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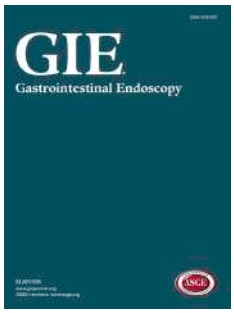

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Endoscopic sleeve gastroplasty in the management of overweight and obesity: an international multicenter study

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ABSTRACT

Background and Aims: Obesity is a pandemic effecting approximately 700 million adults worldwide with an additional 2 billion overweight. Endoscopic sleeve gastroplasty (ESG) is a minimally invasive endoscopic bariatric therapy that involves remodeling of the greater curvature, in an effort to reduce gastric capacity and delay gastric emptying. A variety of ESG suture patterns have been reported. This study is the first to use a uniform 'U' stitch pattern across all centers to simplify technical aspects of the procedure and limit cost. This also uniquely assessed outcomes in all BMI categories and changes in metabolic rate, lean body mass, and adipose tissue composition.
Methods: This is a multicenter analysis of prospectively collected data from 7 centers including patients with overweight and obesity who underwent ESG. Primary outcomes included AWL, %TWL, change in BMI, %EWL at 6 and 12 months in overweight, obese class I, II, and III. Secondary outcomes included adipose tissue, lean body mass reduction, and metabolic rate analyzed by bioimpedance. Additionally, immediate or delayed adverse events were analyzed. Clinical success was defined as achieving ≥25% EWL at 1 year with ≤ 5% serious adverse event rate following the ASGE/ASMBS threshold.

Results: A total of 193 patients underwent ESG during the study period. All groups had >10% TWL and >25% EWL at 6 months follow-up. On avarage, %TWL was 14.25% ± 5.26 and 15.06% ± 5.22 and the %EWL was 56.15% ± 22.93 and 59.41% ± 25.69 at 6 months and 1-year follow-up, respectively. %TWL was 8.91%±0.3, 13.92%±5.76, 16.22%±7.69, and 19.01%±0.95, and %EWL was 56.21%±2.0, 62.03%±27.63, 54.13%±23.46, and 46.78%±2.43 for overweight, obesity class I, II, and III, respectively, at 1 year. Male, age <41 years old, and higher BMI are predictors of achieving a TWL ≥10% at 1-year follow-up. There was a significant reduction in adipose tissue from baseline. Severe adverse events occurred in 1.03% including 2 perigastric collections needing surgery.

Conclusion: Endoscopic sleeve gastroplasty appears to be feasible, safe, and effective in the treatment of patients with overweight and obesity according to the ASGE/ASMBS thresholds.

Key words: Bariatric, Endoscopy, Suturing, Surgery, Weight

INTRODUCTION

Obesity is a pandemic effecting approximately 700 million adults worldwide with an additional 2 billion overweight. Obesity is associated with metabolic conditions, such as type 2 diabetes, hypertension, and other diseases [1,2]. The most effective and durable treatment for obesity is bariatric and metabolic surgery [3-5]. However, disadvantages include the invasive and irreversible nature of the procedure and the

non-negligible morbidity and mortality rates [6-8]. Furthermore, less than 2% of eligible patients who fulfill the criteria for bariatric surgery undergo the procedure. The reasons for this are multifactorial and likely include high surgical risk, morbidity, costs, access, and patient preference [9,10].

As a result, there is a drive to develop less-invasive, reversible, and cost-effective therapies to combat this epidemic. Endoscopic therapies that focus on weight loss are important because they are more effective than pharmacological treatments and lifestyle changes and present lower adverse event rates compared with bariatric surgery [11-13].

Endoscopic sleeve gastroplasty (ESG) is an incisionless, minimally invasive technique that involves remodeling of the greater curvature, via the placement of full-thickness sutures, in an effort to reduce gastric capacity and delay gastric emptying. [14,15]. The original greater curvature ESG was performed using a superficial suction-based suturing device and had limited results due to early suture loss [16,17]. Later, ESG was performed using the current full-thickness suturing device demonstrating technical feasibility, safety, and improved efficacy of this procedure in terms of weight loss in a variety of clinical settings around the world [15-24]. Additionally, improvement in hypertension, and physiological changes including early satiety, delay gastric emptying, and decrease of biomarkers of diabetes have been reported [14,19,22,23]. A variety of suturing patterns have been used as the procedure has evolved, with the main focus remaining greater curvature remodeling. A limitation of the prior literature has been this technical heterogeneity as evidenced by multiple techniques reported across the literature, as well as, within most individual publications. The “U” stitch has recently been adopted by many centers; however, there are limited data on this in the published literature. Additionally, there is no study evaluating the efficacy of this procedure specifically in overweight patients or in those with higher classes of obesity.

In this international multicenter study, we aim to report the efficacy and safety of ESG, with a “U” stitch pattern and a single inner row of sutures, analyzing the results across the full spectrum of overweight-obesity.

METHODS

Participants

This is a retrospective multicenter analysis of prospectively collected data from seven centers (Brigham and Women’s Hospital, Healthme Gerenciamento de Perda de Peso, Angioskope Clinic, Endobatel Endoscopia Bariatrica Avançada, Instituto Mineiro de Obesidade, Endodiagnostic Clinic, Hospital das Clinicas da Faculdade de Medicina da Universidade de Sao Paulo), including 193 consecutives patients undergoing ESG between July 2017 and August 2018. None of these patients were included in previous studies. All patients were overweight or obese adults who failed diet and lifestyle

modifications attempts with no contraindication to ESG, namely, previous gastric surgery, anticoagulation, acute gastric ulceration, cancer, hiatal hernia larger than 5 cm, gastroesophageal motility disorder, and pregnancy. All patients were seen in clinic before the procedure to discuss alternative therapies such as medications, other endoscopic bariatric therapies (EBT) and surgery. Additionally, an appointment with a nutritionist, phycologist, and psychiatrist were required before the procedure.

Ethical concerns

An Institutional Review Board (IRB) approval for retrospective analysis was obtained for each center before collecting data for this study. Additionally, a written informed consent from each center was obtained from all patients before the procedures.

Procedure

All procedures were performed by endoscopists who had a limited experience with this novel technique, including early learning curve, except for the U.S. center, which had a more-extensive experience. All procedures were performed in the endoscopy suite, with the patient in the left-lateral position under general anesthesia and with the use of carbon dioxide insufflation. All patients received prophylactic antibiotics and deep vein thrombosis prophylaxis according to local protocols. An esophagogastroduodenoscopy was performed to confirm absence of exclusion criteria. An esophageal overtube was inserted to prevent mucosal damage during the Apollo OverStitch device (Apollo Endosurgery, Austin, Tex) insertion and to avoid air leakage during the procedure. The endoscopic suturing device mounted on a double-channel gastroscope (GIF2T160 or 180 series, Olympus Optical, Tokyo, Japan) was advanced to the gastric lumen. A catheter type tissue screw, or tissue helix, was used to ensure that sequential full-thickness bites were taken, which is critical for procedure durability. Using the suturing device, we placed 2/0 polypropylene running sutures beginning from the level of the incisura angularis to 1 to 2 cm below the gastroesophageal junction. Each suture was started at the lateral anterior wall, with further bites taken on the greater curvature and then the more proximal posterior wall. On completion of the suture pattern, the needle was released, anchoring the leading end of the suture. Using the proprietary cinching device, the suture was pulled tight to bring the tissue together, and the trailing end of the suture was anchored by deploying a cinch. The suture was contemporaneously trimmed. Generally, 6 to 11 bites per suture were performed. This pattern was then continued in a retrograde fashion, starting each subsequent suture within 1 cm proximal of the prior suture. Importantly, the individual stitches of the proximal suture were staggered in relation to the distal suture to avoid the formation of longitudinal gastric pockets. The fundus was not sutured and no reinforcing inner row of sutures (“reinforcing layer”) was performed. Typically, a total of 4 to 6 sutures, in a “U” stitch pattern were used per patient (Figure 1).

In all centers, patients were discharged on the same day and given a course of oral antibiotics, daily proton pump inhibitor, and oral antiemetics and analgesics as needed. After the procedure, the diet consisted of 3 to 6 weeks of liquid diet, followed by 2 weeks of soft food, and then transitioning to a regular diet, with a maximum intake of 1200 kcal/day. All centers provided patients with a comprehensive ancillary program to help patients establish positive dietary and lifestyle modifications, involving nutritionist, endoscopist, and a psychologist, biweekly or monthly. The programs lasted a minimum of 12 months post-ESG (Table 1).

Outcome Measures

Patient information, including age, sex, and baseline height, weight, and body mass index (BMI), were collected. Variations in BMI, absolute weight loss (AWL), percent total body weight loss (%TWL), percent excess weight loss (%EWL), at baseline 6 and 12 months. Additionally, adipose tissue and lean body mass were measured at 6 months. Primary outcomes included AWL, %TWL, change in BMI, %EWL at 6 and 12 months in overweight (25-29.9 kg/m^2), obese class I (30-34.9 kg/m^2), II (35-39.9 kg/m^2), and III (40 kg/m^2 and above). Secondary outcomes included adipose tissue, lean body mass reduction and metabolic rate analyzed by a horizontal 4-pole electric bioimpedance (Bioimpedance Analyzer-Biodynamics. Model 450, USA). Additionally, immediate or delayed adverse events were analyzed, Initial symptoms such as nausea and emesis and abdominal pain were analyzed in the first, second and third day after the procedure. Adverse events were defined as per the American Society for Gastrointestinal Endoscopy (ASGE) guidelines [25]. Abdominal pain was divided into four categories: severe (required intravenous medication and/or imaging exam), moderate (required oral medications), mild (abdominal discomfort, without needing medications), and no pain. Clinical success was defined as achieving ≥25% EWL at 1 year with ≤5% serious adverse event rate following the ASGE/American Society for Metabolic and Bariatric Surgery (ASMBS) threshold [26,27].

Statistical Analysis

Descriptive statistics were calculated for all demographic and clinical variables and presented as mean ± standard deviation (SD) for continuous variables or proportion (%) for categorical variables. Statistical analysis was done using the Fisher exact test or Chi-squared test (for 2 groups) or ANOVA test (for 3 or more groups) for categorical variables. Additionally, the Student t test (for normal distributed data) and Wilcoxon test (for skewed data) were used for continuous variables. All variables were tested for normality using the Shapiro-Wilk test. The Friedman test and binomial test to compare

groups were also performed. Boxplot was used to display median, minimum-maximum-range, inter-quartile-range, and outliers. Univariable and multivariable logistic regression using Firth's bias-reduced penalized-likelihood logistic regression analyses were then performed to assess predictors of success at 6 months and 1 year. In this analysis, success was defined as at least 10% TWL . Given the number of outcomes, three predictors were put into the multivariable model and these were chosen a priori. These predictors included age (<41 years old and >41 years old), sex, and BMI (overweight, class I, class II, and class III obesity). Analysis were performed using R software version 3.4.3 and IBM SPSS Statistics 22. Statistical significance was determined a priori at $p<0.05$.

RESULTS

Patient demographics

A total of 193 patients from 7 centers underwent ESG during the study period (Table 2). The mean procedure time was 76 ± 24 min. All patients were instructed to follow diet and lifestyle modification. From 193 patients, 12 were lost to follow-up (6.73%) before 6 months and 181 completed 6 months follow-up. Of these 181 patients, 57 have not yet reached 1-year follow-up and 3 patients were lost to follow-up. Therefore, 121 patients completed 1-year follow-up (399±28 days). Patient characteristics are described in Table 3.

Efficacy

AWL and BMI were statistically significant between preprocedure, 6 months, and 1-year follow-up in all groups. The AWL at 6 months and 1 year decreased from 93.4±10.31 kg to 79.9 ± 8.13 kg and 78.52 ± 8.62 kg, respectively (Figure 2). The BMI decreased from 34.11±2.97 kg/m^2 to 29.21±2.64 kg/m^2 after 6 months and to 28.91 ± 2.99 kg/m^2 after 1 year. Additionally, a statistical difference was found in BMI reduction in all groups. Class 3 obesity group had the higher BMI reduction at 1-year follow-up.

On avarage, %TWL was 14.25%±5.26 at 6 months and 15.06% ± 5,22 at 1-year follow-up. Obesity class II and III had higher %TWL at 1-year follow-up with a %TWL of 16.22% ± 7.69 and 19.01% ± 0.95, respectively (Figure 3). The %EWL was 56.15% ± 22.93% at 6 months and 59.41% ± 25.69 at 1-year follow-up. All groups had a %EWL higher than 50% at 1-year follow-up (Figure 4). Table 4 summarizes the primary outcomes of the study, including all results related to AWL, %TWL, BMI, and %EWL, including subgroup analysis.

Bivariable analysis

In the bivariable analysis, the chi-square test showed a significant association at 1-year follow-up between TWL >10% and patients younger than 41 years old, male sex, and higher BMI (Table 5).

Univariable and multivariable logistic regression

Univariable and multivariable regression analyses were performed to identify predictors of success for TWL ≥10%. This analysis showed significant association between sex (male) and achieving a TWL ≥10% at 6 months follow-up. The chance of a female achieving a10% TWL at 6 months follow-up after ESG is 0.182 times lower than that for male subjects in the univariable analysis, and 0.220 times lower in the multivariable analysis. Additionally, male, age <41 years old, and obese (class I, II, and III) showed significant association with achieving a TWL ≥10% at 1-year follow-up. In the univariate analysis, female sex was associated with a lower chance (0.208 times) of achieving clinical success (TWL ≥10%) and patients <41 years old were 3 times more likely to achieve success than patients over 41 years old. Patients that were overweight were 0.008 times less likely to achieve success than patients with class III obesity. Regarding the multivariable analysis, patients <41 years old were associated with a 3.529-fold increased chance of achieving clinical success than older patients. Finally, patients with class III obesity were associated with an increased chance of achieving 10% TWL compared with overweight patients (Table 6).

Modification in adipose tissue and lean body mass

The modification in adipose tissue and lean body mass were also analyzed at 6 months follow-up in 2 centers, including a total of 101 patients. A reduction was observed in adipose tissue ($p<0.05$) and no statistical difference was found in lean body mass (Figure 5). Additionally, the metabolic rate was also evaluated, and no statistical difference was observed (Figure 6). The results including adipose tissue, lean body mass and metabolic rate pre and 6 months after ESG are summarized in Table 7.

Safety

No intraprocedural adverse events were reported. All patients were discharged on the day of procedure. Mild adverse events such as nausea, emesis, and abdominal pain occurred in more than 50% of patients on the first day, as expected. These symptoms improved between the first and third day ($p<0.05$) and eventually subsided after 1 week. The change in symptoms over time are detailed in Table 8. Additionally, one patient

developed a deep venous thrombosis (DVT) that was successfully managed with medications.

Moderate adverse events occurred in 1.03% (2/193) of patients, including 2 patients with upper GI bleeding within 1 week of the procedure. Both presented with melena and received one unit of packed red blood cell.

Severe adverse events (SAE) occurred in 1.03% of patients including 2 that presented with severe abdominal pain and imaging revealing perigastric fluid collections. One of these patients underwent surgery to evacuate a collection that was found to be a hematoma, 1 week after the procedure. The other patient was found to have a leak 3 days after ESG and surgery was performed to drain the cavity and repair the leak. An endoscopy was also performed to cut the suture and relief the intraabdominal pressure in this case.

DISCUSSION

This is the first multicenter study of ESG in the management of overweight-obesity across the full BMI spectrum. Most guidelines do not recommend endoscopic or surgical interventions in patients with BMI between 25 kg/m^2 and 30 kg/m^2 (overweight). However, in some Brazilian centers endoscopic bariatric procedures are routinely performed in this patient population. In the Brazilian intragastric balloon consensus (28), which included data from more than 40 thousand patients, a BMI> 25 kg/m^2 was determined to be an indication for balloon placement. Hence, endoscopic sleeve gastroplasty is also performed in many of these centers in this patient population. A uniform technique employing the recently promoted “U” stitch pattern was used in all cases to minimize variability. Postprocedure symptom trends were also analyzed in detail. This study confirms that ESG can induce significant and sustained weight loss in this broad cohort for at least one year, according to the minimal thresholds of 25% EWL with <5% SAE recommended by the ASGE/ASMBS threshold for EBT [26,27]. Furthermore, this is the first study to evaluate changes in other relevant parameters including body composition, adipose tissue, lean body mass, and metabolic rate.

ESG with full-thickness suturing has demonstrated clinical effectives and safety, however, the technique continues to evolve. This concept was originally inspired by 2 older procedures, an abandoned endoscopic technique (endoluminal vertical gastroplasty) performed by Fogel et al [29] that focused on emulating a vertical banded gastroplasty along the mid proximal gastric body not involving the greater curvature, and the surgical gastric imbrication procedure. Greater curvature ESG was first performed in 2008 [16], followed by ESG with the current full-thickness suturing device being performed in 2012 by Thompson and Hawes [30]. Since this report, different numbers of sutures, orientation of sutures, spacing and frequency of bites, and the

tightness of cinching have been reported [31]. The different patterns, including “V,” “Z,” or “U” patterns, interrupted or running, with or without reinforcing sutures, show variable, but similar weight loss in the literature, including 6 months and 2-year follow-up [18,20,31-33]. In this multicenter study, all centers followed the same suture pattern, the “U” pattern, which consisted of 6 to 11 bites beginning at the anterior wall to greater curvature, and finally more proximal posterior wall. Typically, a total of 4 to 6 sutures were performed and the fundus was preserved.

It is well known that at least 10% TWL is related to improvements in obesity-related comorbidities [34,35]. Lifestyle modifications, diet and pharmacotherapies rarely can achieve 10% TWL, and when initially effective, weight regain is common [36]. EBT, such as intragastric balloons (IGB), frequently achieve 10% TWL; however, these are associated with a significant degree of weight regain after 1-year of follow-up [11,37]. In our study, a %TWL higher than 10% was achieved after ESG at 6 months (14.25%) and maintained at 1-year (15.06 %) follow-up. The %TWL was also analyzed in all subgroups, and a %TWL higher than 10% was achieved in the overweight subgroup at 6 months and in all obesity class subgroups at 6 months and 1-year follow-up. Additionally, a %TWL >15% was reported in patients with BMI greater than 35 Kg/m^2 at 1-year follow-up. Other studies report 2-year follow-up data and also showed %TWL higher than 15% [18,38].

In our study %EWL exceeded the recommended 25% EWL [26,27] by 2-fold with a mean of 56.15% at 6 months and 59.41% at 1-year, similar to previous reports [22,38]. In lower BMI groups, a higher %EWL was expect [39] and was confirmed in this study with a %EWL of 63.45% for the overweight group versus 49.42% for the class 3 obesity group at 6 months follow-up. From our population, 95% and 91% of patients achieved 25% EWL at 6 months and at 1-year follow-up, respectively. Additionally, significant AWL and BMI reduction was also demonstrated in all groups.

There are currently a variety of techniques used to perform ESG, with many centers using fewer sutures with a goal of increasing safety while decreasing procedure time and cost. In this study, we use the “U” stitch pattern, which is relatively easy to perform and train. This pattern spreads forces along several points in the tissue, without a large gap that occurs with other patterns. Additionally, this pattern can be performed with only 4 to 6 sutures, which is less expensive and could allow broader use of the technique. However, there is a question regarding lack of reinforcing sutures and the potential effect on clinical outcomes. Our BMI reduction at 6 months, without the use of reinforcement sutures, was 4.85 kg/m^2 compared with 5.6 kg/m^2 reported by Sartoretto et al [40], which included many patients with reinforcement sutures. Furthermore, when compared with a study including only patients with reinforcement sutures [23] this

unreinforced pattern appears to produce less weight loss (5.88 kg/m^2 versus 8.2 kg/m^2 at 1-year follow-up). Although direct comparisons between different studies are challenging for this procedure and patient population due to technical variability and differences in diet plans and use of weight loss medications, we believe that reinforcing sutures should be recommended.

The multivariable regression analysis showed that age less than 41 years old, male sex, and higher BMI were significant predictors for weight loss (TWL>10%), unlike what was reported in a prior study [18]. Sex was no longer significant at 1 year, whereas the association with age and BMI persisted. This is not surprising as younger more active patients are thought to be more likely to respond well to bariatric procedures. It is also well understood that patients with a higher initial BMI can more easily achieve greater total weight loss, whereas overweight patients are more likely to achieve greater %EWL. Nevertheless, this analysis was based on a relatively small number of patients and should be interpreted with caution.

In the literature, there are no studies evaluating changes in adipose tissue, lean body mass and metabolic rate before and after ESG. In this multicenter study, all patients were evaluated with horizontal 4-pole electric bioimpedance before the procedure and at the 6-month follow-up. The adipose tissue mass decreased with statistical significance, with similar results compared with other EBT such as IGB or bariatric surgery [41,42]. The lean body mass percentage slightly increased; however, no statistical difference was found. Additionally, the metabolic rate was evaluated and showed no difference between pre and post ESG measures.

Overall, ESG was well tolerated. In the literature, mild adverse events such as abdominal pain, nausea and emesis are not analyzed in detail because they are expected and managed conservatively with improvement after few days [19,22,32]. However, Alqahtani et al [24], reported 3 procedure reversal among 1000 patients due to intractable abdominal pain. In our study, we analyzed improvements of symptoms during the early postoperative period. Nausea and emesis were reported in 34.40% on the first day and the symptoms persisted in just 1.46% of patients on the third day. Mild abdominal pain was the most common symptom reported in 59.05% on the first day and 35.24% on the third day. A recent study [43] reported similar results, with 24.2% moderate abdominal pain and 31.2% nausea and emesis in the first 48 hours. Compared with other EBT, ESG appears to have favorable outcomes regarding these symptoms. IGB and duodenal jejunal bypass sleeves are also associated with approximately 7% and 18% early removals, respectively, whereas ESG reversal is extremely rare [24,26]. In our study, we also report a DVT treated with medication.

Moderate and SAE after ESG are not reported in most studies [14,19-21,40]. A recent review [44], including 9 ESG studies reported a 2.3% SAE rate, including gastric leaks, perigastric fluid collections, pulmonary embolism and pneumoperitoneum with pneumothorax. In our series, we report a 1.03% moderate and 1.03% SAE, including 2 upper GI bleeds and 2 perigastric fluid collections. All these AE occurred within 1 week after the procedure. The 2 postprocedure GI bleeds presented with melena. Similar to a recent study [24], endoscopy was performed in these patients and did not reveal any abnormal findings. In our study, both patients received a transfusion of one unit of packed red blood cells. Two patients with severe abdominal pain were diagnosed with perigastric fluid collections by CT scan. Unlike the previous 7 reports in the literature [18,23,24,45], both of our patients required surgery to evacuate the fluid collection. In one case, similar to prior reports [18], a perigastric hemorrhage was found to be the cause of the collection. In the other case, the patient presented with a leak 3 days after ESG. In this case, an upper GI endoscopy was performed to cut the suture and relieve the intraabdominal pressure. Different from Sharaiha et al [23] who reported a similar adverse event, our patient was already on antibiotics for the first 3 days after the procedure. In summary, ESG is associated with a lower rate of SAE, and no mortality, compared with surgical bariatric procedures which has up to a 20% SAE rate with 0.04% mortality [46-48]. Additionally, the SAE rate <5% achieves the threshold set by ASGE/ASMBS position paper [26,27].

We recognize there are some limitations to our study. This is a retrospective study with the inherent limitations expected with such a design, including potential selection bias, lack of randomization, and loss-to-follow-up. Additionally, this cohort includes the first cases performed at some centers, thus the learning curve could impact clinical results. Two centers with more extensive endoscopic suturing experience provided only 3 patients each, as they typically utilize reinforcement sutures, and have included subjects in previous studies, which are exclusion criteria for this study. Further studies with longer follow-up would be helpful to assess long-term durability of ESG using this ‘U’ stitch pattern. Additionally, prospective comparative studies including endoscopic or surgical techniques, or combination with medical therapy would also be of interest.

In summary, given the worsening obesity epidemic, there is increased demand for less invasive bariatric therapies. Considering the minimally invasive outpatient nature of this procedure, the reproducibility among centers with different experience levels, the low prevalence of SAE, and the robust clinical outcomes, ESG using the “U” stich pattern appears to be feasible, safe, and effective. Some questions remain regarding the optimal number of sutures and need for reinforcement, nevertheless, this study supports the use of ESG for the treatment of obesity across all BMI classes, as delineated by ASGE/ASMBS thresholds for EBTs.

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Figure legends:

Figure 1. “U” stich pattern.

Figure 2. Absolute weight loss at 6 months and 1-year follow-up.

Figure 3. %TWL reduction subgroup analysis at 6 months (A) and 1-year follow-up (B). Mean and standard deviation values are shown in the figures.

Figure 4. % EWL at 6 months and 1-year follow-up. Mean and standard deviation values are shown in the figure.

Figure 5. Parallel graphic between adipose tissue and lean body mass reduction before (A) and 6 months after (B) ESG.

Figure 6. Parallel graphic between metabolic rate before and 6 months after ESG.

TABLES:

Table 1. Follow-up protocol

	Before procedure	**1 month**	**2 months**	**3 months**	**6 months**	**9 months**	**12 months**
Endoscopist	YES	YES	NO	YES *	YES	YES *	YES
Nutricionist	YES	YES	YES	YES	YES	YES	YES
Phychologist	YES	YES	NO	YES*	YES	NO	YES
Physical educator *	YES	YES	YES	YES	YES	YES	YES

Label: * Not required in all centers

Table 2. Patients included in each center

Centers	ESG	6 months	1 year
Healthme	57	53	37
Angioskope Clinic	52	48	33
IMO	33	32	19
Endodiagnostic Clinic	29	27	18
Endobatel	16	15	9
Hospital das Clinicas	3	3	2
Brigham and Women's	3	3	3
TOTAL	193	181	121

Table 3. Patient demographics

Characteristics	Population (n, %)	Male (n)	Female (n)
Patients	193 (100%)	45	148
Age	42.3 ± 9.6	40.4 ± 8.9	42.6 ± 9.9
Height (m)	1.66 ± 0,08	1.76 ± 0.06	1.63 ± 0.06
Weight (kg)	93.4 ± 10.31	110.5 ± 15.1	89.5 ± 9.4
BMI	34.11 ± 2.97	35.6 ± 4.69	33.6 ± 3.02
Overweight	12 (6.21%)	-	12
Obesity class I	111 (57.51%)	22	89
Obesity class II	54 (27.97%)	14	40
Obesity class III	16 (8.29%)	9	7

Mean, ± Standard deviation. BMI, Body mass index.

Table 4. Primary outcomes results

Variables	Initial (n=193)	6 months (n=181)	1 year (n=121)	*P* value
Weight (Kg)	93.4 ± 10.31 Kg	79.9 ± 8.13 Kg	78.52 ± 8.62 Kg	< 0.05
Overweight	80.00 ± 0.0 Kg	71.90 ± 0.0 Kg	72.42 ± 0.6 Kg	< 0.05
Obesity class 1	90.33 ± 7.95 Kg	78.26 ± 7.79 Kg	77.64 ± 7.79 Kg	< 0.05
Obesity class 2	98.41 ± 9.80 Kg	82.75 ± 7.60 Kg	81.06 ± 9.43 Kg	< 0.05
Obesity class 3	111.60 ± 16.12 Kg	88.95 ± 9.97 Kg	89.54 ± 13.07 Kg	< 0.05
% TWL	-	14.25% ± 5.26%	15.06 ± 5.22%	-
Overweight	-	10.13% ± 0.0%	8.91% ± 0.3%	-
Obesity class 1	-	13.33% ± 5.00%	13.92 % ± 5.76%	-
Obesity class 2	-	15.71% ± 5.58%	16.22 %± 7.69%	-
Obesity class 3	-	20.11 %± 2.61%	19.01% ± 0.95%	-
BMI	34.11 ± 2.97	29.21 ± 2.64	28.91 ± 2.99	< 0.05
Overweight	29.74 ± 0.0	26.73 ± 0.0	26.98 ± 0.3	< 0.05
Obesity class 1	32.55 ± 1.47	28.22 ± 2.09	27.92 ± 2.69	< 0.05
Obesity class 2	36.65 ± 1.00	30.90 ± 2.40	30.16 ± 3.75	< 0.05
Obesity class 3	42.16 ± 0.13	33.68 ± 1.20	34.01 ± 0.82	< 0,05
% EWL	-	56.15% ± 22.93%	59.41% ± 25.69%	-
Overweight	-	63.45% ± 0.0%	55.64% ± 0.0%	-
Obesity class 1	-	59.60% ± 26.23%	62.03% ± 27.63%	-
Obesity class 2	-	49.72% ± 16.66%	54.13% ± 23.46%	-
Obesity class 3	-	49.42% ± 6.63%	46.78% ± 2.43%	-

Of the original 193 patients, 12 were lost to follow-up (6.73%) before 6 months, and 181 completed 6-month follow-up. Of these 181 patients, 57 have not yet reached 1-year follow-up and 3 patients were lost to follow-up. 121 patients completed 1-year follow-up.

Table 5. Bivariable analysis at 1-year follow-up

Variables	Patients with ≥25%EWL at 1 year	*P* value	Patients with >10% TBW at 1 year	*P* value
Female	93.55%	0.168	79.57%	**0.035**
Male	100.00%		96.43%	
< 41 years old	96.88%	0.325	90.63%	**0.025**
> 41 years old	92.98%		75.44%	
Overweight	100.00%	0.338	0.00%	**0.000**
Obesity I	97.18%		87.32%	
Obesity II	90.00%		82.50%	
Obesity III	100.00%		100.00%	

Table 6. Predictors of success based on %TWL ≥10%

	% TWL ≥ 10% at 6 months				**% TWL ≥ 10% at 1 year**			
Variables	Univariate		Multivariable		Univariate		Multivariable	
	IC95%	***P* value**	**IC95%**	***P* value**	**IC95%**	***P* value**	**IC95%**	***P* value**
Sex								
Female	0.182 (0.020 – 0,739)	**0.013***	0.220 (0.024 – 0,918)	**0.036***	0.208 (0.022 – 0.884)	**0.031***	0.329 (0.034 – 1.499)	0.166
Male	1		1		1		1	
Age Group								
Up to 41 years	1.508 (0.656 – 3.540)	0.333	1.616 (0.677 – 3.976)	0,280	3.000 (1.136 – 8.723)	**0.026***	3.529 (1.172 – 12.570)	**0.024***
Over 41 years	1		1		1		1	
BMI								
Overweight	0.083 (0.005 – 1.090)	0.059	0.121 (0.001 – 1.803)	0.136	0.008 (0.002 – 0.229)	**0.002***	0.008 (0.002 – 0.313)	**0.006***
Obesity I	0.392 (0.003 – 3.417)	0.470	0.544 (0.004 – 5.288)	0.663	0.506 (0.038 – 4.917)	0.622	0.613 (0.044 – 7.429)	0.715
Obesity II	0.235 (0.001 – 2.166)	0.242	0.275 (0.002 – 2.818)	0.324	0.343 (0.025 – 3.499)	0.425	0.334 (0.023 – 4.202)	0.442
Obesity III	1		1		1		1	

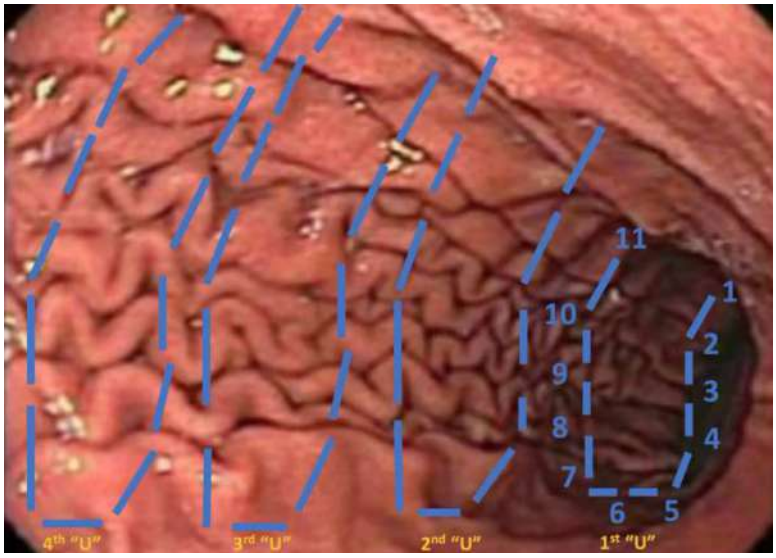
*Statistical significance (95% confidence).

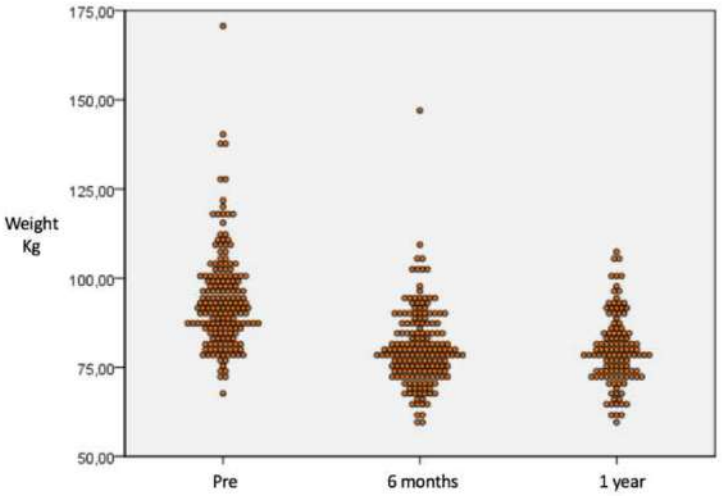
Table 7. Adipose tissue, lean body mass, and metabolic rate before and 6 months after ESG

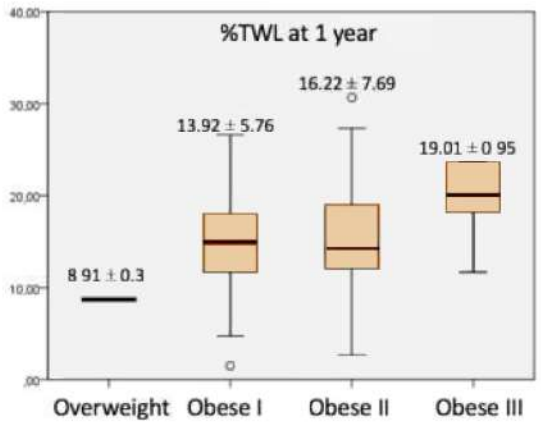
Variables	Initial	6-months post ESG	*P* value
Adipose tissue (Kg)	41.1 ± 6.9	28.3 ± 5.6	**< 0.05**
Adipose tissue (%)	48.5 ± 0.9	43.8 ± 0.2	**< 0.05**
Lean body mass (Kg)	28.0 ± 5.3	27.8 ± 5.2	> 0.05
Lean body mass (%)	22.7 ± 0.4	24.3 ± 0.0	> 0.05
Metabolic rate	1418.1 ± 141.1	1417.7 ± 134.4	> 0.05

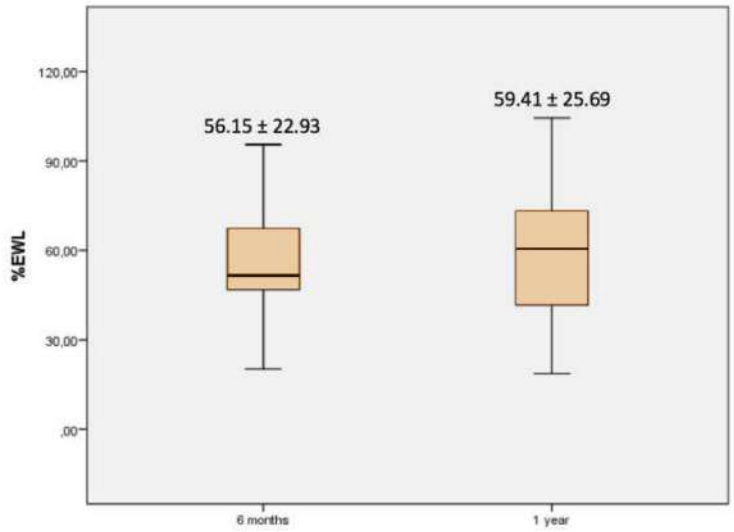
Table 8. Postprocedural symptoms evaluation

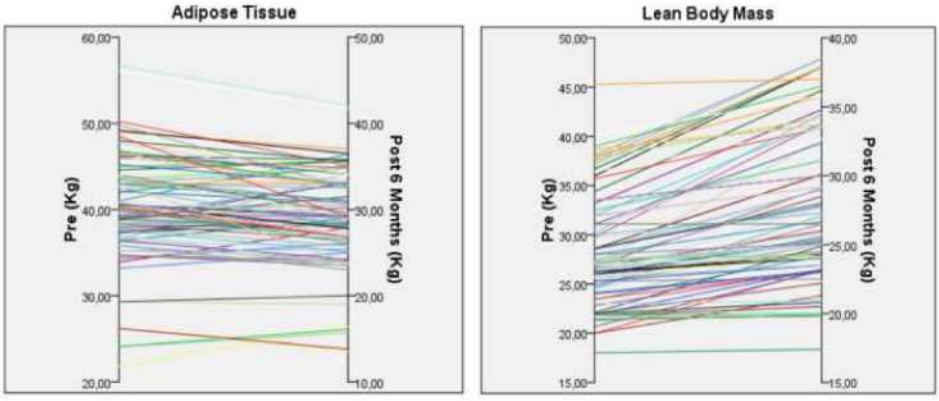
POSTPROCEDURAL SYMPTOMS					
Nausea and emesis	**Yes**	**NO**	***P* value**		
Day 1	34.40%	65.60%	< 0,05		
Day 2	13.87%	86.13%			
Day 3	1.46%	98.54%			
Abdominal pain	**Severe**	**Moderate**	**Mild**	**No pain**	***P* value**
Day 1	6.67%	21.90%	59.05%	12.38%	< 0,05
Day 2	1.90%	6.67%	61.90%	29.53%	
Day 3	0.00%	2.86%	35.24%	61.90%	

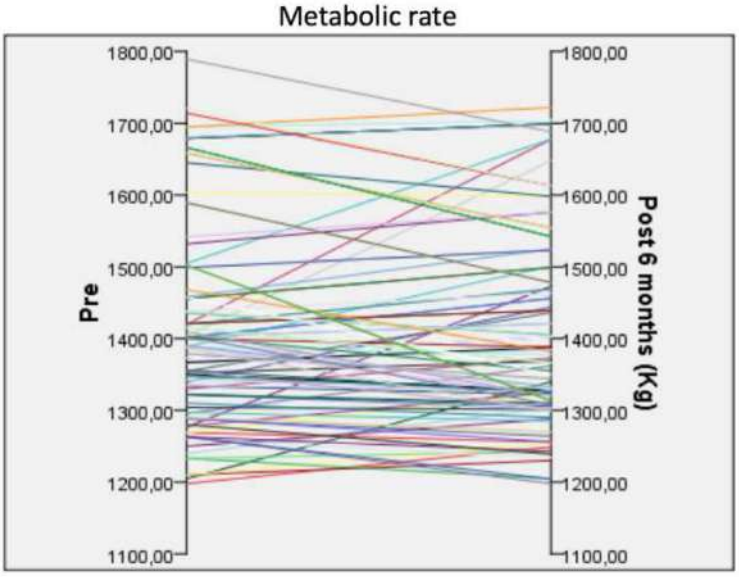












Acronyms

Endoscopic sleeve gastroplasty (ESG)

Institutional Review Board (IRB)

carbon dioxide insufflation (CO_2)

esophagogastroduodenoscopy (EGD)

body mass index (BMI)

absolute weight loss (AWL)

percent total body weight loss (%TWL)

percent excess weight loss (%EWL)

American Society for Gastrointestinal Endoscopy (ASGE)

American Society for Metabolic and Bariatric Surgery (ASMBS)

standard deviation (SD)

serious adverse event (SAE)