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CLINICAL RESEARCH

# Clinical Efficacy of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Gastric Bypass in Obese Type 2 Diabetic Patients: a Retrospective Comparison

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**Abstract**
*Background* Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) are performed in patients with obesity and type 2 diabetes mellitus (T2DM). The aim of this study is to evaluate retrospectively the clinical efficacy of RYGB and SG in two groups of obese T2DM patients.
*Methods* From the hospital database, we extracted the clinical records of 31 obese T2DM patients, of whom 15 (7 F/8 M) had undergone laparoscopic SG (LSG) and 16 (7 F/9 M) laparoscopic RYGB (LRYGB) in the period 2005–2008. The groups were comparable for age (range 33–59 years) and BMI (range 38–57 kg/m$^2$). LRYGB alimentary limb was 150 cm, and biliopancreatic limb was 150 cm from the Treitz ligament. LSG vertical transection was calibrated on a 40-Fr orogastric bougie. Data were analysed at 6, 12 and 18–24 months with reference to weight loss and remission of comorbidities.
*Results* The reduction in body weight was comparable in the two groups. At 18–24 months the percent BMI reduction was 29±8 and 33±11 % in LSG and LRYGB, respectively. Percent excess weight loss was 53±16 and 52±19 % in LSG and LRYGB, respectively. Thirteen patients in LSG and 14 patients in LRYGB discontinued their hypoglycaemic medications. Five (55 %) patients in LSG and eight (89 %) in LRYGB discontinued antihypertensive drugs. Three out of five patients in LSG and one out of two patients in LRYGB withdrew lipid-lowering agents.
*Conclusions* LSG and LRYGB are equally effective in terms of weight loss and remission of obesity-related comorbidities. Controlled long-term comparisons are needed to establish the optimal procedure in relation to patients' characteristics.

**Keywords** Laparoscopic gastric bypass · Sleeve gastrectomy · Type 2 diabetes mellitus · Obesity · Bariatric surgery

## Introduction

Behavioural and medical approaches to obesity result in a body weight loss of approximately 5–10 % in the short term, which tend to wane over time [1]. In contrast, bariatric surgery leads to a much greater weight reduction ranging from 50 to 75 % of excess body weight [2]. More importantly, weight loss is durable as confirmed by long-term follow-up evaluations [3]. Therefore, in the recent international guidelines, bariatric surgery is presented as the most effective treatment for morbid obesity [4]. It is also associated with a high rate of remission of type 2 diabetes mellitus (T2DM) and other obesity-related conditions, namely hypertension, dyslipidemia and obstructive sleep apnea [5]. Adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) are among the most common bariatric interventions [6]. RYGB is considered the gold standard bariatric procedure because of its

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high success rate balanced against a low rate of adverse events and complications [7].

SG, originally developed as a first step for achieving weight loss in super-obese patients before performing RYGB or a biliopancreatic diversion with duodenal switch [8], is now viewed as an effective operation on its own [9]. In addition, this procedure is no longer considered a purely restrictive intervention since it is associated with changes in some gastrointestinal hormones [10]. Indeed, weight loss after SG, at least in short term, is greater than that obtained with AGB [11]. At present, it is difficult to match the different surgical procedures available to different patients' characteristics. The aim of this study is to evaluate the clinical efficacy of laparoscopic RYGB (LRYGB) and laparoscopic SG (LSG) in terms of remission of T2DM and other comorbidities in two comparable groups of obese T2DM patients.

## Materials and Methods

We prospectively maintained a database of all operated patients and extracted the data of 31 obese T2DM patients who underwent bariatric surgery in the period 2005 and 2008 at the department of surgery of a tertiary bariatric centre. These patients were chosen from a larger group of operated people with T2DM so that the LSG and LRYGB groups were comparable for preoperative anthropometric characteristics. The choice of the surgical procedure was decided by a multidisciplinary team taking into account also patients' preferences and, above all, the anticipated compliance of patients to lifelong follow-up and nutritional management.

Diagnosis of T2DM was made according to the American Diabetes Association guidelines. T2DM remission was defined as fasting plasma glucose (FPG) level below 126 mg/dl in the absence of hypoglycaemic drugs. Remission of hypertension was defined by discontinuation of antihypertensive treatment; remission of dyslipidemia was defined by discontinuation of lipid-lowering drugs. Improvement of comorbidities was defined by reduction of drugs dosage. In all patients, body weight, BMI, percent excess weight loss (EWL) and FPG were examined preoperatively and at 6, 12 and 18–24 months after surgery. We also evaluated mortality, peri- and postoperative complications and length of hospital stay with the two types of surgery.

### Assays

Plasma glucose and lipid concentrations were measured by enzymatic method. Glycated haemoglobin (HbA1c) was measured by high-performance liquid chromatography (HPLC).

### Surgical Procedures

All procedures were attempted and completed laparoscopically. LRYGB consisted of a 40-cc gastric pouch. The Roux limb was constructed by transecting the small bowel 100–150 cm distal to the ligament of Treitz (biliopancreatic tract). The circular stapler was introduced transabdominally, to create an antecolic, antegastric end-to-side gastro-jejunostomy. Gastro-jejunostomy was leak tested by injecting 40–60 cc of methylene blue. Jejuno-jejunostomy was performed by a 45-mm linear stapler, 100–150 cm distal to the gastro-jejunostomy (alimentary tract; long limb gastric bypass).

For LSG, the gastric greater curvature was freed up to the cardio-oesophageal junction close to stomach and toward the antrum up to 3–5 cm from the pylorus. The orogastric tube was calibrated with a 40-Fr boogie. Then the stomach was resected with multiple linear staplers parallel to orogastric tube along the lesser curve starting 3–5 cm far from pylorus.

### Statistical Analysis

Data are reported as mean±standard deviation. Paired Student's $t$ tests were used to compare data before and after surgery within each group. Unpaired Student's $t$ test was used for comparisons between groups. Statistical significance was set at a $p$ value less than 0.05. All statistical analyses were performed using SPSS version 13.0 (SPSS Inc., Chicago, IL).

## Results

The main characteristics of the patients studied are shown in Table 1. Preoperative body weight was similar in LSG and

**Table 1** Preoperative characteristics of the patients studied

| | LSG ($n$=15) | LRYGB ($n$=16) | $p$ |
|---|---|---|---|
| Sex (M/F) | 7/8 | 7/9 | ns |
| Age (years) | 45±7 | 45±8 | ns |
| BMI (kg/m$^2$) | 51±8 | 48±4 | ns |
| EW (%) | 129±46 | 110±24 | ns |
| Blood glucose (mg/dl) | 129±38 | 171±76 | ns |
| HbA1c (%) | 7.9±2 | 8.6±1 | ns |
| Duration of diabetes (years) | 3±2 | 3±2 | ns |
| Hypoglycaemic therapy ($n$) | | | |
| Diet | 0 | 1 | |
| Metformin | 13 | 13 | |
| Metformin+insulin | 2 | 2 | |
| Antihypertensive drugs ($n$) | 9 | 9 | |
| Lipid-lowering agents ($n$) | 5 | 2 | |

*BMI* body mass index, *EW* excess weight, *ns* not significant

**Table 2** Changes in BMI, percent BMI and percent EWL after LSG and LRYGB

| | BMI (kg/m$^2$) | | | Decrease in BMI (%) | | | EWL (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | LSG | LRYGB | $p^a$ | LSG | LRYGB | $p^a$ | LSG | LRYGB | $p^a$ |
| 6 months | 39±7 | 37±5 | ns | 26±5 | 22±7 | ns | 47±12 | 44±13 | ns |
| 12 months | 36±6 | 32±4 | ns | 29±8 | 36±19 | ns | 54±15 | 60±17 | ns |
| 18–24 months | 36±7[b] | 32±5 | ns | 29±8 | 33±11 | ns | 53±16 | 52±19 | ns |

*BMI* body mass index, *EWL* excess weight loss, *ns* not significant

[a] Comparison between groups

[b] $n=14$ due to the exclusion of one patient who was re-operated 15 months after LSG

LRYGB. All patients had a duration of T2DM >1 year (3± 2 years), and most of them (68 %) were in poor glycaemic control, as evidenced by HbA1c >7 %. One patient was diet controlled, 26 patients were on hypoglycaemic agents and 4 patients were on combined therapy (metformin plus insulin). Nine patients in both groups (60 and 56 %) were on antihypertensive therapy; five (33 %) patients in LSG and two (12 %) in LRYGB received lipid-lowering agents.

## Weight Loss

The changes in body weight following LSG and LRYGB are reported in Table 2. The percent reduction in BMI was comparable at 6 months (26±5 and 22±7 %), 12 months (29 ±8 and 36±19 %) and 18–24 months (29±8 and 33±11 %) in LSG and LRYGB, respectively. Likewise, EWL percentage was similar in the two groups at all time points of the follow-up.

## Improvement/Remission of Comorbidities

Immediately after interventions, 12 patients in LSG and all patients in LRYGB discontinued their hypoglycaemic medications. These results remained essentially unchanged both at 6 than at 18–24 months (Table 3). Only one patient in LRYGB after 20 months showed a value of FPG >126 mg/dl and an HbA1c >7 %. At 18–24 months, FPG was 105±27 and 106±27 mg/dl and HbA1c reduced from baseline value of 7.9±2 to 6.1±0.6 % in LSG and from 8.6±1 to 5.8± 0.9 % in LRYGB. Five (55 %) patients in LSG and eight (89 %) in LRYGB discontinued antihypertensive drugs. Three out of five patients in LSG and one out of two patients in LRYGB discontinued lipid-lowering agents. All patients that did not experience complete remission of their comorbidities nonetheless did experience significant improvement (i.e. lower doses of medications).

## Postoperative Outcome

The postoperative length of hospital stay averaged 5±4 days (range 3–25 days). None of the patients required conversion to an open procedure. The 30 days, 90 days and 24 months mortality was zero. In the LSG group, three patients underwent laparoscopic duodenal switch: one patient was re-operated 15 months after LSG (therefore was excluded from the 18–24 follow-up evaluation); two patients were re-operated after more than 24 months from the first intervention as a sequential treatment of super-obesity. The duodenal switch was performed after the patients had achieved a ~25-kg weight loss and a substantial improvement of comorbidities; all of them underwent duodenal switch for further weight loss.

An additional three patients had concomitant procedures during the LSG surgery: one cholecystectomy, one umbilical hernia and one hiatal hernia repair/umbilical hernia. In the LRYGB group, there were three concomitant cholecystectomies and one hiatal hernia repair. Three LRYBG patients developed perioperative complications: one patient had a hematoma of the abdominal wall that was treated conservatively, one patient developed an intestinal volvulus 10 days after surgery that was treated with laparoscopic volvolus derotation and one patient had a prolonged

**Table 3** Number of patients who discontinued the pharmacological treatment

| | 6 months | | 12 months | | 18–24 months | |
|---|---|---|---|---|---|---|
| | LSG, *n* (%) | LRYGB, *n* (%) | LSG, *n* (%) | LRYGB, *n* (%) | LSG, *n* (%) | LRYGB, *n* (%) |
| Hypoglycaemic drugs | 12 (80) | 15 (100) | 13 (87) | 14 (93) | 13 (87) | 14 (93) |
| Antihypertensive drugs | 4 (44) | 7 (78) | 5 (56) | 7 (78) | 5 (56) | 8 (89) |
| Lipid-lowering agents | 3 (60) | 1 (50) | 3 (60) | 1 (50) | 3 (60) | 1 (50) |

postoperative fever treated conservatively and discharged after 25 days. Two cases of postoperative complications (more than 30 days after surgery) were observed: one case of intestinal occlusion presented 2 years after primary procedure due to internal adhesion and treated successfully with laparoscopic adhesiolysis; one patient has an incisional hernia and is awaiting surgery. In the LSG group, one patient developed acute renal failure 1 week after surgery due to severe dehydration; this resolved in a few days.

## Discussion

Our study shows that LSG and LRYGB are equally effective in producing a significant weight loss and in improving glucose homeostasis, blood pressure and lipid profile as demonstrated by a similar rate of drugs discontinuation. In contrast, LRYGB showed a higher rate of both peri- and postoperative complications compared to those who had an LSG (31.2 vs 6.6 %). Indeed, the only complication in the LSG group occurred in a patient with pre-existing diabetic nephropathy and was likely precipitated by limited postoperative fluid intake.

Few studies have compared the clinical efficacy of LRYGB and SG, and most of them have been performed in non-diabetic subjects [12, 13]. In a recent paper, Peterli et al. [13] demonstrated that the two procedures improved glucose homeostasis to the same extent in morbidly obese subjects 3 months after surgery by increasing similarly insulin, glucagon-like peptide-1 (GLP-1) and PYY levels. Notably, in that study, only three patients had T2DM. Our findings extend these observations to diabetic patients and confirm that LSG and LRYGB have a similar clinical efficacy up to 18–24 months follow-up. A systematic review by Buchwald et al. reported that bariatric surgery induces an overall remission of T2DM as high as 78 % that remained at 62 % at 2 years follow-up [2], with malabsorptive procedures more effective than the restrictive ones (95 vs 57 %). With LRYGB an 80 % remission rate of T2DM has been reported over 2 years follow-up [2]. In our patients, the remission rate of T2DM was 87 % in LSG and 94 % in LRYGB. The higher rate of T2DM remission obtained in our study can be due to the short duration of the disease (average 3 years); indeed, diabetes duration and preoperative oral hypoglycaemic therapy are important determinants of remission. Whether these results will persist longer after surgery remains to be determined.

There is extensive evidence that the remission of T2DM occurs early after bariatric procedures before a significant weight loss is evident [14]. This phenomenon has been related to changes in gut hormones consequent to the anatomic modifications of intestinal nutrient transit [15–17]. The more rapid delivery of indigested food to the distal intestine results in a greater release of some enterohormones such as GLP-1 [16] which is known to exert multiple beneficial effects on glucose homeostasis. Indeed, plasma GLP-1 levels increase up to tenfold after bariatric surgery.

SG is considered a restrictive procedure, and therefore, the remission of diabetes is expected to be the consequence of weight loss. Actually, in SG two thirds of the stomach is removed, including the gastric fundus where ghrelin-producing cells are located. Since ghrelin is an orexigenic peptide and exerts several diabetogenic effects, it is likely that its suppression contributes to improvement in glucose metabolism.

Although LRYGB is a restrictive–malabsorptive technique whereas LSG is only restrictive, we did not observe significant differences in the patients' postoperative eating pattern. The only difference was in their ability of fluid ingestion, since the presence of pylorus in LSG strongly limits fluid intake especially in the first 3–6 months.

In the present study, we did not compare the two procedures in terms of cost/effectiveness. However, previous publications on this topic indicate that LRYGB surgical costs are quite comparable to those of LSG, but reliable long-term outcome data are scarce or lacking [18].

In conclusion, LSG and LRYGB are equally effective in terms of weight loss and remission of obesity-related comorbidities. Controlled long-term comparisons among different bariatric interventions are needed to establish the optimal procedure in relation to patients' characteristics.

**Conflict of Interest Statement** All contributing authors declare that they have no conflicts of interest.

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