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Original article

Comparison of early type 2 diabetes improvement after gastric bypass and sleeve gastrectomy: medication cessation at discharge predicts 1-year outcomes

Keyvan Heshmati, M.D., David A. Harris, M.D., Hassan Aliakbarian, M.D., Ali Tavakkoli, M.D., F.A.C.S., Eric G. Sheu, M.D., D.Phil., F.A.C.S.*

Department of Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts

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Abstract

Background: Although weight loss–dependent type 2 diabetes (T2D) improvement after sleeve gastrectomy (SG) is well documented, whether SG has a weight-independent impact on T2D is less studied.

Objectives: To evaluate early, weight-independent T2D improvement after SG and Roux-en-Y gastric bypass (RYGB) and its relationship to longer-term T2D outcomes.

Setting: University Hospital, United States.

Methods: We completed a retrospective cohort study of patients with T2D who underwent SG (n = 187) or RYGB (n = 246) from 2010 to 2015. Pre- and postoperative parameters, including demographic characteristics, T2D characteristics, and T2D medication requirements, blood glucose, glycosylated hemoglobin, weight, and body mass index, were reviewed.

Results: T2D improved within days after both SG and RYGB, with more patients off T2D medications after SG than RYGB (39% versus 25%, respectively; $P < .01$) at the time of discharge (2.5 ± .8 versus 2.7 ± 1 d; $P = .04$). Over the initial postoperative 12 months, T2D medication cessation rates remained relatively stable after SG but continued to improve after RYGB (at 12 mo: 52% versus 68%, respectively; $P < .05$). T2D medication cessation at discharge predicts 12-month T2D medication cessation (92% [RYGB] and 78% [SG] positive predictive value). In a mixed-effects regression model adjusting for weight loss and severity of diabetes, discharge T2D medication cessation remained a significant predictor of T2D outcomes after both RYGB (odds ratio, 51; 95% confidence interval, 16.1–161; $P < .0001$) and SG (6.4; 95% confidence interval, 2.8–14.7; $P < .0001$).

Conclusions: Both SG and RYGB lead to high rates of T2D medication cessation within days of surgery, suggesting both operations activate weight loss–independent anti-T2D pathways. T2D medication cessation at discharge is predictive of 12-month T2D outcomes, particularly in noninsulin requiring patients. By 1 year after the surgery, RYGB leads to more weight loss and higher rates of T2D medication cessation than SG. (Surg Obes Relat Dis 2019;15:2025–2032.) © 2019 American Society for Bariatric Surgery. Published by Elsevier Inc. All rights reserved.

Key words: Roux-en-Y gastric bypass; Sleeve gastrectomy; Bariatric surgery; Type 2 diabetes

*Correspondence: Eric G. Sheu, M.D., D.Phil., Division of General and Gastrointestinal Surgery, Department of Surgery, Brigham and Women's Hospital, 75 Francis Street, ASBII-3rd Floor, Boston, MA 02115.

E-mail address: esheu@bwh.harvard.edu (E.G. Sheu).

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Obesity affects over one-third (39.8%) of adult Americans, and nearly 90% of patients with type 2 diabetes (T2D) are obese or overweight [1]. Bariatric surgery in the form of sleeve gastrectomy (SG) or Roux-en-Y gastric bypass (RYGB) has been shown to be the most effective and durable intervention for weight reduction and leads to T2D remission in 70% to 80% of patients [2–4]. Multiple, prospective randomized control trials have demonstrated that RYGB and SG are superior to intensive medical therapy in terms of T2D improvements and weight loss [5–7].

RYGB has been demonstrated to have early effects on T2D, with patients demonstrating significant improvement in glycemic control and even T2D remission, within days of surgery and before significant weight loss [8–12]. Subsequent continued improvements in T2D occur in association with weight loss [13]. This observation has led to the concept of weight-independent and -dependent metabolic effects of RYGB, and the biological mechanisms of the weight-independent effects of surgery are an area of intense research interest.

Whether SG also causes early improvements in T2D independent of weight loss is less studied. In the largest trials comparing SG and RYGB, the earliest time point for assessment of T2D was at 3 months [5–7]. We performed a retrospective analysis to characterize early and late T2D medication changes after SG and RYGB. We hypothesized that, like RYGB, SG also activates weight loss–independent mechanisms leading to early T2D resolution after surgery. We then examined whether the strength of SG and RYGB's early anti-T2D effects are associated with longer-term T2D outcomes.

Methods

Study group

After obtaining institutional review board approval, we designed a retrospective cohort study to compare outcomes between patients with T2D undergoing RYGB or SG from January 2010 to December 2015. Inclusion criteria for our study were as follows: (1) age >18 years, (2) history of laparoscopic RYGB or SG, and (3) diagnosis of T2D on medication before receiving bariatric surgery.

Interventions

Patients eligible for bariatric surgery were offered both RYGB and SG. Specific benefits and risks of each operation, relative to the patient's medical history, including T2D, reflux, prior abdominal surgery, and inflammatory bowel disease, were reviewed and procedure choice was ultimately made by the patient.

SG was performed in standard fashion with vertical resection of the greater curvature of stomach over a 36- to 40-Fr bougie based on surgeon's preference. RYGB was performed in standard fashion, with a lesser curve based gastric pouch, antecolic gastrojejunostomy formed using a linear stapler technique, and a 40- to 60-cm biliopancreatic limb and 100- to 150-cm Roux limb.

SG and RYGB were placed on the same pre- and postoperative diet pathway. A low calorie, shake-based diet was advised beginning 2 weeks preoperative. After the surgery, patients were kept on liquids for 10 days before advancing to a mechanical soft diet.

Outcome measures

Pre- and postoperative parameters, including demographic characteristics, T2D medications used, blood glucose, glycosylated hemoglobin concentration, T2D complications, T2D duration, hospital length of stay, weight, and body mass index (BMI), were collected by review of prospectively maintained clinical records within a single-bariatric surgery practice. The source of data included office and hospital charts, follow-up notes, and laboratory studies. Patients were routinely scheduled for follow-ups at 2 and 6 weeks and 3, 6, and 12 months during the first year of surgery and then once a year in the Bariatric Surgery clinic.

Change in diabetes status and medication requirements

After bariatric surgery, all patients underwent standardized evaluation by a small team of diabetologists and endocrinologists focused on inpatient diabetes management. The primary factor used for medication adjustment was blood glucose levels (at least 4 times/d) during patients' hospital stay. Other factors, like duration of diabetes, preoperative T2D medication regimen, baseline HbA1C, and clinical parameters related to beta-cell function and insulin resistance (e.g., central obesity, skin tags, or acanthosis nigricans, etc.), also factored into diabetologist's decision to adjust medications. In general, patients with a fasting blood glucose <180 with shorter duration of T2D and on noninsulin T2D medication regimens (specially glucagon-like peptide 1 agonists) were more likely to come off all T2D medications at discharge (T2D medication cessation).

To compare the insulin usage between the groups, the 24-hour average total insulin units (including short and long acting) was used. HbA1C was collected at baseline and 3, 6, and 12 months after surgery with the average follow-up rates of 93%, 59%, 50%, and 53%, in RYGB group and 98%, 53%, 40%, and 45% in SG group, respectively. At baseline, patients were categorized into 4 groups based on their T2D medication use as follows: patients on insulin with or without other antidiabetic medications were considered as "insulin users" while patients on noninsulin diabetes medications (NIDM) were grouped based on the number of agents prescribed—1, 2, or 3. After bariatric surgery, T2D medication requirements were evaluated at discharge, at 2- and 6-week follow-ups, and at 3-, 6-, and 12-month follow-ups after surgery. Follow-up rates for the mentioned

time points were 100%, 94%, 87%, 85%, 82%, and 80% in RYGB group and 100%, 98%, 94%, 92%, 86%, and 88% in SG group, respectively. Patients who followed up at 12 months were homogenous with the study population in terms of their preoperative T2D medication requirements, reducing the chance of sampling bias.

Weight loss

Patients' height and weight were measured during their last visit before surgery and then at each postoperative follow-up in the bariatric surgery clinic. Weight change was measured in terms of absolute BMI or percentage of total weight loss (%TBWL). Follow-up rates on weight data at baseline; 2 and 6 weeks; and 3, 6, and 12 months were 100%, 96%, 82%, 75%, 80%, and 75% in RYGB group and 100%, 97%, 84%, 71%, 71%, and 68% in SG group, respectively.

Statistical analysis

Continuous variables with normal distribution were reported as means ± standard deviation. Categorical variables were presented as percentages. Comparisons between groups were performed using independent-samples t test or χ^2 tests as appropriate. Longitudinal data were analyzed by a linear and logistic mixed-effects model analysis to account for repeated measures and within-subject correlations [14]. Pairwise comparisons between RYGB and SG groups were performed for each time point separately, with multiple unpaired t tests with subsequent step-down Bonferroni-Holm correction for P value adjustment for multiple comparisons. Multilevel mixed-effects logistic regression was used to evaluate the potential predictors of T2D medication cessation at 2 weeks through 12 months. Using backward stepwise selection methods, the final mixed-effects logistic regression model included the predictors that were significant ($P < .05$) in multivariable analysis as fixed effects. Two-sided P values $< .05$ were considered statistically significant. Statistical analyses were performed using R, version 3.5.0 (R Statistical Computing, Vienna, Austria) and GraphPad Prism version 7.00 for Windows (GraphPad Software, La Jolla, CA, USA).

Results

Preoperative demographic characteristics and T2D status

Of the 433 diabetic patients who underwent bariatric surgery between 2010 to 2015, 246 had RYGB and 187 had SG. Preoperative demographic characteristics, weight and BMI, HbA1C level, T2D-related complications, duration of T2D, and T2D medication requirements are listed in Table 1. There were no significant differences in age (48.19 ± 10.6 versus 50.12 ± 10 yr), sex, (72% versus 67% female), or race (64% versus 54% Caucasian) between RYGB and SG groups, respectively. Furthermore, there were no significant differences in preoperative weight or BMI.

Table 1
Preoperative demographic characteristics, BMI, and diabetes characteristics

	RYGB (n = 246)	SG (n = 187)	*P* value
Age, yr	48.2 ± 10.6	50.1 ± 10	NS†
Sex (% female)	72	67	NS†
Race (% white)	64	58	NS†
Baseline BMI, kg/m^2	44.2 ± 7.4	44.8 ± 8.1	NS*
Baseline Weight, lb	272.1 ± 57.1	273.5 ± 61.5	NS*
HbA1C, %	7.4 ± 1.3	7.2 ± 1.3	NS*
Mean number of yr diagnosed T2D	8.6 ± 7.3	8.5 ± 6.8	NS*
Mean age diagnosed T2D, yr	40.2 ± 10.2	42.6 ± 10.8	NS*
Family history of T2D, %	80	67	<.01†
Fasting glucose, mg/dL	142 ± 43	132 ± 43.1	<.05*
Diabetes complications, %	28	19	<.05†
1 complication, %	20	9	<.05†
2 complications, %	6	6	
3 complications, %	2	4	
Insulin users, %	42	41	NS†
1 NIDM, %	39	47	
2 NIDMs, %	15	9	
3 NIDMs, %	4	3	
Insulin usage, units/24 hr‡	92 ± 65	73 ± 56	<.05*

BMI = body mass index; RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; NS = nonsignificant; HbA1C = glycosylated hemoglobin; T2D = type 2 diabetes; NIDM = noninsulin diabetes medication.

* t test.

† χ^2 test.

‡ Sum of short- and long-acting insulin units/24 hr among insulin users.

There were no significant differences in baseline HbA1C (7.4 ± 1.3 versus 7.2 ± 1.3); T2D duration (8.6 ± 7.3 versus 8.5 ± 6.8 yr); patient's age at the time of T2D diagnosis (40.2 ± 10.2 versus 42.6 ± 10.8 yr); or proportion of patients taking insulin or 1, 2, or 3 NIDM between the RYGB and SG groups (Table 1). For those on insulin, average 24-hour insulin usage (92 ± 65 versus 73 ± 56 units) was higher in RYGB patients. Furthermore, T2D-related complications including neuropathy, nephropathy, and retinopathy were more prevalent among patients who underwent RYGB compared with SG. To understand the adequacy of T2D treatment at baseline, we compared HbA1C levels between RYGB and SG in different subgroups. Based on recommendations of the American Diabetes Association, glycemic control was considered as HbA1C <7%, regardless of T2D medications [15]. At baseline, the proportion of patients with well-controlled T2D (HbA1C < 7%) who were on 1 NIDM (65% versus 72%), 2 NIDMs (41% versus 41%), 3 NIDMs (67% versus 17%), or insulin users (25% versus 25%) was not significantly different in RYGB versus SG, respectively ($P > .05$).

Diabetes medication cessation is seen within days after both SG and RYGB

To assess the appropriateness of discharge T2D medication regimens, average blood glucose on the day of surgery

and postoperative days 1 and 2 were compared between all patient groups after both RYGB and SG. At each time, the blood glucose of those who were discharged off their T2D medications was significantly lower than those that were not (Supplement 1). In virtually all patients who came off T2D medications by discharge, for those with available HbA1C level, it was <6.5% at 3 months. Therefore, T2D medication cessation was used as a surrogate for T2D improvement (Supplement 2 shows follow-up rates for T2D medication, weight, and HbA1C at 1 yr).

T2D medication requirements at baseline; discharge; 2 and 6 weeks; and 3, 6, and 12 months are shown in Fig. 1 for both RYGB and SG groups. Patients were discharged 2.7 ± 1 and 2.5 ± .8 days after RYGB and SG, respectively ($P = .04$). There was a significantly higher proportion of patients who were off T2D medications at discharge in the SG group compared with RYGB (39% versus 25%, respectively; $P < .01$). This difference was absent at 2 weeks (37% in SG versus 44% in RYGB, $P = .8$). Starting at 6 weeks, however, and through to 12 months of follow-up, the proportion of patients off T2D medications was higher in the RYGB group compared with SG (at 12 mo: 52% in SG versus 68% in RYGB; $P < .05$; Fig. 1).

At baseline, 42% and 41% of the patients were on insulin before RYGB and SG, respectively. At discharge, the percentage of insulin users reduced to 24% and 23% for RYGB and SG, respectively. This proportion was stable in SG group through to 12 months; however, there was a continued reduction in the percentage of insulin users after RYGB during this period. At 12 months, the percentage of insulin users was significantly lower in RYGB group compared with SG group (14% versus 28%; $P = .02$).

Weight loss after RYGB and SG

BMI and weight were recorded at baseline; 2 and 6 weeks; and 3, 6, and 12 months after RYGB and SG. As shown in Fig. 2, preoperatively, the actual BMI was similar between the groups (RYGB: 44.1 versus SG: 44.8 kg/m^2; $P = .4$). Up to 6 weeks, the actual BMI was not significantly different between 2 groups, but from 3 to 12 months, weight loss was greater after RYGB than SG (absolute BMI at 12 mo after RYGB versus SG: 30.9 versus 35.5 kg/m^2; $P < .01$).

Mean %TBWL showed no significant difference at 2 weeks between RYGB and SG (8.1% versus 7.7%, respectively; $P = .07$), but from 6 weeks to 12 months, it was significantly greater in RYGB compared with SG (at 6 wk: 13.7% versus 12.2%, $P < .01$; and at 12 mo: 29.8% versus 19.6%, $P < .0001$, respectively).

Cumulative T2D medication cessation and relapse

Cumulative T2D medication cessation and relapse after RYGB and SG was calculated by adding the ratio of the patients who came off all T2D medications at each time point. At discharge, the proportion of patients off all T2D medications (off meds) is significantly lower after RYGB compared with SG (25% versus 39%, $P < .01$). At 2 and 6 weeks, there were no significant differences in cumulative off med proportions between SG and RYGB groups (47% in both, $P = .97$; and 61% versus 53%, $P = .12$, respectively). At 3-, 6-, and 12-month time points the cumulative off med proportions were significantly higher after RYGB compared with SG (66% versus 57%, $P < .05$; 74% versus 63%, $P = .01$; and 78% versus 66%, $P < .01$, respectively).

Relapse was defined as patients who were put back on any T2D medications after being taken off medications. At 2 weeks, the relapse rate was significantly lower in RYGB group compared with SG (3% versus 10%; $P < .01$). This significant difference was maintained up to 12 months (13% versus 20%; $P < .05$; Fig. 3).

Pre- and postoperative HbA1C levels after RYGB and SG

As shown in Table 2, mean HbA1C level at baseline was similar between RYGB and SG group (RYGB: 7.4 versus SG: 7.2; $P = .1$). After 3 months, HbA1C significantly

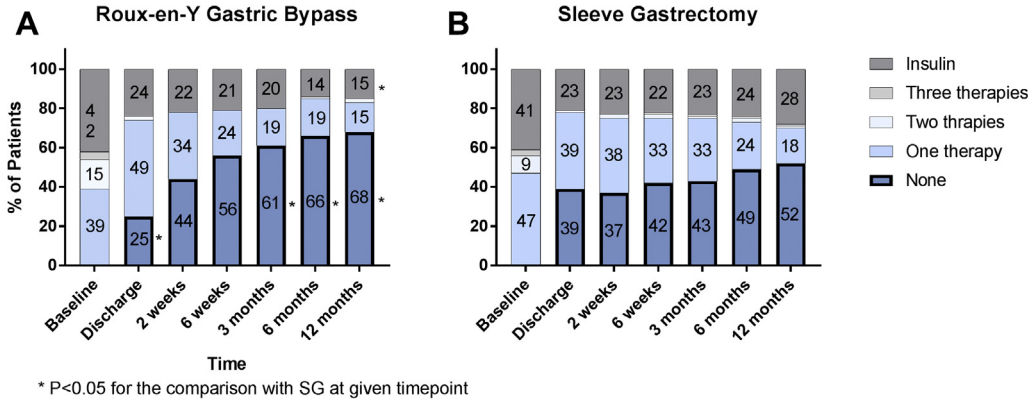

Fig. 1. Type 2 diabetes medication requirements following Roux-en-Y gastric bypass (A), and sleeve gastrectomy (B).

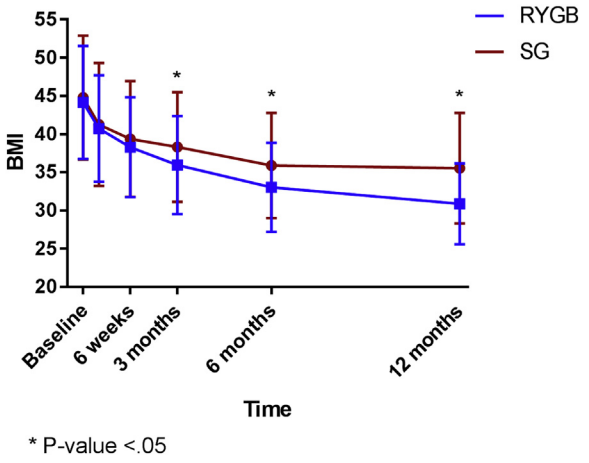

Fig. 2. Absolute BMI change following RYGB and SG. I bars indicate standard deviations.

dropped and was comparable in both groups (RYGB: 6.4 versus SG: 6.4; $P = .7$). At 6 and 12 months, HbA1C levels were significantly lower after RYGB compared with SG (6.2 versus 6.7; $P < .01$, and 6.1 versus 6.5; $P < .05$, respectively).

T2D medication cessation at discharge after SG and RYGB predicts 12-month outcomes

We next sought to explore the ability of T2D medication cessation at discharge to predict patients' 12-month T2D medication requirements. When looking at the whole cohort, in both RYGB and SG, there was a strong correlation between the number of patients who were off T2D medications at discharge and 12 months. The discharge T2D medication cessation after RYGB and SG was predictive of 12-month T2D medication cessation with a sensitivity of 35% and 60%, specificity of 94% and 82%, positive predictive value of 92% and

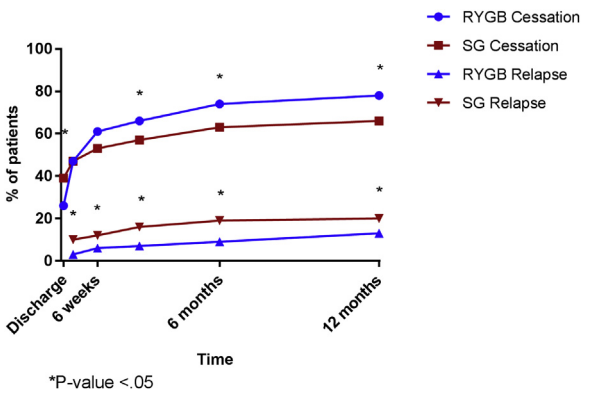

Fig. 3. Cumulative percentage of medication cessation and relapse following RYGB and SG.

Table 2
HbA1C levels at baseline and after RYGB and SG

	RYGB (n = 246)	SG (n = 187)	*P* value*
HbA1C at baseline, % (SD)	7.4 (1.3)	7.2 (1.3)	NS
HbA1C at 3 mo, % (SD)	6.4 (1)	6.4 (1.1)	NS
HbA1C at 6 mo, % (SD)	6.2 (1)	6.7 (1.4)	<.01
HbA1C at 12 mo, % (SD)	6.1 (1)	6.5 (1.5)	<.05

HbA1C = glycated hemoglobin; RYGB = Roux-en-Y gastric bypass.
* Adjustment by step-down Bonferroni-Holm correction for multiple comparisons for the number of subitem tests.

78%, and negative predictive of 40% and 63%, respectively (Table 3).

Insulin usage has been shown to be one of the most important predictors for T2D medication cessation in prior studies [16,17]. Therefore, we analyzed noninsulin T2D medication users and insulin users separately. When taken as a separate cohort, there was a steady increase in the number of noninsulin users off T2D medications from discharge to 12 months after RYGB and SG (Fig. 1). In both RYGB and SG noninsulin users, discharge T2D medication cessation was predictive of 12-month T2D medication cessation with a sensitivity of 39% and 66%, specificity of 100% and 79%, positive predictive value of 100% and 92%, and negative predictive value of 14% and 38%, respectively (Table 3).

There was a decrease in the average insulin units used per 24 hours and total number of T2D medication requirements in insulin users after RYGB and SG. However, the proportion of the patients who came off all T2D medications was limited at all time points. When using hospital discharge T2D medication cessation as a predictor of 12-month T2D outcomes after RYGB and SG, there was 19% and 20% sensitivity, 92% and 83% specificity, 56% and 23% positive predictive value, and 69% and 82% negative predictive value, respectively (Table 3). This highlights that insulin usage remains an important predictor of T2D medication cessation at 12 months after either RYGB and SG.

We used a mixed-effects logistic regression model to control for known T2D remission predictive factors, including age, preoperative BMI, baseline HbA1C, types of T2D medication, duration of T2D, and %TBWL, to evaluate the role of discharge T2D medication cessation on T2D clinical outcomes. Patients were categorized into the following 3 groups in terms of T2D medication use: metformin, other noninsulin T2D medications, and insulin alone or in combination. Predictors that have significant effect on the model are shown in Table 4. The most potent predictor of T2D clinical outcomes after RYGB and SG was hospital discharge T2D medication cessation (odds ration [OR], 51; 95% confidence interval [CI], 16.1–161, and OR, 6.4; 95% CI, 2.8–14.7, respectively). Preoperative insulin use (OR, .17; 95% CI, .09–0.33 in RYGB and OR, .33; 95% CI, .13–.86 in

Table 3
T2D remission at discharge predicts 12-month T2D outcomes

	RYGB (all patients with T2D)				SG (all patients with T2D)		
	Off at 12 mo	On at 12 mo			Off at 12 mo	On at 12 mo	
Off at DC (n = 51)	47	4	PPV = 92%	Off at DC (n = 63)	49	14	PPV = 78%
On at DC (n = 145)	87	58	NPV = 40%	On at DC (n = 100)	37	63	NPV = 63%
	Sens = 35%	Spec = 94%			Sens = 60%	Spec = 82%	
	RYGB (noninsulin T2D med users)				SG (noninsulin T2D med users)		
	Off at 12 mo	On at 12 mo			Off at 1 yr	On at 1 yr	
Off at DC (n = 42)	42	0	PPV = 100%	Off at DC (n = 50)	46	4	PPV = 92%
On at DC (n = 77)	66	11	NPV = 14%	On at DC (n = 40)	25	15	NPV = 38%
	Sens = 39%	Spec = 100%			Sens = 65%	Spec = 79%	
	RYGB (Insulin users)				SG (Insulin users)		
	Off at 12 mo	On at 12 mo			Off at 12 mo	On at 12 mo	
Off at DC (n = 9)	5	4	PPV = 56%	Off at DC (n = 13)	3	10	PPV = 23%
On at DC (n = 68)	21	47	NPV = 69%	On at DC (n = 60)	12	48	NPV = 80%
	Sens = 19%	Spec = 92%			Sens = 20%	Spec = 83%	

T2D = type 2 diabetes; RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; Off at DC = off T2D medications at discharge; PPV = positive predictive value; On at DC = on T2D medications at discharge; NPV = negative predictive value; Sens = sensitivity; Spec = specificity.

SG), duration of T2D (OR, .92; 95% CI, .88–.96 in RYGB and OR, .9; 95% CI, .81–.96 in SG), and %TBWL (OR, 1.08; 95% CI, 1.05–1.11 in RYGB and OR, 1.06; 95% CI, 1.02–1.1 in SG) were also important predictors for T2D clinical outcomes.

Discussion

Early improvement of T2D after RYGB has been demonstrated in multiple studies [9–12,18–21]. However, there are limited data on whether a similar phenomenon occurs after SG [22,23]. Our results show that a considerable proportion of patients achieved T2D medication cessation within days of surgery, before significant weight loss, after either RYGB or SG. This finding suggests that SG, like RYGB, can trigger early T2D improvement independent of significant weight loss.

Peterli et al. [23] published 1 of the only studies examining early T2D remission after RYGB and SG. In this study, T2D was evaluated in 27 patients 1 week and 3 months after randomization to RYGB (n = 13) or SG (n = 14). T2D improvements were associated with early changes in gut hormonal levels, such as glucagon-like peptide 1 and increased insulin sensitivity, supporting weight loss independent anti-T2D actions of bariatric surgery. Another retrospective study by Bayham et al. [22] also documented T2D resolution in 262 patients after RYGB (n = 123) and SG (n = 139) at the day of discharge and 8 week postoperative [22]. However, this study did not examine longer-term outcomes. Our study confirms these prior findings supporting weight-independent anti-T2D effects of SG. Moreover, we extend on these studies by demonstrating that early T2D medication cessation is an independent predictor of 12-month T2D outcomes.

There is an increasing body of evidence that support weight loss independent mechanisms activated by bariatric surgery that improve glycemic control [19]. Whether the early improvements in T2D after RYGB reflect weight-independent metabolic actions of bariatric surgery versus effects of caloric restriction has been the source of debate [24,25]. Studies comparing RYGB with nonsurgical patients on a matched diet support the impact of RYGB on T2D beyond diet [26,27]. In our study cohort, both SG

Table 4
Multivariable mixed-effects logistic regression model for predictors affecting T2D remission after RYGB and SG*

Variables	RYGB (n = 246)	*P* value	SG (n = 187)	*P* value
	OR (95% CI)		OR (95% CI)	
Discharge T2D medication cessation	51 (16.1–161)	<.0001	6.4 (2.8–14.7)	<.0001
Insulin use	.17 (.09–.3)	<.0001	.33 (.13–.86)	<.05
Duration of T2D, yr	.92 (.88–.96)	<.001	.9 (.81–.96)	<.01
Total weight loss, %	1.08 (1.05–1.11)	<.0001	1.06 (1.02–1.1)	<.01

T2D = type 2 diabetes; RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; OR = odds ratio; CI = confidence interval.

* Final model by using backward stepwise selection models with a significance level of $P < .05$ for retention in the model.

and RYGB patients were placed on the same preoperative diet 2 weeks before surgery and were maintained on a hypocaloric, liquid diet for 10 to 14 days postoperatively [28]. We observed an equivalent and even greater early impact of SG on T2D medication cessation compared with RYGB, suggesting that SG also has a weight loss–independent effect on T2D.

Late T2D medication cessation patterns differed between SG and RYGB. For patients that underwent SG, the percentage of patients off all T2D medications at discharge was relatively stable through 12 months. However, there was continued T2D improvement in the RYGB group over the follow-up period. Weight loss after both surgeries was comparable up to 6 weeks; however, there was a greater weight loss after RYGB than SG from 6 weeks through 12 months. Therefore, one interpretation is that SG and RYGB have early, weight-independent anti-T2D effects; however, RYGB has a better weight loss and, consequently, superior weight-dependent anti-T2D effects.

Our results show that although SG and RYGB are comparable in their early T2D medication cessation rates; over time, the RYGB is superior to SG in terms of anti-T2D effects. A greater percentage of T2D medication cessation and a reduced number of T2D medication showed a better control of T2D after RYGB compared with SG, which is reflected by a greater improvement of HbA1C level at 6 and 12 months [29]. One of the concerns in the patients who achieve T2D medication cessation after bariatric surgery is the risk of relapse. This study showed that patients who underwent SG had higher rates of T2D relapse than RYGB. It is possible that the early anti-T2D effects of SG are less durable than those of the RYGB as reflected by higher T2D relapse rates after SG.

We tested whether discharge T2D cessation was associated with T2D clinical at 12 months. We found that T2D discharge medication cessation was a highly accurate predictor of 12-month T2D outcomes, particularly in noninsulin users. Moreover, in a multivariable model adjusted for weight loss and known preoperative factors that influence T2D remission rates, such as insulin use and duration of diabetes, early T2D medication cessation remained an independent predictor of 12-month T2D outcomes. This finding suggests that the early weight loss–independent anti-T2D of both SG and RYGB directly affects longer-term T2D outcomes, separate from weight loss.

Our study has several limitations. Our analysis suggested that recommendations for T2D medication cessation at discharge were appropriate for both SG and RYGB groups (Supplement 1); however, we cannot exclude any unknown bias of the consulting endocrinologist based on the surgery performed. Also, although most baseline T2D characteristics were comparable in the SG and RYGB groups, the RYGB likely had more severe T2D, reflected in higher baseline insulin usage. Given our retrospective design, there are likely additional unmeasured differences in those patients undergoing RYGB and SG. Last, while we had excellent rates of postoperative follow-up for weight and medication usage, we did not have sufficient HbA1C follow-up data to test our models using more stringent American Diabetes Association and other recommended definitions of T2D remission, and instead relied on T2D medication usage as a surrogate for T2D improvement. It would be interesting to test our findings in an independent cohort with longer-term HbA1C follow-up.

Conclusions

SG and RYGB lead to T2D medication cessation by discharge in a significant proportion of patients, consistent with both surgeries triggering weight loss–independent T2D resolution. T2D medication cessation at discharge is predictive of 12-month T2D outcomes, particularly in non-insulin requiring patients.

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The authors have no commercial associations that might be a conflict of interest in relation to this article.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.soard.2019.04.004.

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