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Original Research

Nutritional and hematological changes after sleeve gastrectomy

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Abstract

Background and aims: In this century, obesity is one of the most important health problems responsible for mortalities and morbidities worldwide. Bariatric surgery is an effective treatment modality used in the treatment of obesity. We aimed to elucidate the effect of bariatric surgery on hematological and nutritional parameters at post-operative 3rd, 6th, and 12th months after sleeve gastrectomy (SG). **Subjects and methods:** Totally 298 patients, who underwent SG in general surgery clinic between 2015 and 2017, were included in the study. We evaluated the levels of complete blood cell parameters [hemoglobin (Hb), hematocrit (Htc), white blood cell (WBC), lymphocyte (LYM), neutrophil (NTRL), mean corpuscular volume (MCV), platelet (PLT) counts], serum iron (SI), serum iron-binding capacity (SIBC), serum ferritin (FER), serum folate (FOL) and serum vitamin B12 (Vit B12)] at the pre-operative visit, and post-operative 3rd, 6th and 12th-month visits. **Results:** Hb, Htc, WBC and PLT levels decreased significantly at 12th-month after SG ($p<0.001$ for both comparisons). LYM and NTRL levels were found to be decreased in the post-operative period ($p=0.006$ and $p<0.001$, respectively). MCV levels were higher than pre-operative values ($p<0.001$). Vitamin B12 levels did not change after SG. Folate values were lower in post-operative visits than pre-operative visits ($p<0.001$). Serum iron and ferritin levels were increased after SG, whereas, serum iron-binding capacity levels were observed to be decreased ($p<0.001$). **Conclusions:** Long-term results of sleeve gastrectomy have not been elucidated adequately. Although this procedure has better outcomes on diabetes, hypertension, hyperlipidemia it can cause deleterious multisystemic consequences. Close follow-up of the patients in the post-operative period will prevent, unfavorable outcomes.

Keywords: hematological parameters, nutrients, bariatric surgery.

Background and aims

Obesity is a chronic disease characterized by increased body fat composition. In this century, it is one of the most important health problems responsible for mortalities and morbidities worldwide. The National Institute for Health and Care Excellence (NICE) classification for overweight and obesity according to body mass index (BMI) cut-off points are as follows:overweight: (25–29.9), obesity I: 30–34.9, obesity II: 35–39.9 and obesity III: 40 or more [1].

The present obesity treatment includes lifestyle modification, physical exercise, diet and nutritional regulation, antiobesity drugs and bariatric surgery [2]. Bariatric surgery is an effective method for weight loss. Because of the lifelong effects and possible complications of bariatric surgery, patients need to adhere to a careful follow-up program. Bariatric surgery is indicated for adult patients with BMI ≥40 kg/m^2 or BMI 35–40 kg/m^2 with co-morbidities. Currently used surgical techniques for weight loss are adjustable gastric banding, sleeve gastrectomy, Roux-en-Y gastric bypass, biliopancreatic diversion, and biliopancreatic diversion/duodenal switch [3]. SG is a restrictive procedure that limits food ingestion. It has beneficial and deleterious effects as seen in other surgical methods. One of these effects is the changes in serum blood parameters and vitamins [4, 5].

Our purpose in this study is to investigate the possible changes in hematological and nutritional parameters at post-operative 3rd, 6th, and 12th months after SG.

Methods

We retrospectively investigated 298 patients who underwent SG in general surgery clinic, between 2015 and 2017. During this 2-year period, the number of patients who underwent SG operation in our hospital was over 600. Despite this, we were able to include only 298 patients due to insufficient data and problems in patient follow-up.

The patients are younger than 18-years-old, patients who had missed visits and patients with inflammatory or infectious diseases were excluded from the study. Laboratory measurements such as complete blood cell parameters [Hb, Htc, WBC count, LYM count, NTRL count, MCV, PLT count], SI, SIBC, Fer, Fol, and Vit B12 levels were recorded at the pre-operative visit, and post-operative 3rd, 6th, and 12th-month visits. The pre-operative visit is shown as (0), and post-operative 3rd, 6th, and 12th-month visits are shown as (1–3), respectively.

A nutrition team consisting of a surgeon, an internal medicine specialist and a dietician who was experienced in bariatric surgery, educated patients on nutritional needs and possible complications before surgery. In the post-operative period, the patients applied to a dietician at each visit. For possible electrolyte and mineral deficiencies, a strict diet that contained these nutrients was recommended. Electrolyte and mineral levels were controlled on every visit. Medication was prescribed only to patients with vitamin B12, iron, and folate deficiency. We aimed to keep vitamin B12, iron, and folate levels in normal ranges and we made dose adjustments in line with the needs. Tablets containing 100 mg Fe^{+2} were given daily to patients with iron deficiency. The duration of treatment was decided by calculating the iron deficit. Daily 0.5 mg folic acid therapy was given to patients with folate deficiency. The duration of treatment was generally determined as three months. In patients with vitamin B12 deficiency, 1000 µg of vitamin B12 (Cyanocobalamin) was given in daily, weekly or monthly doses, depending on the level of deficiency.

Nutritional support was given to a total of 122 (40.9%) patients. Iron replacement treatment was given to 24 patients (8.0%), folate treatment to 41 patients (13.8%) and Vit B12 to 88 patients (29.5%), respectively. Statistical analyzes for nutritional parameters were performed only for patients who did not receive nutritional support.

The distribution of the continuous variables was determined by the Kolmogorov–Smirnov test. Continuous variables with normal distribution were expressed as mean±SD. Variables with skew distribution were expressed as median [Inter Quartile Ranges (IQR) % 25–75], and categorical variables were expressed as a percentage. The paired sample t-test was used for normally distributed variables and the b Wilcoxon rank-sum test was used for skew-distributed variables. Pearson and Spearman's analysis was used to identify correlations between study parameters. Freidman test (for non-normal data) was used for comparison of 4 dependent measurements and Dunn multiple comparison test was performed for subgroup analyses. For all statistics, a two-sided p-value <0.05 was considered to be statistically significant. All analyses were performed with SPSS 24.0 for Windows.

The study was approved by the University of Health Sciences, Kecioren Teaching and Research Hospital Ethics Committee (Number: 032019/1871, date: 13.03.2019).

Results

Our study included 298 adult patients (age: mean 38.6, minimum 18, maximum 69-years-old), 247 of whom were female (82.9%) and 51 were male (17.1%). Pre-operative BMI measurements [median 45.4 kg/m^2 (minimum 36.8, maximum 66.6 kg/m^2)] decreased significantly at 12th month after SG [26.8 kg/m^2 (minimum 18, maximum 47.2 kg/m^2)], ($p<0.0001$ for whole comparison). Changes in laboratory measurements of complete blood cell parameters [Hb, Htc, WBC count, LYM count, NTRL count, MCV, PLT count], SI, SIBC, Fer, Fol and Vit B12 levels at the pre-operative

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Table 1: Median and IQR 25–75% values at pre-operative visit and post-operative 3rd, 6th and 12th month visits.

	0	1	2	3	p-Value
Variables	**Median (25%-75%)**	**Median (25%-75%)**	**Median (25%-75%)**	**Median (25%-75%)**	
Hb (g/dl)	13.65 (12.8–14.8)	13.8 (12.8–14.9)	13.7 (12.9–14.6)	13.4 (12.4–14.4)	**<0.001**
Htc (%)	41.1 (38.7–44.3)	41.5 (38.1–44.5)	41.3 (38.5–44)	39.85 (37.25–43.05)	**<0.001**
WBC (×10^3/µl)	8.57 (7.25–10.2)	7.3 (6.1–8.94)	7.23 (5.95–8.61)	7.1 (6–8.38)	**<0.001**
LYM (×10^3/µl)	2.5 (2.09–3.1)	2.38 (1.91–3.04)	2.43 (2.01–2.93)	2.4 (2.04–2.98)	**0.006**
NTRL (×10^3/µl)	5.1 (4.16–6.3)	3.95 (3.26–5.27)	4.03 (3.2–5.02)	3.9 (3.11–4.87)	**<0.001**
MCV (fl)	86.1 (82.5–88.9)	86.3 (83.2–89)	87.45 (83.9–90.3)	87.4 (84.1–90.85)	**<0.001**
PLT (×10^3/µl)	281 (243–335)	264 (217–308)	264 (226–316)	267 (224 -314)	**<0.001**
SI (µg/dl)	69.08±34.73*	67.23±24.00*	75.68±32.98*	81.95±37.18*	**<0.001**
SIBC (µg/dl)	293.99±75.71*	258.91±63.04*	248.88±76.05*	259.62±85.29*	**<0.001**
FER (ng/ml)	37.75 (17.55–70.48)	44.50 (21.05–95.75)	41.70 (17.25–85.60)	29.56 (11.20–71.48)	**<0.001**
FOL (ng/ml)	6.00 (4.70–7.80)	6.00 (4.20–8.25)	5.20 (3.93–7.75)	5.50 (3.80–7.33)	**<0.001**
VIT B12 (ng/MI)	269.0 (217.0–341.0)	295.0 (230.0–366.0)	280.0 (225.0–354.0)	277.0 (219.3–375.3)	**0.226**

SI: serum iron, SIBC: serum iron binding capacity, FER: ferritin, VIT B12: vitamin B12, WBC: white blood cell, FOL: folate, LYM: lymphocyte, NTRL: neutrophil, Hb: hemoglobin, Htc: hematocrite, MCV: mean corpuscular volume, PLT: platelet, *SD: standart deviation.

visit, and post-operative 3rd, 6th, and 12th-month visits shown in Table 1.

Hematological parameters

Hb and Htc levels decreased significantly in the 12th month after SG (p<0.001 for both comparisons) (Figure 1). WBC levels decreased significantly at 3rd, 6th and 12th-month visits (p<0.001) (Figure 2). LYM and NTRL levels were found to be decreased in the post-operative period (p=0.006, and p<0.001, respectively), and MCV levels were found to be higher than pre-operative values (p<0.001). PLT levels were decreased in post-operative visits (p<0.001). Differences between pre- and post-operative values at each of the time periods were as follows:

Hemoglobin

Post-operative hemoglobin levels in the third visit were significantly lower than pre- and post-operative other visits. There was no statistically significant difference between pre- and post-operative 1st and 2nd visits (Table 2a).

Hematocrite

Post-operative hematocrit levels in the third visit were significantly lower than pre- and post-operative other visits correlated with hemoglobin level. There was no statistically significant difference between pre- and post-operative1st and 2nd visits (Table 2b).

White blood cell

Pre-operative WBC levels were significantly higher than post-operative levels and the decrease in WBC levels continued at each post-operative visit. But post-operative levels were not significant in each other (p WBC0–WBC1<0.001, p WBC0–WBC3<0.001, p WBC0–WBC2:0.001), pWBC1–WBC2=0.583, p WBC1–WBC3=0.059, p WBC2–WBC3=0.180).

Lymphocyte

Pre-operative lymphocyte levels were significantly higher than post-operative levels. But post-operative levels were not significant in each other (Table 2c).

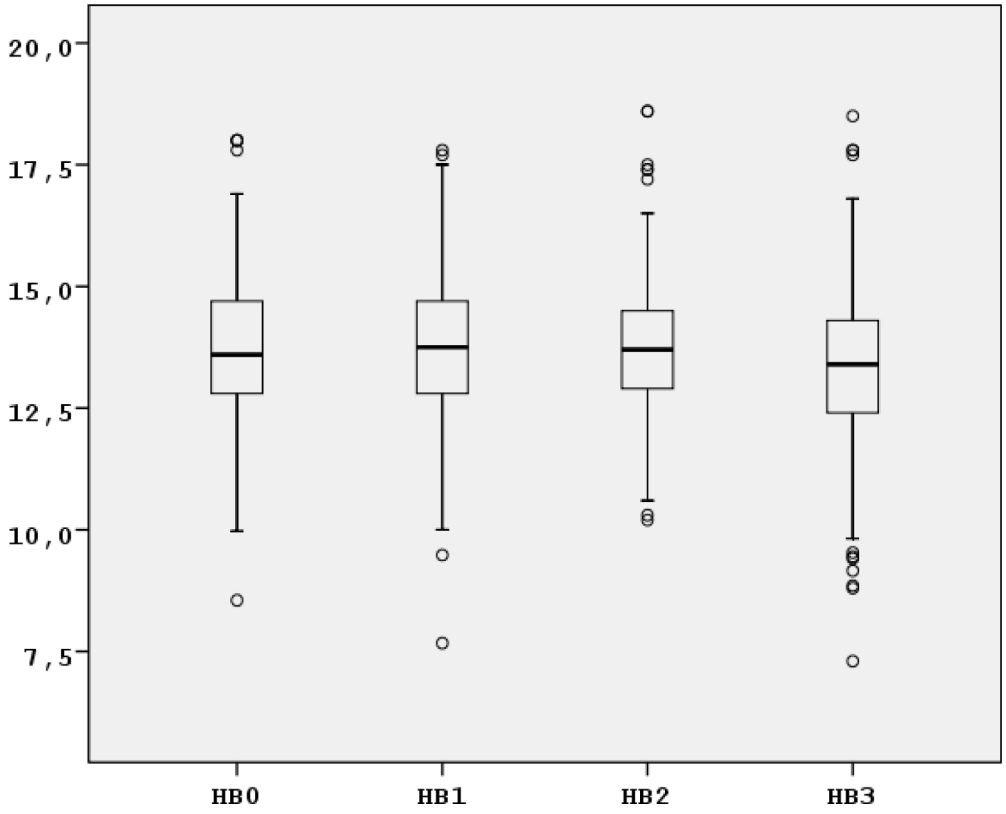

Figure 1: Hemoglobin levels in pre- and post-operative periods.

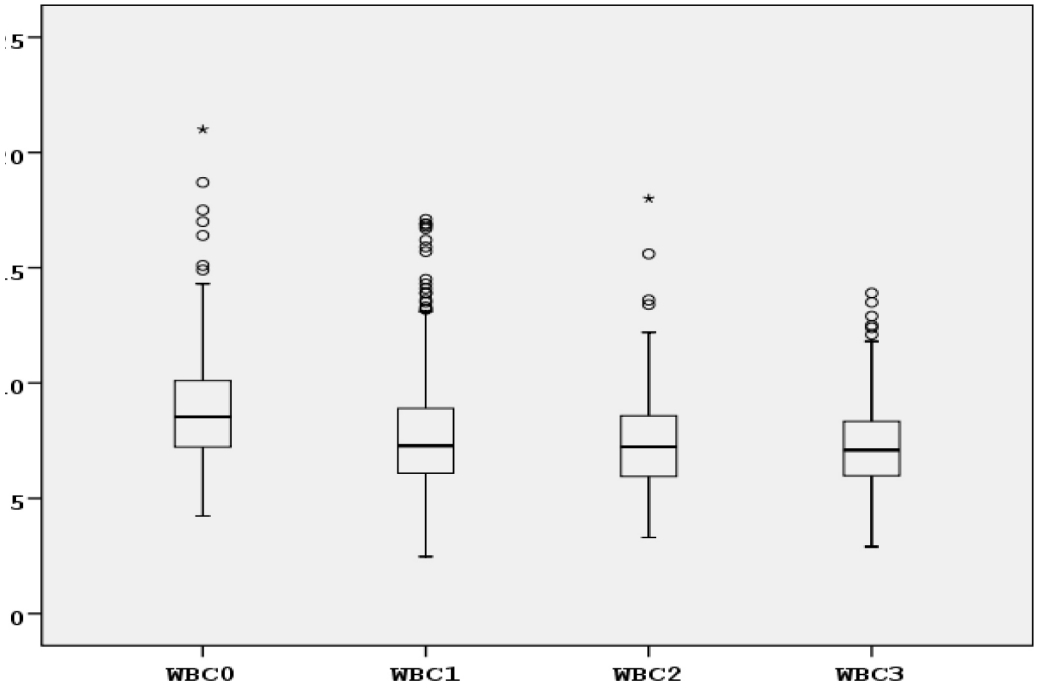

Figure 2: White blood cell levels in pre- and post-operative periods.

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Table 2a: Dunn's multiple comparison test results for Hb.

Visit time	p-Value
Hb 3 – Hb 0	**<0.001**
Hb 3 – Hb 2	**<0.001**
Hb 3 – Hb 1	**<0.001**
Hb 0 – Hb 2	0.884
Hb 0 – Hb 1	0.315
Hb 2 – Hb 1	0.391

Table 2b: Dunn's multiple comparison test results for Htc.

Visit time	p-Value
Htc 3 – Htc 2	**<0.001**
Htc 3 – Htc 1	**<0.001**
Htc 3 – Htc 0	**<0.001**
Htc 2 – Htc 1	0.459
Htc 2 – Htc 0	0.161
Htc 1 – Htc 0	0.509

Table 2c: Dunn's multiple comparison test results for LYM.

Visit time	p-Value
LYM 3 – LYM 1	0.847
LYM 3 – LYM 2	0.519
LYM 3 – LYM 0	**<0.001**
LYM 1 – LYM 2	0.652
LYM 1 – LYM 0	**<0.001**
LYM 2 – LYM 0	**<0.001**

Neutrophil

Pre-operative neutrofil levels were significantly higher than post-operative levels [p(ntrl0–ntrl1)<0.001, p(ntrl0–ntrl2)<0.001, p(ntrl0–ntrl3)<0.001). But post-operative levels were not significant in each other [p(ntrl1–ntrl2)=0.796, p(ntrl1–ntrl3)=0.106, p(ntrl2–ntrl3)=0.174).

Mean corpuscular volume

The increase in MCV levels continued at each postoperatively visit and this increase is statistically significant. But there was no statistically significant difference between pre-operative levels – post-operative first visit and post-operative 2nd–3rd visits (Table 2d).

Platelet: Pre-operative PLT levels were significantly higher than post-operative levels. But post-operative levels were not significant in each other (Table 2e).

Nutritional parameters

Serum iron: There was statistically difference in iron levels between pre-operative and all post-operative visits (p<0.05). Serum iron levels were decreased in first post-operative visits and than increased significantly in second and third post-operative visits, compared to pre- and post-operative first visit p(iron 3-iron 2)=0.064), p(iron 3-iron1)<0.001), p (iron 3-iron0)<0.001, p(iron 2-iron1<0.001), (p(iron 2-iron 0)<0.001), (p(iron 1-iron 0)<0.001).

Serum iron- binding capacity

Serum iron-binding capacity levels were significantly higher in pre-operative visits than in post-operative visits. There was no statistically significant difference through each post-operative visit value (Table 3a).

Ferritin

Serum ferritin levels increased significantly in post-operative first and second visits and then decreased in third visits. There was statistical significance between pre- and post-operative in all visits except pre-operative visit value and post-operative second visit value (Table 3b).

Table 2d: Dunn's multiple comparison test results for MCV.

Visit time	p-Value
MCV 0 – MCV 1	0.094
MCV 0 – MCV 3	**<0.001**
MCV 0 – MCV 2	**<0.001**
MCV 1 – MCV 3	**<0.001**
MCV 1 – MCV 2	**<0.001**
MCV 3 – MCV 2	0.439

Table 2e: Dunn's multiple comparison test results for PLT.

Visit time	p-Value
PLT 1 – PLT 3	0.834
PLT 1 – PLT 2	0.134
PLT 1 – PLT 0	**<0.001**
PLT 3 – PLT 2	0.197
PLT 3 – PLT 0	**<0.001**
PLT 2 – PLT 0	**<0.001**

Table 3a: Dunn's multiple comparison test results for SIBC.

Visit time	p-Value
SIBC 2 – SIBC 1	0.121
SIBC 2 – SIBC 3	0.088
SIBC 2 – SIBC 0	**<0.001**
SIBC 1 – SIBC 3	0.877
SIBC 1 – SIBC 0	**<0.001**
SIBC 3 – SIBC 0	**<0.001**

Table 3b: Dunn's multiple comparison test results for FER.

Visit time	p-Value
FER 3–FER 0	**<0.001**
FER 3 – FER 2	**<0.001**
FER 3 – FER 1	**<0.001**
FER 0 – FER 2	**<0.001**
FER 0 – FER 1	**<0.001**
FER 2 – FER 1	**<0.001**

Folate levels

There was statistically difference in folate levels between pre-operative and all post-operative visits ($p<0.05$). Values at post-operative visits, folate levels decreased significantly in all post-operative visists compared to pre-operative visit. There was no statistically significant difference through each post-operative visit values [p(folate 3-folate 2)>0.05, p(folate 3-folate 1)>0.05), p (folate 3-folate 0)<0.001, p(folate2-folate 0 <0.001), (p (folate2-folate 1) >0.05), (p (folate1-folate 0) <0.001)].

Vitamin B12

There was no statistical significance in vitaminB12 levels between pre-operative and post-operative visits ($p>0.005$).

Alterations of nutrient levels are demonstrated at the pre- and post-operative periods in Figure 3.

Discussion

Sleeve gastrectomy (SG) is now being used commonly in the treatment of obesity. Several studies have investigated the biochemical and nutritional abnormalities after SG. Previous studies conducted on the effects of SG on hematological parameters studied these parameters separately [6, 7] but in our study, the effects of SG on hematological and micro nutritional parameters such as Hb, Htc, WBC, LYM, NTRFL, PLT, MCV, FER, FOL, SI, SIBC, and Vit B12 were examined together. We found that Hb, Htc, WBC, LYM, NTRFL, PLT, FOL, and SIBC measurements decreased. MCV, FER, and SI increased significantly after SG. However, only Vit B12 levels remained unchanged.

Previous studies about hematological parameters and nutrients after SG had found conflicting results. Saif et al. showed that hemoglobin and hematocrit levels decreased as in our study; serum iron, ferritin, and serum

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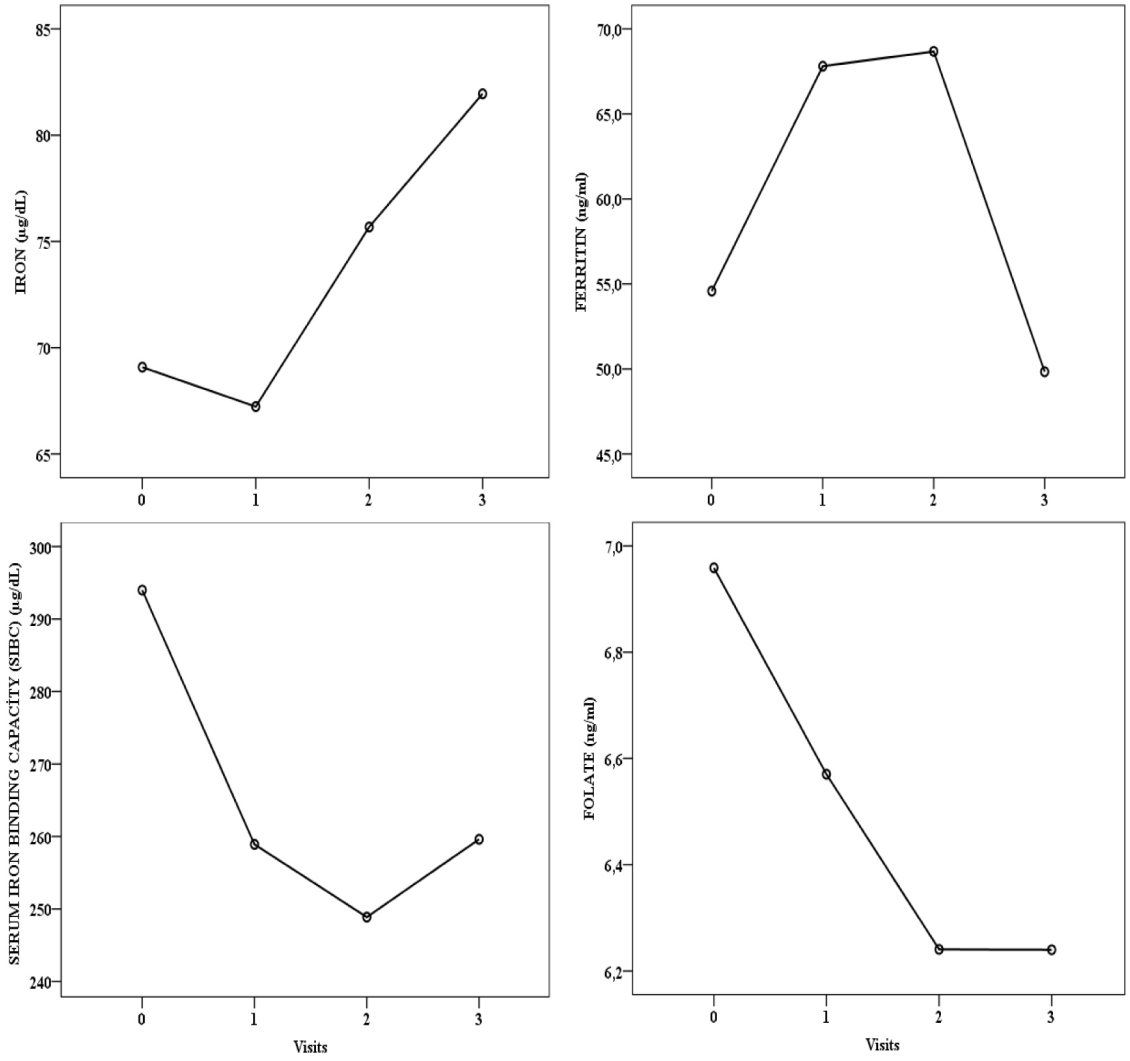

Figure 3: Nutritient levels in pre- and post-operative periods.

iron-binding capacity levels did not change after SG [8]. In another study which was conducted in adolescents were shown low ferritin, vitamin B12 and folate levels compared to baseline values, whereas, serum iron, hemoglobin, and hematocrit did not change after SG [5]. Hakeam et al. found lower hemoglobin, folate, and ferritin levels, and also high iron and MCV levels compared to pre-operative levels 6 months after SG [9].

In this retrospective study, we found that post-operative Hb levels in the third visit were significantly lower than pre-operative and post-operative other visits. There was no statistically significant difference between pre- and post-operative 1st and 2nd visits. Although there was no significant decrease in the first 6 months postoperatively, a statistically significant decrease was found after the 6th month, although the replacement of Fe^{2+} was given to the patients with deficiency. In coordination with Hb values, post-operative hematocrit levels were significantly lower at the third visit than at other pre- and post-operative visits.

In another study, Gregory et al. found a decrease in hemoglobin, ferritin, MCV, and vitamin B12 measurements [10]. In contrast to this study, the increase in MCV levels continued at each post-operative visit in our study, and this increase was statistically significant. However, there was no statistically significant difference between pre-operative levels, first post-operative visit and post-operative 2nd-3rd visits.

In a study investigating nutritional deficiencies after SG, Tair Ben-Porat et al. reported

that SI, Vit B12, FOL, and serum Vit D levels decreased after SG. They also concluded that evaluating the patients' pre-operative nutritional status and customizing an additional program for each patient could prevent possible post-operative nutritional deficiencies [11]. There was statistical difference in FOL levels between pre-operative and all post-operative visits in our research.

SI levels in our study decreased at the first post-operative visit and increased significantly at the second and third post-operative visits compared to the pre-operative and first post-operative visits. Additionally, there was no statistically significant difference in FER values of each post-operative visit. However, there was a statistically significant difference between pre- and post-operative visits except pre-operative visit value and post-operative second visit value. This is most likely due to the initiation of Fe^{2+}replacement therapy. The change in this second visit may indicate that the iron storage is filled first with the effect of Fe^{2+}replacement therapy, but then this storage is insufficient due to multiple factors. These findings support the definition of "ferritin levels decreased over time, even with Fe^{2+} replacement supplementation" reported by Gillon et al. [12].

In our study WBC, LYM, NTRFL and PLT levels were found to be decreased after SG. Chen et al. showed that white blood cell count and C-reactive protein (CRP) levels were increased in patients with obesity, and after surgery, a decrease was observed in WBC and CRP levels [13]. In a study of 596 patients, who underwent Roux-en-Y gastric bypass surgery, white blood cell count and hematocrit levels were found to be lower after surgery. Besides, neutropenia had not developed in any of the patients [14].

Bariatric surgery also affects lymphocyte subtypes. After weight loss with gastric bypass surgery, CD4+ and CD3+ T cell counts increase significantly. The mechanism behind this effect may stem from the change in the production of adipokine leptin from adipose tissue [15–17]. Unfortunately, we could not examine LYM subtypes in our study.

PLT counts also decrease after sleeve gastrectomy. In a study conducted by Hans-Erik Johansson et al. from Sweden, a significant decrease was reported in PLT counts [18]. Studies conducted by Raoux from France and Kutluturk from Turkey, have reported similar results that bariatric surgery caused a decrease in PLT counts, as well as mean PLT volume [19, 20]. Besides an increase in leucocyte and PLT counts in obese patients, obesity stimulates the leucocyte and PLT activities leading to inflammation and thrombotic events. After bariatric surgery, this inflammatory and thrombotic risk decreases [21, 22]. Considering the relation between increased PLT hyperactivity and cardiovascular risk, a decrease in platelet count and mean PLT volume may contribute to a decrease in cardiovascular mortality.

The limitation of this is undoubtedly its retrospective nature. For this reason, although more than 600 surgeries were performed in our hospital at the time of the study, we could only include 298 patients due to insufficient data. This study has a relatively small sample size. The fact that the follow-up period of the patients included in the study reflects a 12-months period is another limiting factor in our study.

Conclusion

Hematological and nutritional changes occur after sleeve gastrectomy. The mechanism of hematological changes is complex and has not been elucidated yet. Nutritional changes are probably related to insufficient supplementation and anatomical alterations. All bariatric surgery methods have multisystemic effects. Therefore, regular follow-up of the patients who undergo this surgery may prevent complications in the post-operative period.

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