ORIGINAL ARTICLE

Perioperative Micronutrient Deficiencies in Bariatric Surgery Patients: A Single-Center Study at a Tertiary Care Hospital

Chaithawat Peetathawatchai, MD[1], Veeradej Pisprasert, MD[1], Pranithi Hongsprabhas, MD[1], Sornwichate Rattanachaiwong, MD[1], Thunchanok Kuichanuan, MD[1]

[1] Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

Background: Bariatric surgery is effective for weight loss and managing obesity-related comorbidities, but micronutrient deficiencies may occur before and after the procedure. The present study evaluates the prevalence of these deficiencies during the perioperative period.

Materials and Methods: A retrospective study was conducted at Srinagarind Hospital, Khon Kaen University, Thailand, reviewing medical records of patients living with obesity treated between January 2014 and January 2024. Levels of vitamin B1, vitamin B12, folate, vitamin D, vitamin A, iron, copper, and zinc were measured pre-surgery and at intervals post-surgery: 1 month, 3 months, 6 months, 12 months, 18 months, 2 years, 3 years, 4 years, and 5 years.

Results: Of the 72 patients, 55.6% were female, with a median age of 30.5 years and a mean BMI of 45.54 kg/m^2. Most underwent sleeve gastrectomy (84.7%). Pre-surgery, deficiencies were most common in vitamin D (94.8%), zinc (34.4%), and iron (33.3%). Post-surgery, vitamin D deficiency persisted in over 50% of patients throughout all follow-up periods, zinc deficiency ranged from 25% at 3 months to 58.3% at 24 months, and iron deficiency varied from 7.3% to 18.8% between 3 to 24 months. Vitamin B12 deficiency was noted in 11.9% pre-surgery and emerged early post-surgery. No deficiencies were found pre-surgery in vitamin B1, folate, vitamin A, or copper, and their post-surgery incidence was minimal.

Conclusion: Micronutrient deficiencies, notably of vitamin D, iron, and zinc, are prevalent both before and after bariatric surgery, necessitating regular monitoring and appropriate supplementation to optimize patient health.

Keywords: Bariatric surgery; Micronutrient; Micronutrient deficiency; Obesity; Trace element; Vitamin

Received 11 February 2025 | Revised 13 April 2025 | Accepted 14 July 2025

J Med Assoc Thai 2025;108(Suppl.2):S124-129

Website: http://www.jmatonline.com

In recent years, the prevalence of obesity has increased significantly among individuals in Thailand. According to data from Thai statistical sources, the prevalence of Class I and Class II obesity rose from 18.2% and 3.1% in 1991 to 26% and 9% in 2009, respectively[1]. Bariatric surgery is considered the most effective intervention for inducing and managing weight loss in patients living with obesity, while also effectively controlling obesity-related comorbidities[2]. Despite its effectiveness, bariatric surgery carries potential risks of complications, both in the short and long term, particularly the development of micronutrient deficiencies. These deficiencies may involve inadequacies in essential vitamins and trace elements, including vitamin B1, B12, folate, A, D, calcium, iron, zinc, copper, among others.

Postoperative micronutrient deficiencies following bariatric surgery may develop over a period ranging from months to years, depending on the type of procedure performed and the specific micronutrients affected. Notably, iron deficiency can occur between three months and a decade after bariatric surgery, with a prevalence of less than 18% following sleeve gastrectomy (SG) and ranging from 20% to 55% after Roux-en-Y gastric bypass (RYGB). In contrast, vitamin B12 deficiency is typically diagnosed 2 to 5 years post-surgery, with a prevalence of under 20% following SG and ranging from 4% to 20% after RYGB[3].

Following bariatric surgery, standard guidelines recommend vitamin and trace element supplementation, a practice that is also implemented in Thailand[1,3]. Nevertheless, micronutrient deficiencies persist in the Thai population, with iron deficiency observed in 25.8% of patients 24 months after undergoing RYGB. In contrast, no cases of iron deficiency were reported among patients who

Correspondence to:

Kuichanuan T.

Department of Internal Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.

Phone: +66-81-9519452

Email: Thunchanok.kuichanuan@gmail.com

How to cite this article:

Peetathawatchai C, Pisprasert V, Hongsprabhas P, Rattanachaiwong S, Kuichanuan T. Perioperative Micronutrient Deficiencies in Bariatric Surgery Patients: A Single-Center Study at a Tertiary Care Hospital. J Med Assoc Thai 2025;108(Suppl.2):S124-129.

DOI: 10.35755/jmedassocthai.2025.S02.S124-S129

underwent SG[4]. Few studies have assessed the prevalence of other micronutrient deficiencies in the Thai population, as most research has predominantly focused on Western populations[5]. Therefore, the present study aims to determine the prevalence of specific vitamins and trace elements in Thai post-bariatric surgery patients, with a particular focus on those in the northeastern region, at Srinagarind Hospital, Khon Kaen University.

Objective

Primary objective

To describe the prevalence of micronutrient deficiencies in patients undergoing bariatric surgery, both preoperatively and postoperatively, at Srinagarind Hospital, Khon Kaen University.

Secondary objective

To assess the adequacy of vitamin and trace element supplementation in patients at Srinagarind Hospital, Khon Kaen University.

Materials and Methods

Study setting

This retrospective descriptive study was conducted at Srinagarind Hospital, Faculty of Medicine, Khon Kaen University. Data were extracted from electronic medical records and outpatient records from both the obesity clinic and the weight loss surgery clinic, covering the period from January 2014 to January 2024.

Inclusion criteria

Eligible patients were at least 18 years of age, diagnosed with obesity, and were candidates for bariatric surgery (BMI ≥37.5 kg/m² or 32.5 kg/m² with comorbidities that failed to achieve adequate control)[1], who underwent bariatric surgery at Srinagarind Hospital.

Exclusion criteria

Exclusion criteria included severe liver and renal dysfunction that could affect micronutrient levels, defined as liver cirrhosis, liver failure (total bilirubin >3, INR >1.5, encephalopathy, or ascites), and chronic kidney disease stage 5 (GFR <15 mL/min/1.73 m²). Patients with documented gastrointestinal bleeding were excluded. Additionally, patients with alcohol use disorder, as defined by DSM-5 or ICD-10 criteria, were excluded.

Data collection

Data collection included demographic and anthropometric information, as well as laboratory investigations. Age, sex, preoperative BMI, preoperative comorbidities, type of bariatric surgery, and micronutrient supplementation were reviewed from the electronic medical record. Postoperative weight loss will be presented as total weight loss percentage (%TWL) and excess weight loss percentage (%EWL).

Laboratory investigations were conducted at the preoperative baseline and during postoperative follow-up intervals of 1 month, 3 months, 6 months, 12 months, 18 months, 24 months, 3 years, 4 years, and 5 years, depending on availability.

Operational definition

Bariatric surgery refers to surgical procedures that alter the stomach and/or intestine to modify the digestive system and metabolism, leading to weight loss. The most common procedures are sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB)[3].

Total weight loss percentage (%TWL) is calculated by dividing the absolute weight loss (in kilograms) by the initial body weight (in kilograms) and multiplying by 100.

%Excess weight loss percentage (%EWL) is calculated by dividing the absolute weight loss (in kilograms) by the excess body weight (in kilograms), where excess body weight is determined by subtracting the ideal body weight from the initial weight and multiplying by 100. Ideal body weight based on a target BMI of 25 kg/m².

$$\%TWL = \left(\frac{initial\ weight - postoperative\ weight}{initial\ weight}\right) x100\%$$

$$\%EWL = \left(\frac{initial\ weight - postoperative\ weight}{initial\ weight - ideal\ body\ weight}\right) x100\%$$

$$ideal\ body\ weight(kg) = 25 x height^2(m)$$

Micronutrient deficiency refers to the depletion or insufficiency of vitamins or trace elements, such as vitamin B1, vitamin B12, folate, vitamin A, vitamin D, calcium, iron, zinc, and copper[6]. These deficiencies are defined according to internationally recognized reference ranges. For the present study, the following reference ranges were used[5]:

Iron which is transferrin saturation (%) <20 or ferritin (ng/mL) <30

Vitamin B12 (pg/mL) <350

RBC folate (ng/mL) <160 or serum folate (ng/mL) <3

Serum 25-hydroxyvitamin D (ng/mL) <20 defined as deficiency, <30 defined as insufficiency.

Vitamin B1 (Thiamine pyrophosphate (TPP)) (µg/L, nmol/L) (28 to 85 µg/L, 66 to 201 nmol/L)

Serum Zn (µg/dL) <70

Serum Cu (µg/dL) <80

Vitamin A (µg/dL) <10

Statistical analysis

In the present study, the sample size included all eligible patients from the obesity clinic and weight loss surgery clinic. Categorical data were presented as frequency

and percentage, while quantitative data were reported as mean ± SD or median with interquartile range (IQR), depending on the data distribution. Baseline demographic data included sex, age, preoperative BMI, comorbidities, type of bariatric surgery, and the number of patients taking supplements prior to surgery. Each micronutrient deficiency (vitamin B1, vitamin B12, vitamin D, folate, vitamin A, iron, zinc, copper) was analyzed for point prevalence at preoperative and postoperative follow-up intervals. Postoperative anthropometric data, including percentage of total weight loss and percentage of excess weight loss, were also calculated.

The relationship between outcomes and adjusted variables was analyzed using a mixed-effects logistic regression model in Stata version 18.0.

The present study received approval from the Khon Kaen University Ethics Committee for Human Research (HE661020).

Results

Baseline demographic data are presented in Table 1. The majority of patients were female (55.6%), with a median age of 30.5 years (range: 28 to 38.5 years) at the time of surgery. The mean body mass index (BMI) was 45.54±7.13 kg/m², and 84% of patients underwent sleeve gastrectomy. Common comorbidities included obstructive sleep apnea (83.3%), hypertension (63.9%), nonalcoholic fatty liver disease (52.8%), dyslipidemia (51.4%), and diabetes mellitus (34.7%).

Table 1. Baseline characteristics

Characteristics (n=72)	
Female gender, n (%)	40 (55.6)
Age at surgery, median (IQR)	30.5 (28 to 38.5)
Preoperative BMI	
Mean (SD)	45.54 (7.13)
BMI Distribution, n (%)	
30 to 40	15 (20.8)
40 to 50	42 (58.3)
>50	15 (20.8)
Comorbidities, n (%)	
Diabetes mellitus	25 (34.7)
Hypertension	46 (63.9)
Dyslipidemia	37 (51.4)
Nonalcoholic fatty liver disease	38 (52.8)
Obstructive sleep apnea	60 (83.3)
Coronary artery disease	7 (9.7)
Stroke	2 (2.8)
No comorbidities	0 (0)
Type of bariatric surgery – no. (%)	
Sleeve gastrectomy (SG)	61 (84.7)
Roux-en-Y gastric bypass (RYGB)	11 (15.3)
Patients taking any supplements before surgery, n (%)	28 (38.9)

n=Numbers of patient

%TWL at 1-year and 2-year post-operation was 29.66±9.61 and 24.33±8.27, respectively. The %EWL at 1-year and 2-year post-operation was 69.19±22.82 and 57.26±23.8, respectively.

Preoperatively, vitamin D insufficiency and deficiency were the most common micronutrient deficiencies, with rates of 52.1% and 37.5%, respectively. Zinc deficiency was present in 34.4% of patients, and iron deficiency had a prevalence of 33.3%, which was similar to the rate of zinc deficiency. No deficiencies in folate, vitamin B1, or copper were detected before surgery. Table 2 presents the prevalence of other preoperative deficiencies and provides data categorized by type of bariatric surgery. Preoperative micronutrient supplementation was noted in 28 patients (38.9%), with vitamin D being the most commonly supplemented nutrient (33.3%).

In the postoperative period, micronutrient deficiencies were assessed at various time points from 1 month to 5 years, as shown in Table 3. Vitamin D insufficiency or deficiency and zinc deficiency were observed at every follow-up time point. The prevalence of vitamin D insufficiency and deficiency exceeded 50% at nearly all time points. Zinc deficiency exhibited a prevalence ranging from 25% at 3 months to 58.3% at 24 months. The prevalence of iron deficiency was 32.1% at 1 month and gradually decreased over time to 7.3% at 6 months, with a slight increase to 13.3 to 18.8% after 6 months post-operation. Few patients exhibited vitamin B12 deficiency, which was detected from 1 month to 4 years post-surgery. No more than one patient had folate, vitamin B1, or copper deficiency, with these deficiencies showing a prevalence of 0% at nearly all time points.

Postoperative micronutrient supplementation was primarily guided by recommendations based on standard guidelines. The average daily dosages of these supplements were as follows: 3,066.67 IU (range: 900 to 3,416.67 IU) for vitamin D, 1.31 mg (range: 0.6 to 1.71 mg) for folate, 40 µg (range: 3 to 60 µg) for vitamin B12, 5 mg (range: 2 to 6.5 mg) for vitamin B1, 66.7 mg (range: 38 to 132 mg) for elemental iron, 400 mg (range: 175 to 600 mg) for elemental calcium, 0 mg (range: 0 to 15 mg) for elemental zinc, and 0 mg for copper. The dosage of the micronutrient supplement would be adjusted based on subsequent blood levels.

For the regression analysis, no statistically significant effect was found between vitamin D deficiency, iron deficiency, zinc deficiency, and vitamin B12 deficiency after adjusting for follow-up time points. The analysis excluded vitamin B1 deficiency, folate deficiency, copper

Table 2. Prevalence of preoperative micronutrient deficiencies

Micronutrients	Type of bariatric surgery		
	Sleeve gastrectomy, n (%)	Roux-en-Y gastric bypass, n (%)	Total, n (%)
Iron	13/34 (38.2)	1/8 (12.5)	14/42 (33.3)
Vitamin B12	3/34 (8.8)	2/8 (25)	5/42 (11.9)
Folate	0/25 (0)	0/4 (0)	0/29 (0)
Vitamin D			
Insufficiency	20/39 (51.3)	5/9 (55.5)	25/48 (52.1)
Deficiency	15/39 (38.5)	3/9 (33.3)	18/48 (37.5)
Vitamin B1	0/24 (0)	0/5 (0)	0/29 (0)
Zinc	9/24 (37.5)	2/8 (25)	11/32 (34.4)
Copper	0/17 (0)	0/3 (0)	0/20 (0)
Vitamin A	1/9 (11.1)	0/2 (0)	1/11 (9.1)

n=Numbers of patient

deficiency, and vitamin A deficiency, as these deficiencies had a prevalence of 0% at nearly all follow-up time points.

Discussion

Micronutrient deficiencies can develop both before and after bariatric surgery. It is important to note that individuals who are overweight or obese often consume higher amounts of processed and fat-rich foods while consuming fewer fruits and vegetables. As a result, they may not receive adequate levels of essential vitamins and trace elements to meet daily nutritional requirements, despite a high caloric intake[7]. In our study, the highest prevalence of preoperative micronutrient inadequacy was observed for vitamin D (89.6%), followed by common deficiencies in zinc (34.4%) and iron (33.3%). These findings are consistent with those reported by Kuichanuan et al. where the most prevalent preoperative micronutrient deficiencies were vitamin D, iron, and zinc respectively[8]. An additional observational study suggests that increased body fat may reduce the availability of fat-soluble vitamins, such as vitamin D, in the serum. Furthermore, the chronic low-grade inflammation associated with obesity stimulates the synthesis of hepcidin, a protein that inhibits iron absorption[9,10]. Vitamin B12 deficiency can occur early in the preoperative period, as observed in our study with a prevalence of 11.9%. Several studies have reported preoperative vitamin B12 deficiency with varying prevalences, ranging from 3.6% in the study by Schweiger et al.[11], to 18.1% in the study by Ernst et al.[12]. The authors observed postoperative micronutrient deficiencies within a timeframe ranging from one month to five years post-surgery. However, for practical management purposes, the representative prevalence, which is limited to a follow-up duration of 24 months, should be primarily used, as data beyond this timeframe are limited.

Vitamin D deficiency was the most common after surgery, despite being the most used preoperative supplement, which is concerning due to its essential role in bone health. The reduced absorption of dietary fat following bariatric surgery is one factor contributing to decreased vitamin D absorption[13]. According to our results, the prevalence of vitamin D insufficiency and deficiency exceeded 50% at nearly every postoperative time point. Therefore, regular screening every 3 months is recommended.

The next most common postoperative deficiency was zinc, which is linked to inflammatory skin disease, alopecia, delayed wound healing, and cardiomyopathy[14,15]. Notably, 42 to 65% of patients develop zinc deficiency within 6 to 18 months post-surgery[15]. In our study, most patients did not receive zinc supplementation regularly due to the limited availability of zinc in local essential drug (ED) supplements. This underscores the necessity for zinc supplementation in this population during postoperative follow-up, regardless of test results.

Iron deficiency is also commonly observed following bariatric surgery. Kuichanuan et al. reported a prevalence rate of approximately 30% at 1-year post-operation, with an increase in prevalence over time[8]. In our study, the prevalence of postoperative iron deficiency ranged from 7.3% to 18.8% within 3 to 24 months. Postoperative gastric hypochlorhydria and bypassing the duodenum are the primary factors contributing to reduced iron absorption and subsequent deficiency[16]. As a result, regular screening every 3 to 6 months remains recommended.

Postoperative vitamin B12 deficiency typically becomes evident 1 to 2 years after surgery[3,9], although we observed a small prevalence as early as 1 to 6 months post-surgery. Symptoms of vitamin B12 deficiency generally appear when reserves have depleted to 5 to 10% of initial levels[17]. For cost-effectiveness, a single screening for vitamin B12 deficiency within the first-year post-surgery may be appropriate, followed by annual screenings if levels

Table 3. Postoperative micronutrient deficiencies

Micronutrient deficiency-no./No. (%)	Postoperative follow-up								
	1 month	3 months	6 months	12 months	18 months	24 months	3 years	4 years	5 years
Iron	9/28 (32.1)	5/33 (15.2)	3/41 (7.3)	7/47 (14.9)	2/15 (13.3)	3/16 (18.8)	0/6 (0)	0/6 (0)	3/6 (50)
Vitamin B12	1/8 (12.5)	0/7 (0)	2/16 (12.5)	1/35 (2.9)	1/3 (33.3)	2/12 (16.7)	1/4 (25)	1/5 (20)	0/4 (0)
Folate	0/8 (0)	0/13 (0)	0/17 (0)	1/19 (5.3)	0/4 (0)	0/9 (0)	0/1 (0)	0/2 (0)	0/1 (0)
Vitamin D									
Insufficiency	7/18 (38.9)	13/27 (48.1)	13/38 (34.2)	14/37 (37.8)	1/10 (10)	8/15 (53.3)	2/3 (66.7)	2/3 (66.7)	3/6 (50)
Deficiency	3/18 (16.7)	1/27 (3.7)	7/38 (18.4)	6/37 (16.2)	1/10 (10)	0/15 (0)	0/3 (0)	1/3 (33.3)	1/6 (16.7)
Vitamin B1	0/8 (0)	0/16 (0)	0/15 (0)	1/15 (6.7)	0/1 (0)	0/8 (0)	N/A	N/A	N/A
Zinc	5/12 (41.7)	5/20 (25)	13/32 (40.6)	11/29 (37.9)	5/10 (50)	7/12 (58.3)	3/6 (50)	3/6 (50)	2/6 (33.3)
Copper	0/5 (0)	1/14 (7.1)	1/20 (5)	1/20 (5)	0/6 (0)	0/6 (0)	1/4 (25)	0/3 (0)	0/4 (0)
Vitamin A	N/A	N/A	0/4 (0)	0/4 (0)	N/A	0/2 (0)	0/1 (0)	N/A	0/1 (0)

no.=Numbers of patient; No.=Total numbers of available recorded data; N/A=No available recorded data in this study population

remain normal.

No deficiencies in folate, vitamin B1, or copper were observed during the preoperative period, and their prevalence remained consistently at 0% for nearly all postoperative time points. Vitamin A deficiency was noted in only one patient (1 out of 11) preoperatively, with no cases (0 out of 12) postoperatively. These findings may be influenced by the limited retrospective data and the small study population, resulting in small sample sizes for certain time points and, in some cases, a lack of available data (N/A). Due to these limitations, the prevalence of deficiencies in folate, vitamin B1, copper, and vitamin A is not fully represented. Further research is necessary to assess other nutrients, such as vitamins K, C, B6, and selenium.

Conclusion

Our study underscores the importance of adhering to international guidelines for routine supplementation in patients undergoing bariatric surgery. This is crucial as they are at risk for micronutrient deficiencies both before and after the procedure. The authors identified vitamin D, zinc, and iron deficiencies as the most common, pointing to the need for regular screening and supplementation, regardless of blood test results. Inadequate recommendations can lead to deficiencies, and even minimal adherence to guidelines may still result in low micronutrient levels. Ensuring patient compliance and regular monitoring of micronutrient levels are essential for maintaining long-term safety and adequacy. Additionally, the study highlights the necessity of follow-up care and the involvement of a multidisciplinary team after bariatric surgery.

What is already known on this topic?

Bariatric surgery results in substantial weight loss but is also associated with micronutrient deficiencies, which can lead to long-term complications after surgery.

What this study adds?

Micronutrient deficiencies are common in patients living with obesity, both before and after bariatric surgery. The three most prevalent deficiencies are vitamin D, zinc, and iron. Physicians managing these patients should be aware of these risks and ensure appropriate routine micronutrient supplementation to prevent deficiencies and long-term complications.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Techagumpuch A, Chansaenroj P, Boonyagard N, Wittayapairoch J, Poonthananiwatkul T,

Chanswangphuvana P, et al. Thai Society for Metabolic and Bariatric Surgery consensus guideline on bariatric surgery for the treatment of obese patients in Thailand. J Med Assoc Thai. 2020;103:300-7.
2. Brolin RE. Bariatric surgery and long-term control of morbid obesity. JAMA. 2002;288(22):2793-6.
3. Mechanick JI, Apovian C, Brethauer S, Garvey WT, Joffe AM, Kim J, et al. Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures. Obes. 2019;25(12):1346-59.
4. Polruang N, Rungprai D, Tejavanija S, Linananda S, Santimaleeworagun W. Prevalence and incidence of iron deficiency in patients undergoing bariatric surgery: A teaching hospital experience in Thailand. J Med Assoc Thai 2020;103:115-20.
5. ASPEN. The ASPEN adult nutrition support core curriculum. 3rd ed. Silver Spring (MD): ASPEN; 2017.
6. Berger MM, et al. ESPEN micronutrient guideline. Clin Nutr. 2022;41(6):1357-424.
7. Xanthakos SA. Nutritional deficiencies in obesity and after bariatric surgery. Pediatr Clin North Am. 2009;56(5):1105-21.
8. Kuichanuan T, Sumritpradit P, Putadechakum S, Lepananon T, Taonam N, Sitthisorn S, et al. Micronutrient deficiency before and after bariatric surgery. Abstract in ASPEN 2022: Nutrition Science & Practice Conference, March 26-29, 2022; Seattle, WA. JPEN J Parenter Enteral Nutr 2022;46(S1):S41-2.
9. Gillis L, Gillis A. Nutrient inadequacy in obese and nonobese youth. Can J Diet Pract Res. 2005;66(4):237-42.
10. Bjørklund G, Peana M, Pivina L, Dosa A, Aaseth J, Semenova Y, et al. Iron deficiency in obesity and after bariatric surgery. Biomolecules. 2021.
11. World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. 2011.
12. Ernst B, Thurnheer M, Schmid SM, Schultes B. Evidence for the necessity to systematically assess micronutrient status prior to bariatric surgery. Obes Surg. 2009;19(1):66-73.
13. Lespessailles E, Toumi H. Vitamin D alteration associated with obesity and bariatric surgery. Exp Biol Med (Maywood). 2017;242(10):1086-94.
14. Ogawa Y, Kinoshita M, Shimada S, Kawamura T. Zinc and skin disorders. Nutrients. 2018;10(2):199. doi: 10.3390/nu10020199.
15. Yahalom M, Koren O, Rozner E, Turgeman Y. Cardiomyopathy associated with zinc deficiency after bariatric surgery. Int J Angiol. 2019;28(2):145-6.
16. Velazquez A, Apovian CM, Istfan NW. The complexities of iron deficiency in patients after bariatric surgery. Am J Med. 2017;130(7):e293-e4.
17. Komorniak N, Szczuko M, Kowalewski B, Stachowska E. Nutritional deficiencies, bariatric surgery, and serum homocysteine level: review of current literature. Obes Surg. 2019;29(11):3735-42.