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ORIGINAL CONTRIBUTIONS

A New Concept in Bariatric Surgery. Single Anastomosis Gastro-Ileal (SAGI): Technical Details and Preliminary Results

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Abstract
Background In one anastomosis gastric bypass (OAGB), the measurement of the afferent limb starting at the angle of Treitz may result in insufficient absorptive surface of the intestine of the remaining efferent limb. To address this concern, we recently modified the technique of OAGB by constructing the gastrointestinal anastomosis at a fixed distance from the ileocecal valve (i.e., 300 cm). We adopted the new concept and named it the single anastomosis gastro-ileal bypass (SAGI).
Methods Seven consecutive patients with morbid obesity underwent the SAGI procedure.
Results There were no intraoperative complications and there were no deaths. The mean excess weight (EW) loss was 55.1 % at 3 months and 82.1 % at 6 months.
Conclusions The SAGI procedure may constitute a safer alternative to the conventional OAGB.

Keywords Single anastomosis gastro-ileal · One anastomosis gastric bypass · Single anastomosis duodenal-ileal · Malabsorpitive procedure · Billroth 2 anastomosis

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Introduction

Surgery has proven to be the most effective treatment for obesity and weight-related diseases. Most weight loss operations combine a restrictive action with a rerouting of the intestinal passage, as in Roux-en-Y gastric bypass (RYGB), one anastomosis gastric bypass (OAGB), bilio-pancreatic diversion (BPD), and, recently, single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) (Fig. 1).

Within a few years after its inception, OAGB has become the fourth most popular operation worldwide and is only preceded by sleeve gastrectomy (SG), RYGB, and gastric banding (GB). The swift success of OAGB may find an explanation in its relative technical simplicity together with remarkable effectiveness in terms of weight loss and improvement of weight-related comorbidities. In its usual embodiment, OAGB presents a long and narrow gastric pouch, which is quite similar to the gastric pouch in the Magenstrasse and Mill (M&M) operation or even of a SG. The gastric pouch is connected end-to-side to small bowel limb located some 180–200 cm distal to the angle of Treitz. In the small bowel located cephalad to the anastomosis, there is passage of bilio-pancreatic secretions but not food. The delay in mix between food and digestive juices is responsible for the malabsorpitive character of OAGB [1, 2]. However, the absorption of nutrients depends on the surface of bowel that is actually exposed to food stuffs, thus actually located caudal to the anastomosis. Consequently, because in OAGB, the technique of measuring involves the bowel located cephalad to the anastomosis, the length of bowel in contact with food stuffs (the so-called common channel) remains unknown, so this measurement does not allow to define the length of the alimentary tract or common tract (Fig. 2). In order to control the malabsorptive aspect of OAGB, we decided to measure the alimentary tract starting from the ileocecal valve and to adjust the name of the procedure to

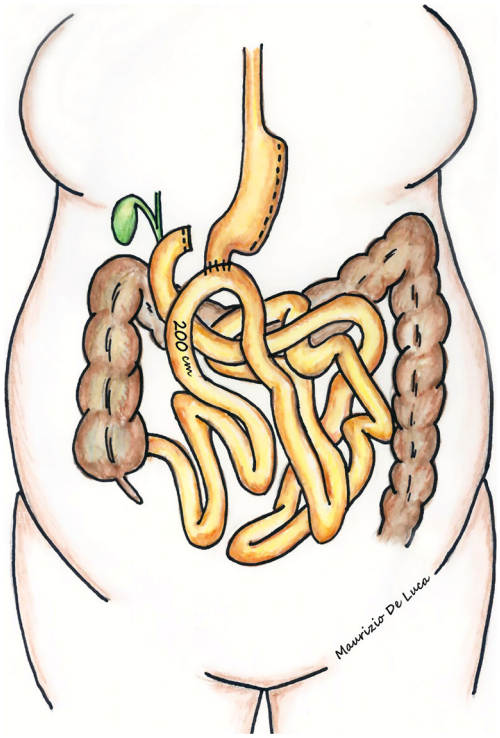

Fig. 1 Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S)

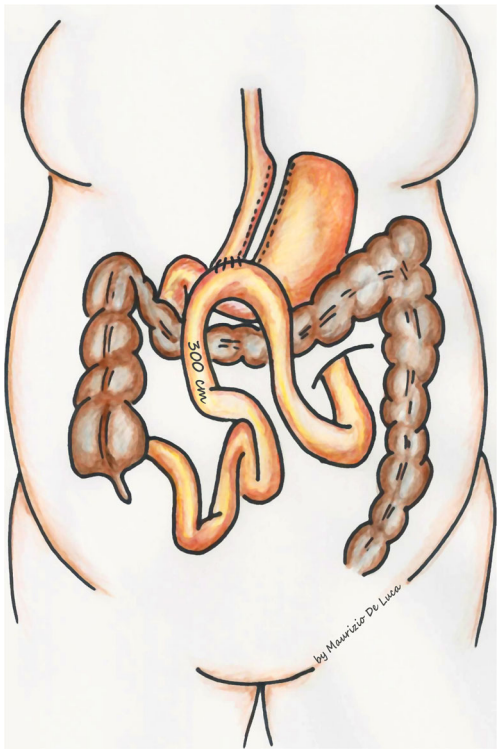

Fig. 3 Single anastomosis gastro-ileal bypass (SAGI)

single anastomosis gastro-ileal bypass (SAGI). Hence, SAGI is very closely related to OAGB, with the difference that the gastro-enteric anastomosis is performed at 300 cm proximal to the ileocecal valve and no longer 180–250 cm distal to the angle of Treitz (Fig. 3).

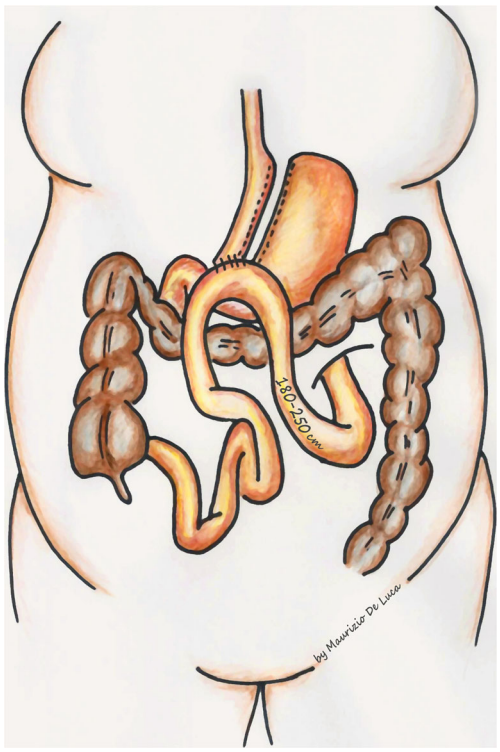

Fig. 2 One anastomosis gastric bypass (OAGB)

Methods

Patients

Seven consecutive patients (5 men) with morbid obesity, aged 45 (28–61) years, underwent SAGI between July 2015 and February 2016, as a primary operation for 3 patients and as remedial surgery for 4 patients, mostly for failure of a sleeve gastrectomy, without sleeve dilatation. Mean preoperative weight was 116 kg (88–141), mean preoperative BMI was 42.1, and the mean excess weight (EW) was 45 kg (32–61). Two patients (28 %) had arterial hypertension (AHT), 2 patients (28 %) suffered from obstructive sleep apnea (OSA), and 3 patients (43 %) had high cholesterol levels, with a mean cholesterol level of 193 mg/100 ml (171–208); one of these latter 3 patients was treated by simvastatin. None of the 7 patients suffered from type 2 diabetes mellitus (T2DM).

Operative Technique

The patient was placed in the split-leg position with the operating surgeon standing between the legs, the second operator on the right side of the patient, and the third operator on the left side of the patient. The anterior phreno-gastric ligament was dissected to

expose the left pillar of the diaphragm at the angle of His. Subsequently, a point at the lesser curvature of the stomach at the level of the crow's foot was identified. Using a perigastric dissecting technique, a space was created between the perigastric vessels at that level and the serosa of the stomach; the lesser sac was entered. The stomach was then partially horizontally transected by a 45-mm linear stapler using blue (Ethicon®) or purple (Medtronic-Covidien®) load. The stomach pouch was then completed by several firings of the linear stapler performed alongside a large bore orogastric tube (36 fench) kept against the lesser curvature. Next, the operating surgeon and the second surgeon moved to the left side of the patient. After identifying the ileocecal valve, the entire small bowel was stretched and measured. Mean total bowel length was 6.20 m (5.80 to 6.70). Then a reference point at 300 cm from ileocecal valve on the ileum was located. On this site, an enterotomy was performed. Finally, the initial position of the operators was resumed and a side to side mechanical gastro-ileal anastomosis was performed with the linear stapler, 45 mm blue (Ethicon®) or purple (Medtronic-Covidien®) load, care being taken to use the posterior surface of the stomach. The introduction opening for the stapler was closed by a running suture of resorbable monofilament suture material. Two or three stitches were additionally placed between the afferent intestinal loop and the excluded gastric body, and a second suture between the small bowel just distal to the anastomosis and the remnant gastric antrum to reach a tension free and well-orientated anastomosis. Airtightness of the anastomosis was checked by injecting methylene blue through the orogastric tube.

Barium swallow X-ray was routinely performed on the second post-operative day, after which patients were started on a liquid diet. Discharge was allowed on the fourth or fifth post-operative day. Patients were seen as outpatients every month during the first year. A low-caloric high-protein liquid diet was maintained over the first month and other foods were sequentially introduced under dietitian supervision. Multivitamins, iron, calcium, and D_3 vitamin were prescribed.

Results

There were no intraoperative complications such as leak or bleeding. One patient suffered a post-operative pneumonia. Peri and post-operative mortality was zero.

Five patients reached 3 months follow-up and two patients 6 months follow-up.

Mean excess weight loss was 55.1 % with BMI 34.3 at 3 months ($n = 7$) and 82.1 % with BMI 27.8 at 6 months ($n = 2$).

No patients complained of diarrhea. Two to four daily bowel movements of soft stool were reported by the patients. The number and softness of bowel movements were related to the oral fat intake.

Blood test was performed every 3 months. Cholesterol level was normalized in 2 patients with untreated hypercholesterolemia (mean cholesterol level 137 mg/100 ml (148–126); the patient on simvastatin was able to reduce drug intake. Regarding 2 AHT patients, one eliminated and one reduced anti-AHT drugs. OSA was clinically solved in both cases.

There was no post-operative anemia or hypoproteinemia. No cases of bile reflux. One patient (14 %) who reported reduced food intake presented low level of albumin concentration at 6 months, 2.9 g/dl (normal range 3.5–5.5 g/dl).

Discussion

SAGI is a variation of the OAGB operation. Quite expectedly, the early clinical outcomes of SAGI are comparable to OAGB, not only in terms of weight loss but also in terms of remission of the comorbidities dyslipidemia and OSAS. OAGB was developed to overcome operative difficulties and risks of gastric bypass (RYGB). It offers the advantages of a simple and reproducible technique, with good outcome, and low morbidity and mortality. In two prospective randomized trials, OAGB was shown to be technically easier and safer, and nevertheless as effective as the standard RYGB, both on the short and long term [3, 4]. OAGB involves a loop anastomosis between a long narrow sleeve gastric tube and an uninterrupted jejunum loop. Compared to GBP, the gastrojejunostomy is placed lower on the stomach, hence allows a tension-free anastomosis that contrasts with the more proximal and challenging anastomosis close to the esophagogastric junction (as in RYGB). Placing the anastomosis low on the stomach pouch also circumvents common anatomical obstacles such as massive left liver lobe hypertrophy that may obscure this area. The technical precision and gentleness in the anastomosis construction in OAGB are essential requisites for the prevention of anastomosis leakage [5]. In addition, avoiding a Roux-en Y limb eliminates the risks related to a second anastomosis and to the division of the mesentery such as obstruction, hematoma, and internal hernia [6, 7]. Moreover, in case of acute obstruction, OAGB allows for easy exploration of the jejunal limbs and prompt repair [8]. Finally, OAGB can be easily revised, reversed, or sleeved if necessary. Quan et al. conducted a comprehensive literature search and identified 16 studies for systematic review and 15 articles for meta-analysis. In comparison with GB, SG, and RYGB, OAGB showed significantly better weight loss [9]. This is the reason why we adopted this type of surgery some years ago. Better weight loss observed after OAGB than after RYGB is likely explained by the enhanced malabsorptive character of the former [9].

In all bypass constructions, the bile and pancreatic secretions follow the bypassed biliopancreatic channel and connect with the alimentary channel (where the food passes) at some

distance from the colon. Some of these secretions are reabsorbed in the biliopancreatic channel before meeting the alimentary tract. The part of the intestines where bile and pancreatic fluids (from the biliopancreatic channel) and food (from the alimentary channel) mix is called the common channel. Compared with RYGB, OAGB comprises a longer biliopancreatic limb. Consequently, food reaches the jejunal mucosa at a point more distal than with RYGB. Hence, with RYGB, caloric absorption starts earlier in the transit. An important issue however is that because the OAGB technique involves measuring the biliopancreatic limb from the angle of Treitz downwards, in some cases, the remaining small bowel that is exposed to food may not suffice to achieve sufficient nutrient absorption. Because in SAGI as we propose it, the length of distal small bowel is kept deliberately at a fixed length of 300 cm, according to the Scopinaro principle the malabsorptive pattern should not exceed a safe level.

In malabsorptive procedures such as the Scopinaro BPD [10] and the duodenal switch (DS) operation [11, 12], incomplete uptake of calories and nutrients occurs via two mechanisms.

First, the bile and pancreatic fluids with high enzymatic content that in normal conditions are released into the duodenum to digest food and break down fats, carbohydrates, and proteins, and in BPD are diverted away from ingested food—hence the name biliopancreatic diversion. When food reaches the diverted distal jejunum and ileum, it is generally not well absorbed because of the lack of enzymes necessary to break down the larger protein and carbohydrate molecules and especially fat, the latter being highly dependent on the presence of bile and lipase. Consequently, fat calorie malabsorption predominates. Undigested fats cause gas and loose, foul-smelling bowel movements, called steatorrhea.

The second mechanism of malabsorption is the overall decreased surface area of intestine with which food is in contact. Reduction of the absorptive mucosal surface causes less nutrient absorption.

Recently, single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) was designed as a variant of DS to deal with the difficulties and related perioperative and medium and long-term complications of BPD and DS. SADI-S involves a duodeno-ileal loop anastomosis rather than a Roux construction as with DS. Sanchez-Pernaute et al. extensively reviewed limb length variations in SADI-S and ultimately decided to construct a common channel of 200 (vs 300) cm. As the SADI-S operation has proven to be safe and effective with no relevant malabsorption in mid-term follow-up, this common channel length should be considered ideal [13, 14]. However, SADI-S, such as DS, requires transecting the duodenum which implies dissection of this structure and its inherent danger for the adjacent bile duct, pancreas, and major blood vessels. Injury to these structures may be life-threatening. In addition, anastomosis to the duodenum is technically difficult and complications such as leak and bleeding are difficult to control laparoscopically or endoscopically.

Conversely, in OAGB or, as we propose, SAGI, the construction involves a gastro-jejunal anastomosis, which is easier to do than a duodenoileal anastomosis, and has a steep learning curve. Moreover, the laparoscopic and endoscopic management in case of leak and/or hemorrhage of the gastrojejunal anastomosis is easier. This is one of the main reasons that prompted us to choose the SAGI operation rather than the SADI-S.

Considering the small number of patients who benefited from SAGI and the limited follow-up, to date, we cannot reach final conclusions regarding the results in terms of weight loss, reduction of comorbidity, and perioperative complications. Best candidates for SAGI may be failures of restrictive operations, such as GB and SG [15] (Fig. 4), especially when the reason of failure is related to patient lack of compliance, and not to dilation of the gastric pouch [16, 17].

Conclusion

SAGI as a variant of OAGB is based on solid physiopathologic principles and is easier to perform than BPD, DS, and SADI-S. It is a mixed restrictive and malabsorptive procedure, mainly malabsorptive in the long-term. The fixed length of the common channel may allow for more consistent outcomes than OAGB and should do away with the uncommon long-term complication of OAGB, i.e.,

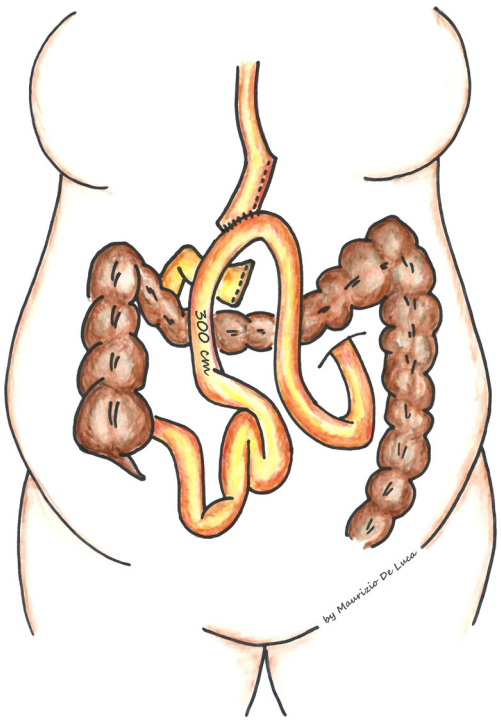

Fig. 4 Single anastomosis gastro-ileal bypass (SAGI) in case of sleeve failure patient

hypoalbuminemia. Longer follow-up and prospective comparison with settled bariatric operations are needed to better define the potential of this operation.

Compliance with Ethical Standards

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

1. Rutledge R. The mini-gastric bypass: experience with the first 1272 cases. Obes Surg. 2001;11:276–80.
2. Chevallier JM, Chakhtoura G, Zinzindohouè F. Laparoscopic mini gastric bypass. J Chir. 2009;146(1):60–4.
3. Lee WJ, Wang W. Laparoscopic Roux-en-Y versus mini-gastric bypass for the treatment of morbid obesity: a prospective randomized controlled clinical trial. Ann Surg. 2005;242:20–8.
4. Lee WJ, Chen JC, Ser KH. Laparoscopic mini-gastric bypass versus Roux-en Y-gastric bypass: five years results and final report of a randomized trial. 14th World Congress of the International Federation for the Surgery of Obesity and Metabolic Disorders. Paris, 2009.
5. Rutledge R, Kular KS, Marchanda N, et al. A comparison of the outcomes of revision of the Roux-en-Y (RNY) and mini-gastric bypass (MGB); hard vs. easy. Eur J Endosc Laparosc Surg. 2014;1:1–6.
6. Gazzalle A, Braun D, Cavazolla LT. Late intestinal obstruction due to an intestinal volvulus in a pregnant patient with a previous Roux-en-Y Gastric Bypas. Obes Surg. 2010;20:1740–2.
7. Paroz A, Calmes JM, Giusti V. Internal hernia after laparoscopic Roux-en-Y gastric bypass for morbid obesity: a continuous challenge in bariatric surgery. Obes Surg. 2006;16:1482–7.
8. Noun R, Zeidan S, Safa N. Laparoscopic latero-lateral jejuno-jejunostomy as a rescue procedure after complicated mini-gastric bypass. Obes Surg. 2006;16:1539–41.
9. Quan Y, Huang A, Ye M. Efficacy of laparoscopic mini gastric bypass for obesity and type 2 diabetes mellitus: a systematic review and meta-analysis. Gastroenterol Res Pract 2015, ID 152852 10.155.
10. Scopinaro N, Gianetta E, et al. Biliopancreatic diversion for obesity at eighteen years. Surgery. 1996;119:261–8.
11. Hess DS, Hess DW. Biliopancreatic diversion with a duodenal switch. Obes Surg. 1998;8:267–82.
12. Marceau P, Hould FS, Simard S, et al. Biliopancreatic diversion with duodenal switch. World J Surg. 1998;22:947–54.
13. Sanchez-Pernaute A, Rubio Herrera MA, Perez-Aguirre E, et al. Proximal duodenal-ileal end-to-side bypass with sleeve gastrectomy: proposed technique. Obes Surg. 2007;17:1614–8.
14. Sanchez-Pernaute A, Herrera MA, Perez-Aguirre ME, et al. Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S). One to three-year follow-up. Obes Surg. 2010;20:1720–6.
15. Langer FB, Bohdajalian A, Shakeri S, et al. Conversion from sleeve gastrectomy to roux en y gastric bypass: indications and outcome. Obes Surg. 2010;20:835–40.
16. Langer FB, Bohdajalian A, Felberbauer FX. Does gastric dilation limit the success of sleeve gastrectomy as a sole operation for morbid obesity? Obes Surg. 2006;16:166–71.
17. Shah M, Simha V, Garg A. Review: long-term impact of bariatric surgery on body weight, comorbidities, and nutritional status. J Clin Endocrinol Metab. 2006;91:4223–31.