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REVIEW ARTICLE

Metabolic significance of nutritional treatment before and after bariatric surgery: a systematic review

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Abstract

Introduction: According to the American Society for Metabolic and Bariatric Surgery (ASMBS), the rate of bariatric surgery (BS) increased from 158 thousand in 2011 to 196 thousand in 2015. Lifestyle modifications, such as healthy eating and correct physical activity programs, can improve surgical results. Thus, the most important aspect in the medical management of bariatric patients refers to nutritional management. **Objective:** It was to carry out a systematic review to list the main approaches and significance of nutritional treatment before and after bariatric surgery, to mitigate the metabolic damage caused by nutrient deficits. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from August to October 2024 in the Web of Science, Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** 127 articles were found. A total of 45 articles were evaluated in full and 30 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 25 studies with a high risk of bias and 27 studies that did not meet GRADE and AMSTAR-2. Most studies showed homogeneity in their results, with X^2=62.5%>50%. It was concluded that the most important aspects of the medical management of bariatric patients refer to nutritional management. Before bariatric surgery, nutritional status should be checked and preoperative weight loss may be attempted. Very low-calorie diets and very low-calorie ketogenic diets are often prescribed in the last few months before surgery. It was observed that the recommendations were gathered to assist in individualized clinical practice in the nutritional management of patients with obesity, including nutritional management. Iron status can be affected by inflammation of adipose tissue and increased expression of the systemic iron-regulating protein hepcidin. The postoperative recommendation for vitamin B12 (cobalamin) should be 350-500 micrograms/1000 micrograms monthly, and postoperative folate (folic acid) should be 1,000 micrograms per day.

Keywords: Nutrology. Nutrients. Bariatric surgery. Metabolic management.

Introduction

According to the American Society for Metabolic and Bariatric Surgery (ASMBS), the rate of bariatric surgery (BS) increased from 158,000 in 2011 to 196,000 in 2015. However, this increase in invasive techniques does not eliminate unhealthy habits, therefore, lifestyle modifications, such as healthy eating and correct physical activity programs, can improve surgical results **[1]**.

The most important aspects in the medical management of the bariatric patient refer to nutritional management. Before BS, the nutritional status should be verified and preoperative weight loss can be attempted. Very low-calorie diets and very low-calorie ketogenic diets are often prescribed in the last months before surgery. Nutritional deficiencies may arise depending on the type of bariatric procedure and should be prevented and eventually treated **[1,2]**.

In this context, specific nutritional problems, such as dumping syndrome and reactive hypoglycemia, may occur and should be managed largely through nutritional manipulation **[1]**. However, all this care and treatment for bariatric surgery is valuable, since obesity is considered one of the main causes of morbidity and mortality due to its strong association with several health risk factors, such as diabetes, hypertension, and hyperlipidemia. For patients with a body mass index (BMI) ≥40 kg/m^2, bariatric surgery is associated with a 42% reduction in cardiovascular risk and a 30% reduction in all-cause mortality **[1]**.

In this context, it is important to note that most cases of early and late complications can quickly translate into micronutrient deficiency and malnutrition, especially when administered orally **[2-4]**. Obese patients tend to be predisposed to micronutrient deficiency even before surgery due to the obesogenic diet being calorie-dense but nutrient-depleted **[5-7]**.

Given this, it is imperative that nutrition support providers have a better understanding of the complications that necessitate the use of nutritional support, as well as the best technique for nutrition delivery, including its efficacy and associated complications **[8–10]**. There is still a paucity of data available on the outcomes of parenteral and enteral administration as nutritional support after bariatric surgery **[11,12]**.

Therefore, the present study performed a systematic review to list the main approaches and significance of nutritional treatment before and after bariatric surgery to mitigate the metabolic damage caused by nutrient deficiencies.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 09/11/2024. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 09/11/2024.

Data Sources and Search Strategy

The literature search process was carried out from August to October 2024 and developed based on Web of Science, Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors (DeCS /MeSH Terms) were used: "Nutrology. Nutrients. Bariatric surgery. Metabolic management", and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

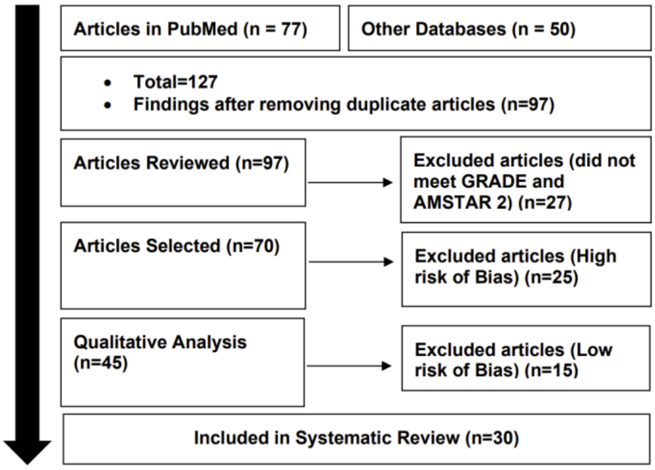
Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's test.

Results and Discussion

Summary of Findings

A total of 127 articles were found and submitted to eligibility analysis, with 30 final studies selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=62.5%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 25 studies with a high risk of bias and 27 studies that did not meet GRADE and AMSTAR-2.

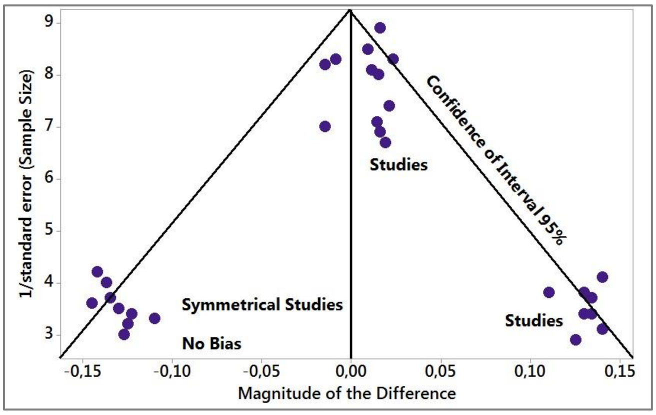
Figure 1. Flowchart showing the article selection process.



Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the bottom of the graph and in studies with large sample sizes that are shown at the top.

Figure 2. The symmetrical funnel plot suggests no risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. Studies with high confidence and high recommendation are shown above the graph (n=30 studies).



Source: Own authorship.

Main Clinical Results – Nutrology and Bariatric Surgery

According to the literature findings, it was observed that the recommendations were gathered to assist in individualized clinical practice in the nutritional management of patients with obesity, including nutritional management in the intragastric balloon, pre- and postoperative nutritional treatment, and supplementation in bariatric and metabolic surgeries (adolescents, adults, elderly, pregnant women and vegetarians), reactive hypoglycemia and hyperinsulinemia, and recurrence of obesity, intestinal microbiota, and inflammatory bowel diseases **[13]**.

The assessment of the nutritional status of candidates for BS before surgery plays an important role in post-surgical management. During the last few years, several studies have shown that patients with severe obesity often have micronutrient deficiencies when compared with normal weight controls. In 2008, Asheim et al. **[14]** analyzed the vitamin status of 110 patients affected by severe obesity compared with 58 normal-weight individuals. Patients with obesity had significantly lower concentrations of vitamins A, B6, C, 25-hydroxyvitamin D, and lipid-standardized vitamin E.

Similarly, Van Rutte et al. **[15]** demonstrated in 200 patients affected by severe obesity that 38% of them had low serum iron, 24% had low serum folate, 11% had low serum vit. B12 and 81% had hypovitaminosis D (55% severe deficiency with a level < 30 nmol/L). Furthermore, Peterson et al. **[16]** demonstrated a frank deficiency of vitamin D (< 20 ng/mL) and iron (< 35 ug/dL for women and < 50 ug/dL for men) in 71.4% and 36.2% of 58 BC candidates. Micronutrient deficiencies in patients with severe obesity may be attributed to a low-quality, unvaried, hypercaloric, and high-fat diet. For example, excess simple sugar, dairy products, or fats may lead to vitamin B1 deficiency **[17]**.

Furthermore, iron status may be affected by adipose tissue inflammation and increased expression of the systemic iron-regulating protein hepcidin **[18]**. Finally, increased adipose mass could act as a storage site for highly lipophilic molecules such as vitamin D, and this could explain the difference in 25(OH)D levels between people with and without obesity **[19]**. As a corollary to this, the postoperative recommendation for vitamin B12 (cobalamin) should be 350-500 micrograms/1000 micrograms monthly, and for folate (folic acid) postoperatively should be 1000 micrograms daily. Furthermore, to achieve moderate weight loss and reduction of liver volume and steatosis before bariatric surgery, several dietary protocols have been introduced over time, among which low-calorie diets and ketogenic diets are widely prescribed **[20-22]**. In particular, Schiavo et al. **[23]** demonstrated that a 4-week preoperative ketogenic diet is safe and effective in reducing body weight (-10.3%, p < 0.001, in men; -8.2%, p < 0.001, in women) and left hepatic lobe volume (-19.8%, p < 0.001) in obese patients scheduled for bariatric surgery.

In addition, Albanese et al. **[24]**, aiming to compare surgical outcome and weight loss in two groups of patients who received two different types of preoperative diet (low-calorie and ketogenic diets), reported that ketogenic diets presented better results than low-calorie diets in surgical outcome, influencing drainage output, postoperative hemoglobin levels and hospital stay.

Evidence suggests that ketogenic diets can be effective tools to positively manage weight loss, glycemic control and lipid profile changes **[22,23]**. However, these beneficial effects can be limited by poor adherence to the diet. In particular, cultural, religious and economic barriers represent unique challenges to achieving nutritional compliance with ketogenic diets **[22,24]**. A potential solution is represented by enteral nutrition strategies.

In this sense, enteral nutrition strategies based on weight loss have been used in the treatment of obesity, showing promising results. In particular, Sukkar et al. **[25]**, evaluating the feasibility of a modified protein-sparing diet administered via nasogastric tube via the enteral route (with continuous feeding) in the treatment of obesity, showed that 10 days of treatment with enteral nutrition followed by 20 days of a low-calorie diet was safe and effective in reducing total body weight and abdominal circumference, and in improving the respiratory capacity of patients without major complications and side effects.

Similarly, Castaldo et al. **[26]** evaluated the effects of a carbohydrate-free diet delivered through enteral nutrition for two weeks, followed by a nearly equivalent oral diet administered for another two weeks in 112 patients, and reported a significant reduction in BMI and waist circumference with improvement in blood pressure values and insulin resistance without major complications.

In this regard, weight loss induced by the ketogenic diet before bariatric surgery has beneficial effects on reducing liver volume, metabolic profile, and intra- and postoperative complications. However, these beneficial effects may be limited by poor adherence to the diet. A potential solution in patients with poor adherence to the prescribed diet could be represented by enteral nutrition strategies. A recent study by the authors Castaldo et al. (2023) **[27]** evaluated the clinical impact, efficacy, and safety of enteral protein ketogenic nutrition (EPN) versus hypocaloric enteral nutritional (HEN) protocols in obese patients who are candidates for bariatric surgery. 31 patients with EPN were compared to 29 patients with NIE utilizing a 1:1 randomization. Compared to baseline, BW, BMI, WC, WC, and NC were significantly reduced in both studied groups ($p < 0.001$). However, no significant difference was found between the EPN and HEN groups in terms of weight loss ($p = 0.559$), BMI ($p = 0.383$), WC ($p = 0.779$), and WC ($p = 0.559$), while a statistically significant difference was found in terms of NC (EPN, -7.1% vs. HEN, -4%, $p = 0.011$). Furthermore, a significant improvement in the general clinical status was observed in both groups. However, a statistically significant difference was found in terms of blood glucose (EPN, -16% vs. HEN, -8.5%, $p < 0.001$), insulin (EPN, -49.6% vs. HEN, -17.8%, $p < 0.0028$), HOMA index (EPN, -57.7% vs. HEN, 24.9%, $p < 0.001$), total cholesterol (EPN, -24.3% vs. HEN, -2.8%, $p < 0.001$), low-density lipoprotein (EPN, -30.9% vs. HEN, 1.96%, $p < 0.001$), apolipoprotein A1 (EPN, -24.2% vs. HEN, -7%, $p < 0.001$) and apolipoprotein B (EPN, -23.1% vs. HEN, - 2.3%, $p < 0.001$), while no significant difference was noted between the EPN and HEN groups in terms of aortomesenteric fat thickness ($p = 0.332$), triglyceride levels ($p = 0.534$), degree of steatosis ($p = 0.616$) and left hepatic lobe volume ($p = 0.264$). Furthermore, EPN and HEN treatments were well tolerated and no major side effects were recorded.

Early oral feeding is the preferred mode of nutrition for surgical patients. Avoiding any nutritional therapy carries the risk of malnutrition during the postoperative period of major surgery. Considering that malnutrition and undernutrition are risk factors for postoperative complications, early enteral feeding is especially relevant for any surgical patient at nutritional risk, especially for those undergoing upper gastrointestinal surgery **[28,29]**.

In particular, iron and vitamin D deficiencies are the most common. The importance of preoperative correction cannot be underestimated, as the absorption of iron, calcium, and vitamin D is reduced after bariatric procedures **[2]**. Other common preoperative micronutrient deficiencies include vitamin B12, folic acid, and thiamine **[10–13]**. In this context, approximately 30% of patients undergoing bariatric surgery develop a nutrition-related complication, typically a macronutrient or micronutrient deficiency or both, at some point after the operation **[15]**. Specific nutrition-related complications include iron anemia, folate, vitamins B12, A, and E, copper; zinc, metabolic bone disease, calcium, vitamin D, protein-energy malnutrition, steatorrhea, Wernicke encephalopathy (thiamine), polyneuropathy and myopathy (thiamine, copper, vitamins B12 and E), visual disturbances (vitamins A and E, thiamine), skin rash (zinc, essential fatty acids, vitamin A) **[3,4]**. The etiology of most nutritional deficiencies after bariatric surgery is multifactorial, with contributions from reduced food intake, altered food choices, and malabsorption. The number and severity of deficiencies are determined by the type of bariatric surgery performed, the patient's dietary habits, and the presence of other surgery-related gastrointestinal complications such as nausea, vomiting, or diarrhea. For example, operations that result in the flow of nutrients bypassing the distal stomach, duodenum, and proximal jejunum may result in malabsorption of iron, calcium, folate, and vitamin B12 **[2,3]**.

Procedures such as Roux-en-Y gastric bypass (RYGB) may place patients at increased risk for deficiencies in fat-soluble vitamins, calcium, essential fatty acids, copper, and zinc. Although some deficiencies may develop rapidly, most are insidious in onset and may not be apparent clinically. Therefore, all bariatric surgery patients should adhere to lifelong vitamin and mineral supplementation and monitoring for deficiencies **[13,14]**.

It is important to recognize that anemia can also occur as a result of other micronutrient deficiencies or a combination of deficiencies. Deficiencies of vitamin B12 and folate can result in the development of macrocytic anemia. Deficiencies of copper and zinc and vitamins A and E are other potential causes of anemia in bariatric surgery patients. A deficiency of vitamin B12 can also result in a deficiency of folate. Significant deficiencies of vitamin B12 and folate can cause macrocytic anemia, pancytopenia, and glossitis **[29,30]**.

Neurological sequelae, including subacute combined degeneration of the dorsal and lateral spine, a rare complication of vitamin B12 deficiency, may also occur. Furthermore, the most potentially devastating micronutrient deficiency occurring in hospitalized patients after bariatric surgery is thiamine (vitamin B1) deficiency **[12]**. Finally, humans cannot synthesize thiamine, which is absorbed primarily in the proximal small intestine, and body stores of thiamine are low, making adequate dietary intake essential. Thiamine deficiencies after bariatric surgery may manifest clinically as Wernicke-Korsakoff syndrome and beriberi **[12]**. Protein-energy malnutrition is one of the most serious nutritional complications of bariatric surgery. This complication may be a consequence of reduced intake of proteins such as red meat, which is poorly tolerated after bariatric surgery, or the development of other gastrointestinal diseases that result in poor oral intake and excessive weight loss **[2]**.

Conclusion

It was concluded that the most important aspects of the medical management of bariatric patients refer to nutritional management. Before bariatric surgery, nutritional status should be verified and preoperative weight loss can be attempted. Very low-calorie diets and very low-calorie ketogenic diets are often prescribed in the last months before surgery. It was observed that the recommendations were gathered to assist in individualized clinical practice in the nutritional management of patients with obesity, including nutritional management. Iron status can be affected by adipose tissue inflammation and increased expression of the systemic iron regulatory protein hepcidin. The postoperative recommendation for vitamin B12 (cobalamin) should be 350-500 micrograms/1000 micrograms monthly, and for folate (folic acid) postoperatively should be 1000 micrograms daily.

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Author contributions: **Conceptualization -** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira, Mariana Carolina Braga, Lucas Emanuel de Lima Azevedo, Lara Souza Crepaldi, Nathalia Galindo Cordeiro, Rodrigo Siqueira de Carvalho; **Data curation -** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira, Mariana Carolina Braga, Lucas Emanuel de Lima Azevedo; **Formal Analysis -** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira, Mariana Carolina Braga; **Investigation -** Renata Cristina Taveira Azevedo; **Methodology -** Mariana Carolina Braga, Lucas Emanuel de Lima Azevedo, Lara Souza Crepaldi, Nathalia Galindo Cordeiro, Rodrigo Siqueira de Carvalho; **Project administration -** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira; **Supervision-** Renata Cristina Taveira Azevedo; **Writing - original draft -** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira, Mariana Carolina Braga, Lucas Emanuel de Lima Azevedo, Lara Souza Crepaldi, Nathalia Galindo Cordeiro, Rodrigo Siqueira de Carvalho**; Writing- review & editing-** Renata Cristina Taveira Azevedo, Thuany da Silva Teixeira, Alessandra Leal de Oliveira, Mariana Carolina Braga, Lucas Emanuel de Lima Azevedo, Lara Souza Crepaldi, Nathalia Galindo Cordeiro, Rodrigo Siqueira de Carvalho.

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