Central Asian Journal of Medicine

THE EFFECT OF LAPAROSCOPIC SLEEVE RESECTION OF GASTRIC ON NUTRITIONAL STATUS AND THE EFFECTIVENESS OF ITS CORRECTION (LITERATURE REVIEW)

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ABSTRACT

Bariatric surgery is one of the most effective treatments for severe obesity. Laparoscopic sleeve resection of gastric was the most common operation, accounting for 46.0% of all procedures. The low injury rate and high functionality of laparoscopic sleeve resection of the stomach, the preservation of all secreting zones of the stomach, the simplicity of the operation using stapler technology, the absence of the need to leave a foreign body in the abdominal cavity, as well as the possibility of a complete endoscopic examination of the gastrointestinal tract after surgery (unlike gastric bypass surgery) determine its popularity. Despite the fact that metabolic bariatric surgery remains the most effective method of treating morbid obesity, such interventions are associated with the risk of postoperative complications.

Early and late complications of gastric sleeve resection remain a problem of bariatric surgery, as their elimination or prevention leads to repeated surgical or minimally invasive interventions (bleeding, suture failure, stenosis, GERD), or prolonged maintenance of nutritional status in case of nutritional deficiency, which lengthens the length of hospital stay and increases the economic costs of medications to replenish deficiency of vitamins and trace elements. In this regard, the development of methods for the prevention of complications after LSRG is urgent and requires further development of ways to solve this problem.

Key words: nutritional status; laparoscopic sleeve resection of the gastric; vitamins D, B12; early and late complications; surgical or minimally invasive interventions.

INTRODUCTION

The review examines the effects of laparoscopic sleeve resection of gastric (LSRG) on the nutritional status of patients and the effectiveness of correcting nutritional deficiencies. It is noted that after LSRG, deficiencies of trace elements and vitamins often occur, in particular iron, vitamins D, B12, folic acid and

calcium. The main reasons are a decrease in stomach volume, decreased appetite, malabsorption, and low patient adherence to regular multivitamin supplementation.

An analysis of the literature has shown that the incidence of deficiencies after LSRG remains high even several years after surgery. Despite the recommendations for taking vitamin supplements, patients' compliance with the recommendations is insufficient in the long run. Studies have shown that specialized multivitamin supplements can reduce the risk of anemia and increase levels of folic acid and other vitamins, but iron and vitamin D deficiencies often persist even while taking supplements. There is also a need to develop clearer and more unified guidelines for nutritional support for patients after LSRG.

Vitamin and mineral deficiencies are a common nutritional disorder after bariatric surgery. Although they are more common after malabsorptive procedures such as bypass surgery, they also occur during restrictive procedures such as gastric sleeve resection. The mechanisms that lead to these deficiencies are related to the presence of insufficient intake of nutrients or poor adherence to the regimen of multivitamins and polymineral supplements [4].

A study conducted by Gehrer et al. showed the following deficiency of trace elements and vitamins after LSRG: zinc (34%), vitamin D3 (32%), iron (18%), vitamin B12 (18%) and folic acid (22%) [28].

Although bariatric surgery is effective for weight loss and concomitant diseases, it can lead to the risk of vitamin deficiency. Vitamin deficiency can lead to anemia, hypoimmunity, bone loss, and some neurological diseases, including Wernicke encephalopathy and Guillain-Barre syndrome [13, 20]. Despite regularly recommended multivitamin supplements, previous studies have shown that vitamin deficiency was common during postoperative short- and medium-term follow-up due to diet intolerance and decreased absorption function [1, 16]. However, remodeling of the intestinal mucosa may occur long after surgery, which is likely to lead to increased vitamin intake and absorption efficiency [5]. Moreover, it was suggested that long-term vitamin supplementation was unnecessary for some patients and only a third of patients followed the recommended multivitamin supplements in the long term [23, 24].

Gu L et al. evaluated differences in postoperative nutritional status between LSRG and laparoscopic gastric bypass surgery. After bariatric surgery, there was less anemia and iron deficiency anemia in the LSRG group than in the laparoscopic gastric bypass group. Serum iron, ferritin, and vitamin B12 deficiency levels after LSRG were lower than in patients receiving laparoscopic gastric bypass surgery. And the concentration of parathyroid hormone and serum phosphorus in patients after LSRG was lower than in patients after laparoscopic gastric bypass surgery.

Postoperative LSRG results were better than those of laparoscopic gastric bypass surgery [18].

Several factors contribute to micronutrient deficiency in patients who have undergone LSRG: a decrease in stomach size, which leads to a decrease in food intake, a decrease in ghrelin and other gastrointestinal hormones that reduce appetite, a decrease in the tolerance of certain foods, and a decrease in the metabolism of certain micronutrients, partly due to the loss of intrinsic factor [29]. Moreover, the current recommendations for supplements for LSRG patients are inconsistent and often based on data from patients who have undergone laparoscopic gastroprotection, and are not unique to LSRG patients [14].

Ben-Porat T et al. conducted a study of 77 patients who had undergone LSRG for 12 months. 15% had anemia before surgery. Iron, folic acid, and B12 deficiencies were 47%, 32%, and 13%, respectively. Women had greater iron deficiency (56% of women, 26% of men, $P<0.001$). Before surgery, low levels of vitamin D and elevated levels of parathyroid hormone (PTH) were 99% and 41%, respectively. One year after surgery, the indicators of hemoglobin and vitamin B12 deficiency worsened (20% and 17%, $P<0.001$, $P=0.048$, respectively). One year after surgery, iron, folic acid, vitamin D, and PTH deficiencies improved (28%, 21%, 94%, and 10%, respectively). Hemoglobin, folic acid, and vitamin B12 deficiency before surgery was a predictor of deficiency 1 year after surgery ($P=0.006$ OR=0.090; $P=0.012$ OR=0.069; $P=0.062$ OR=0.165, respectively) [3].

Further studies of Ben-Porat T et al. in 192 patients before surgery, 77 patients 1 year after surgery, and 27 patients 4 years after LSRG. The prevalence of nutritional deficiencies at baseline, 1 and 4 years after surgery, respectively, was especially characteristic of iron (44%, 41,2%, 28,6%), anemia (11,5%, 20%, 18,5%), folic acid (46%, 14,3%, 12,5%), vitamin B12 (7,7%, 13,6%, 15,4%), Vitamin D (96,2%, 89%, 86%) and increased PTH (52%, 15,4%, 60%). Vitamin D levels remained low throughout the period. The PTH level was 37.5 pg/ml 1 year after surgery and increased to 77.3 pg/ml 4 years after surgery ($P=009$). Women had a higher prevalence of elevated PTH levels and a tendency to higher rates of anemia than men 4 years after surgery (80% vs. 20%, $P= 0.025$; and 28% vs. 0%, $P = 0.08$, respectively). Of the patients, 92.6% reported taking multivitamins and 74.1% taking vitamin D supplements during the first year after surgery, whereas after 4 years, only 37% and 11.1% were still taking these supplements, respectively. Based on this, the authors concluded that a high level of nutrient deficiency is common 4 years after LSRG, along with non-compliance with the dietary supplement regimen. Long-term dietary monitoring and maintenance of supplementation are crucial for LSRG patients [2].

In a prospective study conducted in 201 patients who underwent LSRG surgery, parameters such as ferritin, hemoglobin (Hgb), average cell volume, calcium, albumin, 25-hydroxyvitamin D (25-OH-D), PTH, and vitamin B12 were analyzed. Follow-up was 75.6% (n = 152), 63.7% (n = 128), 52.7% (n = 106), and 40.3% (n = 81) at 6, 12, 18, and 24 months, respectively. The average values of all biochemical parameters before and after LSRG were within the reference values. After adjusting for age, weight, and supplement use, trend tests after LSRG were significant for average differences in ferritin (p=0.002), calcium (p=0.017), and vitamin B12 (p=0.034). Prior to LSRG, the proportion of patients with values below the reference values included 25-OH-D (20.4%), ferritin (12.3%), and Hgb (10.0%), while the proportion above the reference values included PTH (29.1%) and ferritin (17.4%). After adjustment, hypoalbuminemia was more common after 1 year; the proportion of patients with a PTH level in the upper limit of normal was higher 6 months after LSRG ($p<0.05$). Multivitamin use increased the preoperative period from 44% to 88% 2 years after surgery. Vitamin B12 supplementation increased from 7% before surgery to 32% 2 years after surgery. Before the operation, abnormal serum biochemistry parameters were detected, indicating a deficiency of trace elements; after the operation, a decrease in abnormal values was observed, probably due to the more frequent use of multivitamins [10].

A prospective randomized trial of patients who had undergone LSRG was conducted. The patients were divided into 2 groups: Group 1 patients who received a multivitamin supplement (Multicentrum, Pfizer, 1 tablet/day) for 3 months and group 2 patients who received a supplement for 12 months. Laboratory parameters were analyzed: vitamins (D, B12, and folic acid) and oligoelements (calcium, iron, phosphorus, magnesium, and zinc) 3, 6, and 12 months after surgery. The study included 80 patients, 40 in each group. After 3 months, 7.5% of patients had iron deficiency and 2.5% had ferritin one, the same in both groups, which was corrected with the help of special additional iron supplements. After 6 months, one patient (2.5%) in group 1 had iron deficiency, and one in group 2 had vitamin D deficiency. After 12 months, only one patient in group 2 had vitamin D deficiency, the deficiency of which was corrected with the help of special supplements. Taking multivitamin supplements for more than 3 months after surgery does not make up for the deficiency sufficiently. It is necessary to monitor laboratory parameters and add specific additives if necessary [23].

A double-blind randomized controlled trial was conducted in which patients in the intervention group received WLS Optimum containing increased doses of several vitamins and minerals for 12 months. Patients in the control group were provided with sMVS containing 100% of the recommended dietary allowance.

139 patients after LSRG were analyzed (WLS Optimum, n=69; sMVS, n=70). Tests revealed more folic acid deficiencies and higher serum vitamin B1 levels in the WLS Optimum group. Protocol analyses showed that serum folic acid and vitamin B1 levels were higher in patients using WLS Optimum, serum PTH levels were lower, and only 1 patient (2.6%) suffered from anemia compared with 11 patients (17.5%) using sMVS ($p<0.05$). No differences were found in the rates of iron deficiency, vitamin B12, vitamin D, and other vitamins and minerals. The optimized multivitamin supplement only affected serum levels of folic acid, PTH, and vitamin B1, as well as anemia rates compared to sMVS. There is an obvious need to further optimize multivitamin supplementation for patients with SG. In addition, non-compliance with multivitamin supplements remains an important issue that should be addressed [12].

A similar study with a vitamin complex was conducted by Smelt et al. This study included 970 patients; 291 patients in the group where patients took WLS Optimum after LSRG and 679 patients in the group without taking this supplement. The WLS Optimum groups showed significantly less deficiency of vitamin B1 (2 years) and vitamin B6 (two and three years), folic acid (1 and 2 years) and vitamin B12 (1 year later). Significant effects of multivitamin supplementation were mainly on ferritin; vitamins B1, B6, B12, and D; and folic acid ($p<0.05$). The total number of deficiencies was significantly reduced throughout the study in patients taking WLS Optimum. The use of a specialized multivitamin supplement resulted in higher average serum concentrations and lower deficiencies of vitamin B1, folic acid, and vitamin B12. This study shows that patients after LSRG benefit greatly from specialized multivitamin supplements, but adjustments are needed for iron and vitamin B6 content [26].

The aim of another study was to study weight loss and the development of nutritional deficiencies in patients 3 years after LSRG. The data included anthropometry, nutrition markers (hemoglobin, iron, folic acid, calcium, PTH, vitamins D and B12), and compliance with supplementation. The study involved 91 patients (men/women; 28:63), with an average age of 51.9±11.4 years with a body mass index of 42.8±6.1 kg/m^2. The percentage of weight loss after 1 and 3 years after surgery was 29.8±7.0 and 25.9±8.8%, respectively. Before surgery, low levels of hemoglobin (4%), ferritin (6%), vitamin B12 (1%), vitamin D (46%) and elevated levels of PTH (25%) were noted. 3 years after surgery, laboratory parameters included low hemoglobin (14% of women, P=0.021), ferritin (24%, P=0.011), vitamin D (20%, P=0.018), and elevated PTH (17%, P=0.010). Compliance with the multivitamin supplementation regimen was noted in 66% of patients. In these patients, LSRG led to marked weight loss 1 year after surgery,

and persisted for 3 years. Nutritional deficiencies were noted among obese patients before bariatric surgery. This deficiency may persist or worsen after surgery. Regular nutritional monitoring and supplementation are essential to prevent and treat these deficiencies [29].

In the following study, the aim was to evaluate the need and safety of vitamin supplements in obese adults after LSRG based on an assessment of intake. Patients with grade III obesity and grade II obesity with concomitant diseases were observed 3, 6, and 9 months after bariatric surgery. Based on a 4-day nutrition questionnaire, vitamin and calorie intake was assessed, as well as a survey regarding supplement intake. The study showed a deficiency in dietary intake of vitamin D, folic acid (B9) and vitamin B1 (in 93-100% of respondents), vitamins E and C (in 53-67% of respondents), vitamins A, PP and vitamins B2 and B6 (in 10-23% of respondents) and vitamin B12 (only 1 woman). Multivitamin supplements were taken by 72% of the respondents, independently, all patients took a vitamin D supplement. Vitamin deficiency was reported only in a small percentage of patients (3-17%) who did not take supplements during the entire follow-up period. Regular supplementation with vitamins D, E, C, B1 and folic acid (B9) made up for nutritional deficiencies in patients. Supplementation of vitamins A, B2, PP, and B6 had no significant effect on overall intake. Taking vitamin B12 supplements proved to be unreasonable in relation to dietary recommendations. Dietary and/or supplemental vitamin intake did not exceed the permissible upper intake level. The results of the study confirm the need to introduce vitamin supplements for bariatric patients [27].

Bariatric surgery is associated with a postoperative decrease in vitamin D levels (25(OH)D) and as a result, skeletal complications. Currently, guidelines for vitamin D assessment and supplementation in bariatric patients before and after surgery are still lacking. The study conducted a systematic analysis of the published experience on the status of 25(OH)D and vitamin D supplements before and after surgery. 2,869 patients were evaluated before surgery. Prevalence of vitamin D deficiency, determined by 25(OH)D <30 ng/ml (75 nmol/L), was 85%, whereas in the determination of 25(OH)D <20 ng/ml (50 nmol/L), it was 57%. The average preoperative level is 25(OH)D was 19.75 ng/ml. After surgery, 39 studies involving 5,296 patients were analyzed, and among those who underwent either malabsorption or restrictive procedures, there was a lower level of vitamin D deficiency and a higher level of 25(OH)D after surgery was observed in patients receiving high-dose oral vitamin D supplementation, defined as ≥2000 IU/day (mainly D3 formula), compared with low doses (<2000 IU/day). Vitamin D

assessment should be performed before and after surgery in all patients undergoing bariatric surgery [9].

The aim of this study was to compare the effects of different doses of vitamin D supplements (low dose (less than 600 international units (IU) per day), moderate dose (from 600 IU per day to 3500 IU per day), high dose (more than 3500 IU per day)) with each other or with placebo in adults with obese patients who underwent bariatric surgery. Data analysis has shown that moderate doses of vitamin D can improve vitamin D status and may lead to little or no improvement in parathyroid hormone levels compared to placebo. Vitamin D supplementation in high doses (over 3,500 IU/day) may increase 25-hydroxyvitamin D levels and may have little or no effect on parathyroid hormone levels compared to a moderate dose, but the evidence for both is uncertain [6].

Some other vital vitamins (C, E, and K) were also analyzed. Vitamin C is a water-soluble nutrient that participates in various physiological processes as an antioxidant. Fresh fruits and vegetables are the main sources of vitamin C, which is mainly absorbed in the upper jejunum. One study reported a long-term vitamin C deficiency with a prevalence of 7.8% [15]. Vitamins E and K are fat-soluble vitamins, the absorption of which requires the participation of bile, pancreatic juice and fatty acids. During laparoscopic gastric bypass and biliopancreatic bypass, the food chium bypasses the upper part of the jejunum, which reduces the interaction of bile/pancreatic juice with vitamins E and K [19]. One guideline reported that vitamin E and K deficiency is rare after bariatric surgery [21], but based on long-term data, vitamin E and K deficiency was not uncommon (16.5% and 9.6%, respectively). However, insufficient studies were included for further analysis of the subgroups [7]. Vitamin C deficiency is associated with the degradation of skin, muscles, and bones [8]. Vitamin E deficiency can lead to peripheral neuropathy and increased hemolysis of red blood cells [17]. Therefore, further research is needed to analyze the prevalence and treatment of vitamin C, E, and K deficiency.

The study included 231 patients. The majority of patients were women (76.2%), with LSRG (78.8%). The average preoperative body mass index was 43.4±7.1 kg/m2. Weight loss ≥2 years after surgery was 33.5±12.4 kg. The most common abnormalities before surgery were: C-reactive protein (47.7%), vitamin D (39%), B12 (31%), PTH (27.6%) and ferritin (12.7%). Vitamin B12 (23.2%), PTH (23%), vitamin D (17.7%), and ferritin (15.9%) were also deficient after surgery. Compliance with the multivitamin regimen was 90% in the first year after surgery, decreasing to 77% after ≥2 years. Gastrointestinal symptoms were predominantly present in the initial stages after surgery, manifested by thiamine deficiency in

6.5% of patients. Despite achieving sustained weight loss, eating disorders and related abnormalities remain a constant problem for bariatric surgery [30].

Wernicke-Korsakov syndrome is an acute neurological disorder resulting from thiamine deficiency. This syndrome consists of two distinct phases: first, Wernicke encephalopathy, the acute phase of this syndrome, which is characterized by a triad of confusion, ocular symptoms, and ataxia, followed by the chronic phase of Wernicke-Korsakov syndrome, called Korsakov syndrome, which is known for the presence of anterograde amnesia and confabulation. This study describes the case of a patient with Wernicke-Korsakov syndrome after bariatric surgery. The patient was a 24-year-old girl with a body mass index of 48 kg/m2 who had undergone LSRG due to obesity. Over the next 2 months, recovery from surgery was complicated by non-specific symptoms such as nausea, recurrent vomiting, and a significant reduction in food intake, which led to the patient being admitted to the emergency department six times. During the 15 days of hospitalization, the patient developed diplopia in the eyes, nystagmus, complaints of rotational vertigo and gait disorders. Magnetic resonance imaging of the head was performed, but no significant changes were detected. After a neurological examination, parenteral treatment with thiamine (100 mg three times a day) was initiated without prior dosing. The observed clinical improvement confirmed the diagnosis of Wernicke-Korsakov syndrome. Based on this case, the authors concluded that bariatric surgery may contribute to thiamine deficiency and, consequently, Wernicke-Korsakov syndrome [4].

The aim of another study was to determine the effects of metabolic bariatric surgery on eating behavior, the prevalence of nutritional deficiencies, the level of dietary adherence, and lifestyle recommendations one year after metabolic bariatric surgery. A cross-sectional study was conducted among adult patients who underwent metabolic bariatric surgery in 2019 and were followed up for a year. 160 patients participated in the study. After 12 months, there was a significant increase in plasma levels of vitamin B12, folic acid, vitamin D, iron, adjusted calcium, albumin, Wernicke-Korsakov syndrome and average cell volume compared with baseline values, as well as a significant decrease in body mass index. This study has shown that nutrients should be carefully monitored before and after bariatric surgery [22].

Studies conducted by Sherf Dagan's et al., which included 77 patients with LSRG, showed that adherence to multivitamin supplementation for 12 months was directly associated with higher serum levels of hemoglobin, iron, folic acid, and vitamins B12 and D [25].

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