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Laparoscopic ileal interposition associated to a diverted sleeve gastrectomy is an effective operation for the treatment of type 2 diabetes mellitus patients with BMI 21–29

A. L. DePaula · A. L. V. Macedo · B. R. Mota · V. Schraibman

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Abstract
Background The objective of this study is to evaluate the clinical results of the laparoscopic interposition of a segment of ileum into the proximal duodenum associated to a sleeve gastrectomy (II-DSG) in order to treat patients with type 2 diabetes mellitus (T2DM) and body mass index (BMI) 21-29 kg/m^2.
Patients and methods The laparoscopic procedure was performed in 69 patients, 22 female and 47 male. Mean age was 51 years (range 41–63 years). Mean BMI was 25.7 (21.8–29.2) kg/m^2. All patients had the diagnosis of T2DM for at least 3 years and evidence of stable treatment with oral hypoglycemic agents and or insulin for at least 12 months. Insulin therapy was used by 44% of the patients. Mean duration of T2DM was 11 years (range 3–18 years). Dyslipidemia was diagnosed in 72.5% and hypertension in 66.7%. Nephropathy was characterized in 29% of the patients, retinopathy in 26.1%, and neuropathy in 24.6%.
Results Overall, 95.7% of the patients achieved adequate glycemic control ($Hb_{A1c} < 7\%$) without antidiabetic medication. Hb_{A1c} below 6% was achieved by 65.2%. Mean postoperative follow-up was 21.7 months (range 7–42 months). Mean postoperative BMI was 21.8 kg/m^2. There was no conversion to open surgery. Median hospital stay was 3.4 days (range 2–58 days). Major postoperative complications were diagnosed in 7.3%. There was no mortality. Fasting glycemia decreased from a mean of 218 to 102 mg/dl, postprandial glycemia from 305 to 141 mg/dl, and homeostasis model assessment of insulin resistance (Homa-IR) from 5.2 to 0.77. All associated comorbidities and complications related to T2DM had significant improvement or control. Arterial hypertension was controlled in 91.3%. Macroalbuminuria was no longer observed. Microalbuminuria resolved in 87.5% of patients. Hypercholesterolemia was normalized in 95% and hypertriglyceridemia in 92% of patients.
Conclusions Laparoscopic II-DSG was an effective operation in controlling T2DM in a nonobese (BM < 30 kg/m^2) population. Associated diseases and related complications were also improved. A longer follow-up period is needed.

Keywords Type 2 diabetes mellitus · Ileal interposition · Neuroendocrine brake · Sleeve gastrectomy · Obesity · Metabolic syndrome

A. L. DePaula (✉)
Av. 136, no. 961, 14° andar, Setor Marista, 74.093-250 Goiania, Goias, Brazil
e-mail: adepaula@uol.com.br

A. L. DePaula · A. L. V. Macedo · B. R. Mota · V. Schraibman
Department of Surgery, Hospital de Especialidades, Goiania, Brazil

V. Schraibman
e-mail: vschraibman@hotmail.com

A. L. DePaula
Gastrointestinal Surgery, Hospital de Especialidades, Goiania, Brazil

A. L. V. Macedo · V. Schraibman
Albert Einstein Hospital, Sao Paulo, Brazil

B. R. Mota
Hospital de Especialidades, Goiania, Brazil

The relative inability of lifestyle change and existing drug treatments to counter the diabetic pandemic has been recognized. Current treatments are largely inadequate in terms of efficacy as well as their ability to tackle important

factors in the pathogenesis of type 2 diabetes mellitus (T2DM). There is also increasing evidence that current treatments do not address the issue of progressive beta-cell failure [1].

Obesity-related diabetes is controlled by bariatric surgery, especially gastric bypass [2] and malabsorptive surgery [3]. The pathophysiological mechanisms through which bariatric surgery achieves these results are not yet well understood. It is suggested that caloric restriction, weight loss, and hormonal changes in the enteroinsulinic axis [4] are possible features of such mechanisms.

Rubino et al. [5] advocated that the presence of an intestinal feature derived from excessive stimulus of the upper digestive tract would cause deficient incretin action and demonstrated in rats that bypassing a short segment of proximal intestine directly ameliorates T2DM, independently of effects on food intake, body weight or malabsorption, i.e., the foregut theory. Strader et al. [6], also in a rat model, suggested that lower intestinal stimulation, the hindgut theory, increased synthesis and release of peptide YY (PYY) and glucagon-like peptide 1 (GLP-1) through ileal interposition. Patriti et al. [7] performed ileal transposition in lean diabetic Goto–Kakizaki rats and concluded that the procedure effectively induced an improvement in glucose tolerance without affecting weight or food intake.

DePaula et al. [8] described an operation (the neuroendocrine brake, NEB) specifically for the treatment of nonmorbid obese T2DM clinical population with micro- and macrovascular disease. There are two versions of the NEB: the standard one, in which duodenum is continuous to digestive tract, and the diverted version, in which the duodenum is bypassed. The NEB intends to address the current pathophysiological mechanisms of T2DM, involving neurohormonal mechanisms, caloric restriction, and weight loss.

The objective of this study is to evaluate clinical results of laparoscopic interposition of a segment of ileum into the proximal duodenum associated to a sleeve gastrectomy (II-DSG) in order to treat patients with type 2 diabetes mellitus (T2DM) and BMI 21–29 kg/m^2.

Patients and methods

Laparoscopic ileal interposition associated with a diverted sleeve gastrectomy was performed in 69 nonobese patients with T2DM (Image 1). There were 47 men and 22 women, with a mean age of 51.4 ± 5.6 years (range 41–63 years). Mean BMI was 25.7 ± 1.9 kg/m^2 (range 21.8–29.2 kg/m^2). Oral hypoglycemic agents were used by 56.5% of the patients (mean number 1.7). Insulin therapy was required by 7.5% of the patients, and 36% were receiving both insulin and oral agents. Mean duration of T2DM was 11 ± 4 years (range 3–18 years). Demographic data are summarized in Table 1. Associated diseases or complications of T2DM were present in all patients. Dyslipidemia was diagnosed in 72.5% and hypertension in 66.7%. Nephropathy was characterized in 29% of the patients, retinopathy in 26.1%, and neuropathy in 24.6%. Coronary artery disease was diagnosed in 11.6% of patients.

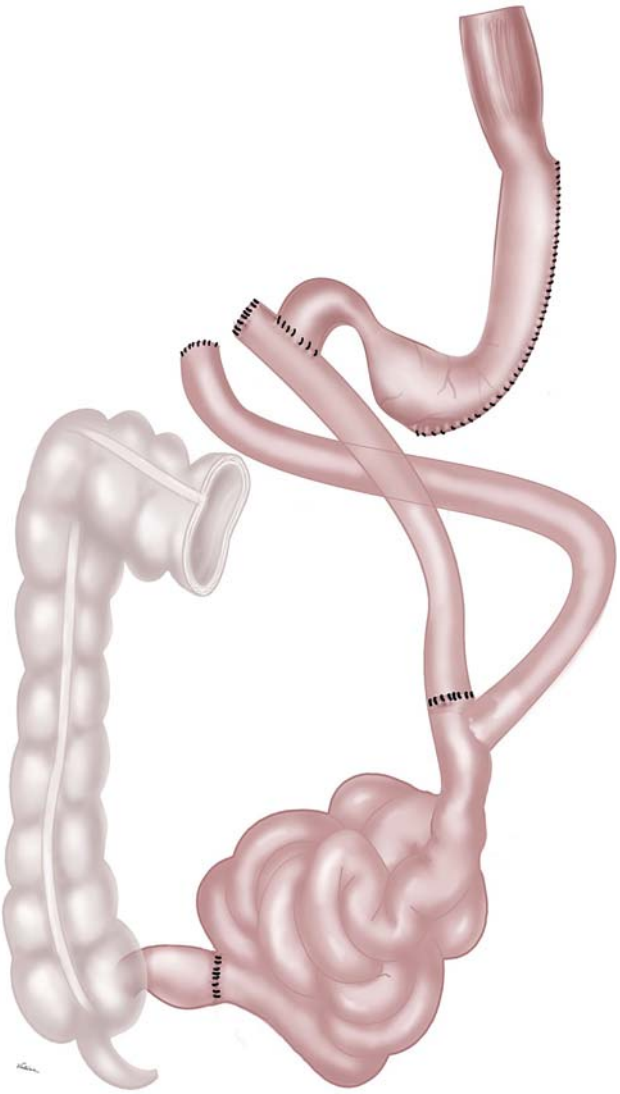

Image 1 Laparoscopic ileal interposition associated with a diverted sleeve gastrectomy

The inclusion criteria specified patients with the diagnosis of T2DM for at least 3 years, documentation of $Hb_{A1c} > 7.5\%$ for at least 3 months, stable weight, defined as no significant change (>3%) over the 3 months prior to enrollment, and evidence of stable treatment with oral hypoglycemic therapy and or insulin for at least 12 months.

Exclusion criteria were patients with C-peptide levels below 0.9 ng/ml, positive anti-glutamic acid decarboxylase

Table 1 Demographic data

	Total
Patients	69
Age, years	51.0 ± 5.6 (41.0–63.0)
Sex (male/female)	47/22
BMI (mean), kg/m^2	25.7 ± 1.9 (21.8–29.2)
Hb_{A1c}, %	8.7 ± 2.1 (7.5–13.7)
T2DM duration, years	11 ± 4 (3–18)
Oral hypoglycemic agents	56%
Insulin	8%
Both	36%

(GAD) test, elderly patients (>66 years), previous major upper abdominal surgery, pregnancy, patients with malignant or debilitating diseases, severe pulmonary or cardiac diseases, severe renal disease (glomerular filtration rate below 30 ml/min), taking appetite suppressant medication, eating disorder such as bulimia or binge-eating, and obesity due to any other endocrine disorder.

The diagnosis of T2DM, goals for glycemia and lipids, and control of blood pressure were based on the criteria established by the American Diabetes Association [9]. Type 2 diabetes mellitus was considered resolved for patients who had normal fasting plasma glucose (<100 mg/dl), normal Hb_{A1c} (<6%), and no need for diabetic medications. Glycemic control was achieved if an Hb_{A1c} of less than 7% without diabetic medication was obtained. Patients were considered improved if they showed more than a 25-mg/dl decrease in fasting plasma glucose and a significant reduction in Hb_{A1C} (>1%). The primary goal in relation to the lipid profile was low-density lipoprotein (LDL) level less than 100 mg/dl, triglyceride level less than 150 mg/dl, and high-density lipoprotein (HDL) level exceeding 40 mg/dl. Blood pressure was targeted at less than 130/80 mmHg.

The preoperative evaluation included general clinical history, that of T2DM, physical examination, blood tests, urinalysis, serum chemistries, abdominal sonogram, upper digestive endoscopy, chest X-ray, pulmonary function test, fasting lipid profile, test for microalbuminuria, serum creatinine assessment, estimation of glomerular filtration rate, Doppler study of carotid arteries, retinopathy screening, and detailed cardiac evaluation. Biochemical markers of T2DM were obtained, including fasting plasma glucose, postprandial plasma glucose, Hb_{A1c}, fasting plasma insulin, and the homeostasis model assessment of insulin resistance (Homa-IR) and C-peptide. Plasma glucose concentrations were measured by glucose oxidase method using a glucose analyzer (YellowSprings InstrumentModelYSI 2300 STATplus analyzer; YSI, Inc., Yellow Springs, OH, USA). Plasma insulin and C-peptide concentrations were measured by auto-DELPHIA automatic fluoroimmunoassay (Wallac, Inc., Turku, Finland).

Preoperative preparation for surgery included clear liquids for 48 h before operation in association with regular insulin according to capillary glucose. Preoperative bowel cleansing, perioperative antibiotics, and low-molecular-weight heparin were administered.

The technique performed consisted of peristaltic ileal interposition (170 cm) up to the first portion of the sectioned duodenum associated to a sleeve gastrectomy, so diverting the duodenum (II–DSG). Sleeve gastrectomy was performed after devascularization of the greater curvature beginning in the distal portion of the antrum (5 cm proximal to the pylorus) utilizing ultrasonic scalpel. A 38-Fr Fouchet orogastric calibration tube was placed by the anesthesiologist along the lesser curvature towards the pylorus. The gastric resection was performed starting at the antrum up to the angle of His, using a linear 45- or 60-mm stapler. A 3-0 polypropylene running invaginating suture covered the staple line. After that, the devascularization along the greater curvature of the stomach continued to the duodenum, 3–4 cm beyond the pylorus. The duodenum was transected using a 60-mm linear stapler. A 3-0 polypropylene running invaginating suture covered the duodenal staple line. The gastric pouch and proximal duodenal were then transposed to the lower abdomen through an opening of the mesocolon. An ileal segment of 170 cm was created 30 cm proximal to the ileocecal valve, interposing and anastomosing it peristaltically to the first portion of the duodenum. For standardization purposes, intestinal measurements were performed with traction, along the antimesenteric border, using a 10-cm marked atraumatic grasper. A point in the jejunum, 50 cm distal from the ligament of Treitz, was measured and anastomosed to the distal part of the interposed ileum. The anastomoses were performed functionally using 45-mm linear staplers, taking care to close mesenteric defects with interrupted 3-0 polypropylene sutures. The duodenum–ileal anastomosis was performed using handsewing techniques with interrupted sutures. The trocars openings were closed.

Outcomes measures were collected prospectively. The main parameters evaluated included fasting and postprandial glucose, Hb_{A1c}, lipid profile, diabetes and antihypertensive medication usage (agents, doses, and frequency), weight loss (expressed as BMI and percentage of initial weight loss), resolution or improvement of associated diseases and complications, reoperation rate, and morbidity/mortality of the procedure. Patient and laboratory evaluations were scheduled to be performed every 3 months during the first year

after the operation, then annually. The ethics committee of the hospital approved the study, and all subjects gave written informed consent.

Statistical analysis

Statistical analysis was done using Fisher's exact test and Student's *t* test according to the data. A significance level of 0.05 ($\alpha = 5\%$) was adopted and levels below this were considered significant ($p < 0.05$). All values are expressed as means ± standard error (SE).

Results

Sixty-nine patients underwent laparoscopic ileal interposition associated with a diverted sleeve gastrectomy and were followed-up for a mean of 21.7 months (range 7–42 months). There was no conversion to open surgery. Associated procedures included four cholecystectomies (5.8%) with cholangiography and four hiatal hernia repairs (5.8%). Mean operating time was 192 min (range 152–261 min). Median hospital stay was 3.4 days (range 2–58 days).

Five patients (7.3%) experienced major postoperative complications during the first 30 days after surgery, including fistula ($n = 1$), gastrointestinal bleeding ($n = 1$), urinary tract infection ($n = 1$), and pneumonia ($n = 2$). Reoperation was needed in one patient (1.4%) with a fistula at the gastroesophageal junction, who had a long hospital stay (58 days). There was no mortality. During the first postoperative month, four patients (5.8%) had to be readmitted to the hospital due to the aforementioned pneumonia ($n = 2$), urinary tract infection ($n = 1$), and vomiting, and dehydration ($n = 1$). The most frequent complaints in the first postoperative month included some degree of physical limitation, nausea, anorexia, early satiety, heartburn, and discomfort in the right lower abdomen. Most patients were able to resume work 1 week after surgery. Symptoms could be controlled with proton pump inhibitors. Patients were routinely submitted to upper digestive endoscopy 30 days after surgery. Erosive esophagitis was diagnosed in 7.3% of the patients. Patients' symptoms progressively improved, with anorexia and some degree of food intolerance been the most important. Heartburn was uncommon. During this follow-up period (mean 21.7 months, range 7–42 months), 11 patients had clinical complications (15.9%) including prolonged diarrhea ($n = 2$, 2.9%), gout attack ($n = 2$, 2.9%), prolonged emesis ($n = 3$, 4.4%), urinary tract infection ($n = 3$, 4.4%), and fungal esophagitis ($n = 1$, 1.4%). Hospitalizations were needed in four cases (5.8%). Iron deficiency was demonstrated in 5.8% of patients. There were also three surgical complications (4.4%), including intestinal obstruction ($n = 2$, 2.9%) and intestinal perforation ($n = 1$, 1.4%). Reoperation was performed in two patients (2.9%), due to intestinal obstruction (lysis of adhesions) and perforation at the distal ileum interposed in one case each.

Overall, 95.7% of patients achieved adequate glycemic control without antidiabetic medication. Hb_{A1c} was less than 6% (remission) in 65.2% of the patients, 6.1–7% (control) in 30.5%, and >7% (improvement) in 4.3% of the patients (Table 2). Rapid normalization of fasting plasma glucose (first 2 weeks) was achieved by 31.9% of patients. Mean Hb_{A1c} decreased from 8.7 ± 2.1% to 5.9 ± 0.9% ($p < 0.001$, Fig. 1). Remission ($Hb_{A1c} < 6\%$) was more frequent among patients with less than 5 years of T2DM and for those on oral agents preoperatively. Glucose control was not related to the amount of weight loss. Oral hypoglycemic agents were still been used by 4.3% of patients. All of them were under insulin therapy preoperatively.

Fasting plasma glucose decreased from 218.1 ± 66.3 mg/dl to 102.0 ± 25.3 mg/dl ($p < 0.001$, Fig. 2) and postprandial plasma glucose from 305.2 ± 108.3 mg/dl to 141.5 ± 4 9.9 mg/dl ($p < 0.001$, Fig. 3). Fasting plasma insulin decreased from 11.9 ± 8.4 mU/ml to 2.8 ± 1.9 mU/ml ($p < 0.001$). The homeostasis model assessment of insulin resistance (Homa-IR) decreased from preoperative levels of 5.2 ± 3.5 to 0.8 ± 0.9 ($p < 0.001$). Fasting C-peptide decreased from 3.0 ± 1.5 ng/ml to 1.7 ± 07 ng/ml ($p < 0.001$). Dyslipidemia was diagnosed in 72.5%. Triglycerides decreased from a mean of 236.5 ± 174.3 mg/dl in the preoperative period to 105.8 ± 43.6 mg/dl postoperatively ($p < 0.001$, Fig. 4. Hypertriglyceridemia was normalized in 92% of patients. HDL increased from a mean of 45.6 ± 7.2 mg/dl to 48.0 ± 7.5 mg/dl ($p = 0.051$). LDL decreased from a mean of 114.6 ± 33.6 mgl/dl to 82.4 ± 22.4 mg/dl ($p < 0.001$). Hypercholesterolemia normalized in 95% of patients. Data are summarized in Table 3.

Mean percentage of weight loss was 17.7 ± 6.2% of the initial weight (range 9–25.1%). Mean BMI decreased from 25.7 ± 1.9 kg/m^2 (range 21.8–29.2 kg/m^2) preoperatively to 21.8 ± 4.1 kg/m^2 (range 17.7–25.8 kg/m^2) ($p < 0.001$, Fig. 5). Twelve patients (17.4%) were underweight (BMI < 20 kg/m^2), 51 (73.9%) had BMI 20–25 kg/m^2), and 6 (8.7%) had BMI above 25 kg/m^2. Serum albumin level was normal in all patients.

Hypertension was characterized in 66.7% of patients in the preoperative workup. All patients were using antihypertensive medications (mean 1.7). Arterial hypertension was controlled in 91.3%, (≤130/≤85 mmHg), without medication, on casual blood pressure measurement. Carotid artery evaluation was abnormal in 31.9% of patients, ranging from intimal–medial thickness, to partial stenosis, to 40% of the arterial lumen. Routine postoperative evaluation at 12 months demonstrated disappearance of

Table 2 Metabolic characteristics of study groups

	Preoperative	Postoperative	*p*
Triglycerides (mg/dl)	236.5 ± 174.3 (97.0–737.0)	105.8 ± 43.6 (53.0–223.0)	<0.001
HDL cholesterol (mg/dl)	45.6 ± 7.2 (33.0–63.0)	48.0 ± 7.5 (33.0–68.0)	0.051
LDL cholesterol (mg/dl)	114.6 ± 33.6 (58.0–182.0)	82.4 ± 22.4 (51.0–152.0)	<0.001
Fasting plasma glucose (mg/dl)	218.1 ± 66.3 (90.0–334.0)	102.0 ± 25.3 (73.0–161.0)	<0.001
Postprandial plasma glucose (mg/dl)	305.2 ± 108.3 (129.0–530.0)	141.5 ± 49.9 (85.0–247.0)	<0.001
Fasting plasma insulin (um/ml)	11.9 ± 8.4 (2.4–36.0)	2.8 ± 1.9 (0.7–8.0)	<0.001
Homa-IR	5.2 ± 3.5 (1.7–15.5)	0.8 ± 0.9 (0.3–3.8)	<0.001
Fasting C-peptide (ng/ml)	3.0 ± 1.5 (1.0–5.7)	1.7 ± 0.7 (0.7–3.2)	<0.001
Microalbuminuria (mcg/min)	55.2 ± 100.1 (2.7–371.0)	44.7 ± 128.0 (1.4–563.0)	0.113
Hb_{A1c}	8.7 ± 2.1 (7.5–13.7)	5.9 ± 0.9 (4.8–8.5)	<0.001

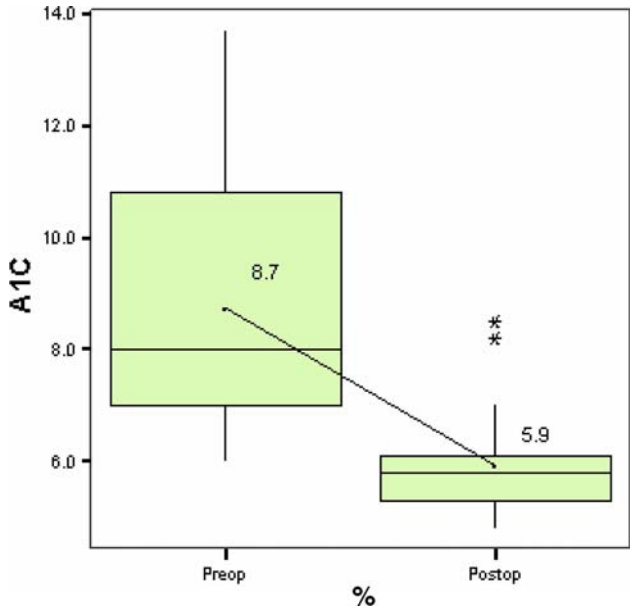

Fig. 1 Pre- and postoperative Hb_{A1c} ($p < 0.001$)

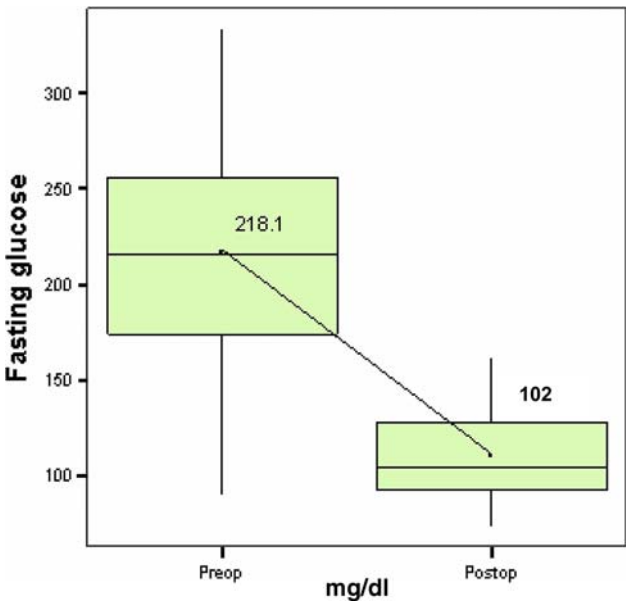

Fig. 2 Pre- and postoperative fasting glucose ($p < 0.001$)

intimal–medial thickness and no change for those with some degree of stenosis. Coronary artery disease was diagnosed in 11.6% of patients. No major cardiac event could be diagnosed during this period of follow-up.

Nephropathy was characterized in 29% of the patients preoperatively. Preoperative microalbuminuria was diagnosed in 80% of patients and macroalbuminuria in 20%. Glomerular filtration rate of 60–89 ml/min was diagnosed in 16% of patients and 30–59 ml/min in 8.7%. Postoperatively, all patients with GFR of 60–89 ml/min had normalized filtration rate (>90 ml/min). Those with GFR of 30–59 ml/min showed substantial improvement in renal function. Macroalbuminuria was no longer observed. Microalbuminuria resolved in 87.5% of the patients.

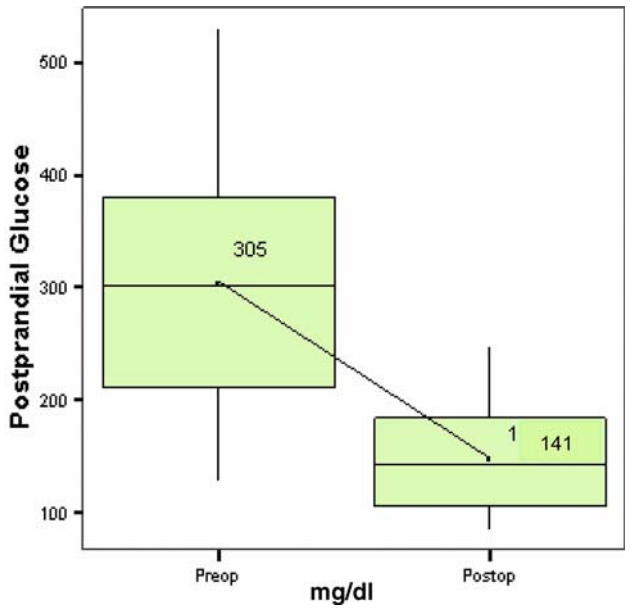

Fig. 3 Pre- and postoperative postprandial glucose ($p < 0.001$)

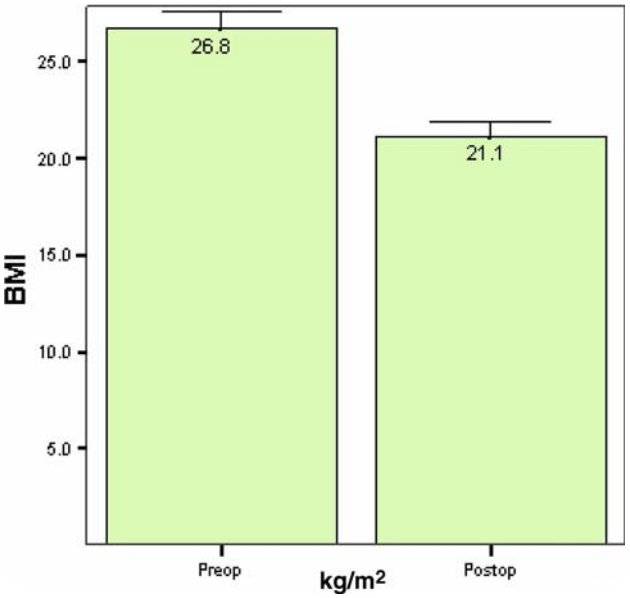

Fig. 4 Pre- and postoperative BMI ($p < 0.001$)

Table 3 Type 2 diabetes mellitus resolution according to Hb_{A1c}

Hyperglycemia	Remission $Hb_{A1c} < 6\%$	Control Hb_{A1c} 6–7%	Improvement $Hb_{A1c} > 7\%$
II - DSG	65.2%	30.5%	4.3
	5.5 ± 0.4	6.6 ± 0.4	8.4 ± 0.2
	(4.8–6.0)	(6.1–7.0)	(8.2–8.5)

Retinopathy was diagnosed in 26.1% of patients preoperatively. Objective improvement of the retinopathy was demonstrated in 44.4% of patients. Symptomatic improvement was observed in all patients.

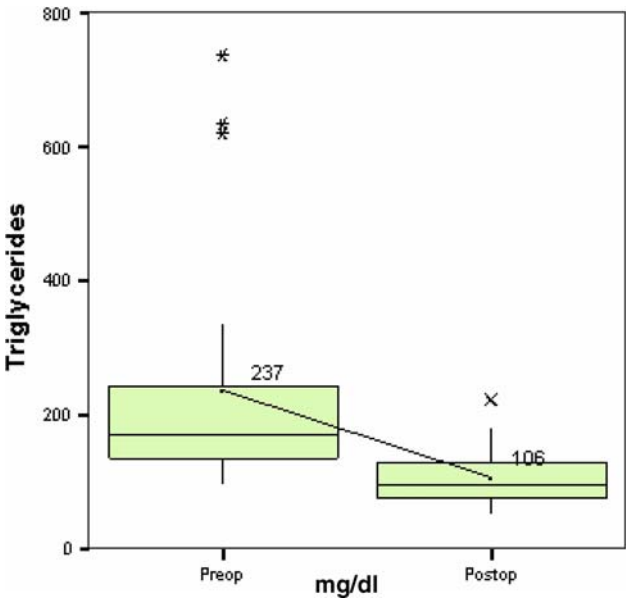

Fig. 5 Pre- and postoperative triglycerides ($p < 0.001$)

Preoperative neuropathy was suspected in 24.7% of patients. Clinical improvement of distal polyneuropathy was demonstrated in 70.5%. Electrophysiological testing was not routinely performed. Autonomic neuropathy was suspected in 17.4% of the patients, as characterized by resting tachycardia, gastroparesis, and constipation.

Discussion

This study in type 2 diabetic patients with BMI 21–29 kg/m^2 and 21.7 months follow-up demonstrates overall glucose control in 95.7% of the patients who were submitted to the laparoscopic ileal interposition associated with a diverted sleeve gastrectomy, without antidiabetic medication. Furthermore, resolution or improvement in associated diseases or complications was remarkable. We demonstrated pleiotropic clinical response to this type of surgery, which might account for the glucose control rates and other achievements. Consistent with current literature in the bariatric field [10], the majority of patients experienced control of diabetes while early complications were kept at acceptable rates, around 7%, without mortality.

We speculate that these results may be secondary to hormonal changes, caloric restriction, and weight loss; identification of the dominant factor is quite unlikely based on the results of this study.

As with bariatric operations, caloric restriction is probably the most important mechanism related to improved glucose metabolism in the short term [11]. However, it is difficult to exclude the possible role of hormonal changes to explain the rapid normalization of glucose achieved by

31.9% of the patients. Flatt suggested that the most attractive hypotheses for rapid improvement of insulin resistance and associated pancreatic beta-cell function are related to surgical ablation of glucose-dependent insulinotropic peptide (GIP)-secreting intestinal k-cells [12].

We believe that, even for this group of patients with preoperative BMI ranging from 21 to 29 kg/m^2, weight loss has a significant effect on overall metabolic improvement. All patients lost weight (mean 17.7 ± 6.2% of initial weight). Different from morbid obese diabetic patients, in whom percentage weight loss is a predictor of remission of diabetes [13], glucose control was not related to amount of weight loss in this subset of patients. Obesity, especially intra-abdominal obesity, causes insulin resistance and is under genetic control. Although the prevalent view is that insulin resistance is the main genetic factor predisposing to development of T2DM, review of several lines of evidence in the literature indicates a lack of overwhelming support for this concept. In fact, the literature better supports the case of impaired insulin secretion being the initial and main genetic factor predisposing to T2DM, especially when considering nonobese patients, as in this study. Lifestyle changes (exercise, weight reduction) and pharmacological agents (e.g., biguanides and thiazolidinediones) that reduce insulin resistance or increase insulin sensitivity clearly have major beneficial effects [14].

The role of diverting the duodenum and its rich k-cells that produces GIP is not well understood. Gault et al. [15] suggested that the use of GIP-R antagonists may, in addition to enhancing insulin sensitivity through depression of hyperinsulinemia and consequent upregulation of insulin receptors, directly improve insulin action in both the absence and presence of decreased adipocyte lipid accumulation. Instead of causing further impairment of glucose homeostasis, preferentially marked improvement of insulin sensitivity results in substantial improvement of the metabolic syndrome. Zhou et al. [16] demonstrated that GIP plays a crucial role in the switch from fat oxidation to fat accumulation under diminished insulin action, and inhibition of GIP signaling ameliorated insulin resistance. In subjects with IGT but not diabetes, not only are fasting plasma levels of GIP elevated, but there is also augmented GIP secretory response to oral glucose load. Relative insensitivity of gut k-cells to intestinal glucose, coupled with desensitization of the GIP receptor following prolonged exposure to increased GIP plasma levels in the impaired state, are the likely causes of dysregulation of GIP secretion at this moment and dysregulation of action seen in T2DM [17].

Following operation, central obesity was completely resolved, with all patients achieving waist circumference parameters below reference points. This was demonstrated by adjusted weight loss, although 17% of the patients reached a BMI lower than 20 kg/m^2. Minimum BMI was 17.7 kg/m^2. None of the patients was characterized as having malnutrition.

Glycemic control prevents or delays microvascular complications and can also reduce macrovascular events. However, iatrogenic hypoglycemia in advanced T2DM may represent a limiting factor to this strategy [18]. As documented by the UK Prospective Diabetes Study [19] alfa cells complications develop and progress despite aggressive therapy. We recently reported [20] the impact of laparoscopic ileal interposition associated to a sleeve or diverted sleeve gastrectomy as adequate treatment for the components of the metabolic syndrome and some other important independent factors. Although we do not want to draw any definitive conclusion, the objective findings of no major cardiac events during this follow-up period, amelioration of glomerular filtration rate, almost universal improvement of cholesterol and triglycerides, control of hypertension, and improvement of both retinal disease and neuropathy are remarkable.

In conclusion, as with a new pharmacological therapy, however, these impressive results of the laparoscopic ileal interposition associated with diverted sleeve gastrectomy are associated with a number of issues that warrant further consideration and evaluation.

References

1. Ranganath LR (2008) The entero-insular axis: implications for human metabolism. Clin Chem Lab Med 46:43–56
2. Hickey MS, Pories WJ, MacDonald KG Jr, Cory KA, Dohm GL, Swanson MS, Israel RG, Barakat HA, Considine RV, Caro JF, Houmard JA (1998) A new paradigm for type 2 diabetes mellitus? Could it be a disease of the foregut? Ann Surg 227:637–644
3. Greenway SE, Greenway FL, Klein S (2002) Effects of obesity surgery on non–insulin-dependent diabetes mellitus. Arch Surg 137:1109–1117
4. Patriti A, Facchiano E, Sanna A, Gulla N, Donini A (2004) The enteroinsular axis and the recovery from type II diabetes after bariatric surgery. Obesity 14:840–848
5. Rubino F, Forgione A, Cummings DE, Vix M, Gnuli D, Mingrone G, Castagnet M, Marescaux J (2006) The mechanism of diabetes control after gastrointestinal bypass surgery reveals a role of the proximal small intestine in the pathophysiology of type 2 diabetes. Ann Surg 244:741–749
6. Strader AD, Vahl TP, Jandacek RJ, Woods SC, D'Alessio DA, Seeley RJ (2005) Weight loss through ileal transposition is accompanied by increased ileal hormone secretion and synthesis in rats. Am J Physiol Endocrinol Metab 288:E447–E453
7. Patriti A, Facchiano E, Annetti C, Aisa MC, Galli F, Fanelli C, Donini A (2005) Early improvement of glucose tolerance after ileal transposition in a nonobese type 2 diabetes rat model. Obes Surg 15:1258–1264
8. DePaula AL, Macedo ALV, Rassi N, Machado CA, Schraibman V, Silva LQ, Halpern H (2008) Laparoscopic treatment of type 2 diabetes mellitus for patients with a body mass index less than 35. Surg Endosc 22:706–16

9. American Diabetes Association (2006) Standards of medical care in diabetes: position statement. Diabetes Care 29(Suppl 1):S4–S42
10. Parikh M, Ayoung-Chee P, Romanos E, Lewis N, Pachter HL, Fielding G, Ren C (2007) Comparison of rates of resolution of diabetes mellitus after gastric banding, gastric bypass, and bilipancreatic diversion. J Am Coll Surg 205:631–635
11. Gumbs AA, Modlin IM, Ballantyne GH (2005) Changes in insulin resistance following bariatric surgery: role of caloric restriction and weight loss. Obes Surg 15:462–473
12. Flatt PR (2007) Effective surgical treatment of obesity may be mediated by ablation of the lipogenic gut hormone gastric inhibitory polypeptide (GIP): evidence and clinical opportunity for development of new obesity-diabetes drugs? Diab Vasc Dis Res 4:151–153
13. Dolan K, Hatzifotis M, Newbury L (2004) A comparison of laparoscopic adjustable gastric banding and biliopancreatic diversion in superobesitiy. Obes Surg 14:165–169
14. Gerich JE (1998) The genetic basis of type 2 diabetes mellitus: impaired insulin secretion versus impaired insulin sensitivity. Endocrine Rev 19:491–503
15. Gault VA, Irwin N, Green BD, Mccluskey JT, Greer B, Bailey CJ, Harriott P, O'Harte, FPM, Flatt PR (2005) Chemical ablation of gastric inhibitory polypeptide receptor action by daily (Pro 3) GIP administration improves glucose tolerance and ameliorates insulin resistance and abnormalities of islet structure in obesity-related diabetes. Diabetes 54:2436–2446
16. Zhou H, Yamada Y, Tsukiyama K, Miyawaki K, Hosokawa M, Nagashima K, Toyoda K, Naitoh R, Mizunoya W, Fushiki T, Kadowaki T, Seino Y (2005) Gastric inhibitory polypeptide modulates adiposity and fat oxidation under diminished insulin action. Biochem Biophys Res Commun 335:937–942
17. Theodorakis MJ, Carlson O, Muller DC, Egan JM (2004) Elevated plasma glucose-dependent insulinotropic polypeptide associates with hyperinsulinemia in impaired glucose tolerance. Diabetes Care 27:1692–1698
18. Cryer PE (2002) Hypoglycaemia: the limiting factor in the glycaemic management in type 1 and type 2 diabetes. Diabetologia 45:937–948
19. UK Prospective Diabetes Study (UKPDS) Group (1998) Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complication in patients with type 2 diabetes (UKPDS 33). Lancet 352:837–853
20. DePaula AL, Macedo ALV, Rassi N, Vencio S, Machado CA, Mota BR, Silva LQ, Halpern A, Schraibman V (2008) Laparoscopic treatment of metabolic syndrome in patients with type 2 diabetes mellitus. Surg Endosc [Epub ahead of print]