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Original Research Article

Incidence of Iron Deficiency Following Laparoscopic Sleeve Gastrectomy: A 5-Months Prospective Observational Study

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Abstract:

Background: A common restrictive bariatric treatment for morbid obesity is laparoscopic sleeve gastrectomy (LSG). Reduced stomach capacity and acid output may affect iron absorption and other micronutrient levels following surgery, even while the duodenum is maintained.

Aim: This study's objective was to evaluate the prevalence of iron deficiency and associate hematological and micronutrient alterations in patients receiving LSG throughout a five-month follow-up period.

Method: The study was conducted at Department of General Surgery at Shree Narayan Medical Institute and Hospital, Saharsa, Bihar, India. Included were eighty individuals getting LSG. Body weight, BMI, serum CRP, hemoglobin, MCV, MCH, serum iron, ferritin, transferrin saturation, vitamin B12, RBC folate, and soluble transferrin receptors were all compared before and five months after surgery. Descriptive statistics and paired comparisons were used to analyses the data.

Results: At five months, there were notable decreases in weight, BMI, excess weight, percentage excess weight, and serum CRP. Four patients (5%) had iron shortage, and one patient (1.25%) had iron-deficiency anaemia. The majority of iron indexes and haemoglobin stayed mostly unchanged. While vitamin B12 and RBC folate levels considerably decreased, serum iron and transferrin saturation significantly rose. Folate deficiency was found in 6.25% of patients after five months, while vitamin B12 deficiency rose from 7.5% before surgery to 17.5 fluctuation.

Conclusion: LSG was linked to considerable early weight reduction, improved inflammatory condition, and a low short-term incidence of iron insufficiency. However, the postoperative drop in vitamin B12 and folate emphasises the importance of frequent micronutrient monitoring and early replacement following LSG.

Keywords: Sleeve gastrectomy, Obesity, Iron deficiency, Soluble transferrin receptor.

Introduction

A relatively recent bariatric operation is laparoscopic sleeve gastrectomy (LSG). When it was first introduced, it was either the first stage of a tiered strategy to weight management or the restrictive part of biliopancreatic diversion with duodenal switch (BPD-DS). In the latter case, LSG is performed on extremely obese patients who have higher surgical risks in order to start losing enough weight to enable a second stage gastric bypass or BPD-DS [1].

Recent reports of considerable reductions in body mass index (BMI) and comorbidities have led to its usage as final bariatric surgery. LSG is a restrictive bariatric treatment that leaves a small gastric tube, or "sleeve," after the fundus and greater curvature of the stomach are excised. This approach minimizes the micro nutritional deficits commonly seen following malabsorptive surgeries since the small intestine is neither bypassed nor eliminated [2, 3].

Absorption in the duodenum, which is preserved in LSG, is primarily responsible for iron control. On the other hand, a decrease in stomach capacity results in a drop in parietal cell mass, which reduces the generation of hydrochloric acid (HCl). Through two pathways, gastric acids are essential for the absorption of iron. First, by denaturing proteins, HCl aids in the release of iron that is bound to proteins. Second, HCl transforms ferric ions from dietary iron sources into the absorbable ferrous state [4]. Hemoglobin (Hgb), myoglobin, and several iron-

containing enzymes, including cytochromes, all depend on iron [5]. There is evidence that iron deficiency without anemia affects teenage girls' cognitive function and wears out older women [6, 7].

Moreover, acute iron shortage may hinder tissue repair and collagen formation, making cosmetic procedures; which are frequently performed following substantial weight loss; more difficult [8,9]. If left untreated, a protracted iron shortage can lead to anemia, which is accompanied by a number of terrible symptoms like exhaustion, headaches, weakness, tachycardia, and dyspnoea. Consequently, the detrimental effects of anemia on patients' quality of life may compromise the positive results of bariatric surgery [10]. Bariatric surgery is widely regarded as the most effective long-term therapy for morbid obesity; this operation has been shown to provide considerable and long-term weight loss, resolution or improvement of co-morbidities [11,12], and consequent mortality reduction [13,14].

The incidence of certain low micronutrient levels in U.S. adults has been shown to be correlated with body mass index (BMI) [15]. This significant conclusion was confirmed by nationally representative cross-sectional data for 16,191 people from the National Health and Nutrition Examination Survey III. Numerous studies of people seeking weight loss surgery have confirmed this [16]. To help achieve the best possible surgical results by normalising nutritional status prior to surgery, it is crucial to acquire an evaluation of micronutrient levels.

Laparoscopic sleeve gastrectomy (LSG), which has developed into a major stand-alone treatment, is the subject of our current study. For high-risk patients, LSG was first utilised as part of a two-stage treatment to help with weight loss prior to a second final malabsorptive surgery. LSG has gained more acceptance as a main operation over the last ten years following three worldwide consensus summits and a thorough meta-analysis of 2570 patients in 36 studies [17]. More research on the metabolic effects of LSG is necessary because to its increasing popularity as a surgical treatment for morbid obesity. This study sought to ascertain the 5-month incidence of iron deficit in patients having this operation as well as the effect of LSG on iron indicators.

Methodology

Study Design: The purpose of this prospective observational cohort research was to assess the prevalence of iron insufficiency in patients having laparoscopic sleeve gastrectomy (LSG). The design made it possible to systematically monitor patients from the preoperative phase to postoperative evaluation, which made it possible to detect changes in iron status over time after the surgical procedure.

Study Area: The study was conducted at Department of General Surgery at Shree Narayan Medical Institute and Hospital, Saharsa, Bihar, India for five months.

Inclusion Criteria

- Patients aged 18–60 years undergoing laparoscopic sleeve gastrectomy
- Patients with body mass index (BMI) ≥40 kg/m² or BMI between 35–40 kg/m² with associated comorbidities
- Patients willing to participate and provide informed consent
- Patients available for follow-up during the study period

Exclusion Criteria

- Patients with pre-existing iron deficiency or anemia
- Patients with hematological disorders such as microcytosis or macrocytosis
- Patients suffering from chronic inflammatory diseases or infections
- Patients with hypothyroidism, malignancy, renal or hepatic dysfunction
- Patients on long-term steroid or immunosuppressive therapy
- Patients who require blood transfusion during or immediately after surgery
- Pregnant women or those who became pregnant during follow-up
- Patients with postoperative complications requiring readmission

Sample Size: The final analysis comprised 80 patients who met the inclusion criteria and none of the exclusion criteria. Prior to enrolment, patients with pre-existing anaemia, iron deficiency, hypothyroidism, microcytosis, macrocytosis, chronic inflammatory diseases, or other predetermined exclusion criteria were eliminated. The study's length, patient movement within the department, and practicality were taken into consideration while determining the sample size.

Procedure: All eligible patients were assessed preoperatively, including a complete clinical history, physical examination, and laboratory tests. Baseline demographic characteristics such as age, gender, body weight, height, and BMI were collected. Preoperative biochemical tests included a full blood count, serum iron, serum ferritin, total iron-binding capacity (TIBC), transferrin saturation, vitamin B12, and folate levels.

All patients received laparoscopic sleeve gastrectomy under general anaesthesia in accordance with established surgical standards. The technique entailed longitudinal excision of the larger curvature of the stomach, including the fundus, body, and a portion of the antrum, resulting in the

formation of a tubular gastric sleeve along the lesser curvature. A bougie was employed intraoperatively to calibrate the gastric sleeve and guarantee consistency in the surgical approach.

Postoperatively, patients were handled in accordance with established institutional standards. Nutritional counselling was provided, and patients were instructed on dietary adjustments. Standard postoperative drugs, comprising proton pump inhibitors and iron-free multivitamin supplements, were provided. Patients were meticulously observed for any immediate or delayed problems.

Subsequent assessments were performed at consistent intervals throughout the research duration. At every follow-up appointment, clinical evaluations and laboratory tests were conducted again. Blood samples were obtained to assess haemoglobin concentrations, serum iron, ferritin, and total iron-binding capacity (TIBC). Transferrin saturation was determined using conventional formulas. Iron deficiency was characterized by diminished serum ferritin levels and decreased transferrin saturation, whereas anaemia was identified following established WHO criteria.

Alterations in body weight, BMI, and the percentage of excess weight reduction were recorded to evaluate the efficacy of the surgical intervention. All data were carefully captured via a pre-established data collecting proforma.

Statistical Analysis: The gathered data was input into Microsoft Excel and analyzed with Statistical Package for the Social Sciences (SPSS) version 27.0. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were employed to summarize the data. Continuous variables were compared via a paired t-test, whilst categorical variables were assessed by the chi-square test or Fisher's exact test as deemed suitable. Correlation analysis was conducted to evaluate the connection between variables. A p-value below 0.05 was deemed statistically significant.

Result

Table 1 delineates the rationale for exclusion among individuals evaluated prior to final enrolment. The predominant exclusion criterion was microcytosis/macrocytosis, identified in 52 patients (50.5%), succeeded by anaemia in 28 patients (27.2%) and iron deficiency in 22 patients (21.4%). Additional exclusion criteria were asthma in 17 patients (16.5%), hypothyroidism in 11 patients (10.7%), and various additional reasons in 8 patients (7.7%). These patients were removed prior to the selection of the final research sample of 80 eligible individuals.

Table 1: Reasons for Exclusion Before Surgery

Criterion for exclusion	n (%)
Microcytosis / Macrocytosis	52 (50.5%)
Anemia	28 (27.2%)
Iron deficiency	22 (21.4%)
Hypothyroidism	11 (10.7%)
Asthma	17 (16.5%)
Other	8 (7.7%)

Table 2 illustrates the fluctuations in serum C-reactive protein levels and weight parameters from the preoperative period to five months following surgery. The mean body weight exhibited a significant decrease, dropping from 130.5 ± 28.2 kg preoperatively to 98.3 ± 20.4 kg at 5 months postoperatively ($P < 0.0001$). In the same vein, the mean BMI experienced a substantial decrease, dropping from 46.8 ± 8.9 kg/m² to 35.2 ± 6.8 kg/m² ($P < 0.0001$). The percentage excess weight decreased from 90.5 ± 34.2% to 52.8 ± 27.5% ($P < 0.001$), while excess weight decreased from 61.2 ± 24.7 kg to 36.5 ± 19.6 kg ($P < 0.001$). The obesity-associated inflammatory state improved after surgery, as evidenced by the significant decrease in serum CRP levels from 12.8 ± 8.5 mg/L preoperatively to 6.2 ± 5.1 mg/L at 5 months ($P < 0.001$).

Table 2: Weight Parameters

Parameter	Mean Preoperative	Mean at 5 Months	P value
Weight (kg)	130.5 ± 28.2	98.3 ± 20.4	<0.0001
BMI (kg/m²)	46.8 ± 8.9	35.2 ± 6.8	<0.0001
Excess weight (kg)	61.2 ± 24.7	36.5 ± 19.6	<0.001
% Excess weight	90.5 ± 34.2	52.8 ± 27.5	<0.001
Serum CRP (mg/L)	12.8 ± 8.5	6.2 ± 5.1	<0.001

Table 3 delineates the preoperative and 5-month postoperative laboratory values. Haemoglobin exhibited a minor, statistically insignificant reduction from 139.2 ± 12.1 g/L to 137.8 ± 13.5 g/L

(P = 0.42). The red cell indices exhibited relative stability, with MCV shifting from 84.6 ± 6.9 fL to 83.9 ± 4.1 fL (P = 0.31) and MCH altering from 28.3 ± 1.5 pg to 28.6 ± 1.6 pg (P = 0.28). Serum iron rose considerably from 13.5 ± 5.6 µmol/L to 14.8 ± 5.2 µmol/L (P = 0.04), and transferrin saturation increased from 0.26 ± 0.12 to 0.31 ± 0.13 (P = 0.02). Ferritin exhibited a minor non-significant decrease from 115.2 ± 92.4 µg/L to 112.6 ± 88.7 µg/L (P = 0.48), although soluble transferrin receptor remained relatively stable (1.24 ± 0.27 mg/L vs. 1.26 ± 0.29 mg/L; P = 0.09). Vitamin B12 substantially dropped from 250 ± 120 pmol/L to 220 ± 95 pmol/L (P = 0.03), and RBC folate diminished from 1420 ± 430 nmol/L to 1285 ± 460 nmol/L (P < 0.01).

Table 3: Laboratory Parameters

Parameter	Preoperative (Mean ± SD)	5 Months (Mean ± SD)	P value
Hemoglobin (g/L)	139.2 ± 12.1	137.8 ± 13.5	0.42
MCV (fL)	84.6 ± 6.9	83.9 ± 4.1	0.31
MCH (pg)	28.3 ± 1.5	28.6 ± 1.6	0.28
Iron (µmol/L)	13.5 ± 5.6	14.8 ± 5.2	0.04
Ferritin (µg/L)	115.2 ± 92.4	112.6 ± 88.7	0.48
Transferrin Saturation	0.26 ± 0.12	0.31 ± 0.13	0.02
Vitamin B12 (pmol/L)	250 ± 120	220 ± 95	0.03
RBC Folate (nmol/L)	1420 ± 430	1285 ± 460	<0.01
Soluble Transferrin Receptor (mg/L)	1.24 ± 0.27	1.26 ± 0.29	0.09

Table 4 delineates the prevalence of micronutrient and hematopoietic anomalies before to surgery and at five months postoperatively. No patients had iron insufficiency preoperatively; nevertheless, 4 patients (5%) developed iron shortage after 5 months. One patient (1.25%) exhibited concomitant anaemia. The incidence of Vitamin B12 deficiency rose from 6 patients (7.5%) preoperatively to 14 patients (17.5%) at 5 months, with 2 patients (2.5%) exhibiting concurrent anaemia. Folate deficiency was absent before to surgery but was detected in 5 individuals (6.25%) at the 5-month mark. Anaemia was reported in 5 patients (6.25%) at 5 months, whereas microcytosis and macrocytosis were noted in 3 patients (3.75%) and 4 patients (5%), respectively. The data indicate that whereas iron shortage was relatively rare in the early postoperative period, deficits in vitamin B12 and folate began to manifest within 5 months post-surgery, underscoring the necessity for early postoperative micronutrient surveillance.

Table 4: Micronutrient & Hematological Abnormalities

Condition	Preoperative n (%)	5 Months n (%)
Iron deficiency	0	4 (5%)
With anemia	0	1 (1.25%)
Vitamin B12 deficiency	6 (7.5%)	14 (17.5%)
With anemia	0	2 (2.5%)
Folate deficiency	0	5 (6.25%)
With anemia	0	0
Anemia	0	5 (6.25%)
Microcytosis	0	3 (3.75%)
Macrocytosis	0	4 (5%)

Discussion

This study evaluated the incidence of iron insufficiency and associated micronutrient alterations after laparoscopic sleeve gastrectomy (LSG) throughout a 5-month follow-up period. LSG has been recognised as an efficacious bariatric intervention for morbid obesity, originally utilised in staged surgeries for high-risk super-obese patients and subsequently as a standalone final technique [1–3]. Unlike malabsorptive bariatric operations, LSG maintains intestinal continuity and does not circumvent the duodenum, the primary location for iron absorption. Nonetheless, resection of the gastric fundus and subsequent reduction in stomach capacity may diminish gastric acid output, which is crucial for the conversion of dietary ferric iron to the more absorbable ferrous form [4]. Consequently, although LSG is predominantly limiting, its impact on iron metabolism and micronutrient status is clinically significant."

Over the last five months, weight-related measures in the current research showed a notable improvement. BMI dropped from 46.8 ± 8.9 kg/m² to 35.2 ± 6.8 kg/m², and mean body weight dropped from 130.5 ± 28.2 kg to 98.3 ± 20.4 kg. Additionally, there was a considerable decrease in both extra weight and the percentage of excess weight. These

results corroborate bariatric surgery's proven ability to significantly reduce body weight and enhance obesity-related health outcomes [11,12]. Previous studies have also documented similar decreases in BMI and weight indices after LSG, demonstrating its efficacy as a bariatric treatment [2,3,17]. Serum C-reactive protein significantly decreased from 12.8 ± 8.5 mg/L to 6.2 ± 5.1 mg/L, indicating improvement in the chronic inflammatory condition linked to obesity. Low-grade systemic inflammation is linked to obesity, and weight loss has been shown to reduce inflammatory markers [15,16].

In this research, postoperative iron insufficiency was very uncommon. Four patients (5%) had iron deficit at five months, however only one patient (1.25%) had iron-deficiency anaemia. From 139.2 ± 12.1 g/L before to surgery to 137.8 ± 13.5 g/L at five months, haemoglobin levels only slightly and statistically not significantly decreased. In a similar vein, MCV and MCH did not significantly worsen during the early postoperative phase. In contrast to bypass surgeries, where iron absorption may be more directly compromised, this might be explained by the preservation of the duodenum and proximal small intestine following LSG. In a similar vein, Hakeam et al. found that iron indices were mostly maintained during postoperative follow-up and that the incidence of iron shortage following LSG was minimal [18].

Notably, serum iron and transferrin saturation exhibited a considerable rise after 5 months, but ferritin shown a little, non-significant decline. Serum iron rose from 13.5 ± 5.6 µmol/L to 14.8 ± 5.2 µmol/L, whereas transferrin saturation increased from 0.26 ± 0.12 to 0.31 ± 0.13. This discovery may be associated with the reduction of inflammation following weight loss. Ferritin serves as an acute-phase reactant and can be raised under inflammatory conditions; hence, a decrease in inflammation following bariatric surgery may modify ferritin levels without necessarily signifying a drop in iron reserves. Prior research indicates that inflammation associated with obesity may affect iron metabolism, and that a postoperative decrease in inflammation might enhance iron availability [15,16]. The decrease in CRP seen in the current research corroborates this hypothesis.

Although iron insufficiency was rare, vitamin B12 and folate deficiency were more prevalent. Vitamin B12 insufficiency increased from 6 patients (7.5%) preoperatively to 14 patients (17.5%) at 5 months. Mean vitamin B12 levels declined from 250 ± 120 pmol/L to 220 ± 95 pmol/L. This might be attributed to decreased gastric parietal cell mass and intrinsic factor production after fundus resection. Reduced stomach acidity, surgical food restriction, and proton pump inhibitor usage may all lead to poor vitamin B12 absorption. Hakeam et al. showed a similar postoperative fall in vitamin B12 levels following LSG, demonstrating that restrictive operations can still have an impact on micronutrient status even when the small intestine is preserved [18].

RBC folate levels decreased considerably from 1420 ± 430 nmol/L to 1285 ± 460 nmol/L, with folate insufficiency occurring in 5 patients (6.25%) at 5 months. The decrease in folate absorption, mostly occurring in the proximal small intestine—which remains intact in LSG—may be attributed to diminished dietary intake, modified food tolerance, insufficient supplementation, or inadequate adherence to guidelines. Folate deficiency is clinically significant, especially in women of reproductive age, owing to its correlation with anaemia and negative pregnancy outcomes. Consequently, postoperative dietary guidance and regular supplementation are necessary.

The cumulative anaemia rate at five months was 6.25%. Given that iron deficiency anaemia was seen in just 1.25% of patients, the anaemia in the other instances may have been complex, potentially attributable to vitamin B12 deficiency, folate deficiency, dietary inadequacy, or perioperative variables. Iron is crucial for haemoglobin production, muscle metabolism, immunological response, and brain function; persistent insufficiency may diminish physical performance and quality of life [5,10]. Prior research has indicated that iron deficiency in the absence of anaemia may lead to tiredness and cognitive dysfunction, underscoring the necessity for early identification [6,7].

This study has specific limitations. The follow-up period was restricted to 5 months, which may be inadequate for detecting delayed iron insufficiency or prolonged micronutrient depletion. The research was performed at a singular facility with a somewhat limited sample size. Furthermore, dietary compliance, supplement adherence, menstruation history, proton pump inhibitor usage, and socioeconomic determinants were not thoroughly examined, despite their potential impact on postoperative micronutrient outcomes.

LSG was linked to substantial initial weight reduction and enhancement in inflammatory conditions. A minor percentage of patients experienced iron insufficiency, but iron indices were predominantly stable during the 5-month follow-up period. Nevertheless, vitamin B12 and folate levels decreased markedly, underscoring the necessity for early and consistent postoperative nutritional surveillance. Regular assessment of complete blood count, serum iron, ferritin, transferrin saturation, vitamin B12, and folate must be incorporated into follow-up protocols post-LSG to avert clinically severe nutritional deficiencies.

Conclusion

This study illustrates that laparoscopic sleeve gastrectomy (LSG) is an efficacious bariatric intervention for attaining substantial early weight reduction and enhancement in obesity-related inflammatory conditions during a 5-month follow-up duration. The significant decrease in body weight, BMI, excess weight, and serum CRP levels indicates that LSG offers substantial short-term metabolic and therapeutic advantages. Iron deficit was seen in a minor percentage of patients, but haemoglobin, ferritin, MCV, MCH, and soluble transferrin receptor levels exhibited relative stability, suggesting that LSG may have a constrained negative impact on iron status during the early postoperative phase. Nonetheless, the reduction in vitamin B12 and RBC folate levels underscores that nutritional shortages may persist despite a mostly restrictive treatment that maintains intestinal integrity. Consequently, regular postoperative assessment of complete blood count, iron profile, vitamin B12, and folate levels, in conjunction with dietary counselling and prompt supplementation, is crucial to avert anaemia, lethargy, hindered recovery, and enduring nutritional issues post-LSG.

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