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ORIGINAL ARTICLE

A Short Term Study on the Effect of Laparoscopic Sleeve Gastrectomy Operation on Iron Absorption Process in Obese Patient

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Abstract

Background: ***The restrictive bariatric procedure known as laparoscopic sleeve gastrectomy (LSG) was a well-developed technique. Theoretically, LSG reduces micronutrient deficits and related problems often seen after malabsorptive treatments.***

Objective: ***Evaluation of iron markers and the occurrence of iron shortage within one year in patients following laparoscopic sleeve gastrectomy (LSG).***

Methods: ***Forty (40) obese individuals were enrolled in the study, with each patient consenting. Every patient underwent an iron profile assessment encompassing serum iron, ferritin, total iron binding capacity (TIBC), and transferrin saturation tests. The impact of laparoscopic sleeve gastrectomy on iron deficiency was assessed one year after the surgery.***

Results: ***Hemoglobin level, serum iron, and hematocrit values were statistically significantly decreased after laparoscopic sleeve gastrectomy 10.96 ± 0.62 vs. 12.05 ± 0.62 g/dl, 34.48 ± 9.64 vs. 45.13 ± 5.96 mg/dL and 35.11 ± 2.55 vs. 37.80 ± 3.25 % respectively.***

Conclusion: ***The successful surgery for treating morbid obesity and the inflammatory condition's causes is laparoscopic sleeve gastrectomy. However, iron deficiency has significantly developed a year after surgery.***

Keywords: Laparoscopic Sleeve Gastrectomy; Iron Indices; Obesity; Prospective Study

1. Introduction

Laparoscopic sleeve gastrectomy (LSG), a bariatric treatment, is a well-developed procedure. It was originally introduced as the constrictive component of biliopancreatic diversion with duodenal switch (BPD-DS) or as the initial step in a gradual weight reduction approach.[1]

In the latter scenario, individuals who are severely obese and have increased surgical risks undergo a procedure called laparoscopic sleeve gastrectomy (LSG) in order to initiate significant weight loss. This weight loss is necessary to facilitate a subsequent stage of either gastric bypass or biliopancreatic diversion with duodenal switch (BPD-DS).[2]

Following reports of a considerable decrease in body mass index (BMI) and comorbidities, it has lately been employed as a conclusive bariatric surgery.[3]

LSG is considered a restrictive bariatric procedure that involves the removal of the fundus and increased curvature of the stomach, resulting in a tiny gastric tube or "sleeve".[4]

This method does not bypass or eliminate the small intestine, which reduces the likelihood of micronutrient shortages that are often seen following malabsorptive surgeries.[5]

One year following restrictive bariatric surgery, the iron status has only been assessed in a few studies. A recent study showed that ferritin levels in the blood were stable for at least one year following surgery in severely obese individuals who underwent vertical banded gastroplasty.[6]

Iron control is mostly achieved by duodenal absorption, preserved in LSG. However, a smaller stomach reduces the amount of parietal cells, which reduces hydrochloric acid (HCl) generation.[7]

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Through two methods, gastric acids play a key role in iron absorption. First, by denaturing proteins, HCl aids in releasing iron bound to proteins. Furthermore, hydrochloric acid (HCl) transforms ferric ions, dietary sources of iron, into ferrous ions, a form that the body may readily absorb.[8]

The hemoglobin (Hgb), myoglobin, and several iron-containing enzymes, such as cytochromes, all possess substantial quantities of iron. Iron deficiency without anemia has been shown to impact the cognitive performance of adolescent girls and cause fatigue in adult women.[9]

Additionally, a severe iron deficit might make it harder for tissues to repair and produce collagen, complicating aesthetic operations, which are typical following a big weight reduction.[10]

Anemia, which is accompanied by several dangerous symptoms, including tiredness, headaches, weakness, tachycardia, and shortness of breath, may develop from untreated, protracted iron deficiency. As a result, the detrimental effects of anemia on patients' quality of life may compromise the positive effects of bariatric surgery.[11]

The objective of this study is to evaluate iron indices and determine the occurrence of iron deficiencies in patients undergoing laparoscopic sleeve gastrectomy (LSG) over one year.

2. Patients and methods

This prospective observational clinical trial was conducted on forty (40) obese individuals at the General Surgery Department, Faculty of Medicine, Al-Azhar University, and Nasser Institute Hospitals from December 2022 until May 2023. The Institutional Ethics Committee approved the study.

2.1.Inclusion criteria: Obese patients attended outpatient clinics and underwent sleeve gastrectomy.

2.2.Exclusion criteria: All patients with comorbidities and unfit for surgery.

2.3.Sampling Method: Convenience targeted sampling.

2.4.Ethical considerations

Patient information and informed consent: Prior to enrollment in the research study, the patient provided informed consent to participate after receiving a clear explanation of the nature, extent, and potential ramifications of the clinical trial in a comprehensible format.

Confidentiality: The case report only included the patient's initials, and the investigators securely stored any other documents, including the patient's name. The scientists kept their patient identification list, including each patient's initials and matching names, to facilitate the identification of records.

2.5.Protocol approval

Before commencing the study, the protocol and associated materials underwent ethical and research approval by the Council of the OB/GYN Department at Al-Azhar University in compliance with local regulations.

2.6.Concerning safety and efficacy

The possible side effects of sleeve gastrectomy include gallstones (which are more likely to occur with rapid or significant weight reduction), surgical hernia, excessive internal bleeding, leaking, perforation of the intestines or stomach, skin separation, and stricture.

2.7.Study procedures

All patients will be subjected to Complete history taking: name, age, sex, residence, date of admission, telephone No., other habits of medical interest, etc. Clinical examination: general (BMI, vital data, blood pressure, pulse, and temperature) and abdominal examination (scars of previous surgeries). Laboratory investigations: Complete blood count (CBC), serum creatinine, international normalized ratio (INR), and iron profile (iron profile tests include serum iron, ferritin, total iron binding capacity (TIBC), and transferrin saturation tests). And pelvi-abdominal ultrasound investigations.

2.8.Surgical procedure

The optimal posture of the patient and strategic placement of ports:

Following the insertion of the ports, the patient was placed in a supine posture and subsequently positioned in the Trendelenberg position. The positioning of a 12mm or 15mm port depends on the patient's size and the pannus. It can be placed at the umbilicus, superiorly, or to the right. A 3mm or 5mm Nathanson liver retractor was used to retract the left lateral part of the liver. The assistance ports consisted of a 5mm port on the left anterior axillary line for the assistant's right hand and a 5mm port on the right upper paramedian for the surgeon's left hand. A 5mm left upper paramedian port was installed for the procedure.

2.9.Gastric mobilization:

Mobilization of the fundus: Using the energy source, create a window into the omental bursa around 4 to 6 cm from the pylorus. Seal and split the short gastric arteries directly on the stomach's serosa by moving superiorly. Once exposure gets challenging, turn around and go the other way.

Mobilization of the antrum: Be mindful that the gastro-duodenal and right gastric arteries will merge to form the gastroepiploic artery when the pylorus is approached. Usually, halting the dissection 2 cm before the pylorus ensured the continuous blood flow to the distal antrum and pylorus while preventing any harm to one of these veins.

Mobilization of the cardia: After repositioning the antrum, retracting the stomach towards the patient's right side became easier, resulting in an improved view of the heart, spleen, and left crus from below. The final posterior short gastric was divided along the left crus. The larger front fat pad obstructs the visibility of the medial cardia and distal esophagus. Reposition this to ensure sufficient visibility of this area for optimal placement of sutures and staples.

2.10.Gastrectomy:

Antrum: Near the pylorus, a 32 French orogastric bougie was inserted. The smallest bougie size that prevents stenosis while reducing the likelihood of antral and pouch dilatation was the 32 French bougie 2 to 3 cm in front of the pylorus, which was stapled with a 60mm cartridge in either black or green. Any type of staple cartridge had the potential to create seromuscular fractures in this region, necessitating the application of sutures for strengthening.

2.11.Angularis/fundus: Due to the second cartridge's closeness to the angularis, stenosis was carefully avoided. By examining the positions of the anvil and cartridge from both the front and the side, we ensured the optimal placement of the cartridge. In this area, black, green, or purple cartridges were common. Smallerpler cartridges were something other than what was not recommended. Later rupture of the staple line may cancel out any further hemostasis that may be produced. Hemostasis was achieved utilizing buttress material; however, when employing thicker materials, be careful not to undersize the cartridge.

2.12.Cardia: The most arduous aspect of precise calibration involved accurately putting the final pair of cartridges at the uppermost region of the stomach. Before securing, it was essential to meticulously examine and withdraw the back part of the stomach wall using the cartridge by twisting the stomach and stapler towards the front. In order to reinforce the suture of the cardia, the last cartridge was placed at a distance of 1 to 2 cm from the gastroesophageal (GE) junction. Employ one or two Lembert sutures to suture the tip of the staple line in an inverted manner.

2.13.Omentopexy:

Identify the upper divided edge of the omentum and fasten it to the points where the staple lines meet using absorbable interrupted sutures. 2 to 3 sutures were utilized at and below the angular. In comparison, 3 to 4 sutures were used above the angular. In addition to strengthening the staple line, this omentopexy also causes moderate traction, possibly lowering the risk of postoperative stomach volvulus or coiling.

2.14.Study outcomes

Primary outcome: Serum iron level.

Secondary outcomes: Time of operation, duration of hospital stay, blood loss, postoperative pain, wound infection, return to work/activities, and hematocrit value.

2.15.STATISTICAL ANALYSIS

The recorded data was evaluated using SPSS version 23.0, a statistical program for social sciences developed by SPSS Inc. in Chicago, Illinois, USA, for parametric (normal) distributions of quantitative data, the mean, standard deviation, and ranges were used. However, the measures used for non-normal distributions were the median and the interquartile range (IQR). Qualitative elements were quantified and represented as percentages and numerical values. The data were analyzed for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

3. Results

Table 1. Demographic data distribution among study group.

DEMOGRAPHIC DATA	TOTAL (N=40)
SEX	
FEMALE	20 (50.0%)
MALE	20 (50.0%)
AGE (YEARS)	
RANGE	25-59
MEAN±SD	42.93±8.77
OCCUPATION	
HOUSEWIFE	18 (45.0%)
MANUAL WORKER	12 (30.0%)
OFFICE WORKER	10 (25.0%)
SPECIAL HABITS	
NON	28 (70.0%)
SMOKER	12 (30.0%)

The age of the participants ranged from 25 to 59 years, with a mean of 42.93 years and a standard deviation of 8.77 years. As regards sex distribution, there was female predominance with 20 females with percentage 50% and 20 males with percentage 50%, regarding occupation there was 18 patients (45%) were housewife, 12 patients (30%) were manual worker and 10 patients (25%) were office worker, as for the special habits was 12 patients (30%).

Table 2. Risk factors distribution among study group.

RISK FACTORS	NO.	%
ASSOCIATED MEDICAL DISORDERS		
YES	6	15.0%
NO	34	85.0%
PREVIOUS SURGICAL OPERATIONS		
YES	0	0.0%
NO	40	100.0%
CURRENT USED MEDICATIONS		
YES	11	27.5%
NO	29	72.5%

The 6 patients (15%) were DM and 11 patients (27.5%) were current used medications, while there are no cases of previous surgical operations.

Table 3. Comparison between pre-operative and postoperative according to BMI among study group.

BMI [WT/(HT)^2]	RANGE	MEAN±SD	PAIRED SAMPLE T-TEST		
			MD±SE	t-test	p-value
PREOPERATIVE	30.21-57.1	40.07±7.75	-11.71±0.82	14.331	<0.001**
POST-OPERATIVE	20.9-36.02	28.36±4.37			

p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

This table shows statistically significant lower mean value of BMI [wt/(ht)^2] in postoperative was 28.36±4.37 comparing to preoperative was 40.07±7.75, while there was mean of reduction 11.71±0.82, with p-value (p<0.001).

Table 4. Comparison between pre-operative and postoperative according to Hb% among study group.

HB%	RANGE	MEAN±SD	PAIRED SAMPLE T-TEST		
			MD±SE	t-test	p-value
PREOPERATIVE	10.93-13.52	12.05±0.62	-1.10±0.09	12.826	<0.001**
POST-OPERATIVE	9.69-12.44	10.96±0.62			

This table shows statistically significant lower mean value of Hb% in post-operative was 10.96±0.62 comparing to preoperative was 12.05±0.62, while there was mean of reduction 1.10±0.09, with p-value (p<0.001).

Table 5. Comparison between pre-operative and postoperative after one year according to serum iron (mg/dL) among study group.

SERUM IRON (MG/DL)	RANGE	MEAN±SD	PAIRED SAMPLE T-TEST		
			MD±SE	t-test	p-value
PREOPERATIVE	37-58	45.13±5.96	-10.65±1.06	10.035	<0.001**
POST-OPERATIVE (ONE YEAR)	20-53	34.48±9.64			

p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

This table shows statistically significant lower mean value of serum iron (mg/dL) in postoperative was 34.48±9.64 after one year comparing to preoperative was 45.13±5.96, while there was mean of reduction 10.65±1.06, with p-value (p<0.001).

Table 6. Comparison between pre-operative and postoperative according to hematocrit value% among study group.

HEMATOCRIT VALUE %	RANGE	MEAN±SD	PAIRED SAMPLE T-TEST		
			MD±SE	t-test	p-value
PREOPERATIVE	32-45.2	37.80±3.25	-2.69±0.45	5.949	<0.001**
POST-OPERATIVE	31-41.7	35.11±2.55			

p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

This table shows statistically significant lower mean value of hematocrit value% in postoperative was 35.11±2.55 comparing to preoperative was 37.80±3.25, while there was mean of reduction 2.69±0.45, with p-value (p<0.001).

Table 7. Intraoperative distribution among study group.

INTRAOPERATIVE	TOTAL (N=40)
TIME OF OPERATION (HRS.)	
RANGE	1.5-1.9
MEAN±SD	1.68±0.12
AMOUNT OF BLOOD LOSS	
LARGE	16 (40.0%)
MINIMAL	24 (60.0%)

The time of operation “hrs.” ranged from 1.5-1.9 with mean 1.68±0.12; while 16 patients (40%) were large and 24 patients (60%) were minimal about amount of blood loss.

Table 8. Duration of hospital stay “days” distribution among study group.

DURATION OF HOSPITAL STAY (DAYS)	NO.	%
2 DAYS	17	42.5%
3 DAYS	17	42.5%
4 DAYS	6	15.0%
TOTAL	40	100.0%

The duration of hospital stay “days” ranged from 2-4 with mean 2.73±0.72; while 17 patients (42.5%) were 2 days, 17 patients (42.5%) were 3 days and 6 patients (15%) were 4 days.

4. Discussion

The impact of sleeve gastrectomy surgery on the degree of serum iron deficiency anemia was examined by Amini et al. They concurred with us and said that the patient's iron levels should be monitored frequently due to the reduction in iron levels following sleeve gastrectomy surgery so that adequate supplements and the diet's high iron content could be modified to prevent anemia and its effects.[12]

Karaca et al., in contrast to us, claimed that the SG patients' iron levels and other iron-related hematological indicators had improved after the procedure. Mean hemoglobin, MCHC, and RDCV levels did not vary significantly from baseline or month to month. After the third month, mean MCV levels considerably varied from baseline values. The 6-month follow-up visit revealed substantially greater serum iron levels.[13]

According to Kwon et al., Effectively managing bariatric patients relies on properly addressing intraoperative anemia and nutritional deficiencies. Nevertheless, there is currently insufficient evidence to determine any dietary risk or benefit for people undergoing bariatric surgery. They examined the most recent research on the relationship between postoperative anemia and nutritional deficits. There are two forms of bariatric surgery: sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB). They found that, in agreement with us, SG is superior to RYGB in reducing the risk of postoperative vitamin B12 insufficiency. However, the two techniques are equivalent in reducing the risk of postoperative anemia and iron deficit. In addition to regular multivitamin and mineral supplements, It is recommended to provide preventative iron and B12 supplements after surgery, as both treatments have an equal risk of deficiency, as demonstrated by subgroup analysis. Compared to the SG group, the RYGB group had an odds ratio of 3.55 (95% confidence interval, 1.26-10.01; P<0.001) for postoperative vitamin B12 deficiency. The subgroup analysis revealed that the administration of preventive iron or vitamin B12 did not have a significant impact on the odds ratio for postoperative vitamin B12 insufficiency.[14]

The study elucidated the frequency and factors associated with iron deficiency, iron deficiency anemia (IDA), and intravenous iron administration after bariatric surgery by Gowanlock et al. Their communication stated that IDA is a delayed consequence of bariatric surgery and that it is possible to assess the risk to patients before the procedure. A total of 388 patients met the inclusion criteria. After a median follow-up period of 31 months, it was shown that 43% of patients exhibited iron insufficiency, 16% suffered iron deficiency anemia (IDA), and 6% reported the use of intravenous (IV) iron.[15]

These findings may be compared to those of a large cohort study by Obinwanne et al. A study was conducted on 959 patients who underwent bariatric surgery to investigate iron deficiency. The findings showed that throughout the follow-up period, 41% of the patients who had laparoscopic Roux-en-Y surgeries had a ferritin level below 30 g/L.[16]

Another retrospective longitudinal research by Salgado et al. found that 48% of patients had iron deficiency, defined as having a ferritin level below 30 ng/mL or a transferrin saturation below 20%.[17]

This is in contrast to a meta-analysis by Kwon et al. that revealed no difference between Roux-en-Y gastric bypass and sleeve gastrectomy in terms of iron shortage or anemia, as well as a study21 that found no difference between the surgery types in terms of iron isotope absorption. Fourteen ten According to Broeke et al., patients who had bariatric surgeries such as biliopancreatic diversion and gastric bypass had higher rates of iron deficiency anemia and dietary deficits, and the patient's hematological state following SG was seldom assessed.[18]

Inflammatory processes, iron metabolism, erythropoiesis, and lipid profiles were examined by Santos et al. about weight reduction after gastric band surgery. They supported our findings and demonstrated a substantial reduction in inflammation three months following gastric banding surgery, accompanied by the loss of adipose tissue. This reduction in inflammation is linked to improved iron absorption and more iron being available for erythropoiesis. Additionally, we discovered lower serum triglyceride levels. These alterations point to the advantages of losing weight, such as a lower risk of cardiovascular disease.[19]

According to WHO, Iron deficiency anemia is the most widespread form of anemia worldwide. Hematological variables, including iron, ferritin, total iron-binding capacity, and transferrin saturation, are evaluated in order to diagnose anemia. The WHO states that anemia is diagnosed when the Hb concentration is below 12 g/dL for females over the age of 15 and below 13 g/dL for men.[20]

According to Barry and James, SG did not alter the structure of the gastrointestinal tract and duodenum, where iron is mostly absorbed. However, lower stomach capacity may still impact iron absorption because gastric acid is necessary to convert non-haem iron into an absorbable form.[21]

4. Conclusion

The successful surgery for treating morbid obesity and the inflammatory condition's causes is laparoscopic sleeve gastrectomy. However, iron deficiency has significantly developed a year after surgery.

Disclosure

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Authorship

All authors have a substantial contribution to the article

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References

1. Biertho L, Thériault C, Bouvet L, et al. Second-stage duodenal switch for sleeve gastrectomy failure: A matched controlled trial. Surg Obes Relat Dis. 2018;14(10):1570-1579.
2. Landreneau JP, Strong AT, Rodriguez JH, et al. Conversion of Sleeve Gastrectomy to Roux-en-Y Gastric Bypass. Obes Surg. 2018;28(12):3843-3850.
3. Ball W, Raza SS, Loy J, et al. Effectiveness of Intra-Gastric Balloon as a Bridge to Definitive Surgery in the Super Obese. Obes Surg. 2019;29(6):1932-1936.
4. Chung AY, Thompson R, Overby DW, Duke MC, Farrell TM. Sleeve Gastrectomy: Surgical Tips. J Laparoendosc Adv Surg Tech A. 2018;28(8):930-937.
5. Zarshenas N, Tapsell LC, Neale EP, Batterham M, Talbot ML. The Relationship Between Bariatric Surgery and Diet Quality: a Systematic Review. Obes Surg. 2020;30(5):1768-1792.
6. Chen JC, Shen CY, Lee WJ, Tsai PL, Lee YC. Protein deficiency after gastric bypass: The role of common limb length in revision surgery. Surg Obes Relat Dis. 2019;15(3):441-446.
7. Ramos, AC,\.; Carraso, HV.; Bastos, EL. Bariatric Procedures: Anatomical and Physiological Changes. Management of Nutritional and Metabolic Complications of Bariatric Surgery. 2021:41-67.
8. Chen X, Fu W, Luo Y, Cui C, Suppavorasatit I, Liang L. Protein deamidation to produce processable ingredients and engineered colloids for emerging food applications. Compr Rev Food Sci Food Saf. 2021;20(4):3788-3817.
9. Xing Y, Gao S, Zhang X, Zang J. Dietary Heme-Containing Proteins: Structures, Applications, and Challenges. Foods. 2022;11(22):3594.
10. Vitagliano T, Garieri P, Lascala L, et al. Preparing Patients for Cosmetic Surgery and Aesthetic Procedures: Ensuring an Optimal Nutritional Status for Successful Results. Nutrients. 2023;15(2):352.
11. Rose, E. (Ed.). Pediatric Hematologic Emergencies. Pediatric Emergencies: A Practical, Clinical Guide. 2020 Aug 18:311.
12. Amini, M.; Zare, A.; Sobhani, Z., et al. The effect of laparoscopic sleeve gastrectomy on serum iron level. International Journal of Nutrition Sciences. 2018 Dec 1;3(4):212-215.
13. Karaca, FC. The short-term effects of laparoscopic sleeve gastrectomy on hematological parameters. Laparoscopic Endoscopic Surgical Science (LESS). 2020;27(1):21-24.
14. Kwon Y, Kim HJ, Lo Menzo E, Park S, Szomstein S, Rosenthal RJ. Anemia, iron and vitamin B12 deficiencies after sleeve gastrectomy compared to Roux-en-Y gastric bypass: a meta-analysis. Surg Obes Relat Dis. 2014;10(4):589-597.
15. Gowanlock Z, Lezhanska A, Conroy M, et al. Iron deficiency following bariatric surgery: a retrospective cohort study. Blood Adv. 2020;4(15):3639-3647.
16. Obinwanne KM, Fredrickson KA, Mathiason MA, Kallies KJ, Farnen JP, Kothari SN. Incidence, treatment, and outcomes of iron deficiency after laparoscopic Roux-en-Y gastric bypass: a 10-year analysis. J Am Coll Surg. 2014;218(2):246-252.
17. Salgado W Jr, Modotti C, Nonino CB, Ceneviva R. Anemia and iron deficiency before and after bariatric surgery. Surg Obes Relat Dis. 2014;10(1):49-54.
18. ten Broeke R, Bravenboer B, Smulders FJ. Iron deficiency before and after bariatric surgery: the need for iron supplementation. Neth J Med. 2013;71(8):412-417.
19. Santos J, Salgado P, Santos C, et al. Effect of bariatric surgery on weight loss, inflammation, iron metabolism, and lipid profile. Scand J Surg. 2014;103(1):21-25.
20. World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. World Health Organization; 2011.
21. Skikne BS, Lynch SR, Cook JD. Role of gastric acid in food iron absorption. Gastroenterology. 1981;81(6):1068-1071.