcohol/drug abuse, and low socioeconomic status. High-quality protein is essential for maintaining a lean body mass during weight loss. Protein powders supplemented in most bariatric procedures have also been observed to improve body composition without impairing renal function. High-quality protein intake should be considered for patients who experience hair loss, which is common in the postoperative period, especially over 6 months. Since severe protein malnutrition may be seen in malabsorptive operations, protein-rich formulas and enteral-parenteral nutrition supplementation may be required for these patients (31,37).

2.4.2 Micronutrient Deficiencies

In bariatric surgery patients, the most common deficiencies of vitamin B_{12}, vitamin D, iron, and folate make individuals vulnerable to the development of anemia (38). Vitamin B_{12} binds to protein in the diet, is cleaved by gastric acid and pepsin, and binds to intrinsic factors before absorption in the terminal ileum. Factors that increase B_{12} deficiency in gastric bypass patients include limited intake of animal proteins, reduced gastric secretions, and decreased secretion and function of intrinsic factors (39). Furthermore, bacterial overgrowth in the dysfunctional ileal segment can lead to B_{12} deficiency due to the absence of protective digestive secretions. This deficiency is manifested by symptoms such as macrocytic anemia, leukopenia, glossitis, thrombocytopenia, paresthesia, and irreversible neuropathies (40).

Vitamin B deficiencies, common in the postoperative period, can lead to mental, cognitive, and neurological complications, while vitamin B_1 deficiency causes symptoms such as constipation, nausea, loss of appetite, and weakness. Vitamin C deficiency can lead to fatigue, delayed wound healing, and scurvy, while vitamin K deficiency increases the risk of blood clotting problems and osteoporosis (10,41). Iron deficiency anemia usually develops asymptomatically, leading to symptoms such as microcytic anemia, fatigue, and hair loss, usually associated with low iron intake and reduced stomach acid (42). Vitamin A deficiency is also observed in 70% of patients with symptoms such as night blindness and dry skin, while vitamin D deficiency is a factor that increases the risk of osteoporosis and fractures, so it is essential to supplement after bariatric surgery (43,44).

In one study, ferritin deficiency, seen in 22% of patients in the preoperative period, continued to increase as anemia in 32% of women and approximately 10% of men after the first year of surgery (45). Schijns et al. concluded that special bariatric multivitamins effectively prevented deficiencies and increased B_{12}, vitamin D, folic acid, and ferritin serum levels in

patients with RYGB (38). In treating macro- and micronutrient deficiencies that may occur in the early postoperative period, offering multivitamin-multimineral formulation supplements to patients for at least the first 3-6 months increases the treatment potential by preventing deficiencies (42).

2.5 Food Intolerances-Tolerances in the Postoperative Period

After bariatric surgery, patients may develop food intolerances for various reasons. Changes in eating habits such as fast eating, inadequate chewing, and consumption of liquids with meals, combined with anatomical changes in the digestive system, may increase intolerance problems. Complications such as rapid gastric emptying, decreased gastric acid secretion, and dumping syndrome are the leading causes of intolerance. In addition, odor and taste sensitivities may accompany this condition in obese patients (46).

Various foods, especially bread, cereals, dairy products, meat, and fibrous vegetables, are most tolerated in the postoperative period. Intolerance can negatively affect diet quality; for example, avoiding red meat can lead to iron deficiency, while consuming refined sugar and fat can prevent dumping syndrome (27). Gobato et al. reported increased food intolerance and decreased eating satisfaction after banded RYGB surgery, while Cynthia et al. found that food tolerance improved with more chewing in patients undergoing RYGB. However, no relationship existed between food tolerance and protein intake (47,48). Patients should be counseled to chew adequately, separate eating and drinking, and eat frequent meals with small portions to reduce intolerances. Preferring protein-based foods and avoiding high-calorie liquids is critical to alleviate food intolerance and prevent nutrient deficiencies (49).

2.6 Nutrition and Antioxidant Capacity in the Post-Bariatric Period

When the pro-oxidant/antioxidant balance is disturbed in obese individuals, this may play a role in the development of metabolic diseases. An increase or decrease in the antioxidant defense system has been observed in morbidly obese patients, but the potential of bariatric surgery to improve redox homeostasis remains unclear. It has been suggested that after bariatric surgery, there is an overall increase in antioxidant production due to decreased oxidative stress, and this increase may be associated with a decrease in proinflammatory cytokine and adiponectin levels (50,51).

In particular, increases in superoxide dismutase (SOD) and glutathione (GSH) levels have been observed after surgery, but some studies have reported a decrease in SOD activity, which may lead to an increase in other enzymes such as glutathione reductase (GR) as an adaptive response (52). Although there was a slight decrease in SOD and glutathione peroxidase (GPX) levels in the first 1-6 months after surgery, plasma malondialdehyde (MDA) levels decreased, indicating a decrease in oxidative stress (53). With surgery and lifestyle changes, an increase in antioxidant enzymes such as GPX, GR, glutathione synthetase (GS), glutathione S-transferase (GST), catalase (CAT) (54), GSH and SOD was recorded and a significant increase in the GSH/GSSG ratio was observed (55). In addition, post-surgical use of bioactive anti-inflammatory dietary components contributed to the reduction of oxidative stress (56).

Zinc, selenium, iron, vitamins D and A, zinc, selenium, iron, vitamin D and vitamin A, which are consumed with the consumption of meat, fish, eggs and dairy products consumed according to the tolerance status after surgery, may have an antioxidant effect by reducing or preventing oxidative stress (57). Consumption of vegetable oils, seeds, vegetables and fruits, vitamin E; vitamin K, especially with the consumption of green leafy vegetables; and red/orange/yellow fruits with their rich vitamin C and A content protect the cell membrane by preventing lipid peroxidation and can also reduce oxidative stress (58). In summary, in addition to the consumption of fresh fruits and vegetables, it is very important to consume seeds and legumes in the post-surgical period as they are natural sources of antioxidants in the diet (59).

3 CONCLUSION AND RECOMMENDATIONS

In the postoperative period, adequate energy and nutrient intake should be ensured primarily for nutrition, postoperative tissue healing during severe weight loss, and maintenance of lean body mass. To avoid nutritional problems in the postoperative trial, great attention should be paid to the foods consumed, how they are consumed, and their frequency. The points to minimize issues in the postoperative period should be given to the patient with the necessary nutrition education. Postoperative fluid intake is the most essential part of a healthy recovery process. It should be ensured that fluid consumption is adequate at regular intervals and that appropriate fluids are preferred. Nutritional priority should be given to foods with high protein content, followed by vegetables and carbohydrate-containing foods. Meals should be consumed slowly in small portions and chewed well. Also, foods with high-fat content, such as fried foods, should be avoided. These recommendations will help minimize problems such as vomiting, nausea, and pain. All these recommendations are significant for reorganizing eating habits in the postoperative period for bariatric surgery, which is an effective method for treating obesity. While individuals need to get the nutrients, they need in a sufficient and balanced manner in the postoperative period, appropriate nutrition plans aim to minimize health complications that may occur by supporting weight loss. In line with surgical patients' changing anatomy and physiological processes, vitamin and mineral deficiencies that may arise due to reduced nutrient intake can be corrected with regular follow-up and necessary treatment.

Ethical Information

Informed Consent: Informed consent is not required for studies.

Copyright Transfer Form: The authors have signed the Copyright Transfer Form.

Authors: RSÇ, HK.

Conflict of Interest: There is no conflict of interest between the authors.

Financial Disclosure: No financial support was received for this study.

Acknowledgments: No person or organization other than the authors contributed to this research.

Ethical Approval: Since this study is a review article, no ethics committee approval is required.

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