



## Bariatric Surgery Improves the Metabolic Profile of Morbidly Obese Patients With Type 1 Diabetes

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A growing body of evidence has demonstrated significant and sustained improvement in glycemic control in type 2 diabetes after bariatric surgery. However, there are limited data on the impact of bariatric surgery in type 1 diabetes (T1D). Only fewer than 10 cases of bariatric surgery in patients with T1D have been reported in the literature, which show a significant weight reduction and improvement in glycemic control (1–3). A recent experimental study in a rat model of spontaneous development of T1D has also shown that a particular type of gastrointestinal bypass (duodenal-jejunal bypass surgery) lowers blood glucose concentration within 2 days after surgery (4). The aim of this study was to assess the metabolic outcomes, including the glycemic status, of patients with T1D after bariatric surgery.

Clinical outcomes and metabolic parameters of 10 morbidly obese patients with poorly controlled T1D who underwent laparoscopic bariatric surgery between 5 January 2005 and 12 December 2012 were retrieved from a database approved by an institutional review board. The diagnosis of T1D was verified for all patients by the presence of pancreatic autoantibodies (islet cell and GAD), absence of C-peptide, and/or documented history of diabetic

ketoacidosis. Baseline characteristics, intraoperative data, and postoperative outcomes were assessed, including changes in weight, A1C, daily insulin requirements, lipid panel, and blood pressure. A paired *t* test was used to analyze changes at the last follow-up point from baseline.

Patients had a male-to-female ratio of 1:9, a mean age of  $45.6 \pm 10.9$  years, a mean baseline BMI of  $41.6 \pm 3.8$  kg/m<sup>2</sup>, a median duration of T1D of 22 years (range 2–43), and a median of 10 (range 5–13) obesity- or T1D-related comorbidities. One patient had history of coronary bypass and one had history of failed kidney-pancreas transplant. Bariatric procedures included laparoscopic Roux-en-Y gastric bypass (*n* = 7), adjustable gastric banding (*n* = 2), and sleeve gastrectomy (*n* = 1). There were no intraoperative complications and no need for conversion to laparotomy. In total, five postoperative complications occurred, including diabetic ketoacidosis on postoperative day 10, deep vein thrombosis, ulcer at gastrojejunal anastomosis, esophageal dysmotility, and persistent nausea. At a mean follow-up of  $36.8 \pm 32.3$  months, excess weight loss >60% was achieved in all patients except one case of adjustable gastric banding. The mean reduction in BMI of  $27.0 \pm 9.6\%$  was associated

with a significant mean reduction in A1C ( $10.0 \pm 1.6$  vs.  $8.9 \pm 1.1\%$ , *P* = 0.039) and daily insulin requirement ( $0.74 \pm 0.32$  vs.  $0.40 \pm 0.15$  units/kg/day, *P* = 0.004). There were also favorable changes in LDL ( $-23.0 \pm 19.3$  mg/dL, *P* = 0.02), HDL ( $10.8 \pm 3.4$  mg/dL, *P* = 0.001), and triglyceride ( $-30.5 \pm 17.1$  mg/dL, *P* = 0.007) following surgery (Table 1). Hypertension resolved or improved in 5 of 7 (71%) hypertensive patients. Albuminuria resolved in one of two patients with preoperative microalbuminuria.

The findings of this study, which is the largest case series to date, indicate that bariatric surgery leads to a remarkable and sustained weight loss in severely obese patients with T1D and results in significant improvement in their glycemic status and comorbid conditions, despite having prolonged diabetes and undetectable C-peptide. The favorable metabolic effects of bariatric surgery may facilitate medical management of T1D in the setting of morbid obesity. The true role of bariatric surgery in patients with T1D awaits longer follow-up studies in a larger cohort.

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**Table 1—Metabolic profile of patients with T1D after bariatric surgery (n = 10)**

	Preoperative value	Postoperative value	P
BMI (kg/m <sup>2</sup> )	41.6 ± 3.9	30.5 ± 5.9	<0.001
Insulin requirement (units/kg/day)	0.74 ± 0.32	0.40 ± 0.15	0.004
A1C (%)	10.0 ± 1.6	8.9 ± 1.1	0.039
A1C (mmol/mol)	86.2 ± 17.3	73.9 ± 11.9	0.042
LDL (mg/dL)	114.7 ± 17.8	91.7 ± 10.5	0.020
HDL (mg/dL)	57.5 ± 18.3	68.3 ± 19.8	0.001
Triglyceride (mg/dL)	96.0 ± 13.0	65.5 ± 13.3	0.007

Data are presented as mean ± SD.

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involved in the management of patients. A.A. performed data collection and analysis and drafted the manuscript. S.A.B., A.A., R.J.R., J.P.K., S.R.K., and P.R.S. reviewed the data. S.A.B., R.J.R., J.P.K., S.R.K., and P.R.S. revised and edited the final manuscript. S.A.B. is the guarantor of this work and, as such, had full access to all the data in the study and takes

responsibility for the integrity of the data and the accuracy of the data analysis.

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