

Pre- and Postoperative Nutritional Deficiencies in Patients Undergoing Bariatric Surgery: A Retrospective Cohort Study

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AIM: To assess the changes in biochemical indicators of nutritional deficiencies before and after bariatric surgery.

METHODS: This retrospective cohort study included 480 adult patients who underwent bariatric surgery between June 2016 and June 2019 at a tertiary care center in Saudi Arabia. Demographic data, comorbidities, and pre- and postoperative biochemical parameters, including hemoglobin, iron profile, Vitamin D, Vitamin B12, albumin, calcium, and parathyroid hormone levels, were extracted from the medical records. These biochemical parameters were used to assess micronutrient status and identify clinically relevant nutritional deficiencies based on established laboratory thresholds. Paired *t*- and McNemar tests were used to compare the pre- and postoperative values. Statistical significance was set at $p < 0.05$.

RESULTS: We found a high prevalence of pre- and postoperative nutritional deficiencies among patients. The mean hemoglobin decreased from 13.09 to 12.34 g/dL (mean difference -0.75 g/dL; 95% CI -0.89 to -0.61 ; $p < 0.001$). We observed a significant association between ferritin and gender pre- and postoperatively, which was lower in women than in men preoperatively and decreased in both sexes postoperatively. The prevalence of 25-hydroxyvitamin D deficiency was 88.0% preoperatively and 72.7% postoperatively in patients with available laboratory data.

CONCLUSIONS: A high prevalence of pre- and postoperative nutritional deficiencies was observed among patients undergoing bariatric surgery in Saudi Arabia. Although certain parameters improved after surgery, others remained prevalent or worsened postoperatively. These findings highlight the importance of structured nutritional assessments and regular biochemical monitoring before and after bariatric surgery.

Keywords: bariatric surgery; nutritional deficiencies; obesity; body mass index

Introduction

Obesity and overweight are major epidemics and risks to public health worldwide [1]. Obesity is defined as abnormal or excessive accumulation of body fat that may impair health, and high body mass index has been identified in global burden of disease analyses as one of the leading risk factors contributing to mortality worldwide [1,2]. Although debated, obesity is now recognized as a pathological condition with its burden on individual, society, and economy [3]. Obesity is diagnosed by body mass index (BMI) obtained by dividing weight in kilograms (kg) by the square of height in meters (m) [1]. Obesity leads to complications such as high blood pressure, heart disease, metabolic syndrome, type 2 diabetes, and certain types of cancer [4,5]. Managing obesity improves quality of life, primarily through

lifestyle interventions with diet and physical activity [6]. Some patients need pharmacotherapy, and recent advancements in obesity pharmacotherapy show promising treatment options through novel agonists targeting neurohormonal pathways involved in appetite regulation and energy balance [7]. Key medications include glucagon-like peptide-1 receptor agonists (GLP-1 RAs) such as semaglutide and liraglutide, which have been associated with significant weight loss by reducing energy intake via central nervous system mechanisms [8]. Recent data from the Ministry of Health in Saudi Arabia show that obesity prevalence among adults has increased over past decades [9]. Projections estimate that adult obesity prevalence rose from 12% in 1992 to 41% in men and from 21% to 78% in women by 2022, with women showing higher rates, especially in ages 35–64 years [9]. Obesity prevalence in Saudi Arabia aligns with trends across other Gulf Cooperation Council (GCC) countries, including Bahrain, Kuwait, Oman, Qatar, and the United Arab Emirates [10]. The GCC region exhibits some of the highest obesity rates globally, with overweight and obesity among adults increasing steadily over the last four decades [10].

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An effective approach to managing obesity involves achieving weight loss, with bariatric surgery serving as a key intervention [11]. This surgical procedure modifies the gastrointestinal tract to restrict food intake and nutrient absorption [12]. Bariatric surgery promotes substantial long-term weight loss and contributes to the resolution of obesity-associated comorbidities, including type 2 diabetes, hypertension, and cardiovascular disease [11]. Bariatric surgery is a vital component of obesity management, improving health outcomes and patients' quality of life [13]. In Saudi Arabia, approximately 15,000 bariatric surgeries are performed annually [14].

Although considered beneficial, bariatric surgery often causes malabsorption and reduced food intake leading to nutritional deficiencies [15]. Preoperative nutritional deficiency contributes to complications during surgery, making pre- and post-operative nutritional assessment crucial for better treatment outcomes [16,17].

A study of 267 patients admitted for nutritional assessment before bariatric surgery showed that patients with two or more comorbidities had micronutrient deficiencies [18]. Research in Germany revealed 51% of obesity patients had at least one deficiency pre- and remained deficient postoperatively [17]. Another study in the USA detected abnormal values for vitamins and trace elements in 100 participants before and after surgery [19].

Although several international studies have evaluated micronutrient deficiency after bariatric surgery, region-specific data from Saudi Arabia are limited. Given the high national prevalence of obesity and baseline Vitamin D deficiency, understanding the perioperative nutritional trends in the Saudi population is of particular clinical importance. This study assessed the prevalence and progression of nutritional deficiencies before and after bariatric surgery in a large Saudi cohort, thereby providing locally relevant evidence to guide structured nutritional monitoring and patient management.

This study identifies the prevalence of electrolyte and nutrient deficiencies pre- and postoperatively among patients with obesity in Saudi Arabia seeking bariatric surgery and correlates the findings with demographic data.

Methods

This retrospective analysis examined 480 individuals who underwent bariatric surgery between June 2016 and June 2019. Patient data were obtained from the medical records of King Abdulaziz University. The study population comprised patients with a BMI ≥ 35 kg/m² or BMI ≥ 27.5 kg/m² with at least one obesity-related comorbidity, according to the institutional eligibility criteria for bariatric surgery. For descriptive analyses, BMI categories presented in Table 1 were classified according to the standard World Health Organization (WHO) adult BMI classification system.

Inclusion criteria

- Adult patients (≥ 18 years).

- Who underwent sleeve gastrectomy or Roux-en-Y gastric bypass between June 2016 and June 2019.

- Patients with available preoperative laboratory data.

Exclusion criteria

- Patients were excluded if they had chronic liver or kidney diseases, known haematological disorders, malignancy, pregnancy, or malabsorption syndrome.

- Patients with incomplete medical records.

- Patients with missing key laboratory measurements.

Biochemical markers were chosen based on established clinical guidelines for nutritional assessment in patients undergoing bariatric surgery, as these procedures are associated with a risk of micronutrient deficiency due to reduced intake and malabsorption. Hemoglobin, iron, ferritin, Vitamins B12 and D, albumin, calcium, magnesium, phosphate, parathyroid hormone, and electrolytes were assessed because they represent commonly reported deficiencies in bariatric populations and are routinely monitored during perioperative care.

Nutritional deficiencies were defined based on abnormalities in micronutrient-related biochemical markers, including hemoglobin, iron indices, Vitamin D, Vitamin B12, and albumin, using established clinical thresholds. Electrolyte-related parameters, including calcium, magnesium, phosphate, and parathyroid hormone, were evaluated separately as biochemical indicators of mineral metabolism and were analysed descriptively rather than as primary outcomes.

Operational definitions of biochemical deficiencies were defined according to internationally recognized clinical guidelines and standard adult laboratory reference ranges as follows:

Anaemia: haemoglobin <12.0 g/dL in women and <13.0 g/dL in men.

Vitamin D deficiency: serum 25-hydroxyvitamin D <50 nmol/L.

Iron deficiency: serum ferritin <15 ng/mL.

Hypoalbuminemia: serum albumin <35 g/L.

Vitamin B12 deficiency: serum Vitamin B12 <200 pg/mL.

Magnesium (hypomagnesemia) <0.7 mmol/L.

Elevated parathyroid hormone (PTH): >65 pg/mL.

Calcium (hypocalcemia) total serum calcium <2.1 mmol/L.

Phosphate (hypophosphatemia) <0.8 mmol/L.

Additionally, comorbidities, such as diabetes mellitus, hypertension, chronic heart disease, and hypothyroidism, were evaluated. Because this was a retrospective study, all eligible patients who underwent bariatric surgery at King Abdulaziz University between June 2016 and June 2019 were included. Therefore, formal sample-size calculations were not performed. The final study comprised 480 patients, representing the complete cohort available during the study period. Due to the retrospective design, not all laboratory investigations were available for every patient at either time point. Analyses were conducted using an available-case (complete-case) approach, in which each biochemical parameter was analyzed with all patients with available pre-

and/or postoperative data for that variable. Therefore, due to differences in the availability of laboratory data for various biochemical markers, the number of patients included in each analysis varies. Imputation methods were not used. The number of patients included in each analysis is shown in the corresponding table.

Ethical approval for this study was granted by the Research Ethics Committee of King Abdulaziz University (reference no. 227.19).

Statistical Analysis

Microsoft Excel 2024 (Microsoft Corporation) was used for data entry, and data analysis was performed using Statistical Package for the Social Sciences (SPSS, Version 26.0, IBM Corporation), with a significance level of $p < 0.05$. The normality of continuous variables was evaluated using the Shapiro–Wilk test and graphical inspection of histograms. Paired t -tests were performed only for patients with available paired pre-and postoperative measurements recorded in the database. Categorical comparisons between paired preoperative and postoperative variables were performed using the McNemar test. Fisher’s exact test was applied when appropriate. Statistical significance was set at a two-tailed p -value < 0.05 . Given the exploratory nature of this study, no adjustments for multiple comparisons were made.

Results

Baseline Demographic and Clinical Characteristics

Of the 480 participants, 317 (66.0%) were women and 163 (34.0%) were men. The participants had a mean age of 38.59 ± 10.61 years, with an age range of 18–65 years and an average BMI of 44.47 kg/m^2 . Of the total participants, 236 (49.2%) were diagnosed with diabetes, 151 (31.5%) with hypertension, and 43 (9.0%) with chronic heart disease (Table 1).

Prevalence of Nutritional Deficiencies

A high prevalence of nutritional deficiencies was observed both before and after bariatric surgery. The prevalence of anemia increased postoperatively in both males and females. Among males, anemia increased from 31.9% preoperatively to 53.2% postoperatively, while in females it increased from 35.3% to 50.2%.

Vitamin D deficiency was highly prevalent, affecting 88.0% of patients before surgery and 72.7% after surgery. Albumin abnormalities remained consistently high at both time points (19.5% preoperatively and 12.1% postoperatively).

Other deficiencies—including Vitamin B12, iron, ferritin, calcium, phosphate, and magnesium—were observed with varying prevalence before and after surgery. Detailed prevalence data for all assessed biochemical parameters are presented in Table 2.

Table 1. Baseline demographic and clinical characteristics of patients undergoing bariatric surgery (n = 480).

Demographics	Total	Male	Female
Sex	480	163 [34.0%]	317 [66.0%]
Age [years]	38.59 ± 10.61	37.87 ± 10.80	38.95 ± 10.50
Age group			
18–29	108 [22.5%]	43 [26.4%]	65 [20.5%]
30–39	164 [34.2%]	50 [30.7%]	114 [36.0%]
40–49	119 [24.8%]	44 [27.0%]	75 [23.7%]
50–65	89 [18.5%]	26 [16.0%]	63 [19.9%]
Nationality			
Saudi	411 [85.6%]	146 [89.6%]	265 [83.6%]
Non-Saudi	69 [14.4%]	17 [10.4%]	52 [16.4%]
Height [cm]	164.16 ± 9.62	172.77 ± 8.17	159.74 ± 6.93
Weight [kg]	119.97 ± 26.07	136.11 ± 28.40	111.66 ± 20.33
BMI [kg/m^2]	44.47 ± 8.59	45.57 ± 8.81	43.90 ± 8.44
BMI			
Overweight	3 [0.6%]	2 [1.2%]	1 [0.3%]
Obesity class I	39 [8.1%]	11 [6.7%]	28 [8.8%]
Obesity class II	120 [25.0%]	27 [16.6%]	93 [29.3%]
Obesity class III	318 [66.3%]	123 [75.5%]	195 [61.5%]
Diabetes mellitus	236 [49.2%]	99 [60.7%]	137 [43.2%]
Hypertension	151 [31.5%]	54 [33.1%]	97 [30.6%]
Chronic heart disease	43 [9.0%]	20 [12.3%]	23 [7.3%]

BMI, body mass index.

Changes in Biochemical Parameters After Surgery

A paired t -test was used to compare the mean levels of each element before and after surgery. The mean hemoglobin decreased from 13.09 to 12.34 g/dL (mean difference -0.75 g/dL ; 95% CI -0.89 to -0.61 ; $p < 0.001$). The mean 25-hydroxyvitamin D levels increased significantly post-surgery from 38.64 preoprtrvliy to 59.57 nmol/L, postoperatively with (mean difference 20.93 nmol/L; 95% CI 14.90 to 26.96; $p < 0.001$). No significant differences were observed in the mean pre- and postoperative albumin and Vitamin B12 levels or in any other biochemical parameters. A significant association was identified between ferritin levels and sex both pre- and postoperatively, with lower levels in females than in males.

Discussion

In this cohort, a high prevalence of micronutrient deficiencies was observed both before and after bariatric surgery, with variable postoperative trends across different parameters. Although certain parameters improved postoperatively, other parameters remained unchanged or worsened. These findings emphasize the importance of structured nutritional assessments and continuous biochemical monitoring in patients undergoing bariatric surgery. Overall, the findings of this study demonstrate heterogeneous changes in nutritional status following bariatric surgery. While certain deficiencies, such as Vitamin D deficiency, showed improvement postoperatively, other conditions—including

Table 2. Prevalence of preoperative and postoperative biochemical abnormalities in patients undergoing bariatric surgery.

Biomarker	Preoperative	Total	Postoperative	Total
Hemoglobin				
Male	52 [31.9%]	163	82 [53.2%]	154
Female	112 [35.3%]	317	154 [50.2%]	307
Albumin	91 [19.5%]	467	35 [12.1%]	289
Total protein	0	466	14 [4.9%]	288
Folate	0	16	5 [12.5%]	40
Vitamin B12	40 [23.3%]	172	49 [25.5%]	192
Calcium	45 [23.1%]	195	45 [23.0%]	196
Phosphate	9 [7.7%]	117	13 [11.5%]	113
Iron	16 [27.6%]	58	14 [14.4%]	97
Ferritin				
Male	4 [10.8%]	37	42 [37.8%]	111
Female	33 [36.3%]	91	4 [8.9%]	45
Magnesium	11 [11.3%]	97	11 [8.6%]	128
PTH	0	90	1 [1.0%]	104
25-hydroxyvitamin D	212 [88.0%]	241	149 [72.7%]	205
Potassium	26 [5.5%]	476	45 [13.2%]	340
Sodium	38 [8.0%]	476	52 [15.2%]	342
Chloride	31 [6.5%]	476	23 [6.7%]	342

Hemoglobin and ferritin were stratified by sex due to established differences in normal reference ranges between males and females. Other biochemical parameters were analyzed using unified reference ranges and are therefore presented as overall values. PTH, parathyroid hormone.

anemia and iron-related deficiencies—persisted or worsened after surgery. In contrast, some biochemical parameters, such as albumin and Vitamin B12 levels, remained relatively stable over time. These findings indicate that bariatric surgery does not uniformly resolve pre-existing nutritional deficiencies and may contribute to the development or persistence of specific micronutrient abnormalities. This underscores the importance of comprehensive preoperative assessment and ongoing postoperative monitoring to optimize patient outcomes.

Our study demonstrated that a substantial proportion of patients who underwent bariatric surgery were female, which is consistent with previous reports [8,20]. The male-to-female ratio among bariatric surgery recipients indicated a marked predominance of female patients. In support of this observation, a study of 303 individuals who underwent Roux-en-Y gastric bypass reported that 73% of the participants were female, further reinforcing the higher utilization of bariatric surgery among women. Additionally, a considerable number of participants presented with comorbid conditions such as diabetes mellitus and hypertension, indicating a higher burden of health problems among individuals with morbid obesity compared with the non-obese population [21,22].

Our findings demonstrate that 25-hydroxyvitamin D deficiency was highly prevalent in obese patients, both preoperatively and postoperatively. Consistent with our results, studies from China, the United States, and France reported similarly high rates of 25-hydroxyvitamin D deficiency in comparable populations [18,19,23,24]. This widespread deficiency is largely attributed to inadequate dietary intake and impaired intestinal absorption of this micronutrient [25].

In Saudi Arabia, 25-hydroxyvitamin D deficiency has been linked to lifestyle choices resulting in significantly lower levels of Vitamin D. In our study, the deficiency in patients could be due to dietary habits, insufficient sun exposure, traditional long-sleeved clothing, and limited outdoor activities because of high temperatures [26,27]. Since 25-hydroxyvitamin D plays a crucial role in surgical wound healing, its deficiency adversely affects the recovery process post-surgery [25]. We observed a significant correlation between age and 25-hydroxyvitamin D levels before and after surgery, with participants aged 18–29 years showing the highest deficiency among all age groups. The most significant finding of this study is the improvement in mean 25-hydroxyvitamin D levels following surgery, consistent with findings from a study conducted in the USA [28]. This postoperative improvement may reflect routine supplementation practices commonly recommended after bariatric surgery. However, adherence to supplementation was not directly assessed in this study.

The preoperative albumin levels observed in our study were consistent with those reported in a study conducted in Germany [29]. Although previous studies have suggested a potential association between elevated BMI and hypoalbuminemia [30,31], this relationship was not formally examined in our cohort and therefore could not be confirmed in the present analysis. Nevertheless, clinicians should be aware that hypoalbuminemia is associated with adverse postoperative outcomes, including prolonged hospital stay and increased complication rates [32].

Our study identified a significant lack of preoperative iron levels, which is consistent with earlier studies conducted in the USA [16,24] and Germany [17]. Regarding ferritin, 28.9% of our study participants were deficient before surgery, which matches the findings of a study in France [18], but contradicts another study that found no ferritin deficiencies in patients undergoing bariatric surgery. There was a notable link between ferritin levels and sex, both before and after surgery, with females exhibiting significantly lower ferritin levels than males, likely due to menstruation [33,34]. This observation is crucial for addressing postoperative iron-deficiency anemia, suggesting the need for higher elemental iron doses in females and for monitoring related clinical signs and symptoms [35,36]. The current findings of a high prevalence of low hemoglobin levels pre- and post-surgery are in line with previously published research. A significant drop in hemoglobin levels

after bariatric surgery can be attributed, at least in part, to substantial blood loss occurring during the surgery itself. Postoperative bleeding, particularly along the staple line, is a recognized complication of bariatric procedures and can lead to a measurable decrease in hemoglobin levels [37]. Strategies, such as intraoperative blood pressure regulation, have been shown to reduce bleeding rates and consequently reduce postoperative hemoglobin drops, emphasizing the direct contribution of intraoperative blood loss to postoperative anemia [37].

In addition to the overall prevalence of nutritional deficiencies, selected associations with demographic variables were observed. Significant sex-based differences were identified in ferritin levels, with females demonstrating lower levels compared to males. These findings highlight the importance of considering demographic characteristics when evaluating nutritional status in bariatric patients.

In addition to the micronutrient deficiencies highlighted above, several biochemical parameters observed in the present study require further consideration. Hypoalbuminemia was highly prevalent both pre-and postoperatively. Although albumin is commonly used as a marker of nutritional status, low serum albumin levels in patients with severe obesity may reflect chronic inflammation, altered protein metabolism, or dilutional effects associated with an increased body mass [30,31]. A previous study has shown that hypoalbuminemia in patients undergoing bariatric surgery is associated with poor postoperative outcomes and increased complication rates [32].

Electrolyte disturbances, including abnormalities in magnesium and phosphate levels, have also been observed in a subset of patients. Such alterations may occur following bariatric surgery due to reduced dietary intake, altered gastrointestinal absorption, and changes in the hormonal regulation of mineral metabolism [12,36]. Hypomagnesemia and hypophosphatemia have been reported in bariatric populations and may contribute to neuromuscular symptoms, bone metabolism disturbances, and metabolic complications if left unrecognized [12,36]. These findings highlight the importance of comprehensive biochemical monitoring in the perioperative management of patients undergoing bariatric surgery.

A key limitation of this study is the absence of laboratory data owing to its retrospective design. Not all biochemical tests were ordered uniformly, and some patients underwent testing at external facilities without documented results in the hospital records. Analyses were performed using an available-case approach, whereby each parameter was analyzed based on patients with available data. Because absence is likely related to clinical decision-making rather than occurring completely at random, selection bias cannot be excluded. This may have influenced the reported prevalence estimates and limited the generalizability of our findings. Finally, the duration and timing of the postoperative follow-up were not standardized, which may have in-

fluenced the observed biochemical trends. Moreover, variations in surgical techniques (e.g., sleeve gastrectomy versus gastric bypass) were not analyzed separately, which may affect the nutritional outcomes differently. Additionally, multiple biochemical parameters were evaluated without formal adjustments for multiple comparisons, which may have increased the possibility of type I errors. Multivariate analyses were not performed to identify independent predictors of biochemical deficiencies; this should be addressed in future research.

Conclusions

This study provides region-specific evidence of the prevalence and progression of micronutrient deficiency among patients undergoing bariatric surgery in Saudi Arabia. While certain deficiencies, such as Vitamin D deficiency, improved postoperatively, others, including anemia and iron deficiency, demonstrated an increased prevalence following surgery. These findings highlight the need for structured postoperative nutritional surveillance programs, standardized laboratory monitoring protocols, and patient education initiatives tailored for the Saudi population. Future prospective multicenter studies with longer follow-up periods are warranted to further clarify long-term nutritional outcomes.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

MRA conceptualized and designed the study, acquired and analyzed the data, and performed the formal analysis. WJ contributed to the methodology, data interpretation, and manuscript drafting. Both authors have been involved in revising the manuscript critically for important intellectual content. Both authors gave final approval of the version to be published. Both authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

Ethical approval for this study was granted by the Research Ethics Committee of King Abdulaziz University (reference no. 227.19). The study was conducted in accordance with the principles of the Declaration of Helsinki. Given the retrospective nature of the study and the use of deidentified medical record data, the requirement for informed consent was waived by the Research Ethics Committee of King Abdulaziz University.

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Conflict of Interest

The authors declare no conflict of interest.

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