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Prevalence of Nutritional Deficiencies in Post-Bariatric Surgery Patients: A Cross-Sectional Analysis

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Abstract **Background:** Bariatric surgery is an effective treatment for morbid obesity and its associated comorbidities. However, due to altered gastrointestinal anatomy and physiology, patients are at risk of developing nutritional deficiencies, which may impair long-term health and quality of life. Identifying the prevalence of such deficiencies is essential to guide appropriate follow-up and supplementation strategies. **Objective:** To determine the prevalence of nutritional deficiencies among patients who underwent bariatric surgery and to compare outcomes between sleeve gastrectomy and gastric bypass. **Methods:** This cross-sectional analytical study included 365 patients who had undergone bariatric surgery. Adult patients aged 18-65 years with at least six months of postoperative follow-up were enrolled, while those with prior gastrointestinal surgery, chronic systemic illnesses or incomplete records were excluded. Data were collected on demographics, surgical procedure type and laboratory investigations including hemoglobin, ferritin, vitamin B12, folate, calcium and vitamin D. Standardized cut-off values were used to define deficiencies. Statistical analysis was performed using SPSS version 26, with results expressed as Mean±Standard deviation for continuous variables and frequencies and percentages for categorical variables. Comparisons between groups were made using Chi-square test, with $p<0.05$ considered significant. **Results:** Of 365 patients, 208 (57.0%) underwent sleeve gastrectomy and 157 (43.0%) gastric bypass. The mean age was 40.9±10.1 years and 220 (60.3%) were female. The most common deficiency was vitamin D, present in 202 patients (55.3%), followed by iron deficiency in 146 (40.0%) and anemia in 142 (38.9%). Vitamin B12 deficiency was observed in 110 (30.1%), folate in 81 (22.2%) and calcium in 76 (20.8%). Multiple deficiencies were noted in 134 patients (36.7%). Deficiencies were significantly more frequent in gastric bypass compared to sleeve gastrectomy for vitamin D (62.4% vs. 50.0%, $p = 0.02$) and iron (45.9% vs. 35.6%, $p = 0.03$). Women were more likely to have anemia (45.9% vs. 28.3%, $p = 0.001$) and vitamin D deficiency (60.5 vs. 47.6%, $p = 0.01$). The prevalence of deficiencies increased with time since surgery, with the highest rates observed beyond two years. **Conclusion:** Nutritional deficiencies are common after bariatric surgery, particularly vitamin D and iron deficiency and are more prevalent following gastric bypass than sleeve gastrectomy. Women and patients with longer follow-up durations are at greater risk. These findings underscore the need for structured postoperative monitoring, lifelong supplementation and patient education to prevent long-term health complications.

Key Words Bariatric Surgery, Nutritional Deficiency, Vitamin D, Iron Deficiency, Sleeve Gastrectomy, Gastric Bypass

INTRODUCTION

Obesity is now recognized as one of the most pressing public health challenges worldwide, with prevalence rates increasing at an alarming pace. According to the World Health Organization (WHO), more than 1.9 billion adults are overweight, of which over 650 million are obese [1]. The condition contributes significantly to global morbidity and mortality, as it is strongly associated with type 2 diabetes

mellitus, hypertension, dyslipidemia, cardiovascular disease, obstructive sleep apnea, non-alcoholic fatty liver disease and several malignancies [2]. Lifestyle modification and pharmacotherapy are often insufficient for long-term management, especially in patients with morbid obesity, leading to an increasing reliance on bariatric surgery as the most effective intervention [3]. Bariatric surgery has become the standard of care for individuals with severe obesity who fail to achieve sustained weight loss with conservative approaches. Commonly performed procedures include Laparoscopic Sleeve Gastrectomy (LSG) and Roux-en-Y Gastric Bypass (RYGB). While sleeve gastrectomy functions mainly through gastric restriction, gastric bypass combines restriction with a malabsorptive mechanism, leading to greater weight reduction and more pronounced metabolic effects [4]. Both procedures result in significant improvements in glycemic control, blood pressure and lipid profile and they are often associated with remission of type 2 diabetes and reduction in cardiovascular risk [5]. However, these benefits come at the expense of a heightened risk of nutritional deficiencies, which remain among the most concerning long-term complications of bariatric surgery [6].

The mechanisms underlying postoperative nutritional deficiencies are multifactorial. Reduced oral intake due to early satiety, avoidance of certain food groups (particularly red meat and dairy), altered gastric acid production and changes in gastrointestinal hormone dynamics all contribute [7]. In gastric bypass patients, the exclusion of the duodenum and proximal jejunum bypasses key absorption sites for iron, calcium and certain vitamins [8]. Furthermore, rapid gastric emptying and changes in gut microbiota may also alter nutrient metabolism [9]. These physiological changes make patients vulnerable to a spectrum of micronutrient deficiencies if not properly monitored and supplemented. The most commonly reported deficiencies after bariatric surgery include iron, vitamin B12, folate, calcium and vitamin D. Iron deficiency anemia is among the most prevalent, reported in up to 40-50% of patients and is attributed to reduced heme iron intake, diminished gastric acid and bypass of the duodenum, the primary site of absorption [10]. Vitamin B12 deficiency occurs in 20-35% of cases, particularly after gastric bypass, due to reduced intrinsic factor secretion and impaired absorption in the ileum [11]. Folate deficiency, though less frequent, can still affect 15-25% of patients, often compounded by poor dietary compliance and inadequate supplementation [12]. Calcium deficiency, occurring in up to 20-30% of cases, is clinically important due to its role in bone health; malabsorption combined with vitamin D deficiency often leads to secondary hyperparathyroidism and increased risk of osteoporosis [13]. Vitamin D deficiency is particularly widespread, affecting more than half of post-bariatric patients in some series, reflecting both baseline insufficiency in obese individuals and postoperative malabsorption [14].

Multiple concurrent deficiencies are common, with some studies reporting up to one-third of patients affected. Gastric bypass patients generally experience higher rates of deficiencies compared to those undergoing sleeve gastrectomy, owing to the additional malabsorptive component [15]. The timing of deficiencies also varies: while vitamin B12 and iron deficiencies often develop within the first year, calcium and vitamin D deficiencies may appear later, reflecting long-term absorption and storage dynamics [16]. Previous research has consistently highlighted the importance of regular biochemical monitoring and supplementation following bariatric surgery. International guidelines recommend lifelong follow-up with multivitamin, iron, calcium and vitamin D supplementation, alongside routine laboratory surveillance [17]. Despite this, compliance with supplementation and follow-up tends to decline over time, particularly in resource-limited settings, contributing to persistent deficiencies [18]. Furthermore, most available evidence originates from Western populations, whereas dietary habits, sun exposure, socioeconomic factors and genetic predispositions differ significantly in South Asian and Middle Eastern populations, potentially influencing prevalence patterns [19]. Given these gaps, there is a pressing need for regional data on the prevalence of nutritional deficiencies after bariatric surgery. Such data would provide clinicians with evidence to optimize follow-up protocols, tailor supplementation strategies and prevent long-term complications such as anemia, neuropathy, osteoporosis and impaired quality of life [20]. Therefore, this study was designed to determine the prevalence of key nutritional deficiencies-including iron, vitamin B12, folate, calcium and vitamin D-among post-bariatric surgery patients. Additionally, it aims to compare outcomes between sleeve gastrectomy and gastric bypass patients, thereby contributing valuable evidence to support clinical decision-making and improve postoperative care.

Objective
To determine the prevalence of nutritional deficiencies among patients who underwent bariatric surgery and to compare outcomes between sleeve gastrectomy and gastric bypass.

METHODS
Study Design
This was a cross-sectional analytical study.

Setting
Conducted at Hail.

Duration
The study was carried out over a period of one year.

Sample Size
A total of 365 patients who had undergone bariatric surgery were included in the study.

Sampling Technique
Non-probability consecutive sampling was used to recruit eligible participants.

Inclusion Criteria
Adult patients aged 18-65 years.

- Both male and female patients
- Patients who underwent sleeve gastrectomy or Roux-en-Y gastric bypass

- Patients with at least six months of postoperative follow-up and available laboratory data

Exclusion Criteria

- Patients with previous bariatric or gastrointestinal surgery
- Patients with chronic liver, renal or hematological disorders that could influence nutritional status
- Patients with incomplete medical or laboratory records

Data Collection

Data were collected from postoperative follow-up records of patients who had undergone bariatric surgery and fulfilled the inclusion criteria. Demographic information including age, gender and type of surgical procedure (sleeve gastrectomy or Roux-en-Y gastric bypass) was recorded. Laboratory investigations were retrieved from patient files and included hemoglobin, serum ferritin, vitamin B12, folate, calcium and vitamin D levels. Standardized definitions were used to classify nutritional deficiencies: anemia was defined as hemoglobin <13 g/dL in males and <12 g/dL in females; iron deficiency as serum ferritin <30 ng/mL; vitamin B12 deficiency as <200 pg/mL; folate deficiency as <4 ng/mL; calcium deficiency as <8.5 mg/dL; and vitamin D deficiency as <20 ng/mL. Patients with incomplete laboratory data or confounding chronic illnesses were excluded to ensure reliability of the findings.

Statistical Analysis

All data were entered and analyzed using SPSS version 26. Continuous variables such as age were expressed as Mean±Standard deviation, while categorical variables including gender distribution, type of surgery and prevalence of nutritional deficiencies were summarized as frequencies and percentages. Comparisons of nutritional deficiency prevalence between sleeve gastrectomy and gastric bypass patients were performed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant. Results were presented in tabular form to illustrate the overall prevalence as well as subgroup differences between surgical techniques.

RESULTS

Among 365 patients, 208 underwent sleeve gastrectomy and 157 gastric bypass. The mean age was about 41 years in both groups. Females formed the majority overall (60%), with 62% in the sleeve group and 59% in the bypass group. Nearly two-thirds of patients were urban residents in both groups. The average duration since surgery was approximately 19 months and no significant demographic differences were observed between the two surgical types (Table 1).

Sleeve gastrectomy was the more common operation, performed in 57% of patients, while gastric bypass accounted for 43%, reflecting a preference toward sleeve procedures in this population (Table 2).

Nutritional deficiencies were highly prevalent. Vitamin D deficiency was the most common, affecting more than half of patients (55%). Iron deficiency was seen in 40%, anemia in 39% and vitamin B12 deficiency in 30%. Folate and calcium deficiencies were less frequent, reported in 22 and 21% of patients, respectively. Notably, over one in three patients (37%) suffered from multiple deficiencies simultaneously (Table 3).

Deficiency patterns varied by procedure. Iron deficiency was significantly more frequent in gastric bypass patients (46%) compared to sleeve patients (36%). Vitamin D deficiency was also higher in bypass patients (62%) versus sleeve patients (50%). Other deficiencies, including anemia, B12, folate and calcium, were slightly more common in bypass patients but did not differ significantly (Table 4).

Table 1: Baseline Demographic Characteristics of Patients (N = 365)

Variable	Sleeve Gastrectomy (n = 208)	Gastric Bypass (n = 157)	Total (N = 365)	p-value
Age (years, Mean±SD)	40.5±10.2	41.4±9.9	40.9±10.1	0.38
Gender				
Male	80 (38.5%)	65 (41.4%)	145 (39.7%)	0.59
Female	128 (61.5%)	92 (58.6%)	220 (60.3%)	
Residence				
Urban	128 (61.5%)	95 (60.5%)	223 (61.1%)	0.84
Rural	80 (38.5%)	62 (39.5%)	142 (38.9%)	
Duration since surgery (months, Mean±SD)	18.4±6.2	19.1±6.5	18.7±6.3	0.29

Table 2: Distribution of Surgical Procedures

Procedure Type	Frequency (n)	Percentage
Sleeve Gastrectomy	208	57.0
Gastric Bypass	157	43.0
Total	365	100

Table 3: Overall Prevalence of Nutritional Deficiencies (N = 365)

Deficiency	Present n (%)	Absent n (%)
Anemia (low Hb)	142 (38.9%)	223 (61.1%)
Iron deficiency (low ferritin)	146 (40.0%)	219 (60.0%)
Vitamin B12 deficiency	110 (30.1%)	255 (69.9%)
Folate deficiency	81 (22.2%)	284 (77.8%)
Calcium deficiency	76 (20.8%)	289 (79.2%)
Vitamin D deficiency	202 (55.3%)	163 (44.7%)
≥2 Concurrent deficiencies	134 (36.7%)	231 (63.3%)

Table 4: Comparison of Nutritional Deficiencies Between Sleeve and Bypass Patients

Deficiency	Sleeve Gastrectomy (n = 208)	Gastric Bypass (n = 157)	p-value
Anemia	74 (35.6%)	68 (43.3%)	0.14
Iron deficiency	74 (35.6%)	72 (45.9%)	0.03*
Vitamin B12 deficiency	56 (26.9%)	54 (34.4%)	0.12
Folate deficiency	42 (20.2%)	39 (24.8%)	0.29
Calcium deficiency	40 (19.2%)	36 (22.9%)	0.39
Vitamin D deficiency	104 (50.0%)	98 (62.4%)	0.02*
≥2 Concurrent deficiencies	68 (32.7%)	66 (42.0%)	0.07

Table 5: Severity of Deficiencies in the Total Cohort (N = 365)

Deficiency	Mild (%)	Moderate (%)	Severe (%)	Total n (%)
Anemia	62 (43.7%)	56 (39.4%)	24 (16.9%)	142 (38.9%)
Iron deficiency	66 (45.2%)	54 (37.0%)	26 (17.8%)	146 (40.0%)
Vitamin B12 deficiency	58 (52.7%)	38 (34.5%)	14 (12.7%)	110 (30.1%)
Folate deficiency	47 (58.0%)	25 (30.9%)	9 (11.1%)	81 (22.2%)
Calcium deficiency	52 (68.4%)	18 (23.7%)	6 (7.9%)	76 (20.8%)
Vitamin D deficiency	112 (55.4%)	70 (34.7%)	20 (9.9%)	202 (55.3%)

Table 6: Relationship of Multiple Deficiencies with Type of Surgery

No. ofDeficiencies	Sleeve Gastrectomy (n = 208)	Gastric Bypass (n = 157)	Total (N = 365)	p-value
None	82 (39.4%)	49 (31.2%)	131 (35.9%)	0.11
1 Deficiency	58 (27.9%)	42 (26.8%)	100 (27.4%)	
2 Deficiencies	36 (17.3%)	30 (19.1%)	66 (18.1%)	
≥3 Deficiencies	32 (15.4%)	36 (22.9%)	68 (18.6%)	0.09

Table 7: Gender-Based Comparison of Nutritional Deficiencies

Deficiency	Male (n = 145)	Female (n = 220)	p-value
Anemia	41 (28.3%)	101 (45.9%)	0.001*
Iron deficiency	47 (32.4%)	99 (45.0%)	0.02*
Vitamin B12 deficiency	39 (26.9%)	71 (32.3%)	0.28
Folate deficiency	26 (17.9%)	55 (25.0%)	0.11
Calcium deficiency	27 (18.6%)	49 (22.3%)	0.39
Vitamin D deficiency	69 (47.6%)	133 (60.5%)	0.01*

Table 8: Duration Since Surgery and Nutritional Deficiencies

Duration since surgery	Anemia n (%)	Iron deficiency n (%)	Vitamin B12 deficiency n (%)	Vitamin D deficiency n (%)
6-12 months (n = 112)	32 (28.6%)	35 (31.2%)	26 (23.2%)	49 (43.8%)
13-24 months (n = 144)	56 (38.9%)	58 (40.3%)	44 (30.6%)	83 (57.6%)
>24 months (n = 109)	54 (49.5%)	53 (48.6%)	40 (36.7%)	70 (64.2%)
p-value	0.002*	0.01*	0.04*	0.03*

Most deficiencies were mild to moderate, though a proportion were severe. Among patients with anemia, 44% were mild, 39% moderate and 17% severe. Similarly, 18% of iron-deficient patients had severe deficiency. Vitamin B12 and folate deficiencies were mostly mild, while calcium deficiency was mild in two-thirds of patients. Vitamin D deficiency was predominantly mild (55%) but nearly 10% of patients had severe deficiency (Table 5).

More than one-third of patients had no deficiencies, while 27% had a single deficiency. Around 18% of patients suffered from two deficiencies and nearly 19% had three or more deficiencies. Multiple deficiencies were more frequent in gastric bypass patients (23%) compared to sleeve patients (15%), suggesting higher nutritional vulnerability after bypass (Table 6).

Nutritional deficiencies were more common in females. Anemia affected 46% of women compared to 28% of men and iron deficiency was seen in 45% of women versus 32% of men. Vitamin D deficiency was also higher in women (61%) than men (48%). B12, folate and calcium deficiencies were slightly more common in females but not statistically significant (Table 7).

The prevalence of deficiencies increased with time after surgery. Within the first year, 29% had anemia and 31% had iron deficiency. These rates rose to nearly 39% and 40% at 13-24 months and further increased to 50% and 49% after two years. Vitamin B12 deficiency rose from 23% in the first year to 37% after two years. Vitamin D deficiency also increased steadily, from 44% in the first year to 64% after two years. This trend indicates that deficiencies become more frequent and severe with longer follow-up (Table 8).

DISCUSSION

This study assessed the prevalence of nutritional deficiencies among 365 post-bariatric surgery patients and compared outcomes between sleeve gastrectomy and gastric bypass. The findings revealed that nutritional deficiencies are common, with vitamin D deficiency being the most prevalent, followed by iron deficiency, anemia, vitamin B12, folate and calcium deficiencies. Importantly, deficiencies were more pronounced in gastric bypass patients compared to sleeve gastrectomy, particularly for vitamin D and iron. These results emphasize the importance of long-term nutritional surveillance and targeted supplementation in this

patient population. Our study found vitamin D deficiency in over half of patients (55%), with higher rates in gastric bypass (62%) compared to sleeve gastrectomy (50%). This observation is consistent with previous research, which has reported vitamin D deficiency rates ranging from 50-70% after bariatric surgery, largely due to decreased absorption and baseline insufficiency in obese individuals [21]. The progressive increase in deficiency prevalence with longer duration since surgery in our cohort further supports the chronic nature of this problem, mirroring findings in previous research [22].

Iron deficiency and anemia were also common, affecting 40% and 39% of patients respectively, with significantly higher prevalence among gastric bypass patients. These results align with previous research that demonstrated iron deficiency in 30-50% of patients post-surgery, particularly in those undergoing bypass procedures due to exclusion of the duodenum, the primary site of iron absorption [23]. Our finding that nearly one in five patients had severe anemia underscores the clinical relevance of these deficiencies and their potential to impair quality of life if not addressed. Vitamin B12 deficiency was detected in 30% of our patients, with higher rates in gastric bypass patients though not statistically significant. This is comparable to previous research where vitamin B12 deficiency ranged between 20-35%, attributed to decreased intrinsic factor secretion and impaired absorption in the ileum [24]. Folate deficiency, seen in 22% of our patients, was relatively lower but still notable, consistent with previous research that reported prevalence rates between 15-25%. These micronutrient deficiencies carry risks of neuropathy, cognitive impairment and hematological complications, highlighting the need for routine monitoring.

Calcium deficiency was observed in 21% of our cohort, with no significant difference between sleeve and bypass procedures. Previous research has reported calcium deficiency rates of 20-30%, often linked with vitamin D deficiency and secondary hyperparathyroidism [25]. Our findings reinforce the need for integrated bone health monitoring in post-bariatric patients, particularly in long-term follow-up. Multiple concurrent deficiencies were found in nearly 37% of patients, with gastric bypass patients more affected than sleeve gastrectomy patients. This pattern is in line with previous research, which has shown that bypass procedures carry a greater risk of multiple nutritional deficits due to their combined restrictive and malabsorptive effects [26]. Our results further demonstrated that deficiencies became more prevalent with longer postoperative duration, which is also consistent with previous research documenting cumulative risks beyond two years post-surgery. Gender-based analysis revealed that women were disproportionately affected, with significantly higher rates of anemia, iron deficiency and vitamin D deficiency compared to men. These findings reflect those of previous research, which attributed higher prevalence in women to baseline menstrual blood loss, higher rates of pre-existing vitamin D insufficiency and sociocultural dietary patterns [27-30].

Taken together, our findings confirm that nutritional deficiencies are both common and progressive after bariatric surgery, particularly among gastric bypass patients and women. The similarities with previous research strengthen the generalizability of these results, while the regional evidence generated here fills an important gap in understanding the burden of post-bariatric nutritional complications [31-32]. Limitations of this study include its cross-sectional design, which restricts causal inference and reliance on hospital records, which may not fully account for patient compliance with supplementation. Nevertheless, the sample size was large and the findings provide valuable insight into the prevalence and pattern of nutritional deficiencies in this population.

CONCLUSIONS

It is concluded that nutritional deficiencies are highly prevalent among post-bariatric surgery patients, with vitamin D and iron deficiency being the most common. Deficiencies were more frequent among gastric bypass patients compared to sleeve gastrectomy and women were disproportionately affected. The risk of multiple and progressive deficiencies also increased with longer duration after surgery. These findings are consistent with previous research and highlight the importance of structured postoperative monitoring, patient education and lifelong supplementation to prevent long-term complications. Bariatric surgery should therefore be approached not only as a weight loss intervention but also as a procedure requiring comprehensive nutritional follow-up.

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