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Long-limb length difference had no effect on outcomes of laparoscopic Roux-en-Y gastric bypass surgery for obese Chinese patients with type 2 diabetes mellitus

A CONSORT compliant article

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Abstract

Bariatric surgery is effective in treating different components of metabolic syndrome including obesity, type 2 diabetes mellitus (T2DM), and hyperlipidemia. But there is no consensus on the ideal biliopancreatic and Roux limb length. This study aimed to explore the effect of biliopancreatic limb and Roux limb lengths during laparoscopic Roux-en-Y gastric bypass (LRYGB) procedures on weight loss and T2DM control.

We studied the clinical records of 58 patients with metabolic syndrome, T2DM, and body mass index (BMI) 32 to 50 kg/m^2 who underwent LRYGB in our hospital. The short limb group (Group A) underwent LRYGB with a limb length of 160 to 200 cm (n=31) and the long limb group (Group B) underwent LRYGB with a limb length of 210 to 240 cm (n=27) were compared.

The occurrence of acute or chronic internal hernia in Group B was higher than that in Group A (P=.026). Twelve months after surgery, patients from the 2 groups were also observed with reduction in BMI, percent excess weight loss (EWL), preoperative FPG, and HbA1c as compared with these indicators before surgery. However, the differences of these indicators between 2 groups were not significant at the time point of before and 3, 6, 12 months after surgery.

LRYGB had significant effects on weight loss and diabetes control in obese T2DM patients. However, there was no significant difference in the short term on weight loss and diabetes control in the patients receiving different limb lengths.

Abbreviations: ADA = American Diabetes Association, BMI = body mass index, DM = diabetes mellitus, EWL = excess weight loss, FPG = fasting plasma glucose, HbA1C = hemoglobin A1c, LRYGB = laparoscopic Roux-en-Y gastric bypass, T2DM = type 2 diabetes mellitus.

Keywords: bariatric surgery, biliopancreatic limb length, Roux limb length, Roux-en-Y gastric bypass, type 2 diabetes mellitus

1. Introduction

Diabetes mellitus (DM) is a severe pandemic in the modern world. It is the fourth leading cause of death worldwide and an important public health risk in developing countries. In China, according to the National Health Survey of the Chinese Diabetes Society,[1] there is an estimated 9.7% prevalence of DM among the adult population (aged > 20 years), and up to 15.5% have glucose intolerance. In 2008, there were 92 million people with DM.[1] Large numbers of studies indicated that the epidemic of obesity is associated with the rapid growth of T2DM,[2,3] which highlights the importance of the investigation for effective treatments of both obesity and T2DM.

Most dietary interventions and medical treatment of T2DM and obesity rarely achieve sustained T2DM remission and weight loss. Many types of bariatric surgery treatment are proved to be effective to achieve a high rate of remission of T2DM and other obesity-related conditions.[4–6] Among these, Roux-en-Y gastric bypass (RYGB) is one of the most common and frequently performed surgical interventions, and is accepted by many surgeons as the gold standard.[7,8] The malabsorptive element of RYGB is the exclusion of the duodenum and the initial portion of the jejunum, as well as a relatively long biliopancreatic and Roux limb. Thus, the degree of malabsorption can be modified by altering the length of these limbs.[9] This suggests that limb length is very important for weight loss and diabetes control. However, there has been no consensus on the ideal length of the biliopancreatic and Roux limbs for good control of obesity and T2DM while avoiding nutritional and clinical complications.

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The aim of this study was to evaluate the clinical efficacy of short-versus-long limb length in laparoscopic RYGB (LRYGB) in terms of BMI, EWL, remission and improvement of T2DM in 2 comparable groups of Chinese patients with obesity (BMI 32–50 kg/m^2).

2. Methods

2.1. Patients

We prospectively maintained a database of patients who underwent LRYGB to treat T2DM and obesity (BMI ranged from 32 to 50 kg/m^2) between October 2012 and February 2015 at the Department of General Surgery, Beijing Shijitan Hospital, Capital Medical University, China. The data of 58 consecutively enrolled patients then underwent analysis. All patients in our study were aged from 24 to 63 years. The inclusion criteria were patients with a BMI of 32 to 50 kg/m^2, and the value was selected after considering the characteristics of metabolic syndrome in Chinese populations, with T2DM diagnosed according to the standards of the American Diabetes Association (ADA) 2009.[10] The exclusion criteria were superobese patients with BMI > 50 kg/m^2; those planning a pregnancy within 1 year after entry into this study; and those with established diagnoses of type 1 diabetes, latent autoimmune diabetes in adults, malignancy, debilitating disease, unresolved psychiatric illness, or substance abuse.

All patients gave written informed consent after being made aware of the current standards of treatment for T2DM and understanding the risks and benefits associated with the procedure. The study complied with principle of informed consent, and was approved by Ethics Committee of hospital.

2.2. Study design

The indications for LRYGB were: Obese patients of BMI ≥ 28, combined with some metabolic syndromes such as diabetes, hyperlipidemia, and hypertension. The BMI value was lower than European and North American countries because in the Asian-Pacific region a BMI higher than 25 is considered as obesity.

Before the operation, patients were assessed by a specialized team, including a surgeon, an endocrinologist, an anesthetist, a psychiatrist, and a dietician. Patients underwent standard preoperative evaluation consisting of clinical history taking and physical examination by surgeons, routine preoperative blood testing, chest x-ray, electrocardiography, abdominal computed tomography, and electronic endoscopy. Additional tests and consultations in the relevant department were obtained as clinically indicated.

The patients were divided into 2 groups, in which the different limb length was applied for LRYGB. In Group A (short limb group) (n = 31), the total limb length was 160 to 200 cm, and in Group B (long limb group) (n = 27), the total limb length was 210 to 240 cm. The biliopancreatic limb and Roux limb length were approximated. Total limb length was the sum of biliopancreatic limb and Roux limb length. All procedures were completed laparoscopically by a senior chief physician, Dr Nengwei Zhang, an experienced doctor in bariatric surgery and followed standard procedures.[11]

2.3. Clinical data collection and follow-up

On postoperative day 2 or 3, the operation time, estimated blood loss, postoperative length of stay, and mortality were evaluated. Glucose levels were measured on postoperative days 0 to 4 every 4 hours until discharge from hospital, and glycated hemoglobin (HbA1c) was assessed for the first time 4 weeks after surgery.

Postoperative follow-up took place according to the following schedule: the first visit was 4 weeks after surgery, followed by visits at 3, 6, and 12 months after surgery. The content of the follow-up included: BMI, excess weight loss (EWL); T2DM control was assessed using FPG and HbA1c. An experienced diabetologist determined the necessity for administration of antidiabetic medication. Assays for glycemic markers were all performed in the same laboratory.

T2DM evolution after surgery was classified into 1 of 3 categories according to the FPG measurement and use of antidiabetic medication.[12,13] It was considered "remission" when the patient had FPG < 126 mg/dL and was not using any antidiabetic medication. We used 126 mg/dL FPG as the limit because it is the value considered by the ADA as the diagnostic criterion for T2DM.[2] It was considered "improvement" when, compared with preoperative data, there was a positive change in FPG and medication use but not enough to fulfill remission criteria (e.g., the patient had FPG < 126 mg/dL, but was still using antidiabetic medication). It was considered the "same or worse" when FPG and antidiabetic medication use did not change after surgery or had a worsening tendency postoperatively.

2.4. Statistical analysis

Data are reported as mean ± standard deviation (SD) unless otherwise specified and were analyzed by Kolmogorov–Smirnov test, in order to detect whether the data showed normal distribution. The comparisons of measurement data between the 2 groups were analyzed by the unpaired Student's *t*-test. Enumeration data was analyzed by chi-squared test. The Mann–Whitney *U* test was used for the metabolic control status between the 2 groups. Statistical significance was set at $P < .05$. All statistical analyses were performed using SPSS version 17.0 (SPSS Inc., Chicago, IL).

3. Results

3.1. Baseline characteristics

The main characteristics of the patients are listed in Table 1. The 2 study groups were similar in terms of age, sex, mean BMI, duration of DM, DM family history, number of patients on insulin, and comorbidities.

Table 1

Preoperative patient characteristics.

	Group A (n = 31)	Group B (n = 27)	*P* value
Mean age, years	43.9 ± 12.8	46.1 ± 13.0	.517
Sex (M/F)	16/15	13/14	.792
Mean BMI, kg/m^2	40.6 ± 4.4	41.6 ± 4.7	.370
Duration of DM, years	6.8 ± 3.4	6.4 ± 3.4	.652
DM family history (%)			.847
Yes	18 (58.1%)	15 (55.6%)	
No	13 (41.9%)	12 (44.4%)	
Patients on insulin (%)	17 (54.8%)	14 (51.9%)	.820
Mean FPG, mg/dL	185 ± 32	196 ± 34	.205
Mean HbA1c (%)	8.4 ± 1.1	8.8 ± 1.4	.207
Comorbidity, n (%)*	25 (80.6%)	24 (88.9%)	.387

BMI = body mass index, DM = diabetes mellitus, F = female, FPG = fasting plasma glucose, HbA1c = hemoglobin A1c, M = male.
* Comorbidity including lipid disorder, hypertension, sleep apnea, gastroesophageal reflux disorder.

Table 2

Procedure-related characteristics.

	Group A (n=31)	Group B (n=27)	P value
Operating time, minutes	173.5±26.3	183.6±23.9	.136
Mean limb length, cm	177.1±11.9	226.3±10.8	<.001
EBL, mL	33.5±10.8	36.3±10.3	.316
PLS, days	5.7±2.1	5.1±2.0	.278
Conversion to open	0	0	ns

EBL=estimated blood loss, PLS=postoperative length of stay.

3.2. Perioperative characteristics

All patients underwent LRYGB, and no conversions to laparotomy were required. Perioperative data for both groups are shown in Table 2. The limb lengths of the 2 groups were as follows: Group A (177.1±11.9 cm), Group B (226.3±10.8 cm). There was significant difference in the total limb length between both groups ($P<.001$). There were no significant differences in mean operating time, estimated blood loss, or postoperative length of stay between both groups.

3.3. Evaluation of weight loss and T2DM control at follow-up

A total of 58 eligible patients who underwent LRYGB were included in this study during the research stage and were followed up at least for 1 year. BMI was progressively decreased 3 months, 6 months and 12 months after surgery in Group A and Group B. Compared with those before surgery, 3 months, 6 months and 12 months after surgery, both groups had a significant reduction in BMI after surgery ($P<.001$). The mean BMI of Group A was reduced from 40.6±4.4 kg/m^2 preoperatively to 30.4±3.9 kg/m^2, and the mean BMI of Group B decreased from 41.6±4.7 kg/m^2 preoperatively to 29.6±4.1 kg/m^2. However, both A and B group share similar BMI between at the same time point of 3 months, 6 months and 12 months, respectively, after surgery (Fig. 1A), and no statistically significant effect was found for the traditional difference-in-difference estimation (Fig. 1B).

The EWL values of the patients from the 2 groups were progressively increased after surgery. The EWL% of group A increased significantly ($P<.001$) from 21±9% at 3 months to 42 ±11% at 6 months, and 57±13% at 12 months eventually. Similarly, the EWL% of group B increased significantly ($P<.001$) from 24±11% at 3 months to 46±13% at 6 months, and 62±14% at 12 months eventually. However, there was no significant difference in each time point of EWL between Groups A and B (Fig. 2).

In Group A, 31 patients had a mean preoperative FPG of 185± 32 mg/dL and a mean HbA1c of 8.4±1.1%. They had a significant decrease in FPG of 101±20 mg/dL ($P<.001$) and HbA1c of 5.7±0.8% ($P<.001$) at 12 months postoperatively. Among the Group B patients, 27 had a mean preoperative FPG of 196±34 mg/dL and a mean HbA1c of 8.8±1.4%. They had a significant decrease in FPG of 96±15 mg/dL ($P<.001$) and in HbA1c of 5.3±0.7% ($P<.001$) at 12 months postoperatively. There was no significant difference in FPG and HbA1c between the 2 groups at each time point (P>.05), 3 months, 6 months, and 12 months after surgery (Fig. 3).

The number of patients from both groups that met the diagnostic criteria for T2DM decreased gradually and significantly after surgery. During the postoperative follow-up period, 26 (83.9%) Group A patients with T2DM achieved disease

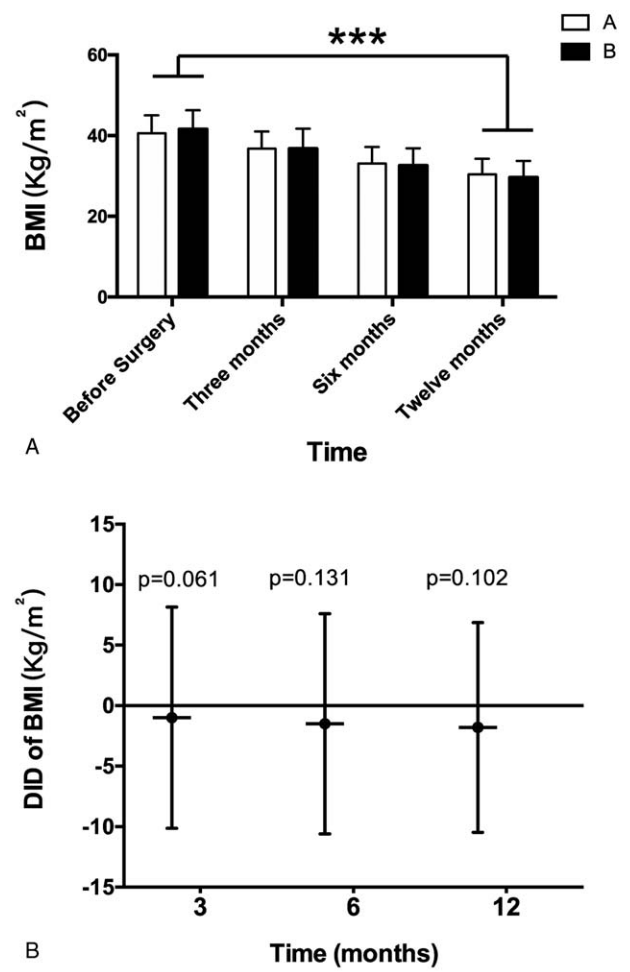

Figure 1. (A) Preoperative and postoperative BMI in the 2 groups: short limb (Group A) and long limb length (Group B), and the relative (B) difference-in-differences (DID) results. Before surgery: Group A BMI 40.6±4.4, Group B BMI 41.6±4.7, $P=.370$. Three months after surgery: Group A BMI 36.8±4.2, Group B BMI 36.8±4.9, $P=.983$. Six months after surgery: Group A BMI 33.1 ±4.1, Group B BMI 32.6±4.3, $P=.659$. Twelve months after surgery: Group A BMI 30.4±3.9, Group B BMI 29.6±4.1, $P=.460$. Error bars represent the SD. $P^{***}<.0001$. BMI=body mass index, DID=difference-in-differences.

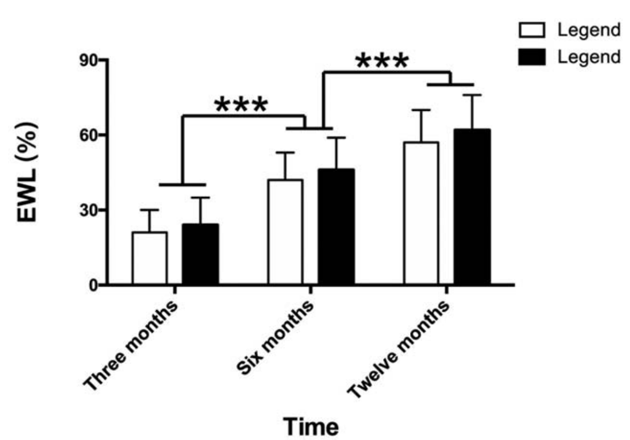

Figure 2. Preoperative and postoperative EWL changes in the 2 groups: short limb (Group A) and long limb (Group B). At 3 months Group A 21±9%, Group B 24±11%, $P=.186$. 6 months Group A 42±11%, Group B 46±13%, $P=.205$. 12 months Group A 57±13% Group B 62±14%, $P=.126$. Error bars represent the SD. $P^{***}<.0001$. EWL=excess weight loss.

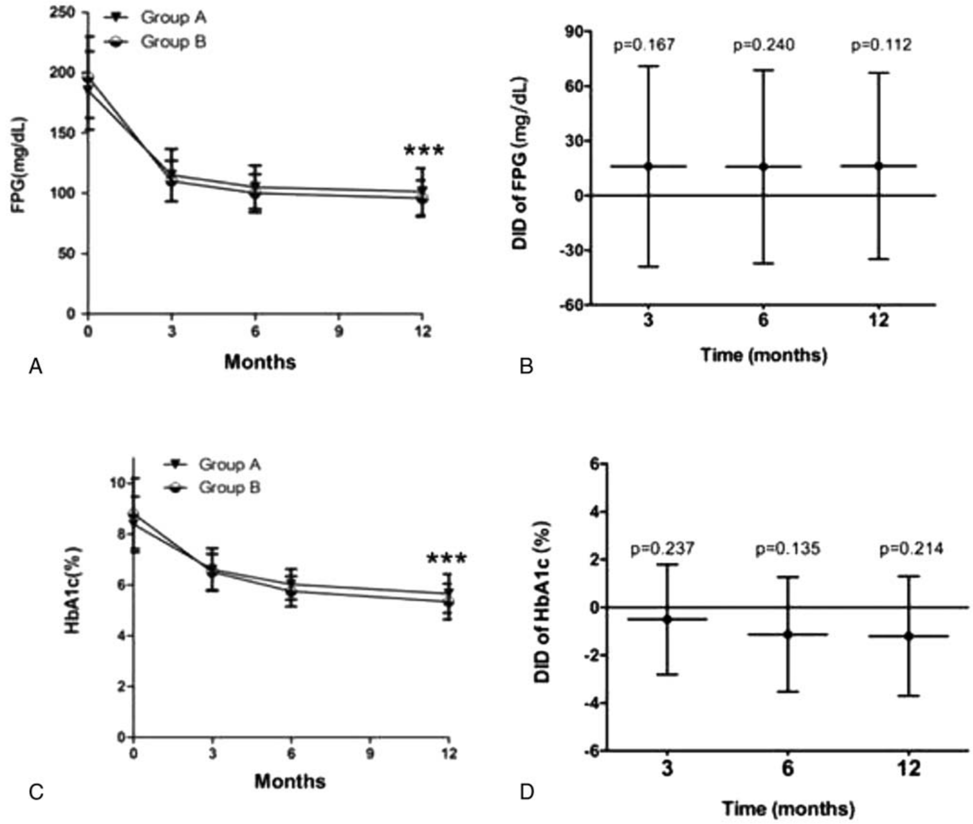

Figure 3. Change in type 2 diabetes mellitus related factors in the 2 groups (A and C), and the relative (B and D) difference-in-differences (DID) results. Short limb (Group A) and long limb (Group C). (A) Mean fasting plasma glucose (FPG) level, and (B) difference-in-differences (DID) results; (C) change in mean glycosylated hemoglobin (HbA1c) level, and (D) difference-in-differences (DID) results. $P^{***} < .0001$, as compared with the indicators at the time of "before surgery." DID = difference-in-differences.

remission, 4 (12.9%) showed improvement, and one (3.2%) was the same or worse. In the Group B patients with T2DM, 24 (88.9%) achieved disease remission, 3 (11.1%) showed improvement, and no patient was the same or worse. There were no significant differences in remission, improvement, and whether the patients were the same or worse between the groups (Table 3). The remission or improvement of T2DM occurred within 2 to 12 weeks after surgery and even before any significant weight loss, and the disease remained in remission or improvement throughout the 1 year follow-up in both groups.

4. Discussion

The aim of this study was to investigate whether the limb length influenced surgery outcomes in 2 groups of Chinese patients with obesity and T2DM who had undergone LRYGB. The results show that while LRYGB was effective at inducing weight loss and diabetes control, and the results were similar in both patient groups. This suggests that limb length in LRYGB has no influence on outcomes in obese patients with T2DM among Asian people.

Some studies have demonstrated that defining biliopancreatic and Roux limb lengths based on BMI can improve T2DM resolution,[12,14–16] and suggested that there is a strong correlation between the length of limb and improved weight loss effect, as well as other complications such as diabetes and hypertension.[17–19] However, the results of some other studies found that limb length is not very important for the outcome of LRYGB in terms of weight loss and diabetes control.[20–23] For example, Abellan et al[21] found the total jejunoileal segment and the percentage of common limb in both obese and super-obese patients had no influence on the %EWL in either group for a two-year follow-up. However, patients with a $<50\%$ common limb had greater nutritional deficiencies in the follow-up period and required supplements and more frequent laboratory tests. The results of a study lasting for 5 years showed that the change of LRYGB surgery limb did not greatly affect the weight loss of obese patients with BMI <50. These outcomes suggested that the restriction elements (pouch size, outlet diameter) might be more influential on weight loss than malabsorption in patients with comparatively less initial excessive weight. Another study focusing on obese patients with BMI <50 showed that difference in limb lengths had no significant effect on the absolute weight decrease range, BMI decrease range and EWL decrease range and deduced that the length of limb had no great influence on the weight loss.[21]

Table 3

Postoperative metabolic control status.

	Group A (n=31)	Group B (n=27)	*P* value
Remission, n (%)	26 (83.9)	24 (88.9)	.558
Improvement, n (%)	4 (12.9)	3 (11.1)	
Same or worse, n (%)	1 (3.2)	0 (0)	

Thus, due to the racial differences, we explored the effects of limb lengths on weight loss and diabetes control in only Chinese group of obese T2DM patients with BMI < 50.

In the present study, due to racial differences, the obesity standard in the Asian-Pacific region and the indications for RYGB surgery are different from those for Caucasians from Europe and America. Thus, our study explored the effects of limb lengths on weight loss and diabetes control in Chinese obese T2DM patients with BMI < 50. The results showed that both groups of obese T2DM patients (BMI < 50) had similar weight loss and rates of T2DM control postoperatively, but there was no significant difference in the treatment results between short and long limb length of LRYGB despite the fact that there was a 50-cm difference in limb length between the 2 groups.

The principal limitations of our study were that the effects of the limb length on T2DM resolution and weight loss may be limited during 1 year follow-up, and the long-term effects of limb length are still unknown. Therefore, continuous follow-up of patients would be helpful for good clinical practice in Asian patients. Further studies are needed on larger numbers of patients to discover whether a larger difference in limb length would result in significant differences in outcomes and whether the results are different for patients with higher BMI than 50. In addition, we concentrated on T2DM control after surgery, but these patients also had metabolic syndrome symptoms, future studies should evaluate changes in blood pressure, cholesterol and triglycerides.

Using LRYGB significantly decreased weight and improved diabetes control. However, for Chinese T2DM patients with BMI 32–50 kg/m^2, the effects of different biliopancreatic and Roux limb lengths on weight loss and T2DM control were not that significant.

Author contributions

Fan Q, Liu C, Zhang DD, Xu GZ, Du DX, Yin G, Li TX collected the data; Yan W analyzed the data and drafted the manuscirpt; Sun ZP, Lian DB and Buhe Amin provided analytical oversight; Zhang NW designed and supervised the study; Gong K, Zhu B and Peng JR revised the manuscript for important intellectual content; Yan W and Zhang NW offered the technical or material support; Zhang NW provided administrative support; all authors have read and approved the final version to be published.

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