Laparoscopic sleeve gastrectomy with ileal transposition (SGIT): A new surgical procedure as effective as gastric bypass for weight control in a porcine model

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Abstract

Introduction  Bariatric surgery has evolved into multiple forms in the last decades, combining food restriction and malabsorption. The aim of this study was to develop a new technique based on food restriction and early stimulation of the distal gut, thus maintaining the alimentary tract continuity.

Methods  Thirty-two Yorkshire pigs, weight 22.2 ± 5.4 kg (mean ± SD) were randomly assigned to four laparoscopic procedures: ileal transposition (IT, n = 8); sleeve gastrectomy with ileal transposition (SGIT, n = 8); Roux-en-Y gastric bypass (GBP, n = 8); sham operation (SHAM, n = 8). Firing 45-mm linear staplers over a 60-F bougie, resecting the greater curvature and fundus, constituted a sleeve gastrectomy. Ileal transposition was performed by isolating a 100-cm ileal segment proximal to the ileocecal valve and by dividing the proximal jejunum 15 cm distal to the ligament of Treitz and performing re-anastomosis. Gastric bypass consisted of creating a proximal gastric pouch and a 300 cm alimentary limb. Sham operation was performed by bowel transections and re-anastomosis in the ileum and proximal jejunum together with gastrotomy and closure. Animals were evaluated weekly for weight increase and food intake. We performed a logistic regression analysis to compare weight progression curves, and analysis of variance (ANOVA) and Bonferroni (Dunn) tests to detect differences in weight and food intake.

Results  We observed significant differences in mean weight after 18 weeks between SGIT (30.9 ± 13.4 kg) and SHAM (72.5 ± 10.7 kg) (p = 0.0002), and GBP (28.6 ± 2.5 kg) and SHAM (p = 0.0001), and IT (56.1 ± 13.4 kg) and SHAM (p = 0.0081). No differences were observed between RYGB and SGIT. We also observed significant differences in food intake (grams per day) in the third month between SGIT (1668 ± 677 g) versus SHAM (3252 ± 476 g) (p = 0.0006), and GBP (2011 ± 565 g) versus SHAM (p = 0.039). No differences were observed in food intake between SGIT and GBP.

Conclusion  SGIT proved to be as effective in the short term as GBP on weight progression with no bypass of the proximal gut.

Keywords  Ileal transposition · Morbid obesity · Gastric bypass · Sleeve gastrectomy · Bariatric surgery · Gut hormones

Obesity is the most prevalent chronic disease of the 21st century. The World Health Organization (WHO) has identified obesity as one of the five leading health risks in developed countries. WHO has reported that over a billion people are overweight and that 300 million are clinically obese, with a projection of 3 million deaths annually worldwide. In the United States, 65% of adult Americans are overweight and 31% are clinically obese. Fourteen percent of American children and adolescents are obese.
Morbid obesity [defined as a body mass index (BMI) > 40 kg/m²] affects 4.7% of Americans and these numbers are rapidly rising. For these patients, surgery represents the most effective treatment. However, failure is a frequent issue in large-volume centers.

Historically, surgical strategies for weight loss have focused on volume restriction, malabsorption, or both [1]. However, recent studies have questioned the real contribution of restrictive or malabsorptive mechanisms, in part due to an increased understanding of body weight control mechanisms involving multiple peptides [2]. Body weight is the result of complex physiological interactions that control food intake and energy expenditure [3]. These physiological interactions involve the hypothalamus, adipose tissue, and gastrointestinal tract, through different pathways [4]. Hormones that regulate food intake have been intensely studied because of their ability to change eating behavior [5]. They can be separated into ones that act rapidly to influence individual meals [3] and those that act more slowly to promote the stability of fat stores [2]. Long-term regulators include insulin and leptin, which are released into the blood stream in proportion to the amount of body fat. Short-term regulators are released while eating, such as cholecystokinin, promoting fullness sensation and inappetence.

However, the recent discovery of the appetite-stimulating hormone, ghrelin, has pointed the importance of mechanisms that promote the decision to eat [6]. Levels of this hormone rise to a peak before meals and fall quickly after food is consumed [7]. It has been demonstrated that ghrelin fails to rise in patients undergoing gastric bypass surgery suggesting that this procedure has a hormonal effect [8].

Intense research has found a number of gut peptides released in the distal small bowel that influence eating behavior [3,9]. Food ingestion causes the release of anorexigenic peptides, as well as causing vagal stimulation via mechanical and chemical receptors in the gut [3]. Peripheral administration of glucagon-like peptide-1 (GLP-1) results in satiety [10,11]. An infusion of oxitomodulin (OXM) reduces caloric intake of normal weight humans by 19.3% [12].

Interestingly, the peptide tyrosine-tyrosine (PYY 3-36) [9,13], a member of the neuropeptide Y family released from the L cells in the distal small bowel and colon, inhibits food intake up to 12 hours after injection [14], suggesting an intermediate time-interval effect between quickly acting peptides that control individual meals (CCK, ghrelin) and more slowly working hormones that control body weight (leptin, insulin). PYY (3–36) infusion resulted in a reduction in food intake by 30% in a nonobese group and 31% in a lean group [14].

These findings highlight the importance of bariatric surgery in terms of the effect it may have on hormone release [15,16]. It can be postulated that malabsorption may play a modest role in weight loss, compared to the early delivery of partially digested nutrients to the distal bowel releasing peptides, a common feature of gastric bypass (GBP) and biliopancreatic diversion (BPD) [17,18]. Other studies have reported the recovery of type 2 diabetes mellitus in more than 80% of the patients [19,20], an effect that occurs before weight loss, possibly implicating an increase of GLP-1 [21], which may improve insulin sensitivity, rather than duodeno-jejunal exclusion [22,23]. This has been supported by the observation of diabetes reversal in patients who underwent a jeuno-ileal bypass (without duodeno-jejunal exclusion) [24].

Based on these studies, we hypothesize that an optimal bariatric procedure could be entirely focused on targeting gut hormones responsible for eating-behavior control, avoiding malabsorption complications, and preserving benefits of normal glucose metabolism. An ideal alternative would maintain lower levels of orexigenic signals (such as ghrelin) and promote early release of anorexigenic peptides such as GLP-1, PYY (3–36) and OXM [10].

To avoid malabsorption and blind-loop complications from bacterial overgrowth, which have been extensively studied in jeuno-ileal bypass, we developed a model of laparoscopic sleeve gastrectomy and ileal transposition (SGIT) to test the ability of this procedure to control eating-behavior hormones and weight loss [25–27].

Recent data using an ileal transposition model in rats support the notion that early stimulation of the ileum can produce high levels of GLP-1 and PYY (3–36), with a negative effect on food intake and more weight loss than the control group with the same absorption capacity [28,29]. This technique had been originally described by Koopmans [26] in 1982, in a rat model, with good results. The authors also noted an enlargement of the exocrine areas of the pancreas. A recent report in 19 patients proved the feasibility of the ileal transposition in humans. In this study, the procedure was combined to a sleeve gastrectomy [30].

The aim of this study was to describe the feasibility of a procedure entirely focused on gut hormones, without malabsorption, but with modest restriction, and compare it with a standard bariatric procedure such as GBP. We studied technical issues and we measured the effect on eating behavior in relation to food intake and weight evolution for a period of 18 weeks.

**Methods**

**Animals**

Thirty-two Yorkshire pigs (22 ± 5 kg) were utilized for this experiment. They were randomly assigned to one of