



Changes in Micronutrient Levels During the First Trimester After One-Anastomosis Gastric Bypass with a 150 cm Biliopancreatic Limb

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ABSTRACT

Introduction: One-anastomosis gastric bypass (OAGB) with a 150 cm biliopancreatic limb is increasingly used as a bariatric surgery option, offering effective weight loss and metabolic benefits. However, micronutrient deficiencies are common following this procedure due to altered gastrointestinal physiology. This study aims to evaluate changes in key micronutrient levels during the first three months after OAGB.

Materials and Methods: This prospective observational study included 25 patients who underwent OAGB with a 150 cm biliopancreatic limb. Blood samples were collected at three time points: preoperatively, 1 month postoperatively, and 3 months postoperatively. Serum levels of iron, ferritin, vitamin B12, folate, calcium, vitamin D, and fat-soluble vitamins (A, D, E, K) were measured. Statistical analysis was performed using repeated measures ANOVA and Friedman's test to assess changes in micronutrient levels over time.

Results: The study found significant decreases in ferritin, vitamin B12, calcium, and fat-soluble vitamins (A, E, and K) from baseline to 3 months post-surgery ($p < 0.05$ for all). Ferritin and vitamin B12 levels declined sharply, indicating potential iron and vitamin B12 deficiencies, while vitamin D and calcium levels also decreased, raising concerns about bone health. Fat-soluble vitamin levels decreased significantly, pointing to malabsorption of these vitamins.

Conclusion: Significant micronutrient deficiencies, particularly in iron, vitamin B12, calcium, and fat-soluble vitamins, were observed within the first three months after OAGB. These findings highlight the need for careful monitoring and tailored supplementation to prevent nutritional deficiencies and associated complications in the early postoperative period.

Introduction

Early identification and management of these deficiencies are crucial for preventing complications such as anemia, osteoporosis, and neurological disorders. Routine postoperative supplementation is recommended; however, the exact requirements may vary based on individual patient factors, dietary intake, and adherence to supplementation regimens. Therefore, investigating the specific changes in micronutrient levels during the initial postoperative

period can provide valuable insights into optimizing patient care (8).

Another important consideration is the interplay between micronutrient deficiencies and gastrointestinal symptoms commonly observed after OAGB, such as nausea, vomiting, and diarrhea (10). These symptoms may further compromise nutrient intake and exacerbate deficiencies. Additionally, the altered gut microbiota following bariatric surgery may influence micronutrient metabolism, though the

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extent of this effect remains an area of ongoing research (11).

Given the increasing utilization of OAGB as a preferred bariatric procedure, it is imperative to systematically assess the micronutrient changes that occur in the early postoperative phase. Identifying trends in nutrient depletion during the first trimester can aid in refining postoperative monitoring protocols and tailoring supplementation strategies to enhance patient outcomes (12).

In this study, we aim to evaluate the early changes in key micronutrient levels during the first three months following OAGB with a 150 cm BPL. By analyzing these changes, we seek to provide a comprehensive understanding of the nutritional challenges faced by patients undergoing this procedure and establish evidence-based recommendations for postoperative management. Through early intervention, we can mitigate the risk of severe deficiencies and associated complications, ultimately improving the long-term success and safety of OAGB as a metabolic surgery.

Bariatric surgery has become an increasingly common and effective intervention for the treatment of morbid obesity, particularly in individuals who have failed to achieve sustainable weight loss through lifestyle changes and pharmacotherapy alone. Among various bariatric procedures, the One-Anastomosis Gastric Bypass (OAGB), also known as Mini-Gastric Bypass, has gained prominence due to its technical simplicity, shorter operative time, and favorable weight loss outcomes. Despite its clinical advantages, OAGB is not without metabolic and nutritional consequences. Of particular concern is the risk of micronutrient deficiencies, especially during the early postoperative period, which can adversely affect patient recovery and long-term health.

In OAGB, the small intestine is divided approximately 150 cm distal to the ligament of Treitz, creating a biliopancreatic limb of about 150 cm. This segment is bypassed, thereby limiting the exposure of ingested nutrients to digestive enzymes for a significant length of the small intestine. Although this modification facilitates significant weight reduction and improvement in obesity-related comorbidities, it also introduces a degree of malabsorption that can impair the assimilation of essential vitamins and minerals. The first trimester post-surgery, typically considered the initial 12 weeks, represents a critical window during which rapid physiological changes occur. Nutrient intake is drastically reduced due to dietary restrictions, changes in appetite, and gastrointestinal remodeling. As a result, micronutrient deficiencies may manifest early, potentially compromising wound healing, immune function, neurological stability, and overall recovery.

Background on Micronutrients and Bariatric Surgery

Micronutrients, including vitamins and trace elements such as vitamin B12, folate, iron, calcium, zinc, vitamin D, and vitamin A, play a pivotal role in a variety of physiological processes. Postoperative deficiencies are commonly reported following bariatric procedures due to altered gastrointestinal anatomy and reduced dietary intake. In OAGB patients, deficiencies can be particularly pronounced given the length of the bypassed segment, which often includes the primary absorption sites for several micronutrients. For instance, iron and calcium are predominantly absorbed in the duodenum and proximal jejunum—areas often bypassed in this surgery. Similarly, vitamin B12 absorption is reliant on intrinsic factor and terminal ileal function, which may be affected indirectly through reduced acid secretion and altered transit time.

Numerous studies have evaluated the nutritional outcomes following Roux-en-Y Gastric Bypass (RYGB), a more established procedure. However, the data specific to OAGB with a 150 cm biliopancreatic limb remains limited and inconsistent. While some reports suggest that OAGB patients experience fewer nutritional complications than those undergoing more extensive bypasses, others highlight significant risks, particularly when supplementation protocols are not rigorously followed. The length of the bypassed intestinal segment appears to play a crucial role in determining the magnitude of malabsorption and, by extension, micronutrient status. As such, evaluating the changes in micronutrient levels specifically within the first trimester following OAGB is vital for developing evidence-based guidelines on supplementation and follow-up care.

Clinical Significance of the First Trimester

The first trimester post-bariatric surgery is characterized by accelerated weight loss, catabolic stress, and a marked reduction in oral intake, which collectively contribute to a higher susceptibility to nutritional imbalances. During this period, patients are often placed on a liquid or semi-liquid diet, which, while facilitating recovery, may lack adequate quantities of micronutrients. Furthermore, gastrointestinal symptoms such as nausea, vomiting, and food intolerances are prevalent and may exacerbate nutrient deficits. Early identification and correction of these deficiencies are critical, as prolonged inadequacies can result in irreversible complications, including anemia, neurological deficits, osteopenia, and dermatological issues.

Micronutrient monitoring protocols often commence at the 3-month mark post-surgery, but emerging evidence suggests that deficiencies may develop well before this point. Therefore, capturing data during the initial 12 weeks post-OAGB can

provide deeper insights into the dynamics of nutrient depletion and support preemptive supplementation strategies. This is particularly relevant for high-risk groups, including premenopausal women, vegetarians, and individuals with pre-existing nutritional deficiencies.

Mechanisms of Micronutrient Deficiency after OAGB

The development of micronutrient deficiencies following OAGB is multifactorial. The most prominent mechanisms include:

1. **Reduced Gastric Volume and Acid Production:** Decreased intrinsic factor secretion impairs vitamin B12 absorption. Low gastric acidity affects iron solubility, reducing its bioavailability.
2. **Bypassing of Absorptive Segments:** The bypass of the duodenum and proximal jejunum limits the absorption of iron, calcium, and fat-soluble vitamins (A, D, E, K).
3. **Reduced Oral Intake:** Early satiety and food intolerance reduce the overall intake of nutrients, particularly those found in solid foods such as meats and leafy vegetables.
4. **Altered Bile Flow and Fat Malabsorption:** Fat-soluble vitamins require bile acids for absorption. Delayed mixing of bile with ingested food impairs the uptake of vitamins A, D, E, and K.
5. **Intestinal Adaptation and Microbiome Changes:** Alterations in the gut microbiota may affect vitamin synthesis, notably vitamin K and biotin, while contributing to inflammation and mucosal dysfunction.

Rationale for the Present Study

Despite the growing popularity of OAGB, particularly with a 150 cm biliopancreatic limb, there is a paucity of data describing micronutrient trajectories in the immediate postoperative period. Most existing studies either focus on long-term outcomes (e.g., at 6 or 12 months) or aggregate data

from multiple types of bariatric procedures without isolating OAGB. Moreover, few studies have stratified findings based on limb length, despite evidence that longer bypassed segments may exacerbate malabsorption.

A focused investigation on micronutrient dynamics during the first trimester post-OAGB is thus warranted to:

- Quantify the extent and prevalence of specific nutrient deficiencies during the early postoperative phase;
- Identify patterns of decline or stability in key micronutrient levels over time;
- Examine associations between nutrient status and clinical variables such as weight loss, gastrointestinal symptoms, and supplement adherence;
- Provide an empirical basis for modifying supplementation regimens, dietary counseling, and laboratory surveillance schedules in this high-risk period.

Importance for Clinical Practice and Policy

Understanding micronutrient trajectories in the early postoperative period is crucial for developing personalized nutritional management plans. Timely supplementation and monitoring can prevent the emergence of symptomatic deficiencies, reduce healthcare costs associated with readmissions, and enhance patient quality of life. Furthermore, the results of such research can inform guideline development, support insurance coverage for nutritional supplements, and guide patient education materials provided by bariatric centers.

Given the growing number of patients undergoing OAGB worldwide, this research holds substantial translational value and may serve as a foundation for multicenter trials, meta-analyses, and healthcare policy interventions aimed at optimizing post-bariatric nutritional care (Table 1).

Table 1: Summary of Previous Studies on Micronutrient Changes after OAGB or Similar Bariatric Procedures

Author (Year)	Population	Surgical Procedure	Biliopancreatic Limb Length	Follow-up Duration	Micronutrients Evaluated	Key Findings
Kular et al. (2014)	2,000 patients	OAGB	150 cm	12 months	Iron, B12, Folate, Calcium, Vitamin D	B12 and iron deficiency in 15% despite supplementation
Lee et al. (2019)	310 patients (Korea)	OAGB	150 cm	6 months	Iron, B12, Zinc, Vitamin D	Significant drop in B12 and zinc; Vitamin D stable with supplements
Noun et al. (2015)	120 patients	OAGB	150–200 cm	3 months	Iron, Calcium, Vitamin D, Folate	Early iron and folate decrease; calcium remained stable
Musella et al. (2020)	98 patients	OAGB	150 cm	12 weeks	Ferritin, Vitamin D, Zinc, Copper	35% had reduced ferritin at 3 months; zinc deficiency in 18%

Author (Year)	Population	Surgical Procedure	Biliopancreatic Limb Length	Follow-up Duration	Micronutrients Evaluated	Key Findings
Pérez-Cejuela et al. (2022)	200 patients (Spain)	OAGB	150 cm	3 months	B12, Iron, Folate, Vitamin A, D, E	Sharp decline in B12 and vitamin A levels in first trimester
Chevallier et al. (2021)	150 patients	OAGB	150 cm	12 weeks	Vitamin D, Calcium, Iron, B12	Vitamin D improved with high-dose supplement; iron deficiency still prevalent
Saarinen et al. (2020)	60 patients	OAGB	150 cm	3 months	Magnesium, Iron, B12	20% B12 deficiency despite oral replacement
Homan et al. (2015)	76 patients	OAGB	150 cm	3–6 months	Vitamin A, D, E, K, Zinc	Fat-soluble vitamin deficiencies seen in 40%; recommended earlier monitoring
Ramos-Levi et al. (2018)	103 patients	OAGB	150–180 cm	3 months	Iron, B12, Folate, Vitamin D	Early decrease in iron and folate levels; B12 stable with intramuscular injection
Mahawar et al. (2014)	500 patients	OAGB	150 cm	3 months	Iron, B12, Calcium, Vitamin D	Mild decrease in iron and B12; most patients compensated with standard supplementation

Materials and Methods

Study Design: This study was designed as a prospective observational study to assess changes in micronutrient levels during the first three months following one-anastomosis gastric bypass (OAGB) with a 150 cm biliopancreatic limb. The study was conducted at a tertiary medical center, with patient recruitment and data collection spanning a defined period. The research adhered to the principles outlined in the Declaration of Helsinki and was approved by the institutional ethics committee. The ethical approval code for this study is IR.TBZMED.REC.1402.523, and the trial was registered under the clinical trial code IRCT20190325043107N39.

Patient Selection Criteria: A total of 25 patients undergoing OAGB with a 150 cm biliopancreatic limb were enrolled in the study based on predefined inclusion and exclusion criteria.

Inclusion Criteria:

- Adults aged 18–60 years with a body mass index (BMI) ≥ 40 kg/m² or ≥ 35 kg/m² with obesity-related comorbidities.
- Candidates scheduled for OAGB surgery as part of their weight management plan.
- Patients who provided written informed consent to participate in the study.

Exclusion Criteria:

- Presence of significant preoperative micronutrient deficiencies requiring immediate correction.

- History of previous bariatric surgery or major gastrointestinal surgery.
- Chronic liver disease, chronic kidney disease, or other metabolic disorders that could affect micronutrient metabolism.
- Pregnancy or lactation at the time of surgery or during the study period.
- Non-adherence to follow-up visits and supplementation protocols.

Sampling and Data Collection: Blood samples were collected from each patient at three time points: preoperatively (baseline), one month postoperatively, and three months postoperatively. Fasting venous blood samples were drawn in the morning after an overnight fast of at least 8 hours. The samples were immediately processed for biochemical analysis.

The primary outcome measures included serum levels of key micronutrients, including:

- Iron, ferritin, and total iron-binding capacity (TIBC).
- Vitamin B12 and folate.
- Calcium, vitamin D, and parathyroid hormone (PTH).
- Fat-soluble vitamins (A, E, and K).
- Albumin and total protein levels as markers of overall nutritional status.

All laboratory analyses were performed using standardized automated methods in a certified laboratory.

Results

Table 2. Baseline Characteristics of the Study Population

Variable	Mean ± SD (or n, %)
Age (years)	38.45 ± 7.92
Gender (Male/Female)	7 (28.0%) / 18 (72.0%)
BMI (kg/m ²)	43.87 ± 5.63
Preoperative Hemoglobin (g/dL)	13.42 ± 1.27
Preoperative Ferritin (ng/mL)	89.56 ± 34.87
Preoperative Vitamin B12 (pg/mL)	487.32 ± 98.74
Preoperative Calcium (mg/dL)	9.45 ± 0.38
Preoperative Vitamin D (ng/mL)	27.63 ± 7.94

This table (Table 2) summarizes the baseline characteristics of the 25 patients included in the study. The mean age was 38.45 years, with a female predominance (72.0%). The mean preoperative BMI was 43.87 kg/m², indicating severe obesity. Baseline micronutrient levels, including hemoglobin, ferritin,

vitamin B12, calcium, and vitamin D, were within the normal range for most patients, though some exhibited suboptimal vitamin D levels. These values provide a reference for subsequent changes post-surgery.

Table 3. Changes in Key Micronutrient Levels over Time

Micronutrient	Preoperative (Mean ± SD)	1 Month Postoperative (Mean ± SD)	3 Months Postoperative (Mean ± SD)	p-value
Hemoglobin (g/dL)	13.42 ± 1.27	12.74 ± 1.43	11.98 ± 1.56	0.012
Ferritin (ng/mL)	89.56 ± 34.87	68.34 ± 27.45	51.87 ± 23.12	<0.001
Vitamin B12 (pg/mL)	487.32 ± 98.74	364.89 ± 82.67	298.76 ± 77.34	<0.001
Calcium (mg/dL)	9.45 ± 0.38	9.21 ± 0.42	8.94 ± 0.49	0.018
Vitamin D (ng/mL)	27.63 ± 7.94	24.12 ± 6.87	21.43 ± 6.45	0.023

Table 3 illustrates the progressive decline in key micronutrient levels following OAGB over the first three months. Hemoglobin levels showed a significant reduction ($p = 0.012$), accompanied by a marked drop in ferritin levels ($p < 0.001$), suggesting a developing iron deficiency. Similarly, vitamin B12 levels exhibited a substantial decline over time ($p < 0.001$), likely due to decreased gastric intrinsic

factor production. Serum calcium and vitamin D levels also decreased significantly ($p = 0.018$ and $p = 0.023$, respectively), raising concerns about potential long-term bone health implications. These findings underscore the importance of close nutritional monitoring and supplementation post-surgery.

Table 4. Comparison of Fat-Soluble Vitamin Levels over Time

Vitamin	Preoperative (Mean ± SD)	1 Month Postoperative (Mean ± SD)	3 Months Postoperative (Mean ± SD)	p-value
Vitamin A (µg/dL)	46.89 ± 8.34	39.87 ± 7.54	34.76 ± 6.98	0.007
Vitamin E (mg/L)	1.21 ± 0.23	1.05 ± 0.19	0.94 ± 0.17	0.014
Vitamin K (ng/mL)	0.93 ± 0.15	0.81 ± 0.14	0.73 ± 0.12	0.011

Table 4 presents the alterations in fat-soluble vitamin levels over the study period. A significant reduction in vitamin A, E, and K levels was observed at both one month and three months postoperatively. The most pronounced decline was in vitamin A levels ($p = 0.007$), followed by vitamin

E ($p = 0.014$) and vitamin K ($p = 0.011$). These deficiencies may result from fat malabsorption due to altered bile acid circulation following OAGB. If left unaddressed, such deficiencies could lead to clinical manifestations, including vision problems (vitamin A deficiency), impaired antioxidant function (vitamin E deficiency), and coagulopathy

(vitamin K deficiency). These findings highlight the need for early supplementation and monitoring of fat-soluble vitamin status in post-OAGB patients. These tables provide a comprehensive overview of the early postoperative changes in micronutrient levels following OAGB, emphasizing the importance of routine follow-up and targeted supplementation to prevent nutritional deficiencies and associated complications.

Discussion

Our results reveal a marked decrease in key micronutrients, including iron, vitamin B12, calcium, vitamin D, and fat-soluble vitamins (A, E, and K), within the first three months after OAGB. The reduction in these micronutrients is consistent with the well-known physiological changes following malabsorptive bariatric procedures. The bypass of the duodenum and part of the jejunum in OAGB leads to reduced absorption of essential nutrients, including iron, vitamin B12, and calcium. Additionally, the altered bile flow and digestive enzyme secretion contribute to impaired absorption of fat-soluble vitamins (14).

Vitamin B12 deficiency is another major concern after OAGB. This vitamin is primarily absorbed in the ileum with the help of intrinsic factor, which is produced in the stomach. Following OAGB, the reduction in gastric acid and bypassing of the proximal small intestine significantly impair vitamin B12 absorption. Our study found a substantial decline in vitamin B12 levels over the three-month period, which is consistent with previous research that highlights the frequency of vitamin B12 deficiency after gastric bypass procedures. The consequences of vitamin B12 deficiency can be severe, including neurological deficits, hematological abnormalities, and cognitive decline. This emphasizes the need for routine vitamin B12 supplementation, often in the form of intramuscular injections, especially in the early postoperative period (16).

Fat-soluble vitamin deficiencies were also observed in our study, with vitamin A, E, and K showing significant reductions over the first three months. The malabsorption of fat-soluble vitamins is a well-known consequence of malabsorptive bariatric procedures, including OAGB. These vitamins rely on bile salts for proper absorption, and the altered gastrointestinal anatomy after surgery impairs bile flow, thereby reducing their absorption. Vitamin A deficiency can lead to vision problems and skin issues, while vitamin E deficiency may affect antioxidant capacity, and vitamin K deficiency can lead to coagulopathy. Although less common than other deficiencies, the findings in our study underscore the importance of supplementing these vitamins and closely monitoring their levels postoperatively (18).

Despite the limitations of a relatively small sample size, our study contributes to the growing body of evidence on the nutritional challenges faced by patients after OAGB. Future studies with larger, more diverse cohorts and longer follow-up periods are warranted to further elucidate the long-term trends in micronutrient deficiencies following OAGB and to establish clearer guidelines for postoperative nutritional care.

The first trimester following One-Anastomosis Gastric Bypass (OAGB) with a 150 cm biliopancreatic limb is a critical period marked by rapid physiological changes, substantial weight loss, and profound alterations in gastrointestinal anatomy and nutrient absorption. This period is particularly vulnerable to the development of micronutrient deficiencies, with iron, vitamin B12, folate, vitamin D, and zinc being among the most commonly affected.

The evidence reviewed in recent studies highlights a consistent pattern: despite routine postoperative supplementation, a significant proportion of patients experience measurable declines in micronutrient levels within the first 12 weeks after surgery. The bypass of the duodenum and proximal jejunum—primary sites for the absorption of several essential nutrients—contributes substantially to this risk. Moreover, early postoperative dietary restrictions, reduced oral intake, altered digestion, and fat malabsorption further exacerbate nutrient depletion. These deficiencies are not only biochemically detectable but may also translate into clinical complications if left unrecognized or inadequately treated. Early signs such as fatigue, anemia, glossitis, neuropathies, or impaired immune responses may emerge within weeks, emphasizing the need for early and proactive nutritional surveillance. Studies show that even standard multivitamin regimens may not be sufficient for all patients, particularly those at higher risk or with preexisting deficiencies.

Therefore, clinicians and bariatric care teams should adopt a more aggressive and individualized monitoring approach during the first trimester post-OAGB. This includes baseline micronutrient assessments before surgery, followed by scheduled evaluations within the first 4–12 weeks, with particular attention to iron, vitamin B12, folate, and fat-soluble vitamins. Where necessary, parenteral supplementation—especially for vitamin B12 and iron—should be considered to prevent or correct early deficiencies.

In summary, while OAGB with a 150 cm biliopancreatic limb remains an effective and relatively safe bariatric procedure, it is not without nutritional risks. Timely recognition, continuous monitoring, and tailored interventions are essential to ensure optimal recovery and long-term health outcomes. Future research should focus on refining supplementation protocols and exploring the role of

gut microbiota, individual absorption variability, and genetic factors in shaping micronutrient dynamics post-surgery

Conclusion

In conclusion, the findings of this study emphasize the significant micronutrient deficiencies that can develop in the early postoperative period following OAGB with a 150 cm biliopancreatic limb. Close monitoring, individualized supplementation, and dietary adjustments are crucial for preventing long-term complications and optimizing patient outcomes. Through comprehensive nutritional management, the risk of deficiencies can be minimized, ensuring the success of the bariatric procedure and promoting overall health and well-being in these patients.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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