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RESEARCH ARTICLE

Enterohormonal Changes After Digestive Adaptation: Five-Year Results of a Surgical Proposal to Treat Obesity and Associated Diseases

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Abstract
Background Recent physiological knowledge allows the design of bariatric procedures that aim at neuroendocrine changes instead of at restriction and malabsorption. Digestive adaptation is a surgical technique for obesity based in this rationale.
Methods The technique includes a sleeve gastrectomy, an omentectomy and a jejunectomy that leaves initial jejunum and small bowel totaling at least 3 m (still within normal variation of adult human bowel length). Fasting ghrelin and resistin and fasting and postprandial GLP-1 and PYY were measured pre- and postoperatively.
Results Patients: 228 patients with initial body mass index (BMI) varying from 35 to 51 kg/m^2; follow-up: 1 to 5 years; average EBMIL% was 79.7% in the first year; 77.7% in the second year; 71.6% in the third year; 68.9% in the fourth year. Patients present early satiety and major improvement in presurgical comorbidities, especially diabetes. Fasting ghrelin and resistin were significantly reduced ($P<0.05$); GLP-1 and PYY response to food ingestion was enhanced ($P<0.05$). Surgical complications (4.4%) were resolved without sequela and without mortality. There was neither diarrhea nor detected malabsorption.
Conclusions Based on physiological and supported by evolutionary data, this procedure creates a proportionally reduced gastrointestinal (GI) tract that amplifies postprandial neuroendocrine responses. It leaves basic GI functions unharmed. It reduces production of ghrelin and resistin and takes more nutrients to be absorbed distally enhancing GLP-1 and PYY secretion. Diabetes was improved significantly without duodenal exclusion. The patients do not present symptoms nor need nutritional support or drug medication because of the procedure, which is safe to perform.

Keywords Obesity/morbid surgery · Ghrelin · Resistin · Glucagon-like peptide 1 (GLP-1) · Peptide YY (PYY) · Sleeve gastrectomy · Visceral obesity · Omentectomy

Locations where the work was developed: Hospital Israelita Albert Einstein, Hospital da Policia Militar, São Paulo, and Hospital Vicentino, Ponta Grossa, Paraná, Brazil.

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Introduction

The physiological satiety provoked by an adequate meal is the result of an array of interacting signals that arise from many sources, including the gastrointestinal (GI) tract. To very briefly summarize the role of GI tract in satiety, it is a sum of a mechanical sensation of a full stomach, rapidly confirmed by neuroendocrine signals that recognize that what was ingested was indeed nutritive (otherwise, ingestion of nonnutritive particles would create an inadequate metabolic postprandial state in the lack of food). In terms of meal termination, the most important of these postprandial neuroendocrine signals are an elevation in the blood of satiety gut hormones (such as GLP-1 and PYY) and a reduction of ghrelin, an orexigenic hormone mainly produced by neuroendocrine cells mostly located in the gastric fundus [1].

These concepts are quite recent. The classic bariatric procedures used nowadays were designed before this knowledge was available, and so, they were based in mechanical restriction, unspecific malabsorption or a mix of both. Mechanical restriction and malabsorption are obviously non-physiological, and a physiological procedure should not include these features, neither should it use prostheses nor create excluded segments. An ideal procedure should maintain gastric, duodenal, jejunal, and ileal functions. However, it would be interesting to create a functional smaller stomach that signalizes earlier with distension, as modern food is more caloric. Also, in case of obesity, it is interesting to diminish fasting levels of ghrelin and enhance secretion of GLP-1 and PYY, especially because the secretion of these two neuropeptides are indeed attenuated in obese patients [2, 3].

Based in these goals, in 2002, we developed Digestive Adaptation (DA) [4, 5], a surgical proposal to treat obesity and associated conditions. It combines, with different metabolic intentions, some well-known procedures: sleeve gastrectomy, omentectomy, and a jejunectomy. In this paper, we present the rationale, the results between 12 to 60 months postoperatively and the enterohormonal changes provoked by the procedure. Initiated in Brazil, in October 2002, DA is part of a new strategy to treat obesity and its metabolic consequences. Currently, this strategy is being utilized in Brazil by many surgeons in different centers and more than a thousand patients have already been treated following this rationale.

Materials and Methods

Patients

Only patients operated on by the authors and followed for more than 1 year were included in this paper. Two hundred and twenty-eight patients were operated on from October 2002 to October 2006. There were 138 women (60.5%) and 90 men (39.5%), with ages varying from 19 to 66 years (average 41 years).

At the time of surgical treatment, patients presented variations from 80 to 184 kg (average 113 kg) in body weight, 146 to 192 cm in height (average 168 cm) and 35 to 51 kg/m^2 in body mass index (BMI; average 39.8 kg/m^2). Most of the heavier patients were submitted to a more potent variation of DA, Digestive Adaptation with Intestinal Reserve [6], and these patients are not included here.

Diagnosed comorbidities included orthopedic problems in 84 patients (36.8%), essential hypertension in 101 (44.3%), diabetes in 75 (32.9%), hypertriglyceridemia in 119 (52.1%), hypercholesterolemia in 102 (44.7%), and respiratory problems in 58 (25.4%).

Technique

The procedure begins through a laparoscopic access. Six trocars are positioned: two 12 mm (one in the midline 5 cm above the umbilicus and the other in the upper left quadrant); three 5-mm trocars (one in the upper right quadrant, one in the epigastrium for the liver retractor, and one lateral in the upper left quadrant, for the surgeons left hand). A sixth trocar (10 mm) is also placed in the midline, 5 cm higher than the first for the camera. Later, both midline incisions will be united to create a minilaparotomy.

First, the omental bursa is opened and the greater omentum is divided with the help of a sealer and divider device (Ligasure®). Dissection starts just beside the gastric greater curvature at a point located 5 cm from the pylorus up to the angle of His. A sleeve gastrectomy is performed with a laparoscopic linear cutting stapler (Fig. 1). A Fouchet's tube is passed to the stomach to guarantee that the gastric tube, left in the lesser curvature, is approximately 3 cm wide. After 3 episodes of bleeding from the stapling line, a running absorbable suture to cover it was routinely used. A suction drain (Blake® or similar) is used and it is exteriorized at the site of the left flank 5-mm trocar).

After that, a small midline laparotomy (6 to 8 cm), uniting the two midline trocar incisions immediately above the umbilicus is made to remove the gastric specimen and the greater omentum (after detaching it from the colon) and to perform an enterectomy. No retractors are used. The bowel is left with at least 3 m. Now, the first 40 cm of jejunum and the last 260 cm of ileum are left (in the initial cases, the proportion of jejunum was greater [4]). An external manual end-to-end enteroenteroanastomosis is performed (Fig. 2). The mesenteric borders are closed to avoid internal hernias. Abdominal wall and laparoscopic incisions are closed. Antibiotic and deep vein thrombosis prophylaxis were used in all patients (cefazolin 1 g q6 h for 1 day; compression stockings in all patients, pneumatic venous compression device in most and enoxiparin 40 mg once daily, preoperatively and for 1 week after the procedure in some).

All patients received only I.V. fluids in the first 48 h and were then instructed to take just liquids (not in more than

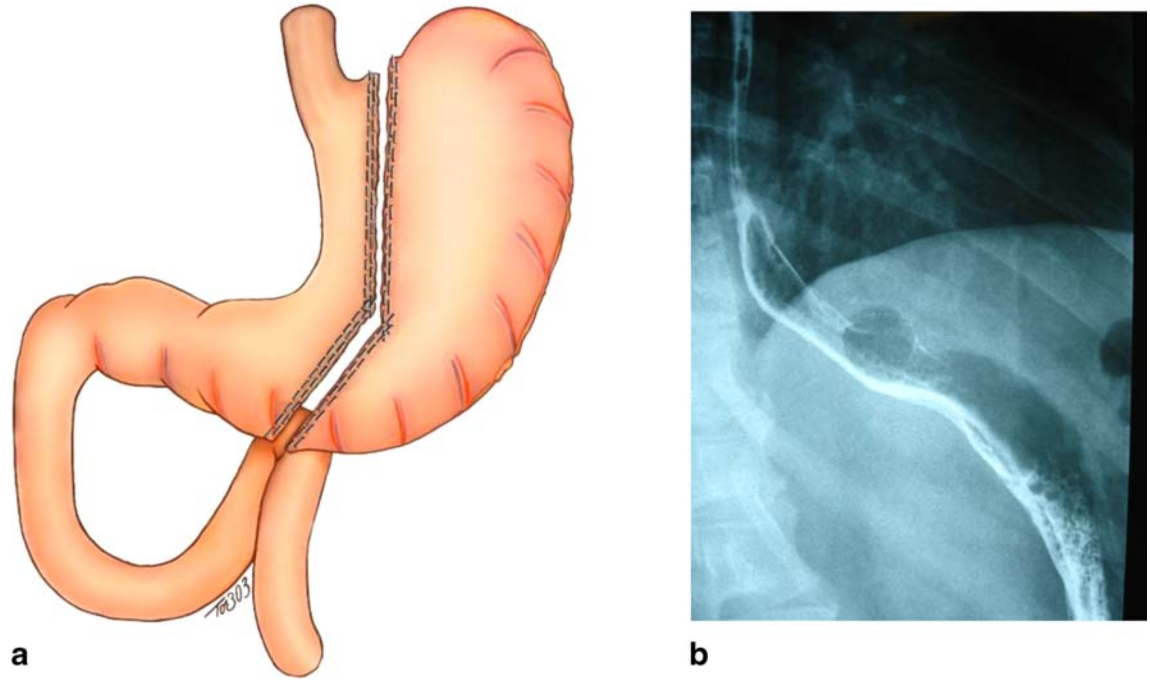


Fig. 1 **a** Scheme for sleeve gastrectomy, performed with a laparoscopic linear cutting stapler, showing also the removed part. **b** Radiographic aspect postoperatively

40 mL every 20 min) for a week and to then progressively start eating soft solids. There was a recommendation that they have small meals starting with a portion of salad. We also recommended that they have small portions of fruits, vegetables, fish, and chicken and we asked them to avoid simple (refined) sugar.

Hormonal Studies

Subsets of consecutive patients were submitted to hormonal studies pre- and postoperatively: ghrelin (10 patients); resistin (13 patients); glucagon-like peptide 1 (GLP-1; 10 patients); polypeptide $YY_{3\text{-}36}$ (PYY; seven patients). Ghrelin and resistin were tested using fasting levels only. GLP-1 and PYY levels were measured after 12-h fasting and also 30, 60, 90, and 120 min after the ingestion of a 300-kcal standard meal (200 mL of Nutridrink®) pre- and postoperatively. All dosages were made using ELISA kits (Phoenix Pharmaceuticals, Inc., Belmont, CA, USA). Results are given as mean±SD. The nonparametric Wilcoxon signed-Rank test was used to estimate the difference between pre- and postprocedure. The profiles of PYY and GLP-1 were analyzed by comparing the area under curve (AUC). Statistical analyses were conducted using the Sign Test–SAS® System (SAS Institute Cary, NC). $P<0.05$ was considered statistically significant.

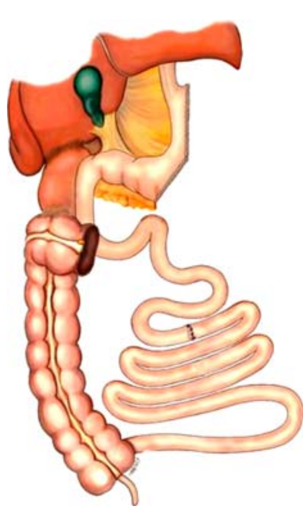


Fig. 2 Final aspect. A reduced GI Tract with proportionally more ileum than jejunum

The Ethical Committee for Research Projects of the "Hospital da Polícia Militar do Estado de São Paulo" approved the first protocol. The procedure was reviewed and also approved by the Ethical Committee for Research Projects of "Hospital Israelita Albert Einstein" and at "Hospital Vicentino". A detailed informed consent was signed by patients.

Results

Clinical Results

Average Length of operative procedures was 170 min (120–300 min). Physical features of the resected specimens are: small bowel length from 120 to 500 cm (average 240 cm)

Table 1 Causes of 30-day surgical complications

Complications	*n* (%)	Management
Late perisplenic abscess (*Staphylococcus aureus*)	1 (0.4)	Surgical drainage on the 26° POD
Gastric laceration 5 mm outside the mechanical suture	1 (0.4)	Suture and drainage on the 1° POD
Abdominal wall bleeding on trocar site	1 (0.4)	External compression with resolution
Internal bleeding	3 (1.3)	Reoperation on 1° (2 pct) and 2° POD
Gastric fistula	3 (1.3)	Surgical drainage and enteral feeding
Prolonged adynamic ileus	1 (0.4)	Surgical revision with no problem detected

POD = postoperative day.

and omentum weight, from 80 to 1880 grams (average 670 g). Thirty days postoperative complications occurred in 10 patients (4.4 %), mainly in the initial cases, and they are listed in Table 1. Late complications included 11 patients (4.8%) who developed gallbladder lithiasis (12 were already submitted to cholecystectomy) and three (1.3%) who developed incisional hernias at the site of the minilaparotomy; surgical repair was performed at the time of plastic surgery. There was no mortality.

Weight Loss Evolution

As a result of less aggressive sleeve gastrectomies in the beginning, earlier patients present smaller weight losses [5].

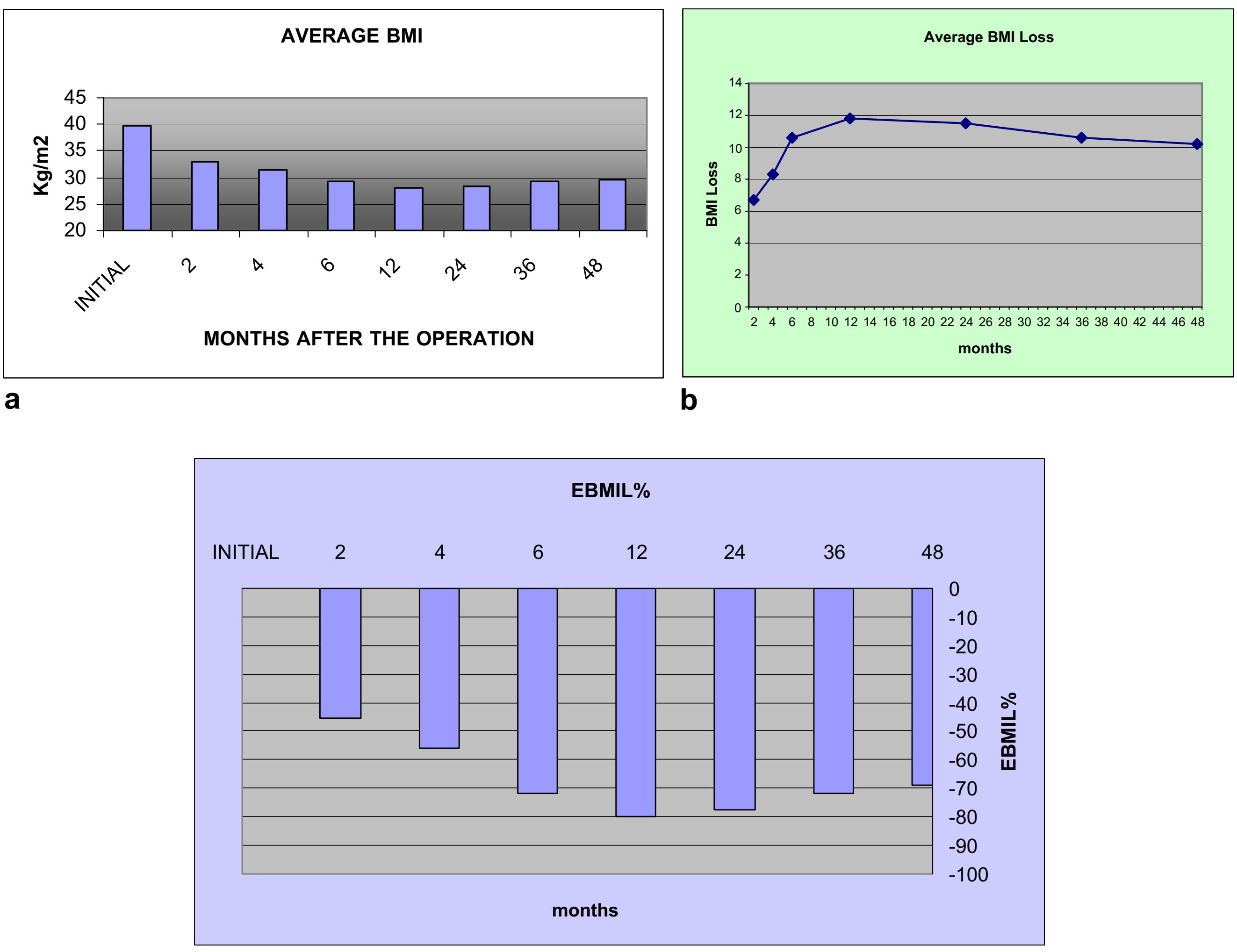


Fig. 3 Graphics showing: **a** the evolution of patients' average BMI after the procedure; **b** average BMI loss; **c** evolution of excess of BMI loss in percentage

Table 2 Clinical resolution (which allowed complete withdrawal of medication) and improvement (which allowed reduction in medication or clinical improvement) of comorbidities after surgical treatment

Condition	Before surgery		After surgery			
	N	% of total patients	Resolved		Improved	
			N	%	*N*	%
Orthopedic problems	84	36.8	62	73.8	22	26.2
Essential hypertension	101	44.3	71	70.3	30	29.7
Diabetes	75	32.9	69	92.0	6	8.0
Hypertriglyceridemia	119	52.1	101	84.9	18	15.1
Hypercholesterolemia	102	44.7	53	52.0	49	48.0
Respiratory problems	58	25.4	48	82.8	10	7.2

Weight was monitored in the form of BMI and percentage of Excess of BMI loss (EBMIL%=preoperative BMI − current BMI × 100 / preoperative BMI − 25) [7]. All these patients were followed for at least 1 year and their BMIs were reduced (in average) as follows: −4.6 kg/m^2 in the first month; Δ=−6.7 kg/m^2 in the first 2 months; Δ=−8.3 kg/m^2 at 4 months; Δ=−10.6 kg/m^2 in the first 6 months; Δ=−11.8 kg/m^2 at the end of the first year; 140 patients were followed for at least 2 years and their medium BMI evolution was Δ=−11.5 kg/m^2; 70 patients were followed for at least 3 years and their medium BMI evolution was Δ=−10.6 kg/m^2; only 15 patients were operated in 4 years or more and they maintain in average a BMI loss of 10.2 kg/m^2 (however, these earlier patients were submitted to a "mild" sleeve gastrectomy). Only one (the first) patient had a 5-year follow-up. She was operated on at 104 kg (BMI 36.4 kg/m^2); today her weight is 70 kg, BMI 24.5 kg/m^2 (EBMIL% 104.4%). DA presented average EBMIL% of 79.7% in the first year; 77.7% in the second year; 71.6% in the third year; 68.9% in the fourth year (Fig. 3).

Follow-up varied from 12 to 60 months (average 28.8 months). During this period, the comorbidities detected before surgical treatment showed clinical resolution or improvement (Table 2). Resolution was defined as the disappearance of the problem or the withdrawal of medication and improvement, a reduction in medication, or an improvement in objective laboratorial results or symptoms.

After surgery, frequency of stools evacuation is kept. In only eight patients (8/180 or 4.4%) frequency of evacuations became a little less frequent, but not enough to generate complains. Five (2.8%) patients had eventual dyspepsia, requiring medication. In one of them, gastroesophageal reflux was diagnosed and she was submitted to a laparoscopic hiatoplasty and a closure of the His angle with a small anterior fundoplication using the dilated residual gastric fundus, and the symptoms disappeared. No postoperative diarrhea was observed. Clinical examination and routine laboratory tests that include hemogram, iron, transferrin, albumin, calcium, PTH, vitamin B12, folic acid, and zinc show no signals of malabsorption. Most of the patients reported great reduction of total daily ingestion and early and prolonged satiety. Lack of symptoms of any kind was a reason for great satisfaction among the patients.

Hormonal Assays Results

As expected, fasting ghrelin fell after the procedure in all 10 patients. Preoperative serum levels ranged from 417 pmol/L to 931 pmol/L (average 639.7 pmol/L; medium 655.5 pmol/L; SD 151.47 pmol/L). In the postoperative

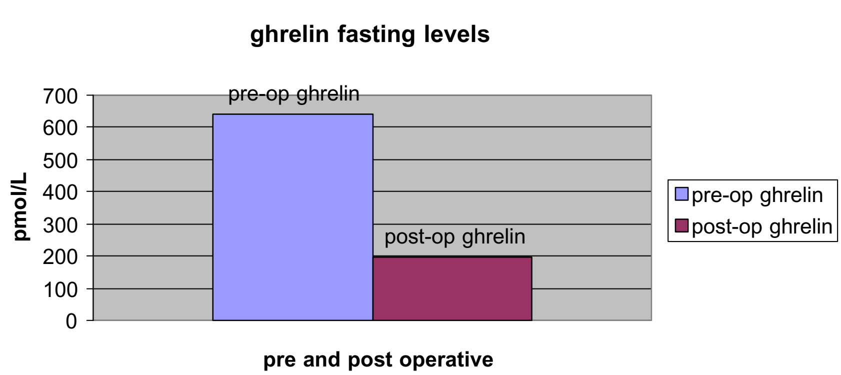
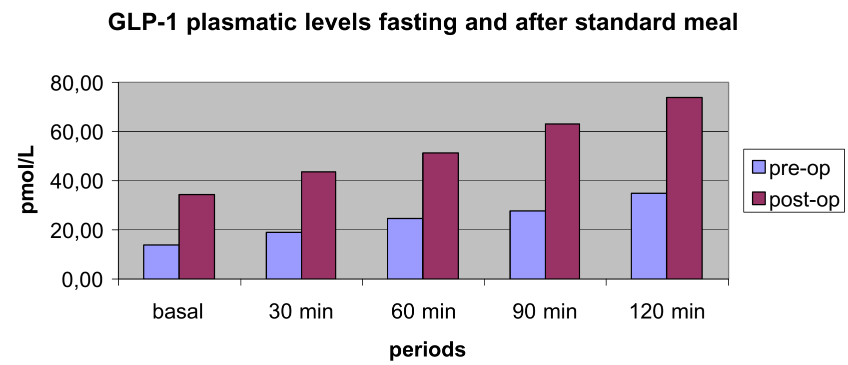


Fig. 4 Comparison between pre and postoperative fasting Ghrelin levels (p=0.002)

Fig. 5 Average levels of GLP-1 pre- and postoperatively after standard meals. Area under curve significantly enhanced postoperatively (p=0.002)



values ranged from 118 pmol/L to 255 pmol/L (average 196.7 pmol/L; medium 201 pmol/L; SD 45.88 pmol/L). The fall in ghrelin was statistically significant (p=0.002) (Fig. 4).

GLP-1 secretion was significantly enhanced in all 10 consecutive patients studied, in all periods of time after standard meal (p<0.05), including basal (fasting). Area under curve of fasting and post prandial GLP-1 levels were significantly enhanced postoperatively (p=0.002; Fig. 5).

PYY was significantly enhanced at fasting levels (mean preop 36 pmol/L; SD 10.37; mean postop 67 pmol/L; SD 17.17; p=0.01), 30 min after standard meal (mean preop 32 pmol/L; SD 12.19; mean postop 68 pmol/L; SD 26.66; p=0.01) and 60 min after the standard meal (mean preop 60 pmol/L; SD 13.75; mean postop 80 pmol/L; SD 25.38; p=0.01). After 90 and 120 min, the enhancement was not statistically significant (p=0.12 and p=0.68). In the postoperative, the area under curve of fasting and post-prandial PYY levels was significantly enhanced (p=0.007; (Fig. 6).

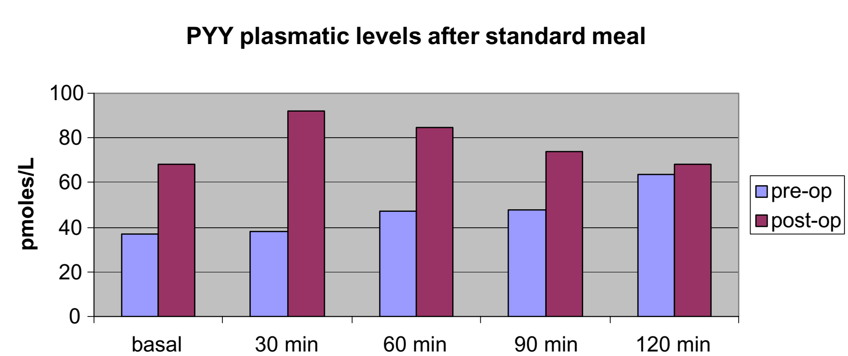
Resistin levels were diminished in all 13 consecutive studied patients. Preoperation values ranged from 206 to 670 ng/mL (average 326.85; medium 307.00; SD 140.9). In the postoperative period, they ranged from 115–289 ng/ml (average 171.85 ng/ml; medium 167 ng/ml; SD 44.36 ng/ml). The difference was statistically significant (p=0.0002).

Discussion

Since the beginning of obesity surgery, malabsorption and mechanical restriction were the tools used in the surgical proposals for this condition. However, in essence, none of these tools are physiologically based, and a normal lean person does not present these elements. In parallel, in the last years many studies have pointed to unplanned neuroendocrine changes provoked by some bariatric procedures (such as reduction in ghrelin, elevation of GLP-1 and PYY). These changes seem to make a positive difference and the procedures capable of provoking them work better than those that cannot. However, these neuroendocrine interventions could not be planned at the time of the design of the currently used bariatric surgeries because most of what is known about these gut hormones was discovered after the development of the procedures.

In Roux-en-Y Gastric Bypass (RYGBP), a procedure designed to be a mix of malabsorption and restriction, malabsorption of caloric nutrients was never demonstrated, and this fact has been mentioned since long ago [8] (only malabsorption of noncaloric nutrients such as iron, folic acid, and calcium were largely demonstrated). But the good results of RYGBP cannot be attributed to restriction only. Indeed, RYGBP causes changes in

Fig. 6 Average PYY levels pre- and postoperatively after a standard meal. Area under curve significantly enhanced in the postoperative (red line) (p=0.007)



neuroendocrine response to food ingestion [9], and most of the metabolic improvement seems to be an unplanned attribute of these changes.

Now, with access to abundant new physiological knowledge, it is possible to propose new surgical strategies, aiming exclusively at functional and neuroendocrine changes. Mechanical obstacles to ingestion of food, such as bands or narrow anastomoses and unspecific malabsorption, are responsible for practically all of the obesity surgery complications and adverse effects (dysphagia, vomiting, nutritional deficiencies, diarrhea, etc.). New strategies that include just neuroendocrine goals and adaptations to modern diet seem possible now. The proposal described in this paper has this spirit and curiously; there are also evolutionary aspects that give support to this design.

Natural (not processed) diet is raw, full of poorly digestible fiber, and hypocaloric. The volume of meals has to be big to achieve the necessary amount of calories. In these conditions, gastrointestinal (GI) tracts have to be voluminous and long to fit and process voluminous food and to efficiently get nutrients out of the cellulose-encased vegetal cells. Herbivores, for these reasons, have longer bowels than carnivores. As a rule, among mammals, the higher the caloric density of food, the shorter and simpler are the digestive tracts [10].

Also among primates, those who eat lower quality food have longer GI tracts [11, 12]. Analyzing our hominid ancestors, there was a continuous enhancement in the quality of diet during the last five million years, especially when these hominids moved from being herbivores and started adding animal food to the diet, selecting ripe fruits and more nutrient-valuable leaves. In this process, simultaneous with the development of larger brains occurred a diminution in GI tracts [13, 14]. Recently, in a few decades, the human diet was refined, enriched, and changed faster than ever. Following an evolutionary line, it would be better to have a further proportional reduction of the GI tract.

Modern diet became unnaturally hypercaloric, poor in fiber, and extremely easy to be absorbed. Indeed, modern diet is predigested by cooking and refining. The product sometimes is completely ready for absorption, such as glucose. After a meal with these characteristics, absorption may occur in more proximal portions of the bowel, creating peaks of nutrient absorption. Distal bowel tends to have less absorption work, which would cause a lack of production of GLP-1 and PYY. Indeed, it was noticed that the diabetic [15] and the obese have a reduced production of GLP-1 [2].

Following this rationale, under these new circumstances, current human small bowel became excessively long and most L cells (that produce GLP-1 and PYY) too distant from the site of major absorption. In addition, it has been shown that obese people tend to have a longer small bowel than thin people, and bowel length is better related to weight than to height [16]. This fact likely worsens the picture, contributing to an even smaller amount of nutrients reaching the distal bowel with less sensation of being fed, through less GLP-1 and PYY.

Nature is doing what it does best: selection. Individuals with strong eating instincts are being killed by obesity, an inadequate neuroendocrine control of hunger, satiety, and energy stores. Obesity is obviously an evolutionary issue. Like it happened before [13, 14], smaller abdomens and shorter small bowels continues to be selected.

The proposal described in this paper aims to better adapt the current human GI tract to modern diet by copying evolution. The sleeve gastrectomy maintains gastric functions as the general structure of the organ is preserved. During meals, distension signals will be emitted earlier in a better accordance to the high caloric density of modern food. During period of fasting, less Ghrelin is produced because this orexigenic hormone is mostly produced by cells located in the gastric fundus [17] that is retrieved. Different than a gastric banding, a sleeve gastrectomy works 24 h a day.

The enterectomy does not aim to cause any malabsorption. The amount of small bowel left is within the normal range as in adults never submitted to surgery [18]. As expected, none of our patients developed any signal of nutritional deficiency. No one developed diarrhea and, taking into account that intestinal adaptation occurs, it is less probable that they will develop it later. Indeed, some of our patients developed a slight diminution in frequency of evacuations of stools, probably because they eat less, absorb food adequately, and the higher levels of GLP-1 and PYY induce a slower intestinal transit and gastric emptying [19, 20].

It seems that the excess of caloric reserve might be linked to voluminous and hypertrophic bowel, especially the jejunum. If results in metaanalyses are observed [21], classic bariatric procedures are progressively more potent according to the amount of excluded proximal bowel, but these exclusions sacrifice sometimes gastric, pyloric, duodenal, and jejunal functions to some extent.

The rationale of this enterectomy is to create a proportionally smaller intestine (but still normal in length and functions, with the epithelial sequence kept), which will promote a more intense reaching of nutrients to the ileum, causing (as shown) a more effective secretion of GLP-1 and PYY. Fasting levels of GLP-1 and PYY were also enhanced. We had observed this fact before [6], and the explanation is not clear to us. These hormones reduce the rate of gastric emptying (making the stomach functionally even smaller), improve insulin secretion, and promote central satiety [22–25]. After all, it aims to correct a detected defect in the production of distal bowel hormones, presented by the obese, not because they have a sick bowel, but probably because a change in the diet occurred.

Enterectomy is the obvious target of criticism. However, the alternatives to diminish proximal absorption are problematic in comparison to a jejunectomy. Jejuno-ileal bypass, a complete exclusion, created problems and is now obsolete [26]. Exclusion of nutrients but not of biliopancreatic secretions, such as in gastric bypass or biliopancreatic derivations, implies loss of proximal bowel functions that induce nutritional problems, as it is well-known [26]. Normal functions might be kept if proportions are revised. During many years working in an "Extensive Bowel Resections Unit", we observed that in some cases of plurimetabolic syndrome, proximal enterectomies could, surprisingly, improve satiety, metabolic profile, and well-being instead of worsening them, something we could not understand in the early 1990s. A few years after, there was information [2] that gave a clue that not only excessive adipose tissue could be detrimental, but also excessive proximal bowel.

Ileal interposition could be a nice option [27, 28]. However, besides being much more complex, it increases GLP-2 [29, 30] and produces an additional whole bowel hypertrophy, increasing visceral mass, in opposition to our goals. Indeed, a proximal bowel hypertrophy, induced by overeating, may well be in the core of the pathophysiology of distal gut attenuated signals [31].

In relation to the jejunectomy, finally the size of the stomach after sleeve gastrectomies influence results in DA. In our observations, large stomachs worsen weight loss, but not metabolic profile improvement, up to the point that we suggested that only the entero-omentectomies could be used in nonobese type II diabetic [32]. Small stomachs improve weight results so much that in the last year, using more aggressive sleeve gastrectomies, we reduced enterectomies to the first half of what was used before (these patients have a follow-up shorter than 12 months, therefore, not included here). Proximal jejunectomy are the safest part of this proposal: none of the complications observed were related to it and it was shown that it is metabolically very helpful in raising distal gut hormones. However, the minimal length of resection, in each individual, that still works well is to be defined.

DA causes intense diminution of triglycerides, especially in the postprandial period. This diminution is superior as observed in RYGBP [33]. Meier and Cols [34]. recently demonstrated that GLP-1 abolishes postprandial rise in triglycerides, and this is probably the main reason for the observed diminution. Diminution in the postprandial level of triglycerides is an important fact. Excess of fat in the blood inhibits insulin action (Randle's effect) [35] and also the production of nitrite oxide, our most important physiological vasodilator [36].

Omentectomy promotes resection of visceral fat, which is associated with Metabolic Syndrome (also by definition now [37]). Visceral fat keeps releasing free fatty acids (FFA) to the portal system. It is believed that insulin resistance of the liver derives from a relative increase in the delivery of FFA from the omental fat depot to the liver (via the portal vein) [38]. Many extremely obese patients with mostly subcutaneous fat present quite good metabolic profiles.

Abdominal fat is also related to resistin. Resistin is a hormone produced by adipose cells that acts on skeletal muscle myocytes, hepatocytes, and adipocytes themselves, reducing their sensitivity to insulin, and it is linked to diabetes [39]. The proposed procedure produced a significant diminution in the plasmatic resistin, probably as a result of weight loss and visceral fat removal, which is recognized as being the main source of resistin [40]. Visceral fat removal leads to improvements in metabolic profile through different ways, especially by reducing insulin resistance so expressively that some authors suggest omentectomy as an independent procedure to treat type 2 diabetes (T2DM) [41].

As shown, many aspects contribute to a major improvement in T2DM: a more intense production of GLP-1 and PYY, the consequent slower rate of intestinal transit, and a diminution of elements related to insulin resistance (excess of weight, circulating free fatty acids, and resistin). As expected, a prompt remission of T2DM occurred in most patients. Duodenal-jejunal exclusion is not necessary to obtain this goal, confirming what was shown before [6].

The results with DA are very stimulating once patients reached a good loss of weight without mechanical obstacles to food ingestion, or malabsorption. Analyzing loss of BMI, the procedure seems to be mildly potent; however, analyzing EBMIL%, the results are excellent. This occurs because we do not submit very heavy patients to this procedure, but to a more potent one [6]. Therefore, EBMIL% is a better way to refer to weight loss once it takes into account also the initial weight, as much as the final weight and height. Had we operated on heavier patients with DA, absolute BMI loss would be increased, EBMIL% decreased, and the results obviously worse. Refereeing weight loss in EBMIL% is a clear progress [7]. An average EBMIL% around 70% is probably ideal. To reach 100% in average, it would imply obtaining excessive weight loss in many patients.

As the proposed procedure is simple and safe, and as it maintains the general structure and important digestive functions unharmed, without malabsorption there is no need for nutritional support.

Weight loss occurs not because the patient cannot eat what he wants or cannot absorb nutrients completely. Patients stop eating earlier for the same reasons anyone does—because they have the feeling that the stomach is full, and of a hypothalamic-generated satiety sensation, which is caused by the perception of nutrients, mainly in their distal bowel. Their quality of life (QOL) seems to be much improved by the loss of weight and its consequences. In parallel, QOL is not worsened by any symptoms or situations (such as dysphagia, vomit, diarrhea, flatulence, need for life-long follow-up or pills) that are sometimes created by traditional procedures. Practically all of these patients have neither symptoms nor other signals, except early satiety.

More patients, longer follow-up, and multicenter experience are all necessary to establish if this procedure can really be what it was designed to be: a physiological surgical intervention able to attenuate the metabolic damage that modern food and new habits have caused in the last decades.

Conclusion

The surgical technique proposed in this article associates three well-known procedures: vertical gastrectomy, omentectomy, and enterectomy. Together, they produce a proportional reduced digestive tract without changing its general structure. There are no obstacles to food ingestion, no prostheses, no excluded segments, no detected malabsorption, and no blind endoscopic areas. No harm was observed to important digestive functions in both short and medium-term follow-ups. The secretion of GLP-1 and PYY is enhanced, and ghrelin and resistin levels reduced. These patients who were operated on lost weight and had their comorbidities resolved or very much improved. They do not need nutritional support or chronic intake of medication because of the procedure. The procedure is simple, complication rates are low, and there was no mortality.

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