What is The Effect of Sleeve Gastrectomy in Patients with a BMI $\geq 50$ kg/m2?

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Abstract

**Background:** To investigate the effect of Sleeve Gastrectomy (SG) in patient with a Body Mass Index (BMI) ≥ 50 kg/m² groups on weight loss and comorbidities as the first and alone option.

**Methods:** The prospectively maintained data obtained from patients with a BMI ≥ 50 who underwent SG between February, 2016 - February, 2020 were evaluated.

**Results:** 138 patient with a BMI ≥ 50 kg/m² underwent surgery. Average BMI: 56.36±7.661, age 37.41±12.33. Forty eight patients underwent cholecystectomy and/or hiatal hernia repair (HHR), as well. The percentage of excess weight loss (%EWL) values of patients in months 3, 6, 12 and 24 were 36.70%, 54.34%, 67.58%, 72.45%, 74.14% and the percentage of total weight loss (TWL%) values were 20.17%, 29.59%, 36.93%, 39.62%, 40.65%, respectively. The mean BMI values in month 0 and in the 3rd, 6th, 12th, 18th, 24th months were 56.36, 45.10, 39.76, 35.48, 33.96 and 33.42 respectively. The values measured in the month 0 and in the 3rd, 6th, 12th, 18th, 24th months were significantly different for EWL%, TWL% and BMI variables (p<0.001), but EWL% (p = 0.527), TWL% (p = 0.396) and BMI (p=0.657) were not found significantly different between the 18th and 24th months. When EWL% was accepted as ≥50, the success rate was found to be 93.55%(n=93) and 92%(n=50) in months 12 and 24, respectively.

**Conclusion:** SG appears to be an effective and safe treatment method as the first option for weight loss and for treatment of concomitant disorders in patient with a BMI ≥ 50 kg/m² groups. Further long-term studies are needed to confirm these results.

Background

Obesity is a major health problem, which underlies may diseases such as diabetes mellitus (DM), hypertension (HT), dyslipidemia, cardiovascular diseases and respiratory system disorders(1). Bariatric surgery is the most effective treatment method in treating obesity in comparison with conventional types of medical treatment (2, 3). It is difficult to perform bariatric surgical procedures in the super obese (SO, BMI ≥ 50 kg/m²) and super-super obese (SSO, BMI ≥ 60 kg/m²) patient groups due to massive hepatomegaly, limited intraabdominal operating space, thick abdominal wall and increased intraabdominal fat tissue(4). In this patient groups, surgery is associated with high mortality, morbidity and increased surgical risk(5, 6). The fact that SG is a procedure which can be applied more easily as a technique in comparison with the Roux and Y Gastric Bypass (RYGB), has a short period of hospital stay and low morbidity makes it more preferable. On the other hand, the fact that not enough weight loss is obtained via sleeve gastrectomy as the first choice in patient with a BMI ≥ 50 kg/m² group may require secondary bariatric surgeries(5, 6, 7). Nevertheless, current studies have shown that sleeve gastrectomy ensures effective weight loss in patient with a BMI ≥ 50 kg/m² group and it eliminates the need for secondary malabsorptive procedures(8, 9, 10). The ideal bariatric surgical type in patient with a BMI ≥ 50 kg/m² group is still subject to controversy. In this study, we aimed to investigate the effect of SG in patient with a BMI ≥ 50 kg/m² group on weight loss and the accompanying comorbidities.

Methods

The prospectively maintained data obtained from patients with a BMI ≥ 50, who underwent SG between February, 2016 - February, 2020, were evaluated. All of the patients were operated on by the same bariatric surgeon. The patients were assessed by a multidisciplinary team consisting of a bariatric surgeon, a dietician, an endocrinologist, a cardiologist, an anesthesiologist and a psychiatrist before surgery. All patients received upper gastrointestinal system endoscopy and abdominal ultrasonography before surgery. The patients were assessed with respect to demographic data (age, sex), anthropometric measurements (weight, height, BMI), accompanying comorbidities, biochemical parameters (lipid profile,
HbA1c, fasting blood sugar), the weight loss in months 3, 6, 12, 18 and 24, the percentages of excess weight they lost and their complications.

BMI was defined as weight (kg)/height (m)$^2$, ideal body weight as that equivalent to a BMI of 25 kg/m$^2$ and excess weight (EW) as the difference between initial weight and ideal weight.

The percentage of excess weight loss (%EWL) = [(initial weight – current weight) / (initial weight – ideal weight)] × 100. The percentage of total weight loss (%TWL) = [(initial weight – current weight/initial weight) × 100 (11). The success of bariatric surgery was assessed according to the modified Reinhold criteria (Table 1) and Brion criteria(12,13,14). As per the Brion criteria, success in patients with BMI $\geq 50$ was defined as post-operative BMI $\leq 40$.

Diabetes was diagnosed according to the criteria of the American Diabetes Association(15). DM was defined as glycated hemoglobin HbA1c $\geq 6.5$ or fasting blood sugar $\geq 126$ mg/dl. Patients without medication whose HbA1c level dropped $\geq 6\%$ were defined as resolved from diabetes and those whose HbA1c level decreased from their preoperative HbA1c level were defined as improved. Hypertension was defined as blood pressure $>140/90$mm Hg. Remission was defined if the patient had normal blood pressure ($\leq 120/80$) without any antihypertensive medications, and improvement was considered if the number of antihypertensive medications or the dose of the antihypertensive medications was lowered. As for the total cholesterol levels, the levels $\leq 200$ were considered Normal, the range of 200-239 Marginally High and $\geq 240$ High. For the LDL levels, the levels $\leq 100$ were considered normal, the range of 130-159 Marginally High and $\geq 160$ High. Patients who had gastroesophageal reflux disease (GERD) symptoms or complaints completed a severity symptom questionnaire. Patients with a severity symptom score above 4 or on regular proton pump inhibitor use, who showed hiatal hernia in their endoscopy, also underwent posterior hiatus repair. Remission was defined as the patient being symptom-free without the use of proton pump inhibitor. An improvement was considered if the patient required a decrease in the dose of proton pump inhibitor or decrease in symptoms(16,17).

**Surgical Procedure**

All of the patients received low molecular weight heparin prophylaxis the night before surgery, which was also maintained in the post-operative period. All surgeries were performed laparoscopically. The first trocar was introduced using visiport (between umbilicus and xiphoid with 1/3 proximity to the umbilicus); 5 trocars were used in total. The greater curvature of the stomach was de-vascularized; The short gastric vessels and gastroplenic ligaments were divided using a ligasure® device. The stomach was transected by starting 2-4 cm proximally from the pylorus, until the gastroesophageal junction was reached. A 38 Fr bougie were used. The first stapler used was an endo GIA™ 60 mm black tri-stapler. The consequent staplers used were endo GIA™ 60 mm purple tri-staplers. Suture reinforcement wasn't performed on the staple line. An intraoperative methylene blue stress leak test was routinely performed. A 10 mm Jackson-Pratt drain was routinely inserted along the suture line in all patients. All of the patients were started on liquid nutrition at the post-operative hour 24.

**Statistical Analysis**

The current study was planned from the outset to increase validity and reliability. For descriptive statistics, the mean and SD values were used if the variables were continuous, while the median and percentage values were used for discrete variables. The normality of the variables was analyzed using the Kolmogorov–Smimov test. Statistical comparisons between groups were performed using the “Repeated ANOVA Test” followed by the Post-Hoc Bonferroni Test. Two-sided p values were considered statistically significant at p $\leq 0.05$. All statistical analyses were carried out by using the R software/programming [version 3.6.2 (2019-12-12) – CRAN].

**Results**
In total, 138 patients were operated on 104 (75.36%) patients were female. All surgeries were performed laparoscopically. The average age was 37.41±12.33, the average BMI 56.36±7.661 and the average EW 82.95±21.15. There were 44(31.88%) patients with BMI ≥60. Ninety (65.21%) patients underwent SG, 23 (16.66%) patients underwent SG + cholecystectomy, 21 (15.21%) patients underwent SG+HHR and 4 (2.89%) patients underwent SG + HHR + Cholecystectomy. The baseline characteristics, obesity-related comorbidities, surgery types, and laboratory parameters in this study are shown in Table 2.

Weight Loss

The average BMI, EWL% and TWL% values in months 0, 3, 6, 9, 12, 18, 24 are provided in Table 3. In months 12, 18 and 24, the average EWL% was found to be 67.58%, 72.45% and 74.14%, the average BMI 35.48, 33.96 and 33.41 and the average TWL% was found to be 36.93%, 39.62% and 40.65% (Table 3, Figure 1). The mean values of all months were found significantly different for EWL%, TWL% and BMI (p<0.001). According to the Bonferroni multiple comparison test result, all possible binary comparison results for the reference months (0, 3rd, 6th, 12th, 18th, 24th) were significantly different for EWL%, TWL% and BMI variables (p<0.001), but EWL% (p = 0.527), TWL (p = 0.396) and BMI (p=0.657) were not found significantly different between the 18th and 24th months. With the success rate for EWL being considered as ≥50%, it was found to be 93.55 in year 1 and 92% in year 2. With the success rate for BMI being considered as ≤35, it was found to be 59.13 in year 1 and 60% in year 2. With the success rate for BMI being considered as ≤40, it was found to be 84.94% in year 1 and 88% in year 2 (Table 4, Figure 2).

No mortality or major morbidity such as stapler line leaks, gastrointestinal bleeding or intraabdominal bleeding was seen within the first 30 days. One patient developed tetany due to hypocalcemia, which improved with intravenous calcium and vitamin D treatment. One patient had fever and gastroenteritis, which improved with treatment. No deep vein thrombosis or pulmonary embolism were seen.

Resolution of Comorbidities

While complete remission of Type 2 diabetes was seen in 42 (89.36%) patients, it was observed that 5 patients had improved. In diabetic patients, the average pre-operative HbA1c was 7.41±1.885 g/dL while the average post-operative HbA1c was 5.482±0.687 g/dL (p=0.00). Complete remission developed in 13 patients with obstructive sleep apnea (OSA) syndrome, they stopped using continuous positive airway pressure equipment. Recovery was seen in only 5 of 11 patients with hyperlipidemia, no remissions were seen. Full remission of hypertension was seen in 41 patients and 3 patients had improvement. The reflux symptoms of 25 patients, who had reflux complaints and received hiatal hernia repair, completely disappeared (Table 5).

Discussion

Today, Sleeve Gastrectomy is the most frequently performed restrictive bariatric surgical procedure in the patient group with BMI ≥50 since it is technically easier than other bariatric procedures and due to patient preference(18,19). SG was developed as the first stage of a 2-stage bariatric surgical procedure especially for the super obese patient group with BMI ≥50(20,21). The consequent studies proved that SG on its own was also an effective bariatric surgical procedure (8,22,23). Some studies performed showed that SG provided more weight loss and caused less development of insulin sensitivity as compared to RYGB(24,25). On the other hand, recent randomized clinical studies showed that SG and RYGB were equally effective in weight loss and treatment of comorbidities(26,27). One of the most important methods used to assess the success of surgery is EWL%. In our study, we identified that the average EWL% was 67.58±13.37 in month 12 and 74.14±10.03 in month 24. The mean values of all months were found significantly different (p<0.001). According to the Bonferroni multiple comparison test, in all possible binary comparisons (3rd, 6th, 12th, 18th, 24th), EWL% were significantly different (p<0.001), except for the 18th – 24th months. It was seen in the study performed that the process of
weight loss continued until month 24, but there were no statistically significant difference between months 18 and 24. accepting the success rate as EWL%≥50 according to the Modified Reinhold criteria, it was found to be 93.55%, 96.8% and 92% in months 12, 18 and 24, respectively. When assessed according to the Biron criteria (BMI<40), it was found to be 84.92%, 92.4% and 88% in months 12, 18 and 24.

As far as current studies are concerned, Bhandari et al performed a study with 514 super obese patients. In years 2 and 3 of this study, the EWL% was found to be 74.24% and 62.38% in the SG group and 71.4% and 69.55% in the RYBG group. Again, in the same study, this rate was identified as 87.88% and 85.11% in the Banded SG group (27). Rendo A et al. performed a study on 134 patients who received SG and their EWL% in years 1 and 2 were 61.3%, 62.6%, respectively (28). In a study conducted by Silva R et al. with 213 SO patients, the group that received SG had EWL% of 58.74 and 59.90 in years 1 and 2, respectively. In the RYGB group, these were 67.58 and 72.19, respectively (29). In a study performed by Arapis K et al. which included 210 SSO patients, the EWL% was 48.81 and 54.17 in the SG group in years 1 and 2, respectively. In the RYGB group, these were 53.96 and 60.64, respectively (10). Celio AC et al. conducted a study with 50987 SO patients, EWL% was 49% and %58 in the SG and RYBG group, respectively (30). In a study conducted by Uno K et al. consisting of 48 SO patients, the EWL% was reported as 57.7% and 65.1% in the SG group in years 1 and 2, respectively; in the RYGB group, it was reported as 73.4% and 73.7%, respectively (31). Wang Y et al. conducted a meta-analysis study comprising 12 studies, where they reported that RYGB was found superior in terms of EWL% in the first 12 months while the situation was equalized between SG and RYGB in month 24(32). Similarly, Bhandari et al. performed a study where they reported similar average EWL% values for RYGB and SG in year 3(27). Arapis K et al. also recommended SG as the primary surgical procedure in a study on a group of SSO patients. Once again, in the same study, it was reported that SG and RYGB produced similar results in terms of changes in EWL% and BMI in year 4(10). (Table 6)

More recently, a randomized Swiss Multicenter Bypass or Sleeve Study (SM-BOSS) which compared bariatric surgery patients that received SG and RYBG reported that no significant differences were seen between the SG and RYGB groups. The excessive Body Mass Index loss was found to be similar between LSG and LRYGB at each time point (1 year: 72.3±21.9% vs. 76.6±20.9%, P =0.139; 2 years: 74.7±29.8% vs. 77.7±30%, P = 0.513; 3 years:70.9±23.8% vs. 73.8±23.3%, P =0.316)(26).

The patients that were operated on were observed to have a significant improvement in comorbid diseases, as well. While full remission or improvements were noted in comorbidities such as DM, HT, Hyperlipidemia, OSA and GERD, full remission was not observed in patients with hyperlipidemia. It was observed that only 45.45% of patients with hyperlipidemia had improvement. There are studies which state that better results are obtained with RYGB in the improvement of comorbid diseases, especially Type 2 DM(32). A recent meta-analysis comparing SG and RYGB, which included 18455 patients and 62 studies to assess obesity-related comorbidities, found that RYGB had a statistically significant superiority in the remission of Hyperlipidemia and GERD. However, no statistically significant differences were seen in the DM and OSA remission(33). Singla V et al. conducted a study with 75 SO patients and found that the remission rate for Type 2 DM was 85.7% in the SG group and 77.7% in the RYGB group (p=0.59)(34). Silva et al. found that there were no differences in terms of the remission of diabetes in years 1 and 2 among RYGB, SG and AGB (p=0.91-p=0.13)(29). Different pathophysiological mechanisms other than weight loss also play a role in the correction of comorbidities following LSG. These include mechanisms such as increased gastric emptying and intestinal transit, increased GLP-1 hormone level and decreased ghrelin levels(35,36). Also in our study, Type 2 DM patients demonstrated a remission rate of 89.36% (n=42). The average HbA1c level of patients in the pre-operative period was 7.41±1.885 g/dL while it was identified as 5.482±0.687 g/dL in the post-operative period. As for the OSA patients, remission was observed in all of them. GERD following SG is an important problem. All patients that had reflux symptom and hiatal failure before surgery also received concomitant hiatal hernia repair. In all of these patients, the reflux symptoms disappeared in the post-operative period.
Especially in the SO patient group, SG can be performed more easily and safely than other surgical procedures given the large liver volume, limited intraabdominal operating space, increased abdominal wall thickness and increased abdominal fat tissue(37). Since the accompanying comorbidities are higher in number in super obese patients, their complications and mortality rates are also higher(28,30,38,39). As the risk of mortal progress is high when super obese patients develop complications, surgeries need to be performed with minimal complications especially in this patient group. Intervening on complications that develop in such patients is more difficult as compared to other patients. This is another factor that affects mortality. As per some studies performed, the rate of complications such as stapler line leaks, stricture, intraabdominal hemorrhage, abscess, PE, DVT, pneumonia, myocardial infarction and wound infection is in the range of 3.8-15.7%. The duration of surgery and hospital stay are also relatively long(5,28,30,40,41). According to the studies conducted, the mortality rate was in the range of 0.008-0.18% in the non-super obese patient group while the super obese patient group had mortality rates ranging up to 3.7%(28,30,39,40,42,43,44). No mortality and major complications were observed in our study. The concomitantly performed surgeries such as cholecystectomy and hiatal hernia repair did not have an effect on mortality and morbidity. One of the major complications that may be observed during SG surgery is stapler line leaks. The possibility of having a leak as a result of a technical error was checked via methylene blue leak test conducted during surgeries. It was ensured during surgery that the stapler line was straight and there were no twists in the stomach. The patients were recommended to avoid drinking liquids in one ago and to drink them slowly, in small sips so to prevent a leak secondary to increased intraluminal pressure in the post-operative period, as well.

**Conclusion**

Our study has shown that SG is a rather effective method on its own for weight loss and resolution of comorbidities in patient with a BMI \(\geq 50 \text{ kg/m}^2\) groups. It can be performed at experienced centers with minimal morbidity and no mortality. Considering the large liver volume, limited intraabdominal operating space and increased abdominal wall thickness in super obese patients, SG should be considered as the first option. Long-term prospective randomized studies are needed in order to confirm these findings.

**Abbreviations**

SG: Sleeve Gastrectomy; BMI: Body Mass Index; HHR: Hiatal Hernia Repair; EWL%: The percentage of excess weight loss; TWL%: The percentage of total weight loss; DM: Diabetes mellitus; HT: Hypertension; SO: Super obese (BMI \(\geq 50 \text{ kg/m}^2\)); SSO: Super-super obese (BMI \(\geq 60 \text{ kg/m}^2\)); RYGB: Roux and Y Gastric Bypass; EW: Excess weight; GERD: Gastroesophageal reflux disease; OSA: Obstructive sleep apnea.

**Declarations**

**Ethics approval and consent to participate**

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional review board of ethics committee and national research committee with the 1964 Helsinki declaration and its later amendments. The institutional review board of our institution approved the study (Biruni University Ethics committee, number 2021/47-46) The informed consent requirement was waived.

**Consent for publication**

Not applicable.

**Availability of data and materials**
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

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The authors have no financial support to declare.

**Authors’ contributions**

Study conception: AO; Study design: AO; Data acquisition: AO, YC; Quality control of data and algorithms: AO, YC; Data analysis and interpretation: AO, YC; Statistical analysis: YC; Manuscript preparation: AO, YC; Manuscript editing: AO; Manuscript review: AO; Final approval of the article: all authors. All authors read and approved the final manuscript.

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**References**

1. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham L, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health. 2009;9:88.

2. Sampalis JS, Liberman M, Auger S, Christou NV. The impact of weight reduction surgery on health-care costs in morbidly obese patients. Obes Surg 2004;14:939-947.

3. Sjostrom L, Narbro K, Sjostrom CD, Karason K, Larsson B, Wedel H, et al. Swedish Obese Subjects S: Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med 2007;357:741-752.

4. Parikh MS, Shen R, Weiner M, Siegel N, Ren CJ. Laparoscopic bariatric surgery in super-obese patients (BMI>50) is safe and effective: a review of 332 patients. Obes Surg. 2005;15:858-63.

5. Zerrweck C, Sepúlveda EM, Maydón HG, Campos F, Spaventa AG, Pratti V, et al. Laparoscopic gastric bypass vs. sleeve gastrectomy in the super obese patient: early outcomes of an observational study. Obes Surg 2014 May;24(5):712-7.

6. Regan JP, Inabnet WB, Gagner M, Pomp A. Early experience with two-stage laparoscopic Roux-en-Y gastric bypass as an alternative in the super-super obese patient. Obes Surg 2013;23:861–864.

7. Thereaux J, Corigliano N, Poitou C, Oppert JM, Czernichow S, Bouillot JL. Comparison of results after one year between sleeve gastrectomy and gastric bypass in patients with BMI ≥ 50 kg/m². Surg Obes Relat Dis. Jul-Aug 2015;11(4):785-90.

8. Lemanu DP, Srinivasa S, Singh PP, MacCormick AD, Ulmer S, Morrow J, et al. Single-stage laparoscopic sleeve gastrectomy: safety and efficacy in the super-obese. J Surg Res 2012 Sep;177(1):49-54.

9. Gagner M, Gumbs AA, Milone L, Yung E, Goldenberg L, Pomp A. Laparoscopic sleeve gastrectomy for the super-super obese (body mass index[60 kg/m(2)]). Surg Today 2008;38(5):399-403.
10. Arapis K, Macrina N, Kadouch D, Parenti LR, Marmuse JP, Hansel B. Outcomes of Roux-en-Y gastric bypass versus sleeve gastrectomy in super-super-obese patients (BMI ≥ 60 kg/m2): 6-year follow-up at a single university. Surg Obes Relat Dis. 2019 Jan;15(1):23-33.

11. Brethauer SA, Kim J, Chaar ME, Papasavas P, Eisenberg D, Rogers A, et al. ASMBS Clinical Issues Committee. Standardized outcomes reporting in metabolic and bariatric surgery. Surg Obes Relat Dis. 2015;11(3):489–506.

12. Christou NV, Look D, Maclean LD. Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 years. Ann Surg. 2006;244(5):734–40.

13. Reinhold RB. Critical analysis of long term weight loss following gastric bypass. Surg Gynecol Obstet. 1982;155(3):385–94.

14. Brion S, Hould FS, Lebel S, Marceau S, Lescelleur O, Simard S, et al. Twenty Years of Biliopancreatic Diversion: What Is the Goal of the Surgery? Obesity Surgery 2004 Feb;14(2):160-4

15. American Diabetes Association. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2020. Diabetes Care. 2020 Jan;43(Suppl 1):S14-S31

16. Vigneri S, Termeni R, Leandro G, Badalamenti S, Pantalena M, Savarino V, et al. A comparison of five maintenance therapies for reflux esophagitis. N Eng J Med 1995; 333: 1106–10.

17. Madan K, Ahuja V, Kashyap PC, Sharma MP. Comparison of Efficacy of Pantoprazole Alone Versus Pantoprazole Plus Mosapride in Therapy of Gastroesophageal Reflux Disease: A Randomized Trial. Dis Esophagus. 2004;17(4):274-8.

18. Brethauer SA, Hammel JP, Schauer PR. Systematic review of sleeve gastrectomy as staging and primary bariatric procedure. Surg Obes Relat Dis Off J Am Soc Bariatr Surg. 2009;5:469–75.

19. Clinical Issues Committee of the American Society for Metabolic and Bariatric Surgery. Updated position statement on sleeve gastrectomy as a bariatric procedure. Surg Obes Relat Dis Off J Am Soc Bariatr Surg. 2010;6:1–5.

20. Ren CJ, Patterson E, Gagner M. Early results of laparoscopic biliopancreatic diversion with duodenal switch: a case series of 40 consecutive patients. Obes Surg 2000 Dec;10(6):514-23; discussion 524.

21. Regan JP, Inabnet WB, Gagner M, Pomp A. Early experience with two stage laparoscopic Roux-en-Y gastric bypass as an alternative in the super-super obese patient. Obes Surg. 2003;13(6):861–4.

22. Hong J, Park S, Menzo EL, Rosenthal R. Midterm outcomes of laparoscopic sleeve gastrectomy as a stand-alone procedure in super-obese patients. Surg Obes Relat Dis. 2018;14(3):297–303.

23. Eid GM, Brethauer S, Mattar SG, Titchner RL, Gourash W, Schauer PR. Laparoscopic sleeve gastrectomy for super obese patients: forty-eight percent excess weight loss after 6 to 8 years with 93% follow-up. Ann Surg. 2012;256(2):262–5.

24. Schauer PR, Kashyap SR, Wolski K, Brethauer SA, Kirwan JP, Pothier CE, et al. Bariatric surgery versus intensive medical therapy in obese patients with diabetes. N Engl J Med 2012;366:1567-1576.

25. Gracia-Solanas JA, Elia M, Aguilella V, Ramirez JM, Martinez J, Bielsa MA, et al. Metabolic syndrome after bariatric surgery. Results depending on the technique performed. Obes Surg 2011;21:179-185.

26. Peterli R, Wolnerhanssen BK, Vetter D, Nett P, Gass M, Borbely Y, et al. Laparoscopic Sleeve Gastrectomy Versus Roux-Y-Gastric Bypass for Morbid Obesity: 3-Year Outcomes of the Prospective Randomized Swiss Multicenter Bypass Or Sleeve Study (SM-BOSS). Ann Surg 2017 Mar;265:466-473.

27. Bhandari M, Ballesteros GPDL, Kosta S, Bhandari M, Humes T, Mathur W, et al. Surgery in Patients With Super Obesity: Medium-Term Follow-Up Outcomes at a High-Volume Center. Obesity Journal 2019 Oct;27(10):1591-1597.

28. Rendo AG, Rodriguez JRM, Bardaji FD, Trujillo BM, Paz FMD, González MDPC, et al. Laparoscopic Sleeve Gastrectomy for High-Risk Patients in a Monocentric Series: Long-Term Outcomes and Predictors of Success. Obes Surg. 2019 Nov;29(11):3629-3637.
29. Bettencourt-Silva R, Neves JS, Pedro J, Guerreiro V, Ferreira MJ, Salazar D, et al. Comparative Effectiveness of Different Bariatric Procedures in Super Morbid Obesity. Obes Surg. 2019 Jan;29(1):281-291.

30. Celio AC, Wu Q, Kasten KR, Manwaring ML, Pories WJ, Spaniolas K, Comparative effectiveness of Roux-en-Y gastric bypass and sleeve gastrectomy in super obese patients Surg Endosc. 2017 Jan;31(1):317-323.

31. Uno K, Seki Y, Kasama K, Wakamatsu K, Umezawa A, Yanaga K, et al. A Comparison of the Bariatric Procedures that Are Performed in the Treatment of Super Morbid Obesity. Obes Surg. 2017 Oct;27(10):2537-2545.

32. Wang Y, Song YH, Chen J, Zhao R, Xia L, Cui YP, et al. Roux-en-Y Gastric Bypass Versus Sleeve Gastrectomy for Super Obese and Super Obese: Systematic Review and Meta-analysis of Weight Results, Comorbidity Resolution. Obes Surg 2019 Jun;29(6):1954-1964.

33. Li J, Lai D, Wu D. Laparoscopic Roux-en-Y Gastric Bypass Versus Laparoscopic Sleeve Gastrectomy to Treat Morbid Obesity-Related Comorbidities: a Systematic Review and Meta-analysis. Obes Surg 2016 Feb;26(2):429-42

34. Singla V, Aggarwal S, Garg H, Kashyap L, Shende DR, Agarwal S. Outcomes in Super Obese Patients Undergoing Laparoscopic Sleeve Gastrectomy. J Laparoendosc Adv Surg Tech A. 2018 Mar;28(3):256-262.

35. Vigneshwaran B, Wahal A, Aggarwal S, Priyadarshini P, Bhattacharjee H, Khadgawat R, et al. Impact of sleeve gastrectomy on type 2 diabetes mellitus, gastric emptying time, glucagon-like peptide 1 (GLP-1), ghrelin and leptin in non-morbidly obese subjects with BMI 30–35.0 kg/m(2): A prospective study. Obes Surg 2016;26:2817–2823.

36. Benaiges D, Más-Lorenzo A, Goday A, Ramon JM, Chollarón JJ, Pedro-Botet J, et al. Laparoscopic sleeve gastrectomy: more than a restrictive bariatric surgery procedure? World J Gastroenterol. 2015;21:11804–14.

37. Villamere J, Gebhart A, Vu S, Nguyen NT, Body mass index is predictive of higher in-hospital mortality in patients undergoing laparoscopic gastric bypass but not laparoscopic sleeve gastrectomy or gastric banding. Am Surg. 2014;80:1039–43.

38. Bloomston M, Zervos EE, Camps MA, Goode SE, Rosemurgy AS. Outcome following bariatric surgery in super versus morbidly obese patients: does weight matter? Obes Surg 1997;7:414-419.

39. Oliak D, Ballantyne GH, Davies RJ, Waselewski A, Schmidt HJ. Short-term results of laparoscopic gastric bypass in patients with BMI ≥ 60. Obes Surg 2002;12:643-647.

40. Stephens DJ, Saunders JK, Belsley S, Trivedi A, Ewing DR, Iannace V et al. Short-term outcomes for super-super obese (BMI ≥ 60 kg/m2) patients undergoing weight loss surgery at a high-volume bariatric surgery centre: laparoscopic adjustable gastric banding, laparoscopic gastric bypass, and open tubular gastric bypass. Surg Obes Relat Dis 2008;4:408-415.

41. Wang C, Yang W, Yang J. Surgical results of laparoscopic Roux-en-Y gastric bypass in super obese patients with BMI ≥ 60 in China. Surg Laparosc Endosc Percutan Tech 2014;24:e216-e220.

42. Abeles D, Kim JJ, Tamoff ME, Shah S, Shikora SA. Primary laparoscopic gastric bypass can be performed safely in patients with BMI ≥ 60. J Am Coll Surg 2009;208:236-240.

43. DeMaria EJ, Pate V, Warthen M, Winegar DA. Baseline data from American Society for Metabolic and Bariatric Surgery-designated Bariatric Surgery Centers of Excellence using the Bariatric Outcomes Longitudinal Database. Surg Obes Relat Dis 2010;6:347-355.

44. Cardoso L, Rodrigues D, Gomes L, Carrilho F. Short- and long-term mortality after bariatric surgery: a systematic review and meta-analysis. Diabetes Obes Metab 2017;19:1223-1232.

Tables

Table 1: Modified Reinhold Classification
| Result        | BMI (kg/m²) | Excessive Weight Loss % |
|---------------|-------------|-------------------------|
| Excellent     | ≥30         | ≥75                     |
| Good          | 30-35       | 50-75                   |
| Failure       | ≥35         | ≤50                     |

Table 2: Patient Characteristic

|                          | n(%)            |
|--------------------------|-----------------|
| Total Number of Patients | 138 (100)       |
| Female                   | 104 (75.36)     |
| Age                      | 37.41±12.33     |
| Height                   | 162.7±8.783     |
| Weight                   | 149.3±24.16     |
| BMI                      | 56.36±7.661     |
| Excess Weight            | 82.95±21.15     |

**Surgery Type**

- Sleeve Gastrectomy      | 90 (65.21)      |
- SG + Cholecystectomy    | 23 (16.66)      |
- SG + HHR               | 21 (15.21)      |
- SG + HHR + Cholecystectomy | 4 (2.89)   |

| Hospital Stay (median)  | 3 (3-6)         |
| Hypertension            | 44 (31.88)      |
| Type 2 DM               | 47 (34.05)      |
| Cardiac Disease         | 7 (5.07)        |
| OSA                     | 13 (9.42)       |
| Respiratory Disease     | 25 (18.11)      |
| GERD                    | 25 (18.11)      |
| Psychological Disorders | 8 (5.79)        |

|                          | Before Surgery  | After Surgery |
|--------------------------|-----------------|---------------|
| HbA1c                    | 6.10±1.498      | 5.20±0.505    |
| -HbA1c (Diabetic Patients)| 7.41±1.885    | 5.482±0.687   |
| Glucose                  | 114.4±36.27     | 88.80±11.08   |
| Total Cholesterol        | 190.9±41.68     | 191.2±41.98   |
| LDL                      | 123.2±30.66     | 122.5±36.22   |
Table 3. Distribution of the mean BMI (kg/m²), EWL% and TWL% for patients in different months and the results of “Repeated ANOVA Test” followed by Post-Hoc Bonferroni Test

| Time (Month) | n  | BMI ±SD | P   | EWL% ±SD | p  | TWL% ±SD | p  |
|--------------|----|---------|-----|----------|----|----------|----|
| 0            | 138| 56.36   | 7.660|          |    |          |    |
| 3rd          | 125| 45.10   | 7.128|          |    |          |    |
| 6th          | 116| 39.76   | 6.165| <0.001*  |    |          |    |
| 12th         | 93 | 35.48   | 6.285|          |    |          |    |
| 18th         | 79 | 33.96   | 5.305|          |    |          |    |
| 24th         | 50 | 33.41   | 6.198|          |    |          |    |

Table 4. Postoperative success rate according to the excess weight loss percentage (EWL%), Body Mass Index (BMI) and Reinhold criteria during follow-up

| EWL| Follow-up | BMI
|----|-----------|----
|    | EWL<50a n (%) | EWL50–74b n (%) | EWL≥75c n (%) | Good and Excellentb,c n (%) | <30a n (%) | 30–35b n (%) | >35c n (%) | Good and Excellenta,b n (%) | BMI>40 n (%)
|----|-------------|-----------------|--------------|-----------------|----------|-------------|-----------|-----------------|-----------|
| 3rd Month | 117/125 (93.60) | 8/125 (6.4) | - | 6.4 | - | 1/125 (0.008) | 124/125 (0.992) | 0.008 | 20/125 (16) |
| 6th Month  | 33/116 (28.45) | 78/116 (67.24) | 5/116 (4.310) | 71.55 | 3/116 (2.586) | 20/116 (17.24) | 93/116 (80.17) | 19.83 | 80/116 (68.96) |
| 12th Month | 6/93 (6.452) | 51/93 (54.84) | 36/93 (38.71) | 93.55 | 17/93 (18.27) | 38/93 (40.86) | 38/93 (40.86) | 59.13 | 79/93 (84.94) |
| 18th Month | 3/79 (3.797) | 38/79 (48.10) | 38/79 (48.10) | 96.8 | 25/79 (31.65) | 31/79 (39.24) | 23/79 (29.11) | 70.89 | 73/79 (92.4) |
| 24th Month | 4/50 (8.0) | 20/50 (40.0) | 26/50 (52.0) | 92.0 | 16/50 (32.00) | 14/50 (28.00) | 20/50 (40.00) | 60.00 | 44/50 (88) |

Table 5. Resolution of Comorbidities
| Conditions         | Patients (n) | Resolved | Improved |
|-------------------|--------------|----------|----------|
| Diabetes          | 47           | 42 (89.36%) | 5        |
| Hypertension      | 44           | 41 (93.18%) | 3        |
| Hyperlipidemia    | 11           | -         | 5 (45.45%) |
| OSA               | 13           | 13 (100%)  | -        |
| GERD              | 25           | 25 (100%)  | -        |

Table 6: Studies of Patients with a BMI ≥ 50 kg/m²

| Study Name and Year | Number of Patients | BMI      | EWL% YEAR 1 | EWL% YEAR 2 | Mortality - Major Complications |
|---------------------|--------------------|----------|--------------|--------------|---------------------------------|
| Silva R (2018)      | SG (67) RYGB (127) | 54.73±4.89 | 58.74±17.78  | 59.90±18.15  | 0% -6.6%                       |
| Rendo A (2019)      | SG (134)           | 55.9±6.7  | 61.3±18      | 62.6±22.7    | 3.7% - 15.7%                   |
| Uno K (2017)        | SG (28) RYGB (20)  | 57.1±5.1  | 57.7±21.4    | 65.1±23.4    | 0-10.7%                        |
| Heredia R (2015)    | SG (77) RYGB (12)  | 64.9±4.2  | 43.6±13.8    | 45.8±19.2    | 0-2.2%                         |
| Singla W (2019)     | SG (50) OAGB (25)  | 54.18±4.06 | 56.2±18.92  | 0 / %4       |
| Celio A C (2016)    | SG (8868) RYGB (42119) | 57.8  | 49±15.7      | 0.2% - 11.1% |
| Arapis K (2018)     | SG (91) RYGB (119) | 68.2±7.1  | 48.81±5      | 54.17±5      | 1.09%-16.1%                    |

Figures
Figure 1

Distribution of the mean BMI (kg/m2), EWL% and TWL% for patients in different months and the results of “Repeated ANOVA Test” followed by Post-Hoc Bonferroni Test. Months (0, 3rd, 6th, 12th, 18th, 24th) were significantly different for EWL%, TWL% and BMI variables ($p<0.001$), but EWL% ($p = 0.527$), TWL ($p = 0.396$) and BMI ($p=0.657$) were not found significantly different between the 18th and 24th months.