Published in final edited form as:

J Surg Res. 2013 November ; 185(1): 1–5. doi:10.1016/j.jss.2013.06.014.

Diabetes remission and glycemic response to pre-bariatric surgery diet

Steven M. Biro, MS^a, Diane L. Olson, RD^a, Michael J. Garren, MD^a, and Jon C. Gould, MD^{b,*}

^aDepartment of Surgery, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin

^bDepartment of Surgery, Division of General Surgery, Medical College of Wisconsin, Milwaukee, Wisconsin

Abstract

Background: Before bariatric surgery, some patients with type 2 diabetes mellitus (T2DM) experience improvement in blood glucose control and reduced insulin requirements while on a preoperative low-calorie diet (LCD). We hypothesized that patients who exhibit a significant glycemic response to this diet are more likely to experience remission of their diabetes in the postoperative period.

Materials and methods: Insulin-dependent T2DM patients undergoing bariatric surgery between August 2006 and February 2011 were eligible for inclusion. Insulin requirements at day 0 and 10 of the LCD were compared. Patients with a 50% reduction in total insulin dosage to maintain appropriate blood glucose control were considered rapid responders to the preoperative LCD. All others were non-rapid responders. We analyzed T2DM remission rates up to 1 y postoperatively.

Results: A total of 51 patients met inclusion criteria and 29 were categorized as rapid responders (57%). The remaining 22 were considered non-rapid responders (43%). The two groups did not differ demographically. Rapid responders had greater T2DM remission rates at 6 (44% versus 13.6%; $P=0.02$) and 12 mo (72.7% versus 5.9%; $P<0.01$). In patients undergoing laparoscopic gastric bypass, rapid responders showed greater excess weight loss at 3 mo (40.1% versus 28.2%; $P<0.01$), 6 mo (55.2% versus 40.2%; $P<0.01$), and 12 mo (67.7% versus 47.3%; $P<0.01$).

Conclusions: Insulin-dependent T2DM bariatric surgery patients who display a rapid glycemic response to the preoperative LCD are more likely to experience early remission of T2DM postoperatively and greater weight loss.

Keywords

Bariatric surgery; Type 2 diabetes; Preoperative liquid diet; Diabetes remission

*Corresponding author. Department of Surgery, Division of General Surgery, Medical College of Wisconsin, 9200 W. Wisconsin Avenue, Milwaukee, WI 53226. Tel.: +1 414 805 5928; fax: +1 414 454 0152. jgould@mcw.edu (J.C. Gould).

Presented as an Oral Quick Shot Presentation at the February 2012 Academic Surgical Congress, Las Vegas, NV.

1. Introduction

According to the Centers for Disease Control and Prevention, 23.5 million United States adults (10.7% of people aged ≥ 20 y) have diabetes mellitus, more than 90% of which is type 2 diabetes mellitus (T2DM) [1]. In 2007 alone, 1.6 million new cases were diagnosed. The prevalence of obesity and T2DM is expected to continually increase in the United States over the upcoming years [2,3]. The relationship between obesity and T2DM is well established. For T2DM, approximately 90% of patients are obese (Body Mass Index [BMI] > 30 kg/m²) [4]. To date, there is no medical cure for T2DM, and current treatment modalities often involve a combination of medication and lifestyle modifications. In morbidly obese individuals with T2DM, bariatric surgery is a viable option as a potential long-term cure of the disease [5]. A recent systematic review by Meijer *et al.* [6] demonstrated that 83% of diabetic patients undergoing Roux-en-Y gastric bypass (RYGB) surgery experience complete T2DM disease remission postoperatively.

Specific variables have been identified as predictors of T2DM reversibility. Percent of excess weight loss (%EWL) after bariatric surgery is correlated with T2DM remission [7,8]. In addition, preoperative duration of T2DM (>5 y) and individual disease severity (high hemoglobin A_{1c} [HbA_{1c}] and injectable insulin use) have been shown to negatively influence the likelihood of diabetes remission in morbidly obese (BMI > 35 kg/m²) patients after bariatric surgery. The exact mechanisms underlying diabetes remission and the variability observed from patient to patient have not yet been fully explained.

In our bariatric surgery program, all patients are placed on a 2-wk preoperative low-calorie liquid diet immediately before surgery. The goal of this preoperative diet is to reduce the size and fat content of the liver, potentially facilitating operative exposure and operability [9]. We have observed that some diabetic patients display significant and immediate improvement in blood glucose control as well as reduced insulin requirements while on the 2-wk low-calorie diet (LCD), even before significant weight loss has occurred. We hypothesized that patients who exhibit a significant glycemic response to the preoperative liquid diet are more likely to experience remission of diabetes in the postoperative period.

2. Materials and methods

A retrospective review was conducted of data prospectively collected on insulin-dependent T2DM patients who underwent laparoscopic RYGB (LRYGB), laparoscopic adjustable gastric banding (LAGB) surgery, or laparoscopic sleeve gastrectomy in the University of Wisconsin Health Bariatric Surgery Program between August 2006 and February 2011. Patients not requiring injectable insulin to manage diabetes were excluded. Information collected from our bariatric surgery program clinical database included patient demographic characteristics, BMI, T2DM disease duration (years), HbA_{1c}, insulin dosage (before preoperative LCD, on day 10 of the LCD, and postoperatively), and type of procedure. Patients with $\geq 50\%$ reduction in total insulin dosage to maintain appropriate blood glucose control while on the preoperative LCD were deemed rapid responders to the preoperative LCD. All others were deemed non-rapid responders. Diabetes remission rates, HbA_{1c}, and weight loss were compared between the two study groups. Diabetes remission was defined

based on a 2009 consensus definition as complete cessation of all antidiabetic medication including oral hypoglycemics, $\text{HbA}_{1c} < 6$, and normal blood glucose levels [10].

Our bariatric surgery program protocols dictate that all patients, regardless of which procedure they are undergoing, participate in a preoperative liquid LCD (1100 cal/d for women, 1300 cal/d for men) for 2 wk, ending on the evening before surgery. In August 2006, we began to check all patients identified as injectable insulin-dependent T2DM patients for insulin dosage requirements at 2 wk before surgery (day 0 of the LCD), and at day 10 of the LCD. At 2 wk before surgery, all bariatric surgery patients attend a preoperative educational nutrition class during which our registered dietician and certified diabetes educator provides instructions regarding the preoperative LCD. All diabetic patients receive individualized education on how to properly adjust insulin levels during the 2 wk in response to blood sugars. Each diabetic patient was contacted at day 10 of the LCD and self-reported current insulin requirements. Patients returned to clinic postoperatively at 2 wk, 6 wk, 3 mo, 6 mo, and then annually for follow-up and monitoring. The program's bariatric health psychologist screens all patients. Routine health psychologist visits are scheduled at 3, 6, and 12 mo postoperatively and as needed. The protocols described above did not vary during the study interval.

In our bariatric program, diabetic patients and patients with a $\text{BMI} > 50 \text{ kg/m}^2$ are encouraged to consider LRYGB. During the period of this study, laparoscopic sleeve gastrectomy was not commonly performed because of poor insurance coverage for this option. As a result, most diabetic patients in the current study underwent LRYGB. Our surgical technique for LRYGB has been previously described in detail [11]. Briefly, a $<30\text{-mL}$ isolated gastric pouch is created. The standard length of the biliopancreatic limb is 50 cm. A 100- or 150-cm Roux limb is fashioned, depending on BMI (longer limb for those with an initial $\text{BMI} > 50 \text{ kg/m}^2$). For LAGB procedures, the band is placed proximally on the stomach such that a 20- to 30-mL gastric pouch is present proximal to the band using the pars flaccida technique [12]. Adjustments are performed in the office based on restrictive symptoms, appetite, and weight loss. Laparoscopic sleeve gastrectomy was performed over a 38- to 42-F bougie, using an endoscopic stapler and staple line reinforcement material [13].

Statistical analysis was performed using MStat version 5.5 (University of Wisconsin, Madison, WI). For continuous variables, a t-test was used for comparison between groups. The level of significance was set at $P < 0.05$. For outcomes with categorical variables, Fisher's exact test was used to discern significance. The University of Wisconsin Institutional Review Board approved this study.

3. Results

3.1. Baseline demographic and clinical characteristics

A total of 562 patients underwent bariatric surgery in the study interval. Of these patients, 183 had T2DM (32.6%). Our study group was composed of the 51 diabetic patients who required injectable insulin for T2DM management. In our study, four patients were lost to follow-up at 6 mo, whereas another eight were lost to follow-up at 1 y, which left 39 patients with complete follow-up information at 1 y. Of the 51 patients included in our study, 29

were defined as rapid responders to the preoperative LCD (displayed a >50% reduction in total insulin dosage; 57%) and the remaining 22 were defined as non-rapid responders. Rapid and non-rapid responder groups did not significantly differ demographically based on patient age, sex, preoperative BMI, HbA_{1c}, duration of T2DM before surgery, %EWL while on the LCD, or bariatric surgical procedure (Table 1).

3.2. Diabetes remission

Diabetes remission was observed in 19.6% of patients (10 of 51) at 3 mo, 29.8% (14 of 47) at 6 mo, and 43.6% (17 of 39) at 1 y. Comparing patients with diabetes remission with those without remission of diabetes, only the preoperative BMI and patient rapid or non-rapid responder status showed a significant impact on diabetes remission outcomes at 1 y (Table 2). Patients with diabetes remission at 1 y had a lower preoperative BMI compared with those who had no diabetes remission. Table 3 illustrates that T2DM remission rates were significantly greater in the rapid responder group at 6 mo (odds ratio, 5.0; $P=0.03$) and 12 mo (odds ratio, 42.7; $P<0.01$).

3.3. Weight loss

A total of 35 patients underwent LRYGB procedures, 10 underwent LAGB, three underwent vertical sleeve gastrectomy, two were previous LAGB procedures converted to LRYGB, and one underwent revisional surgery of a previous LAGB. Assessing %EWL in LRYGB patients only, the rapid responder group showed significantly greater weight loss versus the non-rapid responder group at 3, 6, and 12 mo (Table 4). At 1 y, patients with diabetes remission showed significantly greater %EWL compared with those without remission. Weight loss was not assessed at 1 y in patients undergoing LAGB, vertical sleeve gastrectomy, or revisional procedures owing to small numbers and the fact that weight loss at 1 y after an LAGB is often incomplete and highly variable [14].

3.4. Type 2 diabetes mellitus disease duration

To better assess the influence of disease duration in our study, we compared all patients with longstanding type 2 diabetes (≥ 10 y) with patients with diabetes for < 10 y. Patients with a short history of diabetes (< 10 y) were more likely to have disease remission at 3, 6, and 12 mo, although the difference was statistically significant only at 6 mo (Table 3).

4. Discussion

Our study demonstrated that individuals with T2DM who display a rapid response ($> 50\%$ reduction in total insulin requirements) to the preoperative LCD are more likely to experience both early diabetes remission and greater %EWL (in the case of LRYGB) after bariatric surgery. Although it is common practice for bariatric programs to place patients on an LCD (defined as a diet providing between 800 and 1800 cal/d) [15] or a very LCD (typically ~ 800 cal/d in a nutritionally complete liquid form) [16] immediately before bariatric surgery, little has been reported on the relationship between glycemic response to this diet and diabetes remission after surgery. Previous studies regarding the use of a VLCD before bariatric surgery have focused on the impact of this protocol on intra-operative and postoperative complications, particularly with regard to reducing intrahepatic deposition of

fat. An enlarged and fatty liver has been shown to be the most common cause requiring conversion of a laparoscopic gastric bypass or band surgery to an open procedure [17–19]. Although multiple studies have demonstrated that an increased preoperative weight loss is associated with greater short- and long-term weight loss in bariatric surgery patients, to our knowledge our study is the first to evaluate the relationship between a preoperative LCD and diabetes remission [20–24].

An increased duration of preoperative diabetic disease (> 5 y), elevated HbA_{1c}, and disease requiring the use of injectable insulin for management have all been shown to negatively correlate with postoperative diabetes remission rates in bariatric surgery patients [7,8]. In the current study, all patients required the use of injectable insulin at the time of surgery. Whereas HbA_{1c} levels did not differ, subjects with diabetes for < 10 y had greater remission rates compared with those with diabetes for ≥ 10 y. Weight loss after the different commonly performed bariatric procedures varies by procedure type [6]. The amount of weight lost after bariatric surgery is an important factor in determining the likelihood of diabetes and many other obesity-related comorbid conditions resolving. For the LRYGB and possibly the laparoscopic sleeve gastrectomy, there may be mechanisms of diabetic response independent of any weight loss that may occur [25].

In patients undergoing bariatric surgery, we observed that the rapid responder group to the preoperative LCD displayed statistically significant greater rates of diabetes remission postoperatively compared with the non-rapid responder group. The differences in remission rates between patients could not be explained by preoperative variables with the exception of preoperative BMI. The two groups did not differ with regard to age, sex, HbA_{1c}, disease duration, or % EWL on the LCD. Although we found a relationship between lower preoperative BMI and the likelihood of diabetes remission, the published literature regarding this association is mixed. Robert *et al.* [26] demonstrated in a retrospective review of 46 diabetic patients undergoing a variety of bariatric procedures that initial BMI < 50 kg/m² was positively related to diabetes remission. In a prospective, randomized, controlled trial comparing bariatric surgery (gastric bypass and biliopancreatic diversion) with standard medical therapy for diabetes, bariatric surgery resulted in better glucose control than did medical therapy. Preoperative BMI and weight loss did not predict the improvement in hyperglycemia after these procedures [27]. In another retrospective review of 154 patients with T2DM undergoing gastric bypass, Dixon and colleagues [28] found that a lower initial BMI (< 35 kg/m²) reduced the likelihood of diabetes remission at 1 y. This is contrary to the effect we observed (lower initial BMI associated with a higher remission rate).

We did not assess for patient compliance with the preoperative LCD. It is possible that patients who are not compliant with a preoperative liquid LCD are less likely to be compliant with an intensive medical management regimen for diabetes, and that this might at least partially account for our findings. The fact that %EWL after 10 d on the LCD immediately before surgery did not differ between study groups makes this possibility less likely. One potential mechanism that might account for differences in diabetic response to the preoperative liquid diet may be individual β -cell functional reserve. Individuals with T2DM have both peripheral insulin resistance and functional decline in β -cells. Longstanding hyperglycemia has been demonstrated to have direct glucotoxicity on β -cells,

to reduce β -cell secretory function, and to induce pro-apoptotic cascades, all of which contribute to β -cell “burnout” [29].

These findings have important potential implications for patient care. The effect of bariatric surgery on glycemia is profound. There is a real danger of inducing hypoglycemia in diabetic patients postoperatively if blood glucose levels are not closely monitored and antidiabetic drug dosages adjusted appropriately [30]. Guidelines for adjustments of antidiabetic treatment before and after bariatric surgery are scarce. Information regarding the preoperative glycemic response to an LCD can be used to tailor diabetic treatment after bariatric surgery in a manner that avoids dangerous hypoglycemic episodes yet achieves tight glycemic control peri-operatively. This has been demonstrated to lead to better long-term glycemic control in diabetic patients undergoing bariatric surgery [31].

There are a number of potential limitations to our study. We chose only to monitor the glycemic response to the preoperative liquid LCD in diabetic patients requiring injectable insulin. This limited our sample size and may affect the generalizability of these findings to all diabetic patients. Glycemic response to the preoperative diet was patient reported. Compliance with the diet or diabetic management was not assessed. We selected an LCD rather than a VLCD as used by others. We believe that this may have led to improved compliance with the diet, although we do not have specific data to support this. A total of 12 patients (24%) were lost to follow-up at 12 mo. In a retrospective study of this small size, this may further limit the generalizability of our findings. The different bariatric procedures included in this analysis may have confounded our findings as well. Despite these facts, we believe that we have demonstrated that patients with advanced diabetes (those requiring injectable insulin for adequate control) realize a significant glycemic response to a preoperative LCD. The degree of this response is correlated with the likelihood of diabetes remission and ultimately excess weight loss in LRYGB patients. Further study is necessary to characterize the mechanism of this response and to develop protocols that may be universally adopted to achieve tight glycemic control without hypoglycemia that can be tailored to the individual patient.

Acknowledgment

The authors thank the Department of Surgery, University of Wisconsin, for supporting this project.

REFERENCES

- [1]. Centers for Disease Control and Prevention. National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2007. Atlanta (GA): United States Dept of Health and Human Services, Centers for Disease Control and Prevention; 2008.
- [2]. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA* 2006;295:1549. [PubMed: 16595758]
- [3]. Stewart ST, Cutler DM, Rosen AB. Forecasting the effects of obesity and smoking on U.S. life expectancy. *N Engl J Med* 2009;361:2252. [PubMed: 19955525]
- [4]. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors. *JAMA* 2003;289:76. [PubMed: 12503980]

- [5]. Pories WJ, Swanson MS, MacDonald KG, et al. Who would have thought it? An operation proves to be the most effective therapy for adult-onset diabetes mellitus. *Ann Surg* 1995;222:339. [PubMed: 7677463]
- [6]. Meijer RI, van Wagenveld BA, Siegert CE, Eringa EC, Serné EH, Smulders YM. Bariatric surgery as a novel treatment for type 2 diabetes mellitus: a systematic review. *Arch Surg* 2011;146:744. [PubMed: 21690453]
- [7]. Schauer PR, Burguera B, Ikramuddin S, et al. Effect of laparoscopic Roux-en Y gastric bypass on type 2 diabetes mellitus. *Ann Surg* 2003;238:467. [PubMed: 14530719]
- [8]. Ponce J, Haynes B, Paynter S, et al. Effect of lap-band-induced weight loss on type 2 diabetes mellitus and hypertension. *Obes Surg* 2004;14:1335. [PubMed: 15603648]
- [9]. Lewis MC, Phillips ML, Slavotinek JP, et al. Change in liver size and fat content after treatment with Optifast very low calorie diet. *Obes Surg* 2006;16:697. [PubMed: 16756727]
- [10]. Buse JB, Caprio S, Cefalu WT, et al. How do we define cure of diabetes? *Diabetes Care* 2009;32:2133. [PubMed: 19875608]
- [11]. Gould JC, Garren MJ, Starling JR. Lessons learned from the first 100 cases in a new minimally invasive bariatric surgery program. *Obes Surg* 2004;14:618. [PubMed: 15186628]
- [12]. Di Lorenzo N, Furbetta F, Favretti F, et al. Laparoscopic adjustable gastric banding via pars flaccida versus perigastric positioning: technique, complications, and results in 2,549 patients. *Surg Endosc* 2010;24:1519. [PubMed: 20354885]
- [13]. Abu-Jaish W, Rosenthal RJ. Sleeve gastrectomy: a new surgical approach for morbid obesity. *Expert Rev Gastroenterol Hepatol* 2010;4:101. [PubMed: 20136593]
- [14]. O'Brien P. Is weight loss more successful after gastric bypass than gastric banding for obese patients? *Nat Clin Pract Gastroenterol Hepatol* 2009;6:136. [PubMed: 19204742]
- [15]. Tsai AG, Wadden TA. The evolution of very-low-calorie diets: an update and meta-analysis. *Obesity* 2006;14:1283. [PubMed: 16988070]
- [16]. Howard AN. The historical development, efficacy and safety of very-low-calorie diets. *Int J Obes* 1981;5:195. [PubMed: 7024153]
- [17]. Colles SL, Dixon JB, Marks P, Strauss BJ, O'Brien PE. Preoperative weight loss with a very-low-energy diet: quantitation of changes in liver and abdominal fat by serial imaging. *Am J Clin Nutr* 2006;84:304. [PubMed: 16895876]
- [18]. O'Brien PE, Dixon JB, Brown W, et al. The laparoscopic adjustable gastric band (lap-band): a prospective study of medium-term effects on weight, health and quality of life. *Obes Surg* 2002;12:652. [PubMed: 12448387]
- [19]. Schwartz ML, Drew RL, Chazin-Caldie M. Laparoscopic Roux-en-Y gastric bypass: preoperative determinants of prolonged operative times, conversion to open gastric bypasses, and postoperative complications. *Obes Surg* 2003;13:734. [PubMed: 14627468]
- [20]. Alami RS, Morton JM, Schuster R, et al. Is there a benefit to preoperative weight loss in gastric bypass patients? A prospective randomized trial. *Surg Obes Relat Dis* 2007;3:141. [PubMed: 17331803]
- [21]. Alvarado R, Alami RS, Hsu G, et al. The impact of preoperative weight loss in patients undergoing laparoscopic Roux-en-Y gastric bypass. *Obes Surg* 2005;15:1282. [PubMed: 16259888]
- [22]. Benotti PN, Still CD, Wood GC, et al. Preoperative weight loss before bariatric surgery. *Arch Surg* 2009;144:1150. [PubMed: 20026834]
- [23]. Solomon H, Liu GY, Alami R, Morton J, Curet MJ. Benefits to patients choosing preoperative weight loss in gastric bypass surgery: new results of a randomized trial. *J Am Coll Surg* 2009;208:241. [PubMed: 19228536]
- [24]. Still CD, Benotti P, Wood GC, et al. Outcomes of preoperative weight loss in high-risk patients undergoing gastric bypass surgery. *Arch Surg* 2007;142:994. [PubMed: 17938314]
- [25]. Benaiges D, Flores Le-Roux JA, Pedro-Botet J, et al. Sleeve gastrectomy and Roux-en-Y gastric bypass are equally effective in correcting insulin resistance. *Int J Surg* 2013; 11:309. [PubMed: 23462580]

- [26]. Robert M, Ferrand-Gaillard C, Disse E. Predictive factors of type 2 diabetes remission 1 year after bariatric surgery: impact of surgical techniques. *Obes Surg* 2013;23:770. [PubMed: 23355293]
- [27]. Mingrone G, Panunzi S, De Gaetano A, et al. Bariatric surgery versus conventional medical therapy for type 2 diabetes. *N Engl J Med* 2012;366:1577. [PubMed: 22449317]
- [28]. Dixon JB, Chuang LM, Chong K, et al. Predicting the glycemic response to gastric bypass surgery in patients with type 2 diabetes. *Diabetes Care* 2013;36:20. [PubMed: 23033249]
- [29]. Donath MY, Ehses JA, Maedler K, et al. Mechanisms of beta-cell death in type 2 diabetes. *Diabetes* 2005;54(Suppl 2):S108. [PubMed: 16306327]
- [30]. Thorell A, Hagström-Toft EJ. Treatment of diabetes prior to and after bariatric surgery. *Diabetes Sci Technol* 2012;6:1226.
- [31]. Fenske WK, Pournaras DJ, Aasheim ET, et al. Can a protocol for glycaemic control improve type 2 diabetes outcomes after gastric bypass? *Obes Surg* 2012;22:90. [PubMed: 22052198]

Table 1 –

Preoperative characteristics of rapid and non-rapid responders.

	Rapid (n = 29)	Non-rapid (n = 22)	P
Age, y	56.8 ($\pm$ 3.4)	54.4 ($\pm$ 4.3)	0.36
Sex, % female	52	77	0.83
BMI, kg/m ²	46.9 ($\pm$ 2.8)	50.1 $\pm$ 3.0	0.12
T2DM duration, y	13.9 ($\pm$ 3.3)	14.5 ($\pm$ 4.3)	0.61
HbA _{1c} , %	7.5 ($\pm$ 0.4)	7.7 ($\pm$ 0.5)	0.57
%EWL on LCD	4.8 ($\pm$ 1.4)	4.9 ($\pm$ 1.7)	0.93
Procedure			
LRYGB	21 (72.4%)	14 (63.6%)	0.55
LAGB	3 (10.3%)	7 (31.8%)	0.07

All continuous variables are expressed as mean values (95% confidence intervals). $P < 0.05$ for comparison between rapid and non-rapid responders was considered significant.

Table 2 –

Preoperative characteristics of patients with and without diabetes remission at 1 y after bariatric surgery.

	Remission (n = 17)	No remission (n = 22)	P
Age, y	55.6 ($\pm$ 6.1)	55.5 ($\pm$ 8.6)	0.91
Sex, male/female	9/8	6/16	0.18
BMI, kg/m ²	45.1 ($\pm$ 2.7)	50.7 ($\pm$ 3.5)	0.01
T2DM duration, y	13 ($\pm$ 4.7)	15.5 ($\pm$ 4)	0.4
HbA _{1c} , %	7.5 ($\pm$ 0.7)	7.7 ($\pm$ 0.6)	0.65
%EWL on LCD *	5.0 ($\pm$ 1.9)	4.7 ($\pm$ 1.9)	0.81
LRYGB/LAGB	12/4	14/5	1

* Percent excess weight loss (%EWL) while on 2-wk LCD. Continuous variables are expressed as mean values (95% confidence intervals).

Table 3 –

Type 2 diabetes mellitus remission rates.

	3 mo	6 mo	12 mo
Rapid responders (<i>n</i> = 29)	27.6% (8/29)	44%* (11/25)	72.7%* (16/22)
Non—rapid responders (<i>n</i> = 22)	9.1% (2/22)	13.6% (3/22)	5.9% (1/17)
Duration diabetes mellitus < 10 y	37.5% (6/16)	53.3%* (8/15)	66.6% (8/12)
Duration diabetes mellitus ≥ 10 y	11.4% (4/35)	18.7% (6/32)	33.3% (9/27)

* $P < 0.05$ for comparison of rapid responders and non—rapid responders or duration of diabetes < 10 y or ≥ 10 y.

Table 4 –

Percent excess weight loss in LRYGB patients: rapid versus non-rapid responders.

<i>n</i> = 35 on day of surgery	3 mo	6 mo	12 mo
Rapid responders (<i>n</i> = 21)	40.1 (± 5.2) (<i>n</i> = 21)	55.2 (± 7) (<i>n</i> = 18)	67.7 (± 9.3) (<i>n</i> = 12)
Non-rapid responders (<i>n</i> = 14)	28.2 (± 3.9) (<i>n</i> = 14)	40.2 (± 7.1) (<i>n</i> = 14)	47.3 (± 10.6) (<i>n</i> = 14)
<i>P</i> *	<0.01	<0.01	<0.01

* *P* < 0.05 was considered significant. Results are expressed as mean values (95% confidence intervals).