Bariatric/Metabolic Surgery in Type 1 and Type 2 Diabetes Mellitus

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ABSTRACT

The prevalence of type 2 diabetes mellitus (T2DM) and obesity shows a gradual increase nowadays. Despite the introduction of multiagent treatment modalities, many patients with T2DM still do not have good results. Bariatric/metabolic surgery performed in obese patients to attain weight loss has been shown to improve T2DM. Type 1 diabetes mellitus is another type of diabetes that also shows an increase in prevalence. The aim of the present study was to evaluate the literature about the bariatric/metabolic surgical procedures performed in patients with type 1 and type 2 diabetes.

Keywords: Bariatric surgery, metabolic surgery, type 1 diabetes mellitus, type 2 diabetes mellitus

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic disease that causes many important medical complications and socioeconomic effects. In this disease, insulin is produced but is not sufficient for body requirements, or there is resistance to insulin. Obesity is one of the major causes for the development of T2DM. Despite the introduction of multiagent treatment modalities, many patients still do not have good results [1-3].

Type 1 diabetes mellitus (T1DM) is another type of diabetes in which there is absolute insulin deficiency, the body does not produce insulin, or there is destruction in the insulin-producing beta cells in the pancreas [4, 5].

Recent studies have shown the positive effects of bariatric surgery procedures in the treatment of obese and non-obese patients with T2DM. Therefore, bariatric surgery is also referred to as metabolic surgery due to its effects ranging from weight loss to metabolic control, especially in patients with T2DM. Currently, T2DM can be considered as a gastrointestinal disease that can be treated surgically [6-8]. There is also evidence of such surgery improving the health of patients with T1DM [9, 10].

In the present study, we aimed to evaluate the literature about the bariatric/metabolic surgical procedures performed in patients with type 1 and type 2 diabetes.

Clinical and research consequences

Diabetes mellitus is a metabolic disease that brings many economic and social problems to the affected patients. The number of people with T1DM and T2DM is expected to increase from 415 million in 2015 to 642 million in 2040 according to the International Diabetes Federation [11].

The incidence of obesity has shown an increase in the last years in both children and adults. It is associated with many comorbidities, such as hypertension, dyslipidemia, cardiovascular disease, and diabetes [12]. Therefore, we can say that obesity and diabetes are the twin epidemics of the twenty-first century [6].

In obese patients, the beta cells of the pancreas show a stress failure, resulting in insulin resistance and T2DM. In addition, the adipose tissue that secretes different hormones, such as leptin, es-

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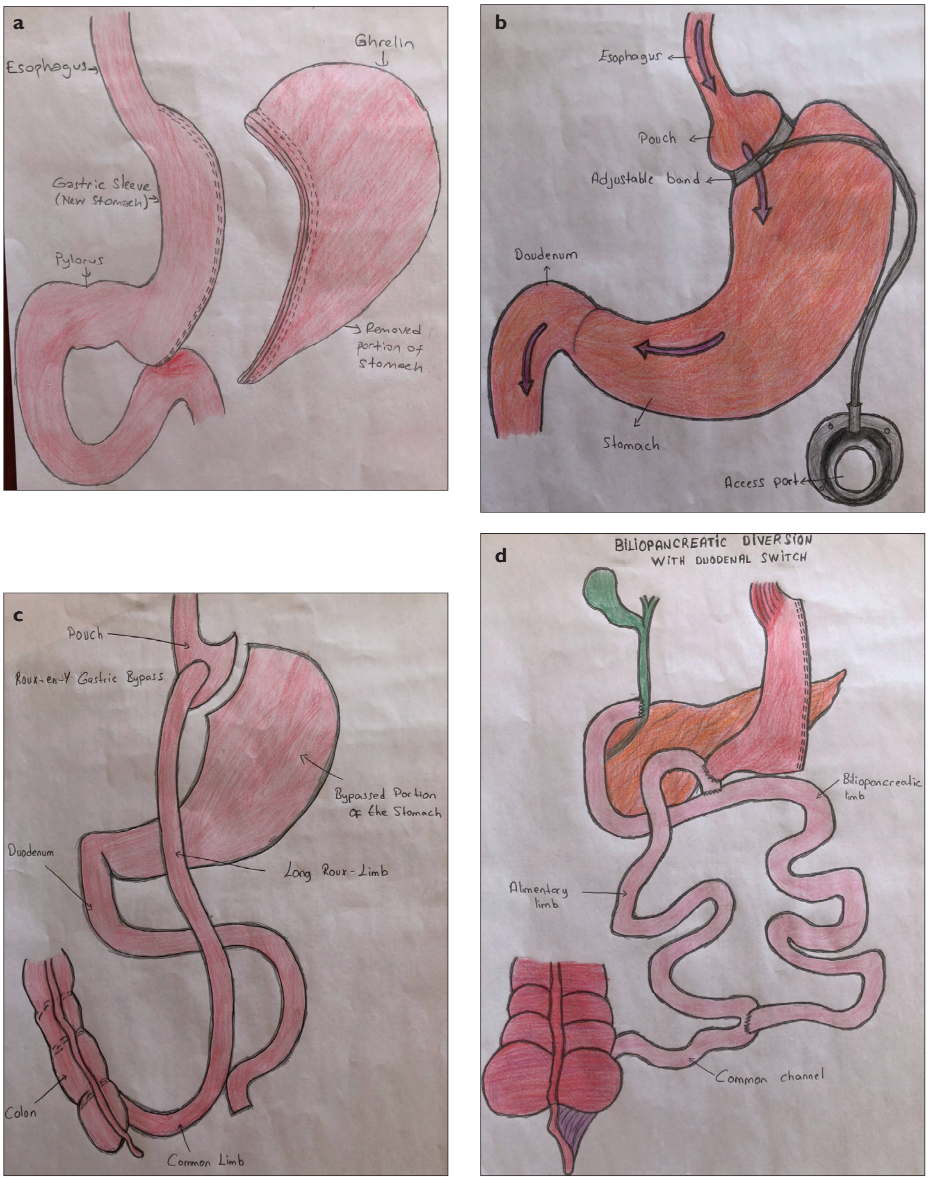


Figure 1. a-d. Laparoscopic sleeve gastrectomy (a), adjustable gastric banding (b), laparoscopic Roux-en-Y gastric bypass (c), laparoscopic biliopancreatic diversion with duodenal switch (d)

trogen, resistin, and adipocytokines, is regarded as an immune tissue and plays important roles in the pathogenesis of obesity and diabetes mellitus [8].

In addition, the gastrointestinal tract has many important roles in diabesity and obesity via hormonal and neural pathways.

The feeding regulation system is located in the hypothalamus, and neuropeptide Y (NPY) is a peptide found there. Disturbance of the NPY system due to the changes of the levels of insulin, leptin, and ghrelin may cause to increase food intake and eventually obesity.

Incretins, gastric inhibitory peptide, and glucagon-like peptide-1 (GLP-1) are intestinal hormones that stimulate postprandial insulin secretion and have played important roles in the development of diabetes mellitus.

The gastric fundus secretes ghrelin and stimulates satiety [2, 3, 8].

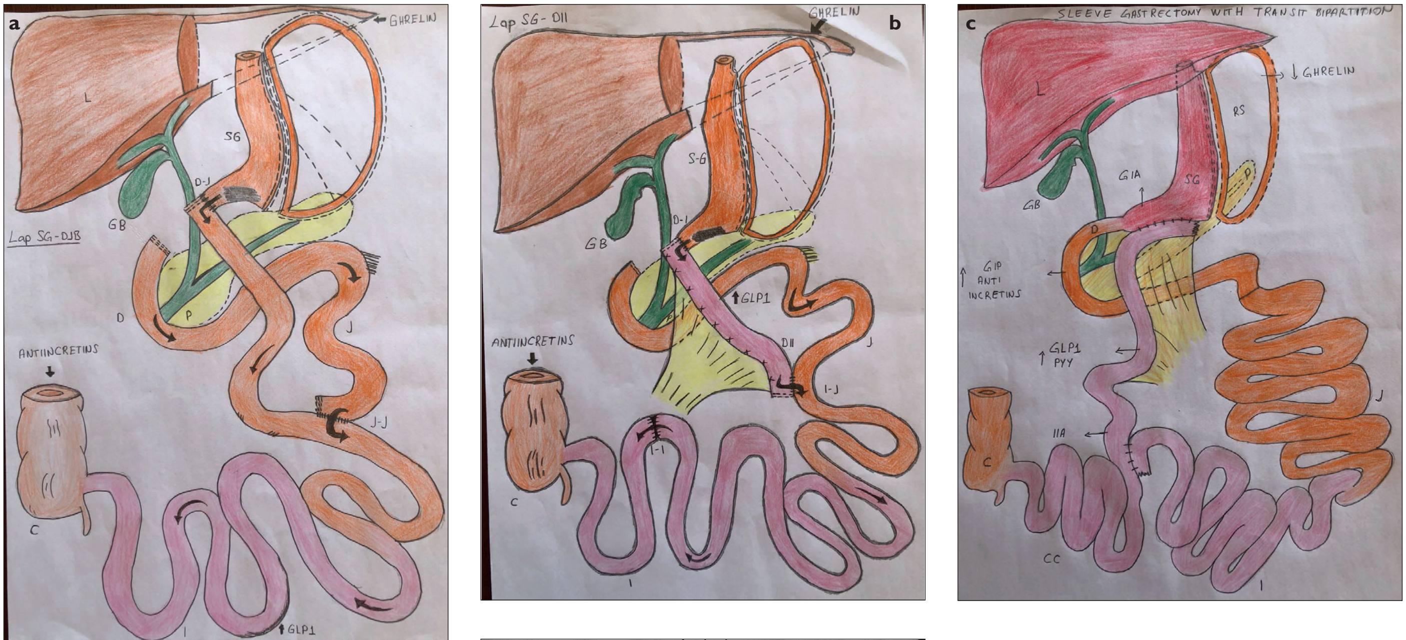
Current studies have focused on host and environmental factors that may have a role in energy gain and loss. One of these factors is the gut microbiota. The gut microbiota composition is changed due to many factors and may cause the development of obesity, T2DM, and T1DM. These factors may increase gut permeability and cause metabolic inflammation, increase energy gain from the diet, impair short-chain fatty acid synthesis, alter bile acid metabolism and FXR/TGR% signaling, and impair glucose metabolism, resulting in insulin resistance [13, 14].

Recent studies have revealed that bile acids not only facilitate lipid absorption but also affect diverse metabolic pathways including glucose metabolism, lipid metabolism, and energy expenditure, resulting in insulin resistance, diabetes, and metabolic syndrome [8, 15].

Gastrointestinal surgery performed for morbidly obese people is called as "bariatric surgery" (baros=weight). It is accepted as the most effective treatment for morbid obesity and has been shown to be successful in treating T2DM in morbidly obese people. Bariatric surgical procedures are classified as restrictive (laparoscopic sleeve gastrectomy (LSG) (Figure 1a) and laparoscopic adjustable gastric banding (LAGB) (Figure 1b)), malabsorptive (intestinal bypass), and both restrictive and malabsorptive (Roux-en-Y gastric bypass (RYGB) (Figure 1c) and biliopancreatic diversion with or without duodenal switch (BPD or BPD-DS) (Figure 1d)). Remission of T2DM has been reported as 66%, 45%, 80%-85%, and 95% after LSG, LAGB, RYGB, and BPD-DS, respectively [2, 3].

The mechanism of the remission of T2DM after bariatric surgery is still controversial. Weight loss due to calorie restriction after restrictive procedures achieves glycemic control. Weight loss reduces metabolically active sick fat. An increase in GLP-1 and NPY due to rapid gastric emptying and a decrease in ghrelin after sleeve gastrectomy play a role in the resolution of diabetes. The nutrients are delivered rapidly to the distal ileum, stimulating GLP-1 and leading to increased insulin release. Malabsorptive procedures exclude the duodenum and upper part of the jejunum, resulting in the inhibition of anti-incretins [2, 3, 8]. It is known that the gut microbiome and bile acid levels are changed after metabolic surgery. Serum bile acid levels increase after bariatric surgery, and this fact results in decreased postprandial blood glucose levels but results in the maximal secretion of GLP-1. The intestinal microorganism pattern changes after gastric and intestinal tract procedures [16, 17].

Bariatric surgery that aims to treat the comorbid conditions, such as diabetes mellitus associated with obesity, is generally called as metabolic surgery. In addition to the above-mentioned most widely used bariatric procedures, various metabolic surgical procedures have been developed to treat T2DM. One of them is LSG with duodenojejunal bypass (DJB) (Figure 2a). It has several advantages over the duodenal switch operation. In this operation, the pylorus is preserved, and the dumping syndrome and reactive hypoglycemia are seen less. Duodenojejunostomy is



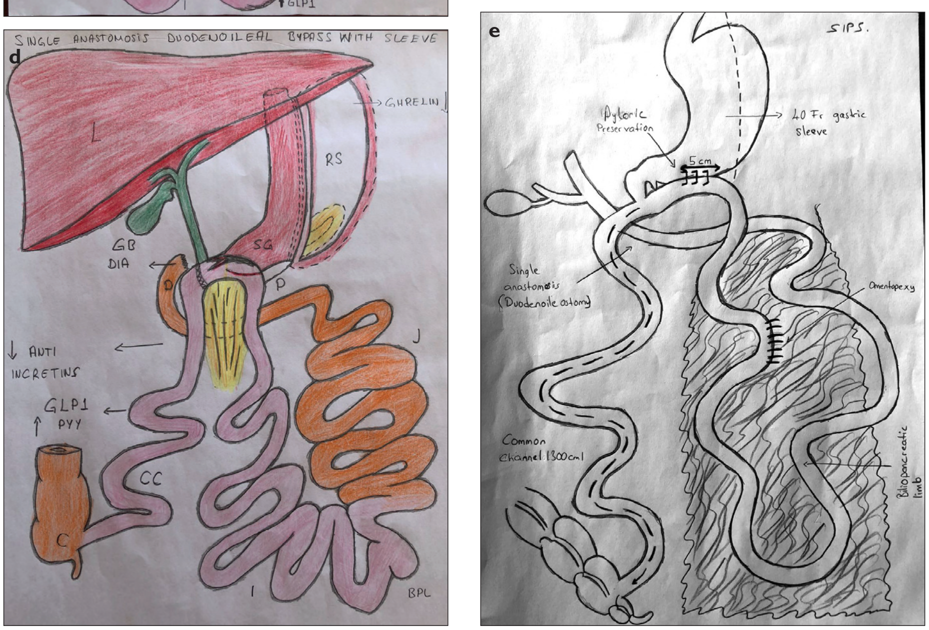


Figure 2. a-e. Laparoscopic sleeve gastrectomy with duodenojejunal bypass (LSG-DJB) (a), laparoscopic ileal interposition with diverted sleeve gastrectomy (II-DSG) (b), laparoscopic transit bipartition with sleeve gastrectomy (TB-SG) (c), laparoscopic single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) (d), laparoscopic stomach intestinal pylorus-sparing surgery (SIPS) (e)

performed at 1-2 cm distal to the pylorus; thus, the anastomosis is wider. The complications of nutritional deficiencies are lower [18, 19]. Seki et al. [18] investigated the effects of LSG-DJB on weight loss and T2DM in 120 patients. The mean total body weight loss was 28.9%, 28.6%, and 63.6% at 1, 3, and 5 years, respectively. Remission of T2DM was 63.6% at 1 year, 55.3% at 3 years, and 63.6% at 5 years.

In ileal transposition (IT) (Figure 2b), a segment of the ileum is translocated into the upper jejunum. It has been combined with sleeve gastrectomy or RYGB in several studies, and it has been reported to change gut hormone secretion and host-microbial relationships, have many positive effects in bile acid metabolism, and decrease metabolic endotoxemia [20-25].

Celik et al. [26] investigated the metabolic results of laparoscopic diverted sleeve gastrectomy (DSG) with IT in 159 obese patients with T2DM. In their study, the mean body mass index (BMI) decreased from 39.33 to 25.51, mean fasting glucose level decreased from 189.9 to 123.5 mg/dL, and mean hemoglobin A1c (HbA1c) decreased from 9.24% to 6.14% at 1 year after surgery. Hypertension resolved in 94.2% of the patients, and blood glucose levels decreased in most of the patients.

Sleeve gastrectomy with transit bipartition (TB) (Figure 2c) is another operation for diabetes and obesity. First, a sleeve gastrectomy is performed, and then TB is performed via a gastrointestinal anastomosis in the antrum. The stomach has two outflow pathways [27, 28].

Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S) (Figure 2d) is an operation in which a sleeve gastrectomy is followed by an end-to-side duodeno-ileal diversion at 250 cm proximal to the cecum. It is a modification of the DS procedure. However, the SADI-S procedure has many advantages. In DS, approximately 80% of the intestine is being bypassed, whereas in SADI-S, 50% of the intestine is bypassed. Therefore, protein, vitamin, and mineral deficiencies are lower in the SADI-S procedure [29, 30].

Another procedure similar to the SADI-S procedure is stomach intestinal pylorus-sparing surgery (Figure 2e), which is a modification of the duodenal switch procedure. This procedure has three steps: creating a sleeve gastrectomy, transecting the duodenum just beyond the outlet valve of the stomach (pylorus), and performing an end-to-side anastomosis between the ileum at 300 cm proximal to the ileocecal valve and duodenum. These modifications are expected to reduce the operative complications, diarrhea, and nutritional deficiencies seen with DS. In addition, this procedure provides a more effective metabolic effect and greater weight loss than LSG and RYGB [31, 32].

We tried to outline the most common surgical procedures that have been performed to improve T2DM beginning from the first report published in 1955 by Friedman et al. [33]. The previous study reported that T2DM is improved after subtotal gastrectomy that was performed for peptic ulcer disease. In 1984, bariatric surgery was reported to have positive effects in patients with diabetes [34]. In 1995, Pories et al. [35] reported that it improves glucose abnormalities and results in T2DM remission. A newer surgical technique is evolving every day, and a technique that is popular today might be accepted as ineffective in the future.

Now we want to define the comparisons of those techniques. Koliaki et al. [36] investigated the effect of bariatric surgery to treat diabetes and showed that the value of those techniques for weight loss and T2DM remission is BPD>RYGB>SG>LAGB.

Colquitt et al. [37] investigated 22 trials with 1798 participants. Weight loss and rates of remission of T2DM and hypertension did not show a difference between RYGB and SG, and both of these procedures had better results than LAGB. For people with very high BMI, BPD-DS resulted in greater weight loss than RYGB.

Yormaz et al. [38] compared the glycemic regulation in patients who have undergone laparoscopic ileal interposition (II) with DSG, laparoscopic TB-SG, and LSG. The purpose was to reach a long-lasting fasting blood glucose <126 mg/dL. Their results showed that II-DSG and TB-SG have important regression rates during the follow-up period. Since the TB-SG had finite anastomoses and intervening segments, it was considered to be a superior procedure over II-DSG and LSG procedures.

Torres et al. [30] investigated the results of weight loss and improvement of blood pressure, lipid profile, and insulin resistance in obese patients with diabetes, and after a follow-up of 3 years, the outcomes were better in the SADI-S procedure than in the RYGB.

Lee et al. [39] investigated T2DM remission, triglyceride improvement, and weight loss between 89 patients who received DJB-SG surgery and patients who received SG. They reported better results in patients with DJB-SG.

Metabolic surgery has been found to be effective in non-obese patients with diabetes as well as in obese patients with diabetes in several studies. Seki et al. [40] investigated 72 patients with T2DM with a BMI of <35 kg/m² who underwent DJB-SG and had moderate weight loss and a superior improvement of glycemic control and cardiovascular risk.

Ramirez et al. [41] investigated the effect of preoperative BMI (obesity class I, II, and III) on patients undergoing laparoscopic gastric bypass and reported that diabetes remission is 57.9% in class I, 61.1% in class II, and 60% in class III, and the other metabolic and clinical profiles presented similar improvement.

Huang et al. [42] aimed to investigate the effect of metabolic surgery on non-obese patients (BMI<30 kg/m²) with type 2 diabetes. After investigating 21 studies including 921 patients, they concluded that non-obese patients can attain normalization in glucose and lipid levels after metabolic surgery.

Age, BMI, duration and severity of diabetes, C-peptide levels, and drug usage have been examined to calculate the improvement of glycemic control following bariatric procedures [1]. Up to date, various scoring systems have been developed. These are the DiaRem score, DSS score, and ABCD score [1, 2, 7]. The ABCD score is the most widely used score based on age, BMI, C-peptide, and duration of T2DM. Scores range from 0 to 10 with higher scores predicting higher remission rates. Remission of T2DM was defined as reaching an HbA1c level <6.5% without the use of oral hypoglycemic drugs or insulin [1, 2].

Nowadays, obesity also affects patients with T1DM. Thirteen per cent of young patients with T1DM have obesity, and approximately 50% of the patients are overweight or obese [43, 44]. Czupryniak et al. reported the first observation of T1DM improvement in a severely obese patient who underwent gastric bypass in 2004 [9, 45].

Moreno-Fernandez and Chico [44] investigated six patients with T1DM who have undergone bariatric surgery (three RYGB and three SG). The total follow-up time from surgery was 4.5±1.4 years. They could not observe a significant HbA1c improvement after surgery, but daily insulin requirement decreased after surgery. They concluded that bariatric surgery induces weight loss but does not improve glycemic control in patients with T1DM.

Hussain [9] reviewed nine studies involving 75 patients with T1DM who have undergone metabolic surgery (LAGB 2, vertical sleeve gastrectomy 11, LRYGB 52, BPD 7, and BPD-DS 3 patients). They reported that there is an improvement in HbA1c, insulin dose, and BMI after surgery. However, there was not any statistical significance in the improvement of HbA1c levels. The relationship between postoperative insulin dose and BMI change was weak, and the relationship between HbA1c and BMI change was negligible after surgery. Therefore, they concluded that an improvement of T1DM in obese patients is not related to loss of excess weight. There may be a role for other factors, such as reduction of insulin resistance, satiety/dietary change, and possible neuroendocrine/hormonal or incretins influence.

In conclusion, bariatric/metabolic surgery in obese and non-obese patients with T2DM has been found to be effective in the improvement of glycemic control. However, the role of bariatric/metabolic surgery in patients with T1DM will require larger and longer studies.

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