## CLINICAL SCIENCE

# GLUCOSE HOMEOSTASIS AND WEIGHT LOSS IN MORBIDLY OBESE PATIENTS UNDERGOING BANDED SLEEVE GASTRECTOMY: A PROSPECTIVE CLINICAL STUDY

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**OBJECTIVE:** To assess glucose homeostasis and weight loss in morbidly obese patients undergoing Silastic® ring sleeve gastrectomy.

**METHODS:** This was a prospective clinical study. Thirty-three female patients with a mean body mass index (BMI) of 42.33 ± 1.50 kg/m$^2$ (range: 40-45 kg/m$^2$), a mean age of 36.7 ± 9.4 years and a mean waist circumference of 118.7 ± 5.98 cm were included in this study. Type 2 diabetes mellitus was observed in 11 patients (33.3%), and glucose intolerance was observed in 4 patients (12.1%). Mean plasma fasting glucose levels were 109.77 ± 44.19 mg/dl (75-320) in the preoperative period. All Silastic® ring sleeve gastrectomy procedures were performed by the same surgical team using the same anesthetic technique. The patients were monitored for at least 12 months after surgery.

**RESULTS:** The mean weight of the patients decreased from 107.69 ± 6.57 kg to 70.52 ± 9.36 kg ($p < 0.001$), the mean BMI decreased to 27.4 ± 2.42 kg/m$^2$ ($p < 0.001$), and the mean waist circumference decreased to 89.87 cm ± 6.66 ($p < 0.001$) in the postoperative period. Excess BMI loss was 86.5 ± 14.2%. Fasting glucose levels were reduced to 80.94 ± 6.3 mg/dl ($p < 0.001$). Remission of diabetes and glucose intolerance was observed in all patients.

**CONCLUSION:** Silastic® ring sleeve gastrectomy was effective in promoting weight loss, waist circumference reduction and control of glucose homeostasis in morbidly obese patients.

**KEYWORDS:** Type 2 diabetes mellitus, Obesity, Bariatric Surgery, Weight loss.

## INTRODUCTION

Obesity is a multifactorial disease that affects millions of people worldwide. It is the main independent risk factor for developing type 2 diabetes mellitus (T2DM),[1,2] leading to a condition known as diabesity.[2,3] In patients with morbid obesity, the likelihood of developing T2DM and glucose intolerance (GI) is further increased.[1,4]

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Bariatric surgery provides sustained weight loss and leads to well-documented remission of T2DM in obese, diabetic patients.[5,6] Patients who undergo bariatric surgery have a decreased rate of long-term mortality compared to obese patients who do not receive bariatric surgery,[7] with 136 lives saved per 10,000 surgical procedures performed.[8] Currently, bariatric surgery is the most effective choice of treatment for morbidly obese patients with T2DM.[9]

Surgical procedures to treat morbid obesity are divided into two groups: gastric restrictive procedures and procedures that combine gastric restriction and malabsorption.[10] The Roux-en-Y gastric bypass (RYGB) procedure is well-established and is the most frequent bariatric surgery performed,[7,11] whereas sleeve gastrectomy

(SG) is an emerging restrictive procedure.[12] SG can be performed as the first of a two-stage operation in patients at high risk of death[13,14] or as a definitive surgical procedure.[15] It has shown good results with regard to weight loss[16] and glycemic control in various studies.[6,14,16,17] The potential advantages of SG include a lower probability of vitamin and mineral deficiencies than RYGB, access to the entire intestinal tract, a lack of need for a subcutaneous access port and a lower risk of intestinal obstruction. In addition, SG can be performed in patients who have inflammatory bowel disease or have undergone previous bowel surgery, and it can be easily converted into a RYGB.[12,15] Both SG and RYGB can be performed with or without the placement of a Silastic® ring.[18,19]

Metabolic control can be achieved with gastric restrictive procedures such as vertical banded gastroplasty,[5] adjustable gastric banding[20] and, more recently, SG.[17] However, previous studies have found that glucose homeostasis is affected by various intestinal mechanisms that are only altered by bariatric surgery procedures that include an intestinal element,[21] such as RYGB.[22-24] A systematic review showed resolution of T2DM in 76.8% of patients undergoing RYGB and improvement of glycemic control in 86% of patients.[25] Of the criteria used to diagnose the metabolic syndrome, fasting glucose levels[26] are the first to return to normal in patients who have undergone Silastic® ring sleeve gastrectomy. The achievement of normoglycemia after bariatric procedures results from multiple changes that occur postoperatively,[6,27,28] such as dietary control,[20,21] decreased plasma ghrelin levels,[29,30] weight loss, reduction of body fat,[6] and the release of gastrointestinal hormones that interfere with the function of pancreatic β cells (incretins).[23,24,31,32]

The main purpose of this study was to assess weight loss in morbidly obese patients undergoing SRSG as well as to evaluate the effects of the SRSG procedure on glucose homeostasis.

## METHODS

### Study protocol

This was a prospective clinical study. It was approved by the Research Ethics Committee of the University Hospital of the Federal University of Espírito Santo, Brazil (protocol no. 049/06). To obtain a homogenous sample, we adopted the following inclusion criteria: we included female patients 20-60 years with a BMI of 40-45 who agreed to provide written informed consent. The exclusion criteria included the following: secondary obesity, alcohol or drug use, presence of a severe psychiatric disorder, binge-eating disorders and previous stomach or bowel surgery.

### Sample

Thirty-three female patients were included in the present study. The patients had a mean age of 36.7 ± 9.4 years, a mean BMI of 42.33 ± 1.5 and a mean waist circumference of 118.7 ± 5.98 cm. The mean preoperative fasting glucose level of the included patients was 108.5 ± 43.76 mg/dl. The diagnoses of diabetes and GI were based on the criteria adopted by the Brazilian Diabetes Society.[33] T2DM was found in 11 patients (33.3%), and GI was found in 4 patients (12.1%). Therefore, 45.4% of the morbidly obese patients analyzed in the present study presented with elevated fasting glucose levels. Most of the diabetic patients were treated with oral hypoglycemic agents. Assessment was performed one year (range: 12 to 14 months) after surgery.

### Surgical procedure

The surgical procedures were performed between December 08, 2006 and July 27, 2007 at *Hospital* at Hospital Universitário Cassiano Antonio Moraes da Universidade Federal do Espírito Santo (HUCAM/UFES, Cassiano Antonio Moraes University Hospital, Federal University of Espírito Santo). The procedures were performed by the same surgeon using similar anesthetic techniques (epidural anesthesia combined with general anesthesia).

Silastic® ring sleeve gastrectomy was performed as follows: the vessels of the greater curvature of the body and fundus of the stomach were ligated, and the fundus and part of the body of the stomach was resected using a linear stapler (80 mm, Tyco®). A 32-Fr tube was then used to calibrate the diameter of the remaining stomach and a 6.2-cm Silastic® ring was placed around the stomach, 5.0 cm below the esophagogastric junction.

The staple lines were then oversewn, and a methylene blue test was performed to verify that the staple line was secure. The patients were given a liquid diet on the first postoperative day and were discharged on the third postoperative day. They received dietary guidance and instructions regarding physical activities and were also prescribed vitamin and mineral supplements.

### Assessment

Weight loss, BMI reduction and waist circumference reduction were assessed. The percentage of excess BMI lost was calculated using the following formula: excess BMI loss = (preoperative BMI - current BMI) ÷ (preoperative BMI – 25) × 100.[34] Glucose homeostasis was assessed through the measurement of fasting plasma glucose levels and an

oral glucose tolerance test, after hipoglicemic agents were discontinued.

### Statistical analysis

The results of the descriptive analyses were expressed as means, standard deviations, medians, frequency (%), minimum values and maximum values. The Wilcoxon matched pairs test was used to analyze the differences between pre-treatment and post-treatment plasma glucose levels. The McNemar test was used to compare the rates of T2DM and GI pre- and post-treatment. Statistical significance was set at $p < 0.05$.

## RESULTS

Although it was not the main focus of the present study, it was noteworthy that two patients (6%) developed a fistula at the staple line at the level of the cardiac notch. Both patients required reoperation. One patient died, and the other underwent total gastrectomy, which led to the resolution of the fistula. These patients, neither of whom had T2DM or GI, were excluded from the postoperative analysis. Therefore, a total of 31 patients were included in the postoperative analysis. In these 31 patients, the mean weight decreased from 107.69 ± 6.57 kg to 70.52 ± 9.36 kg ($p < 0.001$). BMI decreased from 42.27 ± 1.46 kg/m$^2$ to 27.4 ± 2.42 kg/m$^2$ ($p < 0.001$), a reduction of 35.18% (Figure 1). Waist circumference decreased from 118.42 ± 5.71 cm to 89.87± 6.66 cm ($p < 0.001$) (Figure 2). The percentage of excess BMI loss was 86.51 ± 14.2% (46.6 – 108.5%).

The reduction in glucose levels was also significant ($p < 0.001$), with mean plasma glucose values decreasing from a preoperative mean of 109.77 ± 44.19 to a postoperative mean of 80.94 ± 6.3 mg/dl (Figure 3). This reduction was more marked in patients with T2DM and/or GI.

SRSG proved to be effective in promoting the resolution of T2DM and GI in affected patients ($p < 0.001$) (Figure 4). All patients were able to discontinue the use of oral hypoglycemic agents, insulin, or both, during the follow-up period (Table 1).

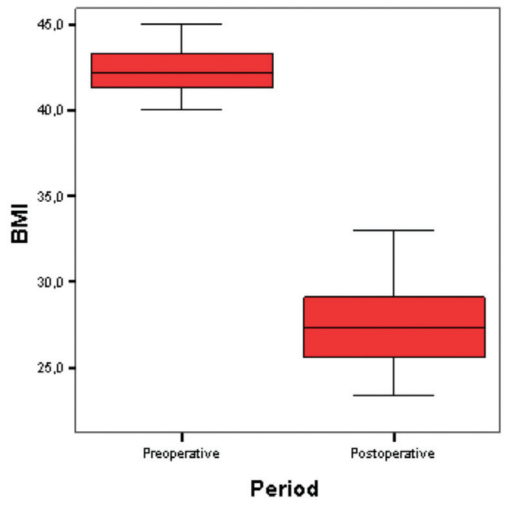


**Figure 1 -** Body Mass Index (preoperative and postoperative)

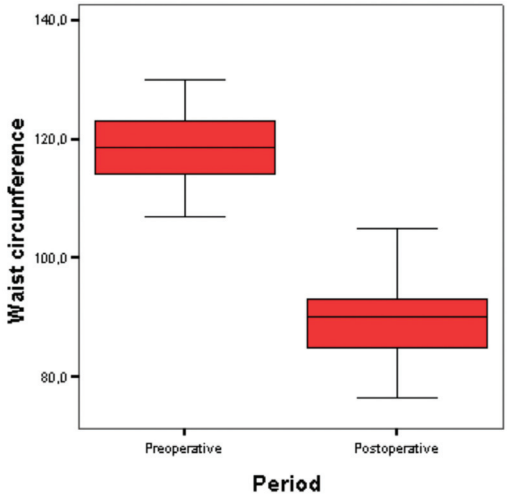


**Figure 2 -** Waist circumference (preoperative and postoperative)

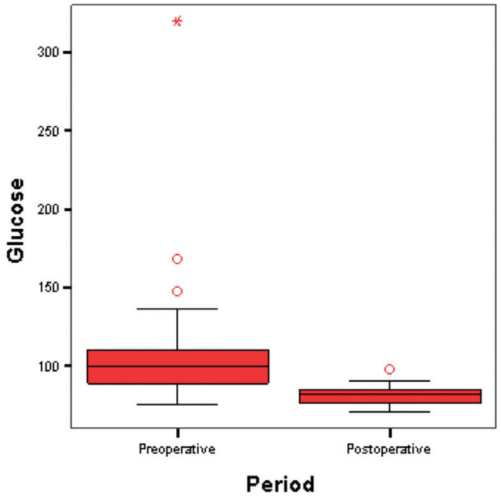


**Figure 3 -** Fasting plasma glucose levels (preoperative and postoperative)

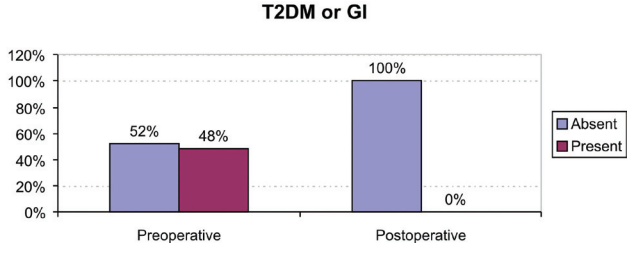


**Figure 4 -** Prevalence of T2DM and glucose intolerance

**Table 1 -** Glucose homeostasis and oral hyperglycemic agent/insulin use before and after SRSG

| Glucose homeostasis | Preoperative period | | Postoperative period | |
|---|---|---|---|---|
| | n | % | n | % |
| Normal | 18 | 54.6 | 31 | 100 |
| Glucose intolerance | 04 | 12.1 | 0 | 0 |
| T2DM — diet controlled | 04 | 12.1 | 0 | 0 |
| T2DM — OHG | 06 | 18.2 | 0 | 0 |
| T2DM — OHG + Insulin | 01 | 3 | 0 | 0 |
| Total | 33 | 100% | 31 | 100% |

T2DM: type 2 diabetes mellitus. GI: glucose intolerance. OHG: oral hypoglycemic agents.

## DISCUSSION

Obesity can cause deleterious effects on many organic functions and impair health and quality of life.[35] The SG procedure is used with increasing frequency in bariatric surgery.[12-17] However, there are few prospective clinical studies in the literature that compare this emerging procedure with the gold standard, RYGB.[12,17]

In the present study, SG was performed, and a Silastic® ring was placed around the stomach. We thus created a small, functional stomach, much like that created during traditional vertical gastroplasty. We also removed the principal site of ghrelin production, which gave the SRSG the characteristics of both bariatric and endocrine surgery.[19] The removal of the principal site of ghrelin production led to a decrease in ghrelin levels, adding a hormonal component to SRSG that other restrictive procedures lack, such as adjustable gastric banding.[31] Some authors have reported the use of added restriction in SG to increase the intensity and duration of weight loss.[19,36,37]

Some researchers have reported that SG is less risky than RYGB.[12-14] In our sample, however, serious complications and death occurred after SG.

We observed significant weight loss, BMI reduction, waist circumference reduction and excess BMI loss in this study. These findings are in accordance with several studies[12,15,17] but are in disagreement with others[13,14] that regarded SG as simply the first stage of a definitive surgery. The promising results of the present study are most likely due (at least in part) to the judicious inclusion criteria we chose, which excluded patients with a BMI greater than 45 and patients who had undergone prior stomach or bowel surgery.

In these patient populations, the results of bariatric surgery have admittedly been less effective. Other factors that might have contributed to the promising results of the present study include the calibration of the remaining stomach using a 32-Fr tube and the placement of a Silastic® ring. In other studies in which weight loss was less pronounced, tubes of a larger caliber were used[39], and a Silastic® ring was not placed.[13,14]

Resolution of T2DM has been well-documented in various types of bariatric surgery.[5] In two studies of patients undergoing SG, control of T2DM was achieved in 80% of patients.[13,14] This remission rate was higher than the rate that is commonly reported for restrictive procedures like vertical banded gastroplasty[5] and adjustable gastric banding.[20] This rate, however, is lower than that obtained with RYGB[9,26] and biliopancreatic diversion procedures.[21]

In the present study, all of the patients with T2DM or GI went into clinical remission, a surprising result also found in another study.[17] Because SRSG is basically a restrictive procedure that does not affect incretin expression, it was expected that the results obtained from this procedure would be inferior to those obtained from procedures in which a duodenal switch is performed with regard to glucose homeostasis.[23,24,27,28] In the present study, glucose levels might have decreased as a result of the marked weight loss observed in all patients, which led to increased insulin sensitivity and decreased leptin production, and thus to increased insulin secretion and remission of GI and T2DM, as noted in previous studies.[6,39] Other hormones produced in adipose tissue might also have been involved in the notable rate of glycemic control observed in the present study.

It is notable, however, that only one patient who underwent surgery in the present study used insulin preoperatively. The other 14 patients with GI or T2DM were treated with oral hypoglycemic agents.

According to previous studies, remission or dietary control of GI/T2DM is more likely to be possible in these patients after bariatric surgery than patients who required insulin preoperatively.[22,24]

The greatest limitations of the present study were the short follow-up period and the lack of a control group for comparison. However, the study sample was comprised of patients with similar baseline characteristics, namely age,

BMI, waist circumference and preoperative fasting glucose levels. The similar baselines among patients is an advantage for this study over previous studies in which the patient populations were not similar at baseline,[12] and the patients often had BMIs of < 40[12,15,17] and/or > 50.[12-17]

## CONCLUSIONS

The surgical procedure in the present study, SRSG, resulted in marked weight loss, BMI reduction, waist circumference reduction, excess BMI loss, improved glucose homeostasis and remission of GI and T2DM in our study population. Further studies need to evaluate SRSG with a longer follow-up period, a control group and the inclusion of other variables, such as hormonal changes, to solidify SRSG's standing as a bariatric surgery procedure.

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