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The Effect of Residual Gastric Volume on Body Mass Index, Excess Weight Loss Rate and Metabolic Response after Sleeve Gastrectomy

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Rezumat

Efectul volumului gastric rezidual asupra indicelui de masă corporală, a ratei de pierdere a excesului de greutate și a răspunsului metabolic după gastrectomia longitudinală

Context/scop: Investigarea răspunsului metabolic şi a reducerea indicelui de masă corporală în funcție de volumul gastric restant între 6-12 luni postoperator la pacienții la care s-a practicat gastrectomie longitudinală laparoscopică pentru obezitate; determinarea relației dintre volumul gastric restant şi îmbunătățirea metabolică.
Materiale şi Metode: Au fost incluşi în studiu pacienți la care s-a practicat gastrectomie longitudinală laparoscopică într-un singur centru, de către aceeaşi echipă şi cu aceeaşi metodă standardizată. Volumele gastrice reziduale au fost calculate din imaginile tomografiei computerizate tridimensionale obținute la 6-12 luni postoperator. IMC, pierderea excesivă în greutate (EWL), colesterolul total, lipoproteinele cu densitate scăzută (LDL), lipoproteinele cu densitate ridicată (HDL), lipoproteinele cu densitate foarte scăzută (VLDL), trigliceridele, valorile hemoglobinei glicozilate (HbA1c), proteinele totale şi albumina au fost înregistrate preoperator şi în momentul măsurării volumului rezidual.
Rezultate: Studiul a inclus 49 de pacienți cu un IMC preoperator mediu de 47,26±6,21 kg/m^2 şi o vârstă medie de 37,51±10,88 ani. Volumul gastric rezidual mediu a fost de 155,36±56,71 mm^3. Volumul gastric rezidual a fost corelat

cu IMC-ul mediu postoperator (28,44±3,23 kg/m^2; p<0,001) şi cu EWL% mediu postoperator (29,27±7,66; p=0,001). Volumul gastric rezidual s-a corelat negativ cu HbA1c medie postoperatorie (p=0,004). HbA1c (p=0,828), LDL (p=0,661), HDL (p=0,848), trigliceride (p=0,641), VLDL (p=0,794), proteinele totale (p=0,539) şi albumina (p=0,824) au fost analizate înainte şi după operație şi nu s-au corelat cu volumul gastric rezidual.
Concluzii: Cu cât volumul gastric rezidual este mai mic după gastrectomia laparoscopică longitudinală, cu atât %EWL este mai mare şi scăderea HbA1c este mai importantă. Acest studiu arată că gastrectomia longitudinală laparoscopică este o procedură chirurgicală eficientă la pacienții cu diabet zaharat de tip 2.

Cuvinte cheie: obezitate, gastrectomie longitudinală laparoscopică, volum gastric rezidual

Abstract
Background/aim: To investigate the metabolic response and body mass index reduction according to the remaining stomach volume between 6-12 months after the operation in patients who underwent sleeve gastrectomy surgery for obesity and to determine the relationship between the remaining stomach volume and metabolic improvement.
Materials and Methods: Patients underwent sleeve gastrectomy in a single center by the same team and with the same standardized method. Residual gastric volumes were calculated from three-dimensional computed tomography images obtained 6-12 months postoperatively. BMI, excess weight loss (EWL), total cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), very low density lipoprotein (VLDL), triglyceride, hemoglobin A1c (HbA1c), total protein, albumin values were recorded preoperatively and at the time of residual volume measurement.
Results: There were 49 subjects with a mean SD preoperative BMI of 47.26±6.21 kg/m^2 and mean age 37.51±10.88 years. Mean residual volume was 155.36±56.71 cc. Residual volume was associated with postoperative mean BMI (28.44±3.23 kg/m^2; p<0.001) and postperative mean EWL%(29.27±7.66; p=0.001). Residual gastric volume was also negative correlated with postoperative mean HbA1c (p=0.004). HbA1c (p=0.828), LDL (p=0.661), HDL (p=0.848), triglycerides (p=0.641), VLDL (p=0.794), total protein relation (p=0.539) and albumin (p=0.824) were analyzed before and after surgery and were not correlated with residual gastric volume.
Conclusion: The smaller the residual gastric volume after laparoscopic sleeve gastrectomy, the higher the %EWL and the greater the decrease in HbA1c. This study show that laparoscopic sleeve gastrectomy is an effective surgical procedure in patients with Type 2 diabetes mellitus.

Key words: obesity, sleeve gastrectomy, residual gastric volume

Introduction

The World Health Organization (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that may impair health (1). The prevalence of obesity has gradually increased in Turkey. In a study conducted by the Turkish Ministry of Health in 2010, 34.6% were overweight, 64.9% were overweight and obese and 2.9% were morbidly obese (2). The aim of obesity treatment is to reduce morbidity and mortality caused by obesity by increasing weight loss. Laparoscopic sleeve gastrectomy (LSG) is the most commonly used method among the easier, safer, cheaper surgical treatments (3). While rapid weight loss is observed in the first six months after LSG, the targeted metabolic effects are observed and the ideal weight is reached between 6-12 months postoperatively (4). Studies have shown that weight loss increase is inversely proportional the residual gastric volume (4), including after sleeve gastrectomy (5). Computed tomography (CT) is recognized as a reliable and reproducible technique for measuring the remaining gastric volume (RGV) (6,7). Using the data obtained from studies on the delay between LSG and CT scanning, it has been shown that the ideal delay is between 6-12 months (4).

In the present study, reduction in body mass index (BMI), amount of excess weight loss (EWL), reduction in hemoglobin A1c (HbA1c) and, metabolic response were analyzed according to the residual volume calculated by 3D-Computed Tomography (CT) method between 6-12 months after the operation in patients who underwent sleeve gastrectomy surgery for obesity.

Materials and Methods

This study included patients who underwent laparoscopic sleeve gastrectomy for obesity. Patients between the ages of 18-65 years, who were at least 6 months and up to 12 months post sleeve gastrectomy and who had not undergone any other surgery for morbid obesity were included in the study. All sleeve gastrectomies were performed laparoscopically using the 4-port technique. A 36 Fr calibration tube was used to standardize the residual gastric volume. Gastric transection started 3-4 cm from the pylorus and ended 1 cm lateral to the esophago-gastric junction. Stapler line hemostasis was maintained with metal clips and no additional suturing was performed. Patients were given drinking water, their stomachs were fully dilated, and a non-contrast CT scan was performed. Patients received fluids in a sitting position immediately before CT; the resulting distension was standardized using the same preparation and technique in each case. Image acquisition was performed in the supine position. All examinations were performed on multidetector CT scanners. Thin section images were reconstructed in 1.5 mm and 1 mm slice thickness increments with 1.2 mm detector collimation. Thin section data were transferred to a dedicated three-dimensional (3D) reconstruction station and 3D volume rendering images were created with a combination of manual and semi-automated segmentation tools. Using height, width, and depth parameters from the cardia to the pylorus, the gastric volume was calculated after multiplane reconstruction and 3D volume rendering. The gastric volume was expressed in cubic centimeters (cc) (*Figs. 1, 2*). Weights, weight change, and EWL were calculated pre- and postoperatively at 6 months and 12 months. Preoperative and postoperative blood samples were taken and HbA1c, lipid panels, total protein, and albumin values were recorded. Only patients who underwent sleeve gastrectomy were included in the study. Patients who had other bariatric surgical treatments were not included.

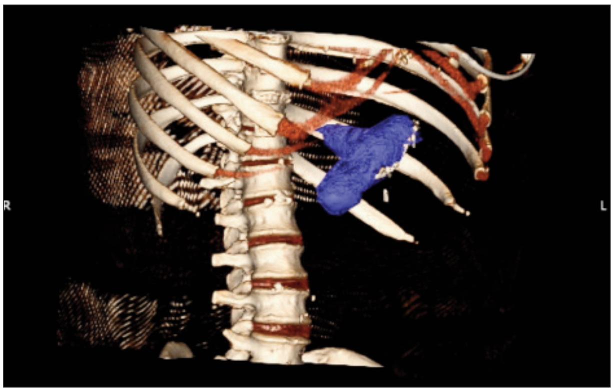

Figure 1. 3D Residual stomach volume after LSG (3D-CT)(47)

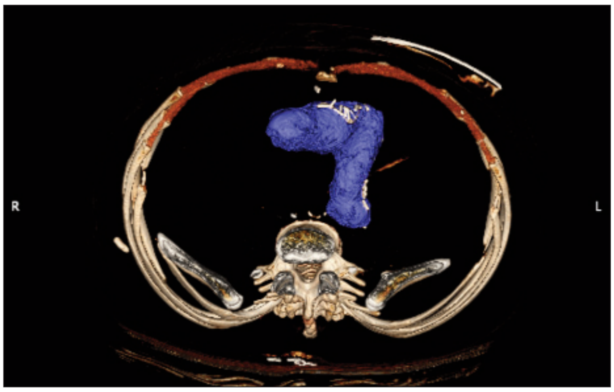

Figure 2. 3D Residual stomach volume after LSG (3D-CT)(47)

Statistical Analysis

Statistical evaluation was performed with IBM SPSS, version 20.0 (IBM Corp., Armonk, NY, USA). The test for conformity to normal distribution was evaluated with the Shapiro Wilk Test. Numerical variables are given as mean ± standard deviation and median (25^{th}-75^{th} percentile). The relationship between numerical variables was evaluated by Spearman Correlation Analysis. A $p<0.05$ was considered sufficient for statistical significance in two-way tests.

Results

This study included 49 patients with post-operative 3D-CT images examined between 6-12 months after LSG. Of the 49 patients, 12 (24.5%) were male and 37 (75.5%) were female. Mean age was 37.5±10.9 years, pre-operative BMI was 47.2±6.2) kg/m^2, postoperative BMI was 28.4±3.2) kg/m^2, pre-LSG mean body weight was 126.1±17.7 kg, post-LSG mean body weight was 75.9±9.8 kg and mean height was 163.55±8.7 cm (*Table 1*).

The mean residual gastric volume after LSG was 155.4±56.7 cc.

The mean EWL was 39.3±7.7%. The relationship with residual gastric volume was statistically significant (p=0.001). Mean EWL% was negatively correlated with residual gastric volume (cc) (p=0.001). EWL% increased as residual gastric volume decreased (*Fig. 3* and *Table 2*). The mean postoperative duration of 3D-Computed Tomography (CT) was 8.69 (±2.82) (minimum 6 months and maximum 12 months) months. The mean postoperative BMI at the time of evaluation was 28.4±3.2 kg/m^2 and the relationship between this value and residual gastric volume was statistically significant ($p<0.001$). Postoperative mean BMI was directly correlated with residual gastric volume (cc) ($p<0.001$) (*Fig. 4* and *Table 2*).

Table 1. Demographic characteristics of patients

Characteristics of patients	Average numerical data (%)
Gender, n (%)	
Female	37 (75.5)
Male	12 24.5)
Mean age, years	37.51±10.88
Mean preoperative BMI, (kg/m^2)	47.25±6.21
Mean postoperative BMI, (kg/m^2)	28.44±3.23
Mean body weight, (kg)	
Preoperative	126.14±17.66
Postoperative	75.88±9.83
Mean height, (cm)	163.55±8.74

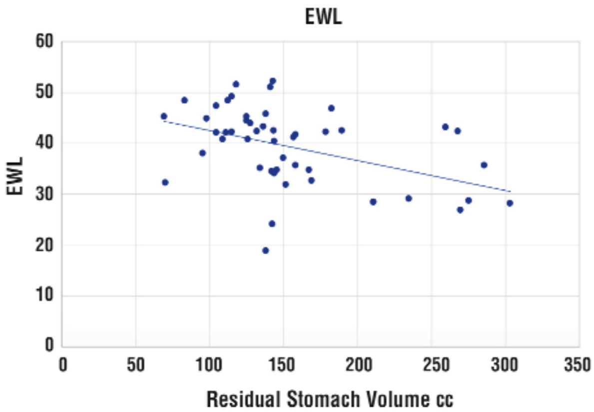

Figure 3. Inverse correlation between EWL% and residual stomach volume (p=0.001)

Table 2. Correlationbetweenpercentage changes and postoperative value of a number of variables with residual stomach volume. P<0.05 significant. -: negatively correlated +: positively correlated

	Preoperative Mean Value	Postoperative Mean Value During Residual Volume Measurement	Relationship between residual volume and percentage change P value	Relationship between residual volume and postoperative mean P value
BMI kg/m^2	47.25(±6.21)	28.44(±3.2)	-/0.001	P<0.001
EWL%	39.27(±7.65)	39.27(±7.65)	-/0.001	-/0.001
Stapler Number	-	5.9 (±0.86)	-	0.06
3d-CT Withdrawal Time	-	8.69(±2.82)	-	0.90

The percentage change of the difference between the mean preoperative and postoperative values of BMI was inversely associated with residual gastric volume (cc) (p=0.001). The relationship between percent change value and residual gastric volume was statistically significant (p=0.001) (*Fig. 4* and *Table 2*).

The mean preoperative HbA1c was 5.6 (±0.46) and the mean postoperative HbA1c was 5.2 (±0.38) (*Fig. 5* and *Table 3*). The relationship between postoperative mean HbA1c value and residual gastric volume was statistically significant (p=0.004). Postoperative mean HbA1c value and residual gastric volume (cc) were directly correlated (p=0.004). (*Fig. 6* and *Table 3*).

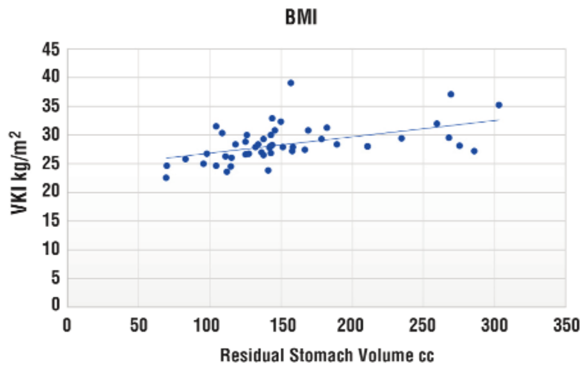

Figure 4. Correlation between BMI and residual stomach volume (p=0.001).

Total cholesterol, LDL, VLDL and triglycerides decreased, whereas total protein, albumin and HDL increased after LSG (*Fig. 5*

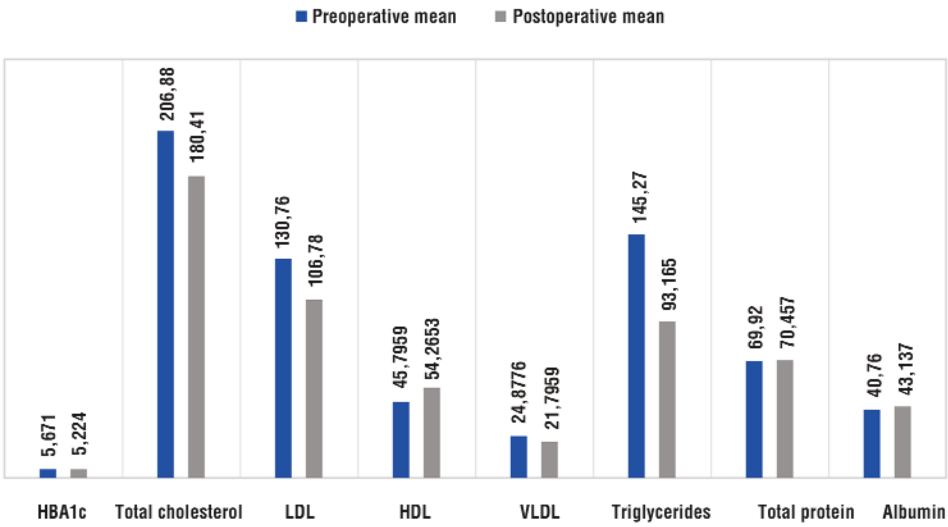

Figure 5. Preoperative and postoperative change graph

Table 3. Correlation between Percentage Changes and Postoperative Values with Remnant Stomach Volume. P<0.05 significant. -: negatively correlated +: positively correlated

	Preoperative mean value	Postoperative mean value at residual volume measurement	Preoperative to postoperative percentage change (%)	Relationship between residual volume and exchange rate P value	Relationship between residual volume and Postoperative Mean P value
HbA1c	5.67 (±0.46)	5.22 (±0.38)	10.42 (3.58- 17.00)	0.896	0.004
Total cholesterol	206.88 (±34.65)	180.41 (±29.71)	16.02 (-0.48- 34.51)	0.887	-/0.828
LDL	130.76 (±30.58)	106.78 (±22.95)	24.05 (-3.34- 47.40)	0.463	-/0.661
HDL	45.79(±5.97)	54.26(±8.35)	-18.36 (-30.1- -9.87)	0.848	-/0.826
VLDL	24.87(±10.5)	21.79(±7.72)	8.70 (-17.96 -34.06)	0.794	0.378
Trigliserid	145.27 (±55.15)	93.165 (±26.67)	53.01 (11.47- 83.64)	0.822	0.641
Total Protein	69.92 (±5.05)	70.45 (±4.67)	-2.70 (-6.20- 5.02)	0.612	0.539
Albumin	40.76 (±5.637)	43.137 (±2.8254)	-7.32 (-11.91- 2.33)	0.385	-/0.824

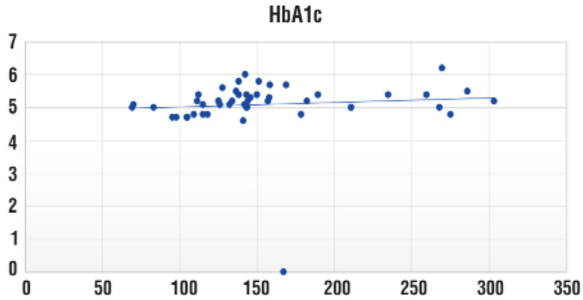

Figure 6. Direct Correlation Between HbA1c and Residual Stomach. HbA1c Decreases as Residual Stomach Volume Decreases

and *Table 3*). These values were not correlated with residual gastric volume.

There were no early or late complications in the patients included in the study. Early anastomotic leakage to their stomachs and late gastric stenosis were not observed.

Discussion

LSG has become the most commonly performed bariatric surgical procedure worldwide, accounting for 61% of all bariatric surgery in a 2022 report of the 7th International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) (3).

The most important mechanism of LSG is a reduction in stomach volume that limits food intake. A 2015 study by Lal Pawanindra et al. found a significant relationship between preoperative gastric volume and preoperative weight and BMI, that is overweight patients tend to have larger preoperative gastric volumes. Thus, the importance of reducing gastric volume to achieve weight loss is suggested (8). Furthermore, these findings suggest that postoperative residual gastric volume is important in achieving optimal postoperative weight. Several factors have been shown to affect the residual gastric volume. These include the size of the spark plug (bougie) used during surgery, the distance of the resection to the pylorus, whether stapler reinforcing suture or support material was used, complete resection of the fundus, and the distance between the stapler line and the spark plug (8-12). Accurate measurement of postoperative residual gastric volume is important and the relationship between this volume and weight loss should be established.

In the present study, the LSG operation was performed using a 36 fr spark plug. This size was chosen because studies have suggested that it is the optimal choice. The use of a spark plug diameter smaller than 36 fr has been shown to increase postoperative gastroesophageal reflux and anastomotic leakage complications due to increased intraluminal pressure (13). In contrast, with a spark plug diameter larger than 36 fr, less weight loss was observed. Weiner et al. showed that the use of small-diameter spark plugs resulted in more weight loss than the use of large-diameter spark plugs (11). A 2018 meta-analysis showed that LSG performed with a $\leq$ 36 fr plug resulted in a significantly higher EWL% compared to a >36 fr plug, without the risk of gastro-esophageal reflux and anastomotic leakage (14).

In the LSG operations performed in the present study, gastric-antrum resection was performed 3-4 cm from the pylorus. The aim was to perform adequate gastric-antrum resection without gastric emptying problems. Weiner et al. recommended reduced antrum resection in order not to disrupt gastric emptying function (11). In the study by Michalsky et al., it was observed that the gastric emptying time was shorter in patients who underwent a greater degree of antrum resection compared to those who did not undergo radical antrum resection (15). Complications, such as gastric emptying failure, were not observed in patients with radical antrum resection and these authors suggested that a greater degree of antrum resection in LSG did not impair gastric emptying functions. Preservation of the gastric antrum has been shown to allow faster gastric emptying and one mechanism for this finding may be that it directly stimulates the postprandial increase of glucagon-like peptide-1 (GLP-1) after LSG (10). The aim of antrum-sparing sleeve gastrectomy is to allow gastric contents to pass into the terminal ileum faster and earlier and to ensure faster and earlier secretion of insulin in patients undergoing LSG for metabolic reasons. Two studies reported a significant correlation between residual gastric volume and weight loss and a higher EWL% was found after 24 months of follow-up when stapling was initiated 4 cm or less from the pylorus (16,17). In an interesting observation by Robert et al, weight loss was associated with estimated residual antral volume, not residual gastric volume (18).

CT was preferred as the imaging method in the present study because it is fast and reliable. Obtaining MRI images may take a prolonged period so that the fluid used to inflate the stomach passes through the pylorus and empties, leading to inaccurate assessment of stomach volume. Ultrasono-graphy (USG) is quick but also introduces inaccuracy because of the operator dependent nature of this modality. In some studies, intraoperative measurement with saline and methylene blue and combinations of oral contrast and IV contrast were preferred (7,11,14,19-21). In a 2020 systematic review, it was observed that the use of sodium bicarbonate granules or an effervescent solution of tartaric acid/sodium hydrogen carbonate salts was the most reliable method to adequately inflate the stomach (4).

One of the aims of the present study was to show that emptying time and 3D volumetric CT reconstruction were more reliable than methods using gastric inflation.In our cohort the mean residual gastric volume after LSG was 155.4cc. Different studies have reported that the mean residual gastric volume after LSG ranged between 50 and 200 mL in the postoperative period (12,22-25). Residual gastric volume after LSG is an important factor for EWL% after sleeve gastrectomy. Traditional methods for calculating residual gastric volume after bariatric procedures have been shown to be often inaccurate; usually using biplanar contrast studies.

A significant correlation was found between residual gastric volume and EWL% at six months after sleeve gastrectomy (16).

In the present study, the relationship between residual gastric volume and EWL% was evaluated between 6-12 months. The first six months after LSG is the period of fastest weight loss but it takes 6-12 months for the metabolic effects to start and to achieve the desired weight. Elbanna et al. measured residual gastric volume within seven days of LSG and this correlated with EWL% at six months (17). In some studies, gastric volume measurements with CT were performed at three months postoperatively. At the third postoperative month, a good correlation was found between residual gastric volume measured at the sixth month and EWL% measured at month 13 or 18 (16,18). Baumann et al. found no correlation between residual gastric volume measured 12 months after LSG and weight loss (20). Deguines et al. found better weight loss in patients with lower RGV when evaluated at 24-36 months post-operatively (26). Disse et al. evaluated RGV at 3 months and 12 months postoperatively and observed a trend towards better weight loss in patients without "gastric dilatation", but this did not reach significance. Furthermore, there was no significant difference in BMI in patients with and without gastric dilatation. However, total weight loss and excess BMI loss were higher in patients without gastric dilatation (27). In the study by Pawanindrave et al. a significant correlation was also found between excised gastric volume and weight loss in the first three months after surgery. However, no correlation was found between residual gastric volume and weight loss at three months postoperatively (8). The post-operative value of BMI decreases as the residual gastric volume decreases. The smaller the residual gastric volume of the patients, the more the BMI value decreases. The percentage change of BMI increases as the residual gastric volume decreases. As the remaining gastric volume of the patients decreases, the BMI value decreases more; the difference between preoperative BMI and postoperative BMI is greater. As a result, as the remaining gastric volume of the patient decreases, the weight lost by the patient increases.

A 2020 systematic review found significant differences in the technique of assessment of residual gastric volume and the timing of residual gastric volume and EWL% assessment. Five studies found a statistically significant association between residual gastric volume and EWL%. Two studies reported that resected gastric volume, rather than residual gastric volume, correlated with EWL%. Meta-analysis of studies reporting the correlation between residual gastric volume and EWL% showed that up to 26.3% of the variability in EWL% could be explained by variations in residual gastric volume. This review demonstarted that a stronger correlation between RGV and EWL% was found when weight loss was measured at 6-12 months of postoperative follow-up. However, there is still no consensus on the optimal timing of residual gastric volume assessment, although evidence is emerging that suggests it is prudent to delay assessment to 6-12 months to obtain the most reliable estimates (4).

In 2013, Vidal et al. were the first to describe the direct relationship between an increase in residual gastric volume and lower weight loss after LSG surgery (19). In the present study, the amount of weight lost increased as the residual gastric volume decreased. This was associated with increased reduction in BMI and also a higher EWL%. In contrast Obeidat et al. found a positive correlation between the resected gastric volume of 1100 cc and EWL% ≥ 50% (28). These authors found that the increase in EWL% correlated with the resected gastric volume, rather than remaining gastric volume. Elbanna et al. found that preoperative gastric volume was positively correlated with baseline BMI, but not with EWL%. Residual gastric volume and percentage of resected stomach were shown to have a significant effect on EWL% after LSG (17).

Braghetto et al. investigated a postoperative increase in residual gastric volume three days and 24 months after LSG and described a postoperative increase in residual gastric volume (29). The long-term rate of weight regain after LSG has been reported to range from 14% to 37% (30). This may lead to the need for revisional surgery after LSG in 10.4% of patients over a 5-year follow-up period (31). In 2020, a study was conducted in which 3D-CT was utilized to identify the factors leading to inadequate weight loss and weight regain after LSG. It was shown that pylorus-stapler distance and residual antrum volume influenced weight loss after LSG. It has been shown that 3D-CT can help in planning treatments to identify factors affecting inadequate weight loss after LSG (32).

The primary risk factor for type 2 diabetes is obesity and 90% of all patients with type 2 diabetes are either overweight or obese. Data from the National Health and Nutrition Examination Survey III (1988-1994) showed that the risk for diabetes was approximately 50% in those with a BMI equal to or greater than 30 kg/m^2 and over 90% with a BMI of 40 kg/m^2 (33,34). Strong evidence published since Pories' first report in 1995 demonstrated the efficacy of bariatric surgery in remission of type 2 diabetes (35). The superiority of surgery over medical therapy has led many authors to investigate different procedures that can improve type 2 diabetes in both morbidly obese and mildly obese patients (36,37). In 2009, Cummings reviewed current assumptions regarding the mechanisms underlying diabetes remission. Based on this study, three main hypotheses were proposed: 1) decreased secretion of the hormone ghrelin decreases appetite and food intake and may also improve glucose tolerance; 2) that L-cell peptides, such as GLP-1,secreted by the distal intestine are stimulated by food after a short period of time; and 3) that decreased contact of the proximal intestine with food is a phenomenon (38). In the upper intestine hypothesis, which suggest that reduced food contact with the proximal intestine is somehow a key in the process by which diabetes is improved, it is believed that unknown factors or processes from the duodenum affect glucose homeostasis (39). In the lower intestine hypothesis, it is proposed that the distal intestine is stimulated shortly after ingestion of food, and that the ingested food reaches the terminal ileum and increases the release of GLP-1. Therefore, bariatric procedures such as LSG, LRYGBP or BPD-DS have been shown to result in remission of type

2 diabetes, as reported in the Buchwald meta-analysis (40), a Danish study (41) and many other studies (42).

Sleeve gastrectomy appears to be associated with changes in gastrointestinal physiology that contribute to reduced hunger and increased satiety. These changes include accelerated gastric emptying, increased post-prandial cholecystokinin secretion, increased blood plasma concentrations of GLP-1 and decreased ghrelin release. Sleeve gastrectomy helps patients lose weight and improve glucose metabolism after surgery. In patients who underwent LSG, glucose and insulin concentrations were better regulated compared to morbidly obese patients. LSG markedly improved glucose homeostasis and produced significant changes in the levels of ghrelin, pancreatic polypeptide (PP), the intestinal hormones peptide-YYY (PYY) and GLP-1 together with amylin and leptin (43,44). LSG has a two-fold efficacy; physical restriction on stomach size and metabolic effects. In the present study, there was a decrease in the mean HbA1c values in the postoperative period which was correlated with residual gastric volume measurements. Furthermore, the percentage change in HbA1c increased as the residual gastric volume decreased.

In a study conducted in 2021 including approximately 500 patients who had either LSG or laparoscopic Roux-en-Y(LRYGB) operations, there was no significant difference in diabetes remission based on American Diabetes Association (ADA) criteria after 5 years. After 5 years, significant improvement in glycemic control was seen in all patients. HbA1c levels were 6.7 at baseline and 6.1% at 5 years in the LSG group and 6.7% at baseline and 5.8% at 5 years in the LRYGB group. HbA1c and fasting plasma glucose levels decreased significantly during follow-up. There was no significant difference between LSG and LRYGB in terms of HbA1c or fasting glucose. However, remission of dyslipidemia was better after LRYGB (45). In a 5-year observational study conducted by Schauer et al. in 2017, it was shown that bariatric surgery plus intensive medical therapy was more effective than intensive medical therapy alone in reducing or in some cases resolving hyperglycemia in patients with type 2 diabetes and BMI between 27 and 43 kg/m^2 (46). In the Surgical Treatment and Medications Potentially Effectively Eradicating Diabetes (STAMPEDE) trial, both laparoscopic Roux-en-Y gastric bypass LRYGB and LSG showed greater efficacy in reducing hyperglycemia at 5-year follow-up compared with medical therapy alone. At five years, there was no significant difference in diabetes control between the two surgical procedures (46).

In LSG, leaving the residual gastric volume ideally neither too much nor too little (100-150cc) is thought to reduce complication rates, resulting in greater weight loss, adequate reduction in BMI, further increase in EWL%, and reduction in HbA1c by improving glucose tolerance.

Conclusions

The results of this study showed that the smaller the residual gastric volume after LSG, the greater the decrease in BMI decreased, the greater the increase in EWL% and the greater the decrease in postoperative HbA1c. LSG is an effective surgical procedure in patients with overweight/obesity and type 2 diabetes. However, the effect of residual gastric volume on postoperative blood measures of metabolic control will require further investigation.

Conflicts of Interests and Source of Funding

The authors declared no potential conflicts of interest and no funding.

Ethical Statement

This study was carried out with the permission of Kocaeli University Ethics Committee dated 21/04/2022 (Annex-1) (Decision No: KÜ GOKAEK-2022/08.26) (Project No: 2022/132).

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47. 3D-CT images were obtained from Kocaeli University Faculty of Medicine Hospital, Department of Radiology Archives.