Diabetes, Metabolic Syndrome and Obesity

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Advances in Perioperative Nutritional Management in Metabolic and Bariatric Surgery

Ying Li, Ting Zhang

Department of Gastrointestinal Surgery, Suzhou Municipal Hospital, The Affiliated Suzhou Hospital of Nanjing Medical University, Gusu School of Nanjing Medical University, Suzhou, Jiangsu, 215000, People's Republic of China

Correspondence: Ting Zhang, Department of Gastrointestinal Surgery, Suzhou Municipal Hospital, The Affiliated Suzhou Hospital of Nanjing Medical University, Gusu School of Nanjing Medical University, No. 26 Daoqian Street, Gusu District, Suzhou, Jiangsu, 215000, People's Republic of China, Tel +8618862120859, Email zhangting_ztg@163.com

Abstract: Metabolic and Bariatric Surgery (MBS) is an effective treatment for severe obesity and its related complications. However, perioperative nutritional management is essential for the patient's surgical outcome and postoperative recovery. This article reviews the research progress in perioperative nutritional management of MBS. Preoperative nutritional assessment and optimization are essential, including monitoring and correction of micronutrient deficiencies, such as vitamin D, iron, folic acid, to reduce the risk of postoperative complications. In terms of preoperative dietary management, the use of a low-carbohydrate ketogenic diet (LCKD) and ready-to-eat low-carbohydrate ketogenic product (RLCKP) showed the potential to promote weight loss and liver volume reduction, creating favorable conditions for surgery. Strategies for preoperative weight loss (WL) need to be cautious, and moderate preoperative WL may help to reduce surgical difficulty and postoperative complications. In addition, the application of preoperative carbohydrate load can reduce postoperative insulin resistance and protein loss and promote postoperative recovery of patients. In terms of postoperative nutritional management, the risk of postoperative micronutrient deficiency is significantly increased. At the same time, the adjustment of postoperative dietary structure and rational use of nutritional supplements are important to maintain the nutritional status of patients and promote weight management. In conclusion, perioperative nutritional management of MBS is a multifaceted and multi-level comprehensive process that requires a multidisciplinary approach involving medical staff, dietitians, and patients. A tailor-made approach based on the patient's unique characteristics, such as nutritional status, surgical type, and personal preferences, is essential to achieve the best surgical results and improvement of patients' quality of life. Major challenges remain in perioperative nutritional management, such as the high prevalence of preoperative malnutrition and the complexity of postoperative nutritional deficiencies. In the future, more accurate preoperative nutritional assessment tools and personalized postoperative nutritional supplementation strategies should be developed.

Keywords: obesity, bariatric surgery, perioperative, nutritional management

Introduction

Obesity has emerged as a global epidemic and has a significant impact on human health and socio-economic outcomes. According to the latest data, the total number of children with obesity, adolescents with obesity and adults with obesity worldwide has exceeded 1 billion. In 2022, 159 million children with obese and 879 million adults with obese worldwide. Obesity is prevalent not only in developed countries, but also rapidly spreading in low- and middle-income countries. More than 750 million adolescents (5–19 years) worldwide are expected to be overweight or obese by 2035.[1,2] The negative health impacts of obesity are multifaceted. Obesity is an important risk factor for non-communicable diseases such as cardiovascular disease, type 2 diabetes, and certain cancers.[3] In addition, obesity is associated with multiple psychosocial problems, such as impaired self-esteem, social discrimination, and decreased quality of life. Obesity in childhood and adolescence not only impacts their immediate health, but also increases the risk of chronic diseases in adulthood.[4] Obesity also places a huge burden on the global economy, and the global cost of overweight and obesity is expected to reach $3 trillion per year by 2030.[5]

Received: 22 January 2025
Accepted: 18 June 2025
Published: 5 July 2025

Metabolic and bariatric surgery (MBS) has a crucial role in the treatment of severe obesity. MBS is one of the most effective methods to achieve sustained long-term weight loss, especially for those patients who fail to achieve successful weight loss with diet, exercise, and medical therapy. Surgery promotes a significant decrease in body weight by altering the anatomy and function of the gastrointestinal tract, reducing the intake and absorption of food, while affecting the appetite regulation mechanisms of patients.[6] MBS is not only effective in reducing body weight, but also significantly improves or resolves a variety of metabolic diseases associated with obesity, such as type 2 diabetes, hypertension, hyperlipidemia and obstructive sleep apnea.[7] The improvement of these diseases not only improves the quality of life of patients, but also reduces long-term medical costs and the risk of death.[7] MBS addresses not only the physical aspects of obesity but also significantly impacts mental health and overall patient experience. Obesity is often associated with psychological challenges such as depression, anxiety, and low self-esteem, which can be exacerbated by social stigma and discrimination. These psychological factors play a crucial role in the success of MBS and the long-term outcome of patients. A comprehensive patient-centered approach that integrates psychological support and addresses patient experience is essential to optimize surgical outcomes and improve quality of life. Preoperative psychological assessment is essential to identify patients who may be at risk for adverse mental health outcomes. This includes screening obese people for prevalent depression, anxiety, and eating disorders. Providing psychological support and counseling before surgery can help patients develop coping strategies and improve mental health, thereby enhancing the preparation of surgery and postoperative recovery. Following surgery, patients' mental health should continue to be prioritized. Many patients experience significant lifestyle changes following MBS, which can lead to emotional and psychological challenges.[1] Regular follow-up with mental health professionals can help address these issues and provide ongoing support. In addition, support groups and peer coaching programs have been shown to be beneficial in improving patient experience and long-term adherence to lifestyle changes. Patient education and participation in decision-making processes are critical components of a patient-centered approach. Patients should be fully informed about the surgical procedure, potential risks, and expected outcomes. Involving patients in the development of their nutrition and lifestyle programs can enhance their sense of control and improve compliance with postoperative recommendations. However, it is important to note that MBS, like any surgical intervention, carries certain risks and potential complications. These may include surgical site infections, bleeding, thromboembolic events, and anesthesia-related risks. Additionally, some patients may experience long-term complications such as nutritional deficiencies, dumping syndrome, or gastrointestinal reflux.[8] Although surgery carries certain risks and complications, its combined benefits in the treatment of severe obesity far outweigh these potential risks, providing patients with a comprehensive and lasting solution.[8] However, it is important to note that MBS, like any surgical intervention, carries certain risks and potential complications.

Perioperative nutritional management plays a crucial role in MBS. First, in the preoperative period, the main goal of nutritional management is to improve the nutritional status of patients and reduce the degree of malnutrition, thereby improving the patient tolerance to surgical trauma and reducing the incidence of postoperative complications.[9] To achieve this, specific interventions are essential. Preoperative dietary modifications should prioritize low-fat and low-energy diets, which can help reduce overall caloric intake while ensuring adequate nutrient intake. Additionally, multivitamin and mineral supplements, including vitamin D, iron, and folic acid, should be administered to address common micronutrient deficiencies observed in obese patients. These supplements are crucial for optimizing nutritional status and preventing postoperative complications such as anemia and metabolic bone disease. Reasonable nutritional therapy, such as low-fat, low-energy diet and multivitamin and mineral supplementation, can effectively reduce the patient's weight, reduce liver volume, improve surgical field exposure, and increase the success rate of surgery.[10,11] In addition, preoperative nutritional management can also help patients adapt to the feeding pattern in the postoperative volume-restricted state and reduce the loss of lean body tissue and bone mass after surgery. During the intraoperative period, perioperative nutritional management helps to maintain blood glucose levels and fluid balance in patients and reduce the damage of surgical stress to the body. After surgery, nutritional management focuses on promoting rapid recovery of patients and preventing the occurrence of malnutrition.[12] A low-energy, high-protein diet should be given early after surgery to maintain muscle mass and promote wound healing. A high-protein diet typically refers to a diet that provides at least 1.2 to 1.5 grams of protein per kilogram of body weight per day, which is higher than the general dietary recommendation for the average adult. For example, a patient weighing 70 kg should aim to consume between 84 and

105 grams of protein daily. This recommendation is based on evidence that higher protein intake supports muscle preservation and overall metabolic health during the recovery phase.[12] Diverse Protein Sources To achieve the recommended protein intake, patients should be encouraged to consume a variety of protein-rich foods. These can include: Animal Proteins: Lean meats such as chicken breast (31 grams of protein per 100 grams), turkey (28 grams of protein per 100 grams), and fish-like salmon (20 grams of protein per 100 grams) and cod (17 grams of protein per 100 grams). Dairy products such as Greek yogurt (10 grams of protein per 100 grams) and cottage cheese (11 grams of protein per 100 grams) are also excellent sources. Plant-Based Proteins: Legumes like lentils (9 grams of protein per 100 grams) and chickpeas (8 grams of protein per 100 grams), as well as tofu (8 grams of protein per 100 grams), provide essential amino acids and support a balanced diet for patients who prefer or require vegetarian options. These foods not only provide essential amino acids but also help in maintaining satiety and supporting overall health. It is important to note that protein sources should be easily digestible, especially in the early postoperative period when patients may experience gastrointestinal sensitivity. In addition to macronutrient management, postoperative micronutrient supplementation is crucial to prevent deficiencies. Patients should receive regular supplementation with key vitamins and minerals, including vitamin D, vitamin B12, folic acid, and iron. Supplementation should be tailored based on individual nutritional assessments and laboratory tests to ensure adequate levels of these micronutrients. Nutritional therapy should be started as early as possible in patients with malnutrition or nutritional risk, and enteral or parenteral nutrition support should be used if necessary.[13] In addition, long-term nutritional monitoring and supplementation are required after surgery to prevent and correct micronutrient deficiencies and maintain the long-term nutritional status of patients. Specifically, it is recommended to perform comprehensive nutritional assessments every 3 months in the first year after surgery, including blood tests for micronutrients such as iron, zinc, copper, vitamin B1, B9, B12, D, A, and E, as well as bone mineral density testing and liver and kidney function indicators. In the second year, monitoring can be adjusted to biannual, and then at least once a year focusing on key indicators. For patients at high risk of nutritional deficiencies, such as those with severe preoperative malnutrition or postoperative complications, more frequent monitoring and personalized supplementation plans are essential. In conclusion, perioperative nutritional management runs through the whole process of MBS and is of great significance to improve the surgical effect and promote the postoperative recovery of patients. To maintain good weight loss, scientific nutritional management is still required during the perioperative period.[14] However, perioperative nutritional management also faces several challenges. These include patient compliance with dietary and supplement regimens, variability in nutritional needs based on individual factors such as surgical type and pre-existing conditions, and the necessity for long-term monitoring to prevent and address nutritional deficiencies. Addressing these challenges is essential to optimize patient outcomes. The aim of this literature review is to present the latest advancements in perioperative nutritional management in MBS and provide insights for optimizing the nutrition of these patients.

Prevalence and Influencing Factors of Preoperative Malnutrition

Preoperative malnutrition is prevalent in patients with MBS and has a high incidence. Studies have shown that obese patients have prevalent deficiencies of multiple micronutrients before surgery, including vitamin D, iron, folic acid, vitamin B12, vitamin A, thiamine, and zinc. Preoperative vitamin D deficiency may be present in up to 76%, iron deficiency in 6% to 50.5%, folic acid deficiency in 0% to 56%, low MCV in 19% to 47.9%, and anemia in 15.8% to 19.6%.[15–19] This malnourished condition not only impacts the quality of life of patients, but may also increase the risk of postoperative complications, such as anemia, neurological disorders, and metabolic bone disease.[20–22] To address these deficiencies before surgery, specific interventions are recommended based on the type and severity of the deficiency. For patients with vitamin D deficiency, oral vitamin D supplements are typically prescribed, with the daily dose adjusted according to serum 25(OH)D levels. The goal is to maintain serum 25(OH)D levels above 30 ng/mL. For iron deficiency, oral iron supplements are usually the first-line treatment, although intravenous iron may be considered in cases of severe deficiency or poor gastrointestinal absorption. Regular monitoring of serum ferritin and hemoglobin levels is essential to assess the effectiveness of the supplementation. In cases of severe anemia, additional interventions such as intravenous iron or even transfusions may be necessary (Table 1).

Table 1 Common Micronutrient Deficiencies and Recommended Supplementation Strategies in Metabolic and Bariatric Surgery

Micronutrient	Preoperative Deficiency Prevalence	Recommended Supplementation
Vitamin D	Up to 76%	Oral vitamin D supplements to maintain serum 25(OH)D levels above 30 ng/mL
Iron	6% to 50.5%	Oral or intravenous iron, depending on severity and absorption
Folic Acid	0% to 56%	Oral folic acid supplements
Vitamin B12	Significant	Oral or injectable vitamin B12
Zinc	Significant	Oral zinc supplements
Vitamin A	Significant	Oral vitamin A supplements
Vitamin E	Significant	Oral vitamin E supplements

The occurrence of preoperative malnutrition is influenced by multiple factors. Obese patients usually have long-term imbalance in dietary intake, and their diet is often dominated by foods with high calorie and low nutritional quality, resulting in insufficient intake of micronutrients.[23] Second, obesity itself decreases the bioavailability of certain nutrients, for example, vitamin D is easily taken up by adipose tissue due to its lipid solubility, thereby reducing its concentration in blood.[24] In addition, obesity-related chronic inflammation can also affect nutrient absorption and utilization, such as iron absorption and utilization may be negatively affected by chronic inflammation. Female patients have a higher risk of preoperative malnutrition due to menstrual blood loss and other reasons, particularly in terms of iron and vitamin D deficiency.[25] Ethnic differences may also have an impact on the development of preoperative malnutrition, and dietary habits and lifestyles vary among ethnic groups, resulting in differences in the type and degree of their nutritional deficiencies.[26]

In summary, preoperative malnutrition is highly prevalent in patients those being considered for MBS, and its occurrence is influenced by multiple factors such as dietary habits, obesity itself, chronic inflammation, gender, and ethnicity. Tailoring nutritional interventions based on the severity of deficiencies is crucial. For mild deficiencies, oral supplements and dietary adjustments may suffice, while more severe cases may require higher doses, intravenous administration, or additional medical interventions. Correction of preoperative malnutrition is important to improve the preoperative status of patients and prevent postoperative complications.

Key Indicators and Methods of Preoperative Nutritional Assessment

Preoperative nutritional assessment for weight loss is an important link to ensure the safety of surgery and postoperative recovery. Key indicators and methods include comprehensive body composition analysis of patients, measurement of height and weight to calculate body mass index (BMI), assessment of body fat percentage, waist circumference, hip circumference and waist-to-hip ratio, and understanding of visceral fat area content, which are important indicators for judging the degree of obesity and health risks.[27] At the same time, micronutrient levels in blood, such as vitamin B1, vitamin B12, vitamin A, vitamin D, zinc, and copper, as well as mineral contents such as calcium, phosphorus, iron, potassium, sodium, and chloride, are measured to identify potential nutritional deficiencies.[28,29] In addition, the nutritional status and metabolic function of patients were assessed by blood tests to understand the content of macronutrients such as protein, fat, and carbohydrates in patients.[30] The evaluation methods mainly include detailed history inquiry, understanding the dietary habits, past disease history and drug use of patients; physical examination, observing the body size, skin condition and hair distribution of patients; laboratory tests, such as blood routine, blood biochemistry, liver and kidney function, blood glucose, blood lipid and endocrine hormone levels, such as insulin and thyroid hormone, to evaluate the metabolic status and endocrine function of patients.[11] Through comprehensive analysis of these indicators and methods obtained information, can comprehensively understand the nutritional status of patients, for the development of personalized preoperative nutritional intervention program to provide the basis, reduce the risk of postoperative complications, and promote postoperative recovery of patients.

It is also important to consider the educational and socioeconomic status of each individual with obesity during preoperative nutritional assessment. Not all individuals have the same access to preoperative weight loss programs, and some may not be able to afford these diets, which can sometimes be expensive. Social discrimination should also be

taken into account when making these decisions, and certain social groups may need further support to ensure equitable access to care. At present, the commonly used nutritional risk screening tools are Nutritional Risk Screening Scale (NRS2002), Malnutrition Universal Screening Tools (MUST) and Mini-nutritional Assessment Short Form (MNA- SF). NRS2002 is recommended as the preferred tool for nutritional risk screening in inpatients by multiple nutrition societies internationally based on strong evidence-based evidence.[31] However, obese patients, especially those with moderate to severe obesity and diabetes, often have micronutrient deficiencies before surgery,[32] and nutritional screening using NRS-2002 is not accurately assessed at this time. Therefore, it is equally important for such patients to use nutritional assessment methods for nutritional screening. The nutritional status of the body was determined by subjective and objective methods such as clinical examination, anthropometry, biochemical examination, body composition measurement, and multiple comprehensive nutritional evaluations of the patients, so as to provide all-round nutritional guidance for the patients.[33]

Type and Effect of Preoperative Dietary Management

Preoperative dietary management for MBS is an essential component of surgical success and aims to achieve moderate weight loss and improve surgical conditions. Common preoperative dietary patterns include energy restricted diets, low-carbohydrate ketogenic diets (LCKD), and dietary regimens incorporating ready-to-eat low-carbohydrate ketogenic products (RLCKPs).[34,35]

Energy restricted diets are the most commonly recommended type of preoperative diet, which promotes weight loss by reducing caloric intake. However, this diet is associated with poorer long-term weight management outcomes and may lead to problems such as weight rebound, increased food craving, binge eating, emotional eating, malnutrition, and eating disorders, thereby reducing future success in changing eating behaviors. In addition, energy restricted diets may increase the likelihood of eating disorders, food consumption anxiety, and internalization of weight stigma, adversely affecting pre- and postoperative outcomes.[34]

In contrast, LCKD showed better results in preoperative dietary management. Studies have shown that weight loss and left lateral liver segment (LLLS) volume reduction can be safely and effectively achieved with LCKD 4 weeks before surgery, thereby reducing the difficulty of surgery and the risk of complications. Most programs require people to follow a low calorie low carbohydrate diet prior to surgery for between 2 to 6 weeks to reduce the size of the liver and make the surgery safer. LCKD promotes lipolysis and energy expenditure by limiting carbohydrate intake and putting the body into a ketogenic state. However, long-term adherence to LCKD can be challenging because it has limited sweetness options and easily triggers a desire for traditional carbohydrate-rich foods.[35] In addition, it is important that patients have access to a dietitian to prepare for surgery. For instance, to help improve the quality of diet and eating patterns.

To address this issue, RLCKP was introduced into preoperative dietary management. RLCKP helps patients adhere more easily to LCKD by replicating the texture and flavor of traditional foods while maintaining low carbohydrate content. The study showed that a 4-week preoperative dietary regimen with RLCKP significantly reduced body weight and LLLS volume, with high patient compliance and satisfaction. The use of RLCKP improves adherence to ketogenic diet regimens and helps to improve the effect of preoperative diet management.[36] Patients following an LCKD may experience significant changes in hunger and mood. Studies have shown that while LCKD can effectively promote weight loss, some patients may report increased feelings of hunger or irritability during the initial adaptation phase. However, with proper support and counseling, these symptoms can be managed, and patient satisfaction can be improved. The use of RLCKP can further enhance patient compliance by providing more palatable and familiar food options, thereby reducing the psychological burden associated with dietary changes.[36]

Overall, the types of preoperative dietary management for MBS are diverse, and different dietary regimens have their own advantages and disadvantages. Although energy-restricted diets are widely used, their long-term effects and effects on eating behavior cannot be ignored. LCKD and RLCKP dietary regimens have shown good results in promoting weight loss and improving surgical conditions, but further studies are still needed to optimize dietary regimens and improve patient compliance, so as to provide more scientific and effective preoperative dietary management strategies for MBS patients.

Necessity and Strategy of Preoperative Micronutrient Supplementation

MBS is an effective treatment for severe obesity and its related complications, however, preoperative and postoperative micronutrient deficiencies are prevalent in patients with MBS and may lead to a variety of complications, such as anemia, neurological diseases and metabolic bone diseases, which seriously affect the quality of life of patients and surgical outcomes. Therefore, preoperative micronutrient supplementation appears particularly necessary.[23,37] Preoperative micronutrient supplementation can not only correct the existing nutritional deficiency status of patients, optimize their nutritional status, create a good physiological basis for surgery, but also prevent the further deterioration of postoperative nutritional deficiency to a certain extent. Studies have shown that preoperative micronutrient deficiency is an important predictor of postoperative deficiency, and preoperative identification and treatment of these nutritional deficiencies can effectively prevent the deterioration of postoperative nutritional status, reduce the incidence of postoperative complications, and promote postoperative recovery of patients.[23]

When developing preoperative micronutrient supplementation strategies, patients first need to undergo a comprehensive nutritional assessment, including a detailed history, physical examination, and relevant laboratory tests, such as blood routine, serum ferritin, vitamin D, folic acid, and vitamin B12 measurements, to accurately understand the specific nutritional deficiency of patients. On this basis, a personalized supplementation program is developed according to the type and degree of micronutrients deficient in the patient. For patients with vitamin D deficiency, oral vitamin D supplements can be used, and the daily dose of supplementation depends on serum 25 (OH) vitamin D levels, and it is generally recommended to maintain serum 25 (OH) vitamin D levels above 30 ng/mL.[38] For patients with iron deficiency, oral iron or intravenous iron supplementation can be given, and changes in serum ferritin, hemoglobin and other indicators should be monitored to assess the effect of supplementation; patients with folic acid and vitamin B12 deficiency can be corrected by oral or injection of the corresponding supplement.[39]

In the selection of supplementary methods, oral supplements are the most commonly used modality and have the advantages of convenience and economy, but their absorption may be affected by factors such as gastrointestinal function and drug interactions of patients, so patients' compliance and supplementary effects need to be closely monitored during supplementation, and other routes of administration such as intramuscular injection or intravenous infusion can be considered when necessary to improve the supplementary effect.[40] In addition, the timing of micronutrient supplementation before surgery also needs to be reasonably scheduled, and it is generally recommended that supplementation be started several weeks before surgery in order to give the patient sufficient time to correct the nutritional deficiency state while avoiding the potential risks resulting from supplementation near the time of surgery.[41] It is worth noting that preoperative micronutrient supplementation is not a once and for all measure, and it is still necessary to continuously pay attention to the nutritional status of patients after surgery, and timely adjust the supplementation regimen according to the postoperative recovery and changes in nutritional requirements to ensure that patients can maintain a good nutritional status and promote health throughout the perioperative period and long-term follow-up after surgery.

Nutritional Management After MBS

Following MBS, patients often face a variety of nutritional deficiencies, and the types, mechanisms, and risk factors of these deficiencies are complex. These deficiencies not only affect the quality of life of patients, but may also lead to complications such as anemia, neurological diseases, and metabolic bone diseases in severe cases.[42] The mechanism of nutritional deficiency is mainly related to physiological changes after surgery. On the one hand, surgery will change the anatomy of the digestive tract, such as reduced gastric capacity, reduced intestinal absorption area, etc., thus affecting the intake of food and nutrient absorption. For example, after gastric bypass surgery, food bypasses parts of the stomach and small intestine, resulting in decreased absorption of vitamin B12 and iron. On the other hand, patients may experience dyspeptic symptoms such as nausea and vomiting after surgery, further limiting the intake of food.[43] In addition, decreased gastric acid secretion after surgery can also affect the absorption of nutrients, such as vitamin B12 requires intrinsic factors in gastric acid to be absorbed. Finally, risk factors for postoperative nutritional deficiencies include patient gender, BMI, ethnicity, etc.[44] Female patients are more likely to present with iron deficiency and anemia due to physiological characteristics, such as menstrual blood loss. Patients with a higher degree of obesity may have nutritional

deficiencies before surgery due to long-term unbalanced diet, and the risk is further increased after surgery.[45] People of different ethnic groups may also be at different risk of nutritional deficiencies due to differences in dietary habits and genetic factors. For example, people of certain ethnic groups may be more vulnerable to vitamin D deficiency.[26] Therefore, for patients with MBS, nutritional assessment and management before and after surgery are essential to prevent and correct nutritional deficiencies and ensure patient health and surgical outcomes. Additionally, post-bariatric hyperinsulinemic hypoglycemia (PBHH) is an increasingly recognized complication, especially after Roux-en-Y gastric bypass (RYGB). This condition can significantly affect the quality of life of patients and requires strict dietary instructions to avoid its occurrence. According to a recent study by Kehagias et al,[46] PBHH was observed in a considerable proportion of patients after laparoscopic Roux-en-Y gastric bypass, particularly among those with obesity and type 2 diabetes. The study highlighted the importance of close monitoring and dietary management to prevent and manage this complication. Patients are advised to follow a structured meal plan with frequent small meals and avoid high-carbohydrate foods to minimize the risk of hypoglycemia.

Long-term micronutrient deficiencies after MBS can lead to significant health issues, such as osteoporosis from chronic vitamin D deficiency and persistent anemia from iron deficiency.[15] Regular nutritional monitoring and personalized supplementation are crucial for managing these deficiencies. Patients should undergo periodic screening for key nutrients (eg, iron, vitamin D, B12) and bone mineral density testing to assess osteoporosis risk.[47] Personalized supplementation plans should be developed based on individual deficiencies and adjusted over time. Additionally, dietary education and lifestyle modifications, such as maintaining a balanced diet and avoiding high-sugar foods, are essential for long-term health. Effective long-term nutritional management requires collaboration among dietitians, surgeons, endocrinologists, and psychologists. Each professional plays a critical role in supporting the patient's nutritional needs and overall well-being.[48]

The structure and habits of the diet also need to be adjusted after surgery. Patients should avoid foods high in sugar, fat, and salt and choose foods low in calories and fiber to help control weight and prevent the recurrence of obesity. At the same time, patients should be encouraged to develop good eating habits, such as regular quantitative eating, chewing slowly, etc., to promote digestion and absorption. Diversity in diet is also important and should include a variety of vegetables, fruits, whole grains, and high-quality protein sources to ensure that patients have access to comprehensive nutrition.[49]

Postoperative nutritional monitoring is essential for patients receiving MBS, as surgery may lead to problems such as decreased food intake, poor nutritional absorption, etc., causing multiple nutritional deficiencies.[49] Trace element and vitamin levels, such as iron, zinc, copper, vitamin B1, B9, B12, D, A, E, etc., these nutrients are easily deficient after surgery, and their plasma concentrations need to be measured regularly to assess whether the patient has the corresponding nutritional deficiency; bone mineral density testing, monitoring bone mineral density changes by DEXA and other methods to assess the risk of osteoporosis, because vitamin D deficiency and calcium malabsorption may lead to osteoporosis; liver and kidney function indicators, such as transaminases, bilirubin, urea nitrogen, creatinine, etc., these indicators can reflect the overall metabolic status and organ function of patients and indirectly indicate nutritional status.[50] In terms of monitoring frequency, it is recommended to perform a comprehensive nutritional monitoring every 3 months in the first year after surgery, including all the above indicators, timely identify nutritional problems and intervene; the second year can be adjusted to biannual monitoring; and then at least once a year, focusing on blood routine, serum protein levels and trace elements, vitamin levels and other key indicators.[51] The frequency of monitoring should be appropriately increased in patients at special nutritional risk, such as those with more postoperative complications, severely inadequate nutritional intake, or specific nutritional deficiency symptoms. Timely intervention for nutritional deficiencies is essential, and once nutritional deficiencies are detected, appropriate supplementation measures should be taken according to the type and degree of nutrients specifically deficient.[52] For patients with iron deficiency anemia, oral iron or intravenous iron supplementation can be given if necessary, and dietary structure can be adjusted to increase iron-rich food intake; vitamin D deficiency requires vitamin D supplementation, oral or injectable formulations can be selected, and appropriate sun exposure can be encouraged to promote vitamin D synthesis in the body; for patients with protein malnutrition, nutritional status can be improved by increasing high-quality protein food intake or protein supplementation. At the same time, nutrition education should also be strengthened to guide patients to reasonably

arrange their diets, avoid bad eating habits such as partial eclipse and picky eating, ensure balanced nutritional intake, and promote postoperative recovery.[18] Perioperative nutritional management in MBS should be tailored to the unique needs of each patient, considering factors such as age, pre-existing comorbidities, and ethnic background. These factors can significantly influence nutritional outcomes and require specific attention.

Collaboration of multidisciplinary teams is essential during postoperative nutritional management. Professionals such as dietitians, surgeons, endocrinologists, and psychologists should participate in the development of nutritional assessment and management plans for patients. Dietitians are responsible for providing personalized dietary advice and nutrition education, surgeons and endocrinologists adjust treatment options according to the specific circumstances of patients, and psychologists help patients cope with psychological problems that may occur after surgery, such as anxiety and depression, which may affect the patient 'dietary behavior and nutritional status.[52]

Perioperative nutritional management also varies between specific patient groups in metabolic versus bariatric surgery. Elderly patients may have more complex nutritional problems due to physiological hypofunction. With age, gastrointestinal function decreases, the absorption capacity of nutrients weakens, and deficiencies of nutrients such as protein, vitamin B12, and calcium are more likely to occur. Therefore, more meticulous examination of these nutrient levels is required during preoperative nutritional assessment. At the same time, elderly patients may have sarcopenia, and muscle mass and function should be assessed emphatically preoperatively and judged by measuring grip strength, gait speed, and other indicators.[53] Older patients recover more slowly after surgery and may have longer hospital stays. Postoperative nutritional support should pay more attention to maintaining muscle mass and improving physical function, and appropriately increase protein intake, such as by whey protein supplementation. In addition, due to the decreased ability of the elderly to metabolize and excrete drugs, attention should be paid to drug interactions when nutritional preparations are supplemented postoperatively to avoid affecting the efficacy of other drugs or increasing adverse reactions.[54] For diabetic patients, preoperative glycemic control is essential. Blood glucose management should be optimized before metabolic and bariatric surgery to avoid increased surgical risk due to hyperglycemia. In preoperative dietary management, in addition to conventional low-calorie diets, the proportion and type of carbohydrate intake can be appropriately adjusted, and foods with low glycemic index can be selected to help better control blood glucose. At the same time, blood glucose changes should be closely monitored, hypoglycemic drug doses should be adjusted according to blood glucose levels, and hypoglycemic regimens should be optimized in cooperation with endocrinologists if necessary.[9] Cardiac function and nutritional status should be assessed preoperatively in patients with cardiovascular disease. In nutritional management, sodium intake should be restricted to reduce edema and cardiac burden. At the same time, adequate protein intake is ensured to maintain myocardial function. For patients with hypertension, preoperative diet should pay attention to blood pressure control, avoid high-salt, high-fat foods, and increase the intake of foods rich in potassium and magnesium, such as green leafy vegetables and fruits, which helps to reduce blood pressure.[29] Diet habits vary significantly among ethnic groups, which can influence the development of nutritional management programs. The diet of people in the Mediterranean region is rich in olive oil, fish, vegetables and fruits, and this diet is rich in unsaturated fatty acids, vitamins and minerals. For patients from the Mediterranean region, preoperative dietary management can appropriately adjust the intake ratio of olive oil and fish to meet nutritional needs. However, some people in Asia mainly eat cereals, and vegetable and fruit intake is relatively small, and it is necessary to increase vegetable and fruit intake and improve nutritional structure before surgery.[44]

In conclusion, nutritional management after MBS is a long-term and integrated process that requires the joint efforts of patients, families, and medical teams. Through reasonable dietary modification, nutritional supplementation and multidisciplinary collaboration, the occurrence of postoperative nutritional deficiency and other complications can be effectively prevented, and the health recovery and quality of life of patients can be promoted.

Challenges in Perioperative Nutritional Management

Perioperative nutritional management plays a crucial role in MBS, but it also faces many challenges. Malnutrition and micronutrient deficiencies are prevalent in obese patients preoperatively. Preoperative vitamin D, iron, folic acid, vitamin B12 and other nutrients deficiencies are high due to long-term unbalanced diets and obesity-related physiological changes, such as reduced bioavailability of vitamin D and chronic inflammation affecting iron absorption. Obese patients

often have a long history of restricted diets and fluctuations in body weight, resulting in depletion of fat-free mass (FFM), further exacerbating the risk of malnutrition.[55] The assessment and optimization of preoperative nutritional status is particularly important, but there is no uniform consensus and standard in the definition of preoperative nutritional evaluation, the selection of screening markers, the determination of pathological cut-off values, and the dose of nutritional supplements, which poses a challenge to clinical practice.

Entering the postoperative phase, challenges in nutritional management escalated further. Patients are more prone to nutritional deficiencies after MBS due to factors such as reduced food intake, anatomical changes leading to inadequate nutrient absorption, and decreased gastric acid and endoplasmic reticulum secretion. Especially for some malabsorptive procedures, such as biliopancreatic diversion plus duodenal switch (BPD-DS), the risk of postoperative nutritional deficiencies is higher.[55] Postoperative nutritional deficiencies not only affect the quality of life of patients, but may also lead to serious complications, such as anemia, neurological diseases and metabolic bone diseases. Therefore, long-term and even life-long monitoring and supplementation of nutrients are required after surgery to prevent and correct nutritional deficiencies. However, the individual differences of patients after surgery are large, different surgical types, basic nutritional status of patients, dietary habits and other factors will affect the effect of nutritional management, how to develop individualized nutritional supplementation program is still a difficult problem.

Future research directions can be developed from the following aspects: First, to strengthen standardized and refined studies of preoperative nutritional assessment. To develop more accurate and comprehensive preoperative nutritional assessment tools and indicators to identify cut-off values for different nutrient deficiencies in order to better identify patients with preoperative malnutrition and provide a basis for preoperative nutritional intervention. Second, to deeply explore the best program of preoperative nutritional intervention. To investigate the effects of different nutritional supplements on preoperative nutritional status and prevention of postoperative nutritional deficiency, and provide more scientific and effective preoperative nutritional intervention strategies for clinical practice. In addition, optimization of postoperative nutritional management is also the focus of future research. Further studies are needed to investigate changes in nutritional requirements at different stages after surgery, explore individualized nutritional supplementation regimens, and how to improve patient compliance with nutritional supplementation. At the same time, attention should also be paid to the impact of postoperative nutritional deficiency on the long-term health of patients, and long-term follow-up studies should be carried out to evaluate the impact of different nutritional management strategies on post-operative complications, quality of life and long-term prognosis of patients, providing a strong evidence-based basis for the continuous improvement of perioperative nutritional management.

Summary

Perioperative nutritional management has a crucial role in MBS. Preoperative nutritional assessment and intervention are essential to improve surgical success. Through preoperative nutritional support, the nutritional status of patients can be improved and the incidence of postoperative complications can be reduced, thereby improving the success rate of surgery. Nutritional management is also essential after surgery. Following MBS, patients may be at risk of deficiencies in nutrients such as protein, vitamin D, calcium, iron, vitamin B12, and folic acid. Deficiencies in these nutrients not only affect the physical health of patients, but may also lead to a decrease in quality of life. Good nutritional management can further enhance this improvement, help patients better adapt to the postoperative lifestyle, and improve their quality of life. In order to further optimize the nutritional management strategy during the perioperative period of MBS, future research and practice need to be explored and improved in the following aspects: First, a more personalized and precise nutritional management program needs to be developed and adjusted according to the specific circumstances and nutritional needs of patients. Second, collaboration among multidisciplinary teams, including dietitians, surgeons, endocrinologists, etc., should be strengthened to jointly develop and implement nutrition management programs. In addition, education and guidance for patients and their families should be strengthened to improve their awareness and compliance with the importance of nutritional management. Through these efforts, the nutritional needs of patients in the perioperative period can be better met, and the success rate of surgery and the long-term quality of life of patients can be improved. Moreover, it is important to address the significant challenges discussed in this review, such as the high prevalence of preoperative malnutrition and the complexity of postoperative nutritional deficiencies. Future research is

essential to develop more accurate preoperative nutritional assessment tools and personalized postoperative nutritional supplementation strategies to optimize perioperative nutritional management.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article.

Ethics Approval and Consent to Participate

An ethics statement is not applicable because this study is based exclusively on published literature.

Funding

There is no funding to report.

Disclosure

The authors have no personal, financial, commercial, or academic conflicts of interest in this study.

References

1. Gerardo G, Peterson N, Goodpaster K, Heinberg L. Depression and obesity. *Curr Obes Rep*. 2025;14(1):5. PMID: 39752052. doi:10.1007/s13679-024-00603-x
2. Yu J, Chen S, Yang J, et al. Childhood and adolescent overweight/obesity prevalence trends in Jiangsu, China, 2017-2021: an age-period-cohort analysis. *Public Health Nurs*. 2024. PMID: 39737852. doi:10.1111/phn.13517.
3. Wong HJ, Lin NHY, Teo YH, et al. Anti-diabetic effects of GLP-1 receptor agonists on obese and overweight patients across diabetes status, administration routes, treatment duration and baseline characteristics: a systematic review. *Diabetes Obes Metab*. 2025;27(4):1648–1659. PMID: 39726212. doi:10.1111/dom.16136
4. Wang M, Flexeder C, Harris CP, et al. Accelerometry-assessed sleep clusters and obesity in adolescents and young adults: a longitudinal analysis in GINIplus/LISA birth cohorts. *World J Pediatr*. 2025. PMID: 39754701. doi:10.1007/s12519-024-00872-5.
5. Marketdata Enterprises LLC. *The U.S. Weight Loss and Diet Control Market*. 17th. Tampa, FL: Marketdata Enterprises LLC. 2023. Report No.: 5313560.
6. Yousefi R, Ben-Porat T, O'Neill J, et al. Understanding the components of eating behaviour-focused weight management interventions adjunct to metabolic bariatric surgery: systematic review of published literature. *Curr Obes Rep*. 2025;14(1):3. PMID: 39753946. doi:10.1007/s13679-024-00596-7
7. Kehagias D, Georgopoulos N, Habeos I, Lampropoulos C, Mulita F, Kehagias I. The role of the gastric fundus in glycemic control. *Hormones*. 2023;22(2):151–163. PMID: 36705877. doi:10.1007/s42000-023-00429-7
8. Morton JM. 2015 American society for metabolic and bariatric surgery presidential address. *Surg Obes Relat Dis*. 2024;30:S1550–7289(24)00917–1. PMID: 39732585. doi:10.1016/j.soard.2024.11.008
9. Mechanick JI, Youdim A, Jones DB, et al. American Association of Clinical Endocrinologists; Obesity Society; American Society for Metabolic & Bariatric Surgery. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient–2013 update: cosponsored by American association of clinical endocrinologists, the obesity society, and American society for metabolic & bariatric surgery. *Obesity*. 2013;1(01):S1–27. PMID: 23529939; PMCID: PMC4142593. doi:10.1002/oby.20461
10. Stenberg E, Reis Falcão LF D, O'Kane M, et al. Guidelines for perioperative care in bariatric surgery: Enhanced Recovery After Surgery (ERAS) society recommendations: a 2021 update. *World J Surg*. 2022;46(4):729–751. PMID: 34984504; PMCID: PMC8885505. doi:10.1007/s00268-021-06394-9
11. Özkan AE, Koca N, Tekeli AH. Assessment of nutritional status and clinical outcomes: a comprehensive retrospective analysis of critically ill patients. *Medicine*. 2023;102(44):e36018. PMID: 37932978; PMCID: PMC10627690. doi:10.1097/MD.0000000000036018
12. Firman CH, Mellor DD, Unwin D, Brown A. Does a ketogenic diet have a place within diabetes clinical practice? Review of current evidence and controversies. *Diabetes Ther*. 2024;15(1):77–97. PMID: 37966583; PMCID: PMC10786817. doi:10.1007/s13300-023-01492-4
13. Mechanick JI, Apovian C, Brethauer S, et al. Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures - 2019 update: cosponsored by American Association of Clinical Endocrinologists/American College of Endocrinology, The Obesity Society, American Society for Metabolic & Bariatric Surgery, Obesity Medicine Association, and American Society of Anesthesiologists - executive summary. *Endocr Pract*. 2019;25(12):1346–1359. PMID: 31682518. doi:10.4158/GL-2019-0406
14. Lewis CA, de Jersey S, Seymour M, Hopkins G, Hickman I, Osland E. Iron, vitamin B12, folate and copper deficiency after bariatric surgery and the impact on anaemia: a systematic review. *Obes Surg*. 2020;30(11):4542–4591. PMID: 32785814. doi:10.1007/s11695-020-04872-y
15. Musella M, Berardi G, Vitiello A, et al. Vitamin D deficiency in patients with morbid obesity before and after metabolic bariatric surgery. *Nutrients*. 2022;14(16):3319. PMID: 36014825; PMCID: PMC9416433. doi:10.3390/nu14163319
16. Sander J, Torensma B, Siepe J, et al. Assessment of preoperative multivitamin use on the impact on micronutrient deficiencies in patients with obesity prior to metabolic bariatric surgery. *Obes Surg*. 2025. PMID: 40199822. doi:10.1007/s11695-025-07853-1.
17. Jáuregui-Lobera I. Iron deficiency and bariatric surgery. *Nutrients*. 2013;5(5):1595–1608. PMID: 23676549; PMCID: PMC3708339. doi:10.3390/nu5051595
18. Grace C, Vincent R, Aylwin SJ. High prevalence of vitamin D insufficiency in a United Kingdom urban morbidly obese population: implications for testing and treatment. *Surg Obes Relat Dis*. 2014;10(2):355–360. PMID: 24411192. doi:10.1016/j.soard.2013.07.017

19. Flores L, Moizé V, Ortega E, et al. Prospective study of individualized or high fixed doses of vitamin D supplementation after bariatric surgery. *Obes Surg*. 2015;25(3):470–476. PMID: 25086955. doi:10.1007/s11695-014-1393-9
20. Gagnon C, Schafer AL. Bone health after bariatric surgery. *JBMR Plus*. 2018;2(3):121–133. PMID: 30283897; PMCID: PMC6124196. doi:10.1002/jbm4.10048
21. Cornejo-Pareja I, Clemente-Postigo M, Tinahones FJ. Metabolic and endocrine consequences of bariatric surgery. *Front Endocrinol*. 2019;10:626. PMID: 31608009; PMCID: PMC6761298. doi:10.3389/fendo.2019.00626
22. Ba F, Siddiqi ZA. Neurologic complications of bariatric surgery. *Rev Neurol Dis*. 2010;7(4):119–124. PMID: 21206427.
23. Reytor-González C, Frias-Toral E, Nuñez-Vásquez C, et al. Preventing and managing pre- and postoperative micronutrient deficiencies: a vital component of long-term success in bariatric surgery. *Nutrients*. 2025;17(5):741. PMID: 40077612; PMCID: PMC11902093. doi:10.3390/nu17050741
24. Sayadi Shahraki M, Khalili N, Yousefvand S, Sheikhbahaei E, Shahabi Shahmiri S. Severe obesity and vitamin D deficiency treatment options before bariatric surgery: a randomized clinical trial. *Surg Obes Relat Dis*. 2019;15(9):1604–1611. PMID: 31402293. doi:10.1016/j.soard.2019.05.033
25. Al-Mutawa A, Anderson AK, Alsabah S, Al-Mutawa M. Nutritional status of bariatric surgery candidates. *Nutrients*. 2018;10(1):67. PMID: 29324643; PMCID: PMC5793295. doi:10.3390/nu10010067
26. Abu-Saad K, Murad H, Lubin F, et al. Jews and Arabs in the same region in Israel exhibit major differences in dietary patterns. *J Nutr*. 2012;142(12):2175–2181. PMID: 23096004. doi:10.3945/jn.112.166611
27. Stegenga H, Haines A, Jones K, Wilding J; Guideline Development Group. Identification, assessment, and management of overweight and obesity: summary of updated NICE guidance. *BMJ*. 2014;349:g6608. PMID: 25430558. doi:10.1136/bmj.g6608
28. Parrott J, Frank L, Rabena R, Craggs-Dino L, Isom KA, Greiman L. American society for metabolic and bariatric surgery integrated health nutritional guidelines for the surgical weight loss patient 2016 update: micronutrients. *Surg Obes Relat Dis*. 2017;13(5):727–741. PMID: 28392254. doi:10.1016/j.soard.2016.12.018
29. O'Kane M, Parretti HM, Pinkney J, et al. British obesity and metabolic surgery society guidelines on perioperative and postoperative biochemical monitoring and micronutrient replacement for patients undergoing bariatric surgery-2020 update. *Obes Rev*. 2020;21(11):e13087. PMID: 32743907; PMCID: PMC7583474. doi:10.1111/obr.13087
30. Lim HS, Kim YJ, Lee J, Yoon SJ, Lee B. Establishment of adequate nutrient intake criteria to achieve target weight loss in patients undergoing bariatric surgery. *Nutrients*. 2020;12(6):1774. PMID: 32545878; PMCID: PMC7353322. doi:10.3390/nu12061774
31. Qin X, Zhang Z, Chen L, Wu G. Gastrointestinal surgery group, Chinese medical association surgery branch, colorectal surgery group, Chinese medical association surgery branch, gastrointestinal surgery committee, Chinese medical doctor association surgery branch. Chinese expert consensus on perioperative whole-course nutrition management for gastrointestinal surgery (2021 Edition). *Chinese J Pract Sur*. 2021;41(10):1111–1125. doi:10.19538/j.cjps.issn1005-2208.2021.10.05
32. Jans G, Matthys C, Bogaerts A, et al. Maternal micronutrient deficiencies and related adverse neonatal outcomes after bariatric surgery: a systematic review. *Adv Nutr*. 2015;6(4):420–429. PMID: 26178026; PMCID: PMC4496736. doi:10.3945/an.114.008086
33. Li ZJ, Chen W. Optimizing perioperative nutrition management in enhanced recovery after surgery. *Zhonghua Wai Ke Za Zhi*. 2019;57(7):513–516. PMID: 31269613. doi:10.3760/cma.j.issn.0529-5815.2019.07.007
34. Nordmo M, Danielsen YS, Nordmo M. The challenge of keeping it off, a descriptive systematic review of high-quality, follow-up studies of obesity treatments. *Obes Rev*. 2020;21(1):e12949. PMID: 31675146. doi:10.1111/obr.12949
35. Khalooeifard R, Rahmani J, Ghoreishy SM, Tavakoli A, Najjari K, Talebpour M. Evaluate the effects of different types of preoperative restricted calorie diets on weight, body mass index, operation time and hospital stay in patients undergoing bariatric surgery: a systematic review and meta analysis study. *Obes Surg*. 2024;34(1):236–249. PMID: 38052747. doi:10.1007/s11695-023-06973-w
36. Santella B, Mingo M, Papp A, et al. Safety and effectiveness of a 4-week diet on low-carb ready-to-eat ketogenic products as preoperative care treatment in patients scheduled for metabolic and bariatric surgery. *Nutrients*. 2024;16(22):3875. PMID: 39599661; PMCID: PMC11597797. doi:10.3390/nu16223875
37. Kaberi-Otarod J, Still CD, Wood GC, Benotti PN. Iron treatment in patients with iron deficiency before and after metabolic and bariatric surgery: a narrative review. *Nutrients*. 2024;16(19):3350. PMID: 39408317; PMCID: PMC11478352. doi:10.3390/nu16193350
38. Pludowski P, Grant WB, Karras SN, Zittermann A, Pilz S. Vitamin D supplementation: a review of the evidence arguing for a daily dose of 2000 international units (50 µg) of vitamin D for adults in the general population. *Nutrients*. 2024;16(3):391. PMID: 38337676; PMCID: PMC10857599. doi:10.3390/nu16030391
39. Lo JO, Benson AE, Martens KL, et al. The role of oral iron in the treatment of adults with iron deficiency. *Eur J Haematol*. 2023;110(2):123–130. PMID: 36336470; PMCID: PMC9949769. doi:10.1111/ejh.13892
40. Magali Sanchez AM, Pampillón N, Abaurre M. Omelanczuk pe. deficiencia de hierro en el preoperatorio de cirugía bariátrica: diagnóstico y tratamiento [pre-operative iron deficiency in bariatric surgery: diagnosis and treatment]. *Nutr Hosp*. 2015;32(1):75–79. PMID: 26262699. doi:10.3305/nh.2015.32.1.8871
41. Hassan M, Barajas-Gamboa JS, Kanwar O, et al. The role of dietitian follow-ups on nutritional outcomes post-bariatric surgery. *Surg Obes Relat Dis*. 2024;20(4):407–412. PMID: 38158312. doi:10.1016/j.soard.2023.10.017
42. Noser MS, Boll DT, Lazaridis II, et al. Opportunistic quantitative computed tomography assessing bone mineral density in patients with laparoscopic Roux-En-Y-Gastric bypass metabolic surgery throughout a 5-year observation window. *J Comput Assist Tomogr*. 2024. PMID: 39631733. doi:10.1097/RCT.0000000000001705.
43. Angrisani L, Santonicola A, Iovino P, et al. Collaborative Study Group for the IFSO Worldwide Survey. IFSO worldwide survey 2020-2021: current trends for bariatric and metabolic procedures. *Obes Surg*. 2024;34(4):1075–1085. PMID: 38438667; PMCID: PMC11026210. doi:10.1007/s11695-024-07118-3
44. Lee PC, Ganguly S, Dixon JB, Tan HC, Lim CH, Tham KW. Nutritional deficiencies in severe obesity: a multiethnic Asian cohort. *Obes Surg*. 2019;29(1):166–171. PMID: 30191504. doi:10.1007/s11695-018-3494-3
45. Al-Mutawa A, Al-Sabah S, Anderson AK, Al-Mutawa M. Evaluation of nutritional status post laparoscopic sleeve gastrectomy-5-year outcomes. *Obes Surg*. 2018;28(6):1473–1483. PMID: 29197046. doi:10.1007/s11695-017-3041-7

46. Kehagias D, Lampropoulos C, Vamvakas SS, Kehagia E, Georgopoulos N, Kehagias I. Post-bariatric hypoglycemia in individuals with obesity and type 2 diabetes after laparoscopic Roux-en-Y gastric bypass: a prospective cohort study. *Biomedicines*. 2024;12(8):1671. PMID: 39200136; PMCID: PMC11351344. doi:10.3390/biomedicines12081671
47. Gudzune KA, Huizinga MM, Chang HY, Asamoah V, Gadgil M, Clark JM. Screening and diagnosis of micronutrient deficiencies before and after bariatric surgery. *Obes Surg*. 2013;23(10):1581–1589. PMID: 23515975; PMCID: PMC3740071. doi:10.1007/s11695-013-0919-x
48. Bednarczuk B, Czekajło-Kozłowska A. Role of nutritional support provided by qualified dietitians in the prevention and treatment of non-communicable diseases. *Rocz Panstw Zakl Hig*. 2019;70(3):235–241. PMID: 31515982. doi:10.32394/rpzh.2019.0080
49. Chinaka U, Fultang J, Ali A, Rankin J, Bakhshi A. Pre-specified weight loss before bariatric surgery and postoperative outcomes. *Cureus*. 2020;12(12):e12406. PMID: 33542862; PMCID: PMC7849210. doi:10.7759/cureus.12406
50. Sherf Dagan S, Goldenshluger A, Globus I, et al. Nutritional recommendations for adult bariatric surgery patients: clinical practice. *Adv Nutr*. 2017;8(2):382–394. PMID: 28298280; PMCID: PMC5347111. doi:10.3945/an.116.014258
51. Roberts R, Williams DM, Min T, Barry J, Stephens JW. Benefits in routinely measured liver function tests following bariatric surgery: a retrospective cohort study. *J Diabetes Metab Disord*. 2023;22(2):1763–1768. PMID: 37975098; PMCID: PMC10638127. doi:10.1007/s40200-023-01311-4
52. Järvholm K, Janson A, Henfridsson P, Neovius M, Sjögren L, Olbers T. Metabolic and bariatric surgery for adolescents with severe obesity: benefits, risks, and specific considerations. *Scand J Surg*. 2024;17:14574969241297517. PMID: 39552134. doi:10.1177/14574969241297517
53. Muscaritoli M, Anker SD, Argilés J, et al. Consensus definition of sarcopenia, cachexia and pre-cachexia: joint document elaborated by Special Interest Groups (SIG) "cachexia-anorexia in chronic wasting diseases" and "nutrition in geriatrics". *Clin Nutr*. 2010;29(2):154–159. PMID: 20060626. doi:10.1016/j.clnu.2009.12.004
54. Morley JE, Argiles JM, Evans WJ, et al. Society for sarcopenia, cachexia, and wasting disease. *J Am Med Dir Assoc*. 2010;11(6):391–396. PMID: 20627179; PMCID: PMC4623318. doi:10.1016/j.jamda.2010.04.014
55. Stefanakis K, Kokkorakis M, Mantzoros CS. The impact of weight loss on fat-free mass, muscle, bone and hematopoiesis health: implications for emerging pharmacotherapies aiming at fat reduction and lean mass preservation. *Metabolism*. 2024;161:156057. PMID: 39481534. doi:10.1016/j.metabol.2024.156057