



ORIGINAL ARTICLE

The role of visceral adipose tissue on improvement in insulin sensitivity following Roux-en-Y gastric bypass: a study in Chinese diabetic patients with mild and central obesity

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Abstract

Background: Most Chinese patients with type 2 diabetes mellitus (T2DM) have mild obesity and central obesity. Central obesity is combined with insulin resistance. The aim of this study was to assess the effect of abdominal adipose tissue on insulin-sensitivity improvement after Roux-en-Y gastric bypass (RYGB) in Chinese diabetic patients with mild and central obesity.

Methods: Seventeen T2DM patients with a mean body mass index of 30.3 kg/m² were scheduled for laparoscopic RYGB. A hyperinsulinemic-euglycemic clamp and dual-energy X-ray absorptiometry were performed prior to surgery and 3 months after RYGB. The primary end points were the correlations between insulin sensitivity and abdominal adipose tissue, including visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT), before and 3 months after RYGB.

Results: Indices of peripheral insulin sensitivity, including glucose-disposal rate (M value) and glucose infusion rate, were significantly increased after RYGB. Body-fat mass, VAT and SAT were significantly reduced after RYGB. The pre-operative M value was significantly correlated with VAT mass ($r = -0.57$, $P = 0.02$), but not correlated with SAT mass. M value changes after RYGB were highly correlated with changes in VAT mass ($r = -0.59$, $P = 0.01$), percentage of VAT mass ($r = -0.66$, $P < 0.01$), VAT area ($r = -0.56$, $P = 0.02$) and percentage of VAT area ($r = -0.57$, $P = 0.02$).

Conclusions: A significant correlation was observed between increased peripheral insulin sensitivity and decreased VAT following RYGB in Chinese patients with mild and central obesity. VAT and SAT were significantly decreased with improved insulin sensitivity after RYGB. VAT mass may be considered as an indication for gastric bypass during patient selection.

Key words: Insulin sensitivity; visceral adipose tissue; gastric bypass; hyperinsulinemic-euglycemic clamp; type 2 diabetes mellitus; non-morbid obesity

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Introduction

The prevalence of obesity has dramatically increased in China. Obesity is always combined with other medical conditions, especially insulin resistance or decreased insulin sensitivity, type 2 diabetes mellitus (T2DM) and dyslipidemia. Insulin resistance is an important mechanism of disease progression and can cause islet dysfunction and T2DM. Roux-en-Y gastric bypass (RYGB) is a good option to reduce obesity and improve related diseases including T2DM, in both the short and the long term [1–4]. Compared to patients of Caucasian descent, Chinese ethnic patients more readily develop visceral obesity and early β -cell dysfunction in the setting of insulin resistance when diagnosed with T2DM [5]. Although the mean body mass index (BMI) of Chinese patients with T2DM is relatively low [6], RYGB significantly improves diabetes and related comorbidities in Chinese ethnic populations with a BMI $< 35 \text{ kg/m}^2$ [7, 8].

A method to evaluate visceral obesity and islet function is necessary. Dual-energy X-ray absorptiometry is widely used in regional body composition studies and has a low radiation exposure and short scanning time compared to magnetic resonance imaging (MRI) or computed tomography (CT). Visceral adipose tissue (VAT) is highly related to peripheral insulin sensitivity [9]. VAT is recognized as the major feature of patients with obesity and T2DM and leads to hyperglycemia and cardiovascular diseases. Dual-energy X-ray absorptiometry has been approved as a reliable and precise method to measure central obesity and VAT [10, 11]. The derived VAT measure is closely related to other indices of obesity, including BMI, waist circumference and waist-to-hip ratio (WHR) [12].

The hyperinsulinemic-euglycemic clamp is recognized as the gold standard for the assessment of peripheral insulin sensitivity [13]. It is rarely used in clinical practice due to its complexity, cost and procedural duration. Few studies have utilized the hyperinsulinemic-euglycemic clamp to evaluate metabolic surgery in Chinese patients. The glucose-disposal rate (M value) represents peripheral insulin sensitivity (including within skeletal muscle and adipose tissue), whereas the homeostasis model assessment of insulin resistance (HOMA-IR) is a measurement of hepatic insulin sensitivity [14]. Compared to the significant reduction of the HOMA-IR within 1 week after surgery, the M value does not substantially improve until 4 weeks after surgery [15].

The aim of the study was to investigate whether abdominal adipose tissue is important for improved insulin-sensitivity status after RYGB in Chinese diabetic patients with mild and central obesity. We also examined the correlation between changes in insulin sensitivity and abdominal adipose tissue, including VAT and subcutaneous adipose tissue (SAT), before and 3 months after RYGB.

Materials and methods

Patients

Seventeen obese patients with T2DM were scheduled for laparoscopic RYGB from October 2014 to December 2015 at the Third Xiangya Hospital, Central South University (Changsha, China). This study was approved by the human ethics committee of the Third Xiangya Hospital, Central South University. All participants gave informed consent for surgery.

The inclusion criteria were as follows. Patients were between the ages of 16 and 65 years and had T2DM history ≤ 15 years in duration. Patients with a BMI $\geq 32.5 \text{ kg/m}^2$ regardless of the level

of glycemic control or obesity-related comorbidities were recommended for surgery. Bariatric surgery was considered for patients with a BMI $\geq 27.5 \text{ kg/m}^2$ and $< 32.5 \text{ kg/m}^2$, inadequately controlled hyperglycemia despite lifestyle and optimal medical therapy, with two additional metabolic syndrome components, including hypertriglyceridemia, low high-density lipoprotein cholesterol, hypertension and central obesity; or with one additional obesity and T2DM-related comorbidities, including insulin resistance, obstructive sleep apnea, nonalcoholic steatohepatitis, hyperuricemia, male sexual dysfunction, polycystic ovary syndrome and renal dysfunction. Bariatric surgery was carefully and thoughtfully recommended for patients with a BMI $\geq 25 \text{ kg/m}^2$ and $< 27.5 \text{ kg/m}^2$, inadequately controlled hyperglycemia despite lifestyle and optimal medical therapy and with two additional metabolic syndromes or one additional obesity and T2DM-related comorbidities. Additionally, the patients had increased central obesity measures according to the recommended grades: waist circumference $\geq 90 \text{ cm}$ for males and $\geq 85 \text{ cm}$ for females.

The exclusion criteria were as follows: a history of T1DM, gestational diabetes or other types of diabetes mellitus; dysgnosis; intellectual immaturity; severe psychiatric conditions; drug abuse or alcohol addiction; and other severe medical conditions. The hyperinsulinemic-euglycemic clamp, dual-energy X-ray absorptiometry scans and oral glucose-tolerance tests were completed preoperatively and 3 months after RYGB.

Surgical procedures

All patients underwent laparoscopic RYGB within the same surgical group. An approximately 30-ml gastric pouch from the top stomach was created and the jejunum, 50 cm distal from the ligament of Treitz, was divided by an Endo-GIA Stapler. An antecolic end-to-side gastric-jejunum anastomosis connected the distal jejunum to the posterior wall of the gastric pouch. A jejunum-jejunum anastomosis was created 100 cm away from the first gastrojejunostomy and connected the biliary-pancreatic limb and the alimentary limb [16]. The total time required for the procedure was approximately 2 hours. No patients underwent conversion to laparotomy.

Hyperinsulinemic-euglycemic clamp

Catheters were placed in an antecubital vein for infusion and in a dorsal vein of the hand for blood sampling. Insulin infusion (40 mU/kg/min) (Humulin R, Eli Lilly, USA) was continued for 150 minutes using a precision infusion pump. Blood samples were collected through an intravenous catheter with glucose concentrations measured every 5 min. Euglycemia ($5.0 \pm 0.1 \text{ mmol/L}$) was reached and maintained. Peripheral glucose uptake (M value) was calculated as the glucose-infusion rate at steady state (30 minutes' duration) [17].

Dual-energy X-ray absorptiometry

Dual-energy X-ray absorptiometry (LUNAR DPX NT+ 74029, GE Medical System, USA) using enCORE Version 13.60 software (2011) was conducted to measure body composition. The total/android fat mass, fat-free mass, body mass, % fat mass (percentage of fat mass in body mass), mass/volume/area of VAT, android fat mass/total fat mass (%), fat mass/weight and android-to-gynoid (A/G) ratio in percent fat mass were measured. The SAT mass was calculated using the following formula: android fat mass – VAT mass.

Outcome measures

The primary end points were the correlations between insulin sensitivity and the total fat mass, android fat mass, VAT and SAT before and 3 months after RYGB. The secondary end points were changes in insulin sensitivity (including the M value and HOMA-IR) and indicators of abdominal adipose tissue (including VAT and SAT) 3 months after RYGB. All patients ingested 75 g of glucose dissolved in 250 ml of water within 5 minutes. Blood samples were drawn from a catheter in an antecubital vein at 0-, 30-, 60- and 120-minute time-points.

Statistical analysis

All data are presented as mean \pm standard deviation (SD) for variables with normal distributions or as median (range) for those with non-normal distributions. The paired difference test or chi-square test was used to compare pre-operative and post-operative data. Pearson correlation was used to analyse the associations between insulin sensitivity (M value and HOMA-IR) and total fat mass, android fat mass, VAT and SAT. Statistical significance was set at $P < 0.05$. All statistical analyses were conducted using SPSS (version 21, IBM, Chicago, IL, USA).

Results

Of the 17 patients undergoing laparoscopic RYGB, no patient was lost 3 months after surgery. There were 10 males and 7 females, with a mean age of 40.8 ± 2.8 years. The mean duration of T2DM was 6.2 ± 4.9 years. The mean BMI, waist circumference and WHR were 30.3 ± 2.7 kg/m², 99.1 ± 6.9 cm and 1.06 ± 0.03 , respectively. The mean fasting plasma glucose (FPG) and HbA1c levels were 10.3 ± 3.9 mmol/L and $8.3 \pm 1.6\%$, respectively.

Changes in insulin sensitivity and abdominal adipose tissue after RYGB

The M value increased significantly 3 months after RYGB (3.5 ± 1.1 vs 6.5 ± 1.4 mg/kg/min, $P < 0.01$). The glucose-infusion rate was also markedly improved (3.1 ± 1.1 vs 5.0 ± 1.2 mg/kg/min, $P < 0.01$). T2DM patients had a significant reduction in HOMA-IR, HbA1c, FPG, 30-minute postprandial plasma glucose (30minPG), 2-hour postprandial plasma glucose (2hPG), fasting plasma insulin (FINS), 30-minute postprandial plasma insulin (30minINS), 2-hour postprandial plasma insulin (2hINS), BMI, waist circumference, WHR and triglycerides after RYGB (Table 1). VAT (mass, area, volume, percentage of VAT mass/android fat mass) was dramatically reduced 3 months after RYGB. A significant remission also occurred in total fat mass, total body mass, total % fat mass, percentage of android fat mass/total fat mass, SAT mass, fat mass/weight and A/G (Table 2). The weight decreased significantly after RYGB from 84.3 ± 8.2 to 66.5 ± 9.4 kg ($P < 0.05$).

Correlation between insulin sensitivity and abdominal adipose tissue

The pre-operative M value was significantly correlated with VAT mass at baseline ($r = -0.57$, $P = 0.02$) (Table 3). Changes in the M value were highly correlated with changes in VAT mass ($r = -0.59$, $P = 0.01$), percentage of VAT mass ($r = -0.66$, $P < 0.01$), VAT area ($r = -0.56$, $P = 0.02$) and percentage of VAT area ($r = -0.57$, $P = 0.02$) from baseline to 3 months after RYGB (Table 4 and Figure 1).

Table 1. Metabolism variables at baseline and 3 months after Roux-en-Y gastric bypass (N = 17)

Outcomes	Baseline	3 months	P-value
M value, mg/kg/min	3.5 ± 1.1	6.5 ± 1.4	<0.01
Glucose-infusion rate, mg/kg/min	3.1 ± 1.1	5.0 ± 1.2	<0.01
Steady-state glucose, mmol/L	5.3 ± 0.3	5.2 ± 0.1	>0.05
HOMA-IR	5.1 ± 6.6	1.6 ± 2.3	<0.01
HAbc1, %	8.3 ± 1.6	6.5 ± 0.7	<0.01
Fasting plasma glucose, mmol/L	10.3 ± 3.9	5.8 ± 0.8	<0.01
30minPG, mmol/L	14.6 ± 2.6	12.4 ± 2.2	<0.01
2hPG, mmol/L	19.6 ± 3.0	8.5 ± 2.8	<0.01
Fasting plasma insulin, uIU/L	10.6 ± 20.1	5.7 ± 9.5	<0.01
30minINS, uIU/L	16.7 ± 3.1	12.9 ± 2.2	<0.01
2hINS, uIU/L	36.8 ± 8.3	24.9 ± 6.5	<0.01
Triglycerides, mmol/L	3.2 ± 1.0	2.3 ± 0.9	<0.01
Cholesterol, mmol/L	5.4 ± 1.5	4.7 ± 0.6	>0.05
Body mass index, kg/m ²	30.3 ± 2.7	24.1 ± 1.5	<0.01
Waist circumference, cm	99.1 ± 6.9	88.3 ± 6.1	<0.01
Waist hip ratio	1.06 ± 0.03	0.90 ± 0.05	<0.01

Data are presented as mean \pm standard deviation.

M value, glucose-disposal rate; HOMA-IR, homeostasis model assessment of insulin resistance; 30minPG, 30-minute postprandial plasma glucose; 2hPG, 2-hour postprandial plasma glucose; 30minINS, 30-minute postprandial plasma insulin; 2hINS, 2-hour postprandial plasma insulin.

Discussion

Most Chinese patients with T2DM have mild obesity (BMI <35 kg/m²) and central obesity instead of general obesity [18]. The patients included in this study had a mean BMI of 30.3 ± 2.7 kg/m² and a mean waist circumference of 99.1 ± 6.9 cm. Peripheral insulin sensitivity was significantly improved by RYGB, as measured by hyperinsulinemic-euglycemic clamp at 3 months after RYGB. A significant reduction was also observed in android fat (SAT and VAT, including VAT mass, volume and area). Most importantly, VAT loss was significantly related to insulin-sensitivity improvement following RYGB in Chinese diabetic subjects with a BMI <35 kg/m² in this study. Impressive improvements in pancreatic β -cell function (as indicated by fasting C peptide and FINS) and glucose metabolism were observed in this study. These results are consistent with those from previous studies [19].

The HOMA-IR may also improve following RYGB [20]. Although the HOMA-IR is utilized as the major measurement of IR in clinical practice due to its convenience, the major limitation of the HOMA-IR is that it can only be used as an indirect surrogate marker. Moreover, the HOMA-IR mainly reflects hepatic insulin sensitivity, not peripheral insulin sensitivity [21]. Peripheral insulin sensitivity, including skeletal muscle and adipose tissue, represents the major contributor to whole-body insulin sensitivity [15]. Additionally, increased insulin sensitivity or insulin resistance may cause islet dysfunction and lead to dysglycemia.

The hyperinsulinemic-euglycemic clamp was used to evaluate peripheral insulin sensitivity in subjects who underwent RYGB in this study. The results showed that peripheral insulin sensitivity (M value) was significantly increased at 3 months after surgery, from 3.5 ± 1.1 to 6.5 ± 1.4 mg/kg/min. In addition, the glucose-infusion rate in the clamp study was markedly improved. Improved insulin signaling in human skeletal muscle and adipose tissue following RYGB may be the major drivers of improvements in whole-body insulin sensitivity [22]. The improvement in peripheral insulin sensitivity, coupled with fat

Table 2. The indicators of abdominal adipose tissue by dual-energy X-ray absorptiometry at baseline and 3 months after Roux-en-Y gastric bypass (N = 17)

Outcomes	Baseline	3 months	P-value	Change	%Change
Total fat mass, kg	27.4 (12.3)	18.1 (5.7)	<0.01	-8.0 (14.9)	-32.4 (50.3)
Total fat-free mass, kg	51.5 (24.8)	50.1 (16.1)	>0.05	-3.6 (19.4)	-7.9 (39.2)
Total body mass, kg	79.3 (28.9)	69.6 (18.4)	<0.01	-12.9 (21.7)	-15.7 (27.7)
Total%fat mass	34.6 (10.8)	27.1 (11.1)	<0.01	-7.0 (13.2)	-22.0 (36.0)
Android fat mass, kg	2.8 (1.4)	1.7 (0.9)	<0.01	-0.9 (1.6)	-31 (51.1)
Android fat-free mass, kg	4.3 (2.3)	3.8 (1.8)	<0.01	-0.5 (2.5)	-10.1 (58.7)
Android body mass, kg	7.2 (3.4)	5.5 (2.3)	<0.01	-1.4 (3.3)	-20.0 (43.1)
Android%fat mass	39.2 (9.0)	30.4 (15.8)	<0.01	-6.9 (15.0)	-17.0 (39.8)
VAT mass, kg	0.8 (0.5)	0.6 (0.3)	<0.01	-0.3 (0.6)	-40.0 (38.7)
VAT volume, cm ³	911 (511.0)	601.0 (189.0)	<0.01	-320.0 (551.0)	-32.7 (33.6)
VAT area, cm ²	182.0 (98.0)	114.0 (36.7)	<0.01	-64.7 (109.0)	-37.4 (35.8)
SAT mass, kg	2.0 (1.3)	1.4 (1.3)	<0.01	-0.5 (1.4)	-25.2 (75.2)
VAT mass/android fat mass, %	30.9 (14.8)	28.7 (20.9)	<0.01	-4.6 (18.8)	
Android fat mass/total fat mass, %	5.8 (2.5)	9.9 (8.0)	<0.01	4.6 (7.0)	
Fat mass/weight	9.8 (3.9)	6.3 (1.8)	<0.01	-1.0 (0.5)	-33.9 (30.5)
A/G	1.40 (0.68)	1.30 (0.60)	>0.05	-0.3 (0.5)	-7.5 (30.6)

Data are presented as median (range).

VAT, visceral adipose tissue; android, waist and abdomen area; gynoid, hip area; A/G, android-to-gynoid ratio in percent fat mass; Fat-free mass, body mass excluded fat mass; %fat mass, percentage of fat mass in body mass; android%fat mass, percentage of fat mass in body mass in android region.

Table 3. Correlation between insulin sensitivity and abdominal adipose tissue at baseline

Variables	M value		HOMA-IR	
	r	P-value	r	P-value
Total fat mass (kg)	-0.46	0.06	-0.64	<0.01
Android fat mass (kg)	-0.27	0.28	-0.33	0.19
VAT mass (kg)	-0.57	0.02	0.13	0.63
VAT volume (cm ³)	-0.38	0.14	-0.09	0.75
VAT area (cm ²)	-0.39	0.12	0.05	0.85
SAT mass (kg)	-0.14	0.60	-0.41	0.10
%VAT mass/android fat mass	-0.16	0.54	0.47	0.06
Fat mass/weight	-0.36	0.15	-0.40	0.12
A/G	0.20	0.45	0.14	0.60

HOMA-IR, homeostasis model assessment of insulin resistance; VAT, visceral adipose tissue; A/G, android-to-gynoid ratio in percent fat mass.

Table 4. Correlation between changes in insulin sensitivity and abdominal adipose tissue at 3 months after Roux-en-Y gastric bypass

Variables	ΔM value		ΔHOMA-IR	
	r	P-value	r	P-value
Δtotal fat mass (kg)	-0.32	0.22	-0.55	0.02
Δandroid fat mass (kg)	-0.42	0.09	-0.32	0.20
ΔVAT mass (kg)	-0.59	0.01	0.14	0.59
ΔVAT volume (cm ³)	-0.24	0.35	-0.17	0.52
ΔVAT area (cm ²)	-0.56	0.02	-0.01	0.98
ΔSAT mass (kg)	-0.31	0.23	-0.43	0.08
ΔVAT mass/android fat mass	-0.15	0.57	0.62	0.01
Δfat mass/weight	0.13	0.62	-0.35	0.17
ΔA/G	-0.08	0.78	0.15	0.57
%change of VAT mass	-0.66	<0.01	0.12	0.65
%change of VAT volume	-0.19	0.45	-0.24	0.35
%change of VAT area	-0.57	0.02	-0.09	0.73

HOMA-IR, homeostasis model assessment of insulin resistance; VAT, visceral adipose tissue; SAT, subcutaneous adipose tissue; %change of VAT, percent of ΔVAT to Android fat.

mass loss, can lead to a distinct improvement at 3 months post surgery [23].

Previous work has indicated that changes in android fat mass are significantly associated with the HOMA-IR in Chinese patients with a BMI < 35 kg/m² [16]. In this study, we attempted to separate VAT from SAT in abdominal adipose tissue. A remarkable reduction was observed in total fat, android fat, VAT and SAT at 3 months after RYGB, indicating that RYGB has a significant effect on body-fat composition, especially android fat. In addition, the current study demonstrated a close relationship between insulin sensitivity and VAT mass at baseline, but no significant correlation between SAT and insulin sensitivity.

Most importantly, the results indicated a strong correlation between increased peripheral insulin sensitivity and decreased VAT following RYGB in Chinese patients with mild and central obesity. The changes in peripheral insulin sensitivity showed significant correlations with the parameters of VAT loss (ΔVAT mass, % change of VAT mass, ΔVAT area and % change of VAT area; all $P < 0.05$) in this study. In contrast, no significant correlation was observed between changes in VAT volume and peripheral insulin sensitivity. Visceral and subcutaneous fat-cell volumes were negatively correlated with insulin sensitivity according to observations utilizing the hyperinsulinemic-euglycemic clamp [24]. Additionally, changes in total fat mass may play an important role in reducing insulin resistance after surgery [20]. For patients with obesity and normal glucose tolerance, no significant improvement was observed in hepatic insulin sensitivity (HOMA-IR) and VAT at 3 months after bariatric surgery. However, insulin sensitivity markedly increased beyond 3 months due to a sustained VAT reduction [25]. Therefore, the improvement in insulin sensitivity was highly associated with VAT loss after RYGB. However, improved insulin sensitivity was not associated with body weight loss [26].

VAT loss by omentectomy does not improve insulin sensitivity in obese patients [27]. Neither acute nor long-term improvement in metabolic disorders occurred after RYGB when VAT was reduced by omentectomy [28]. These findings challenge the notion that increased VAT is a significant cause of insulin resistance in obese patients. However, it is possible that, even if the

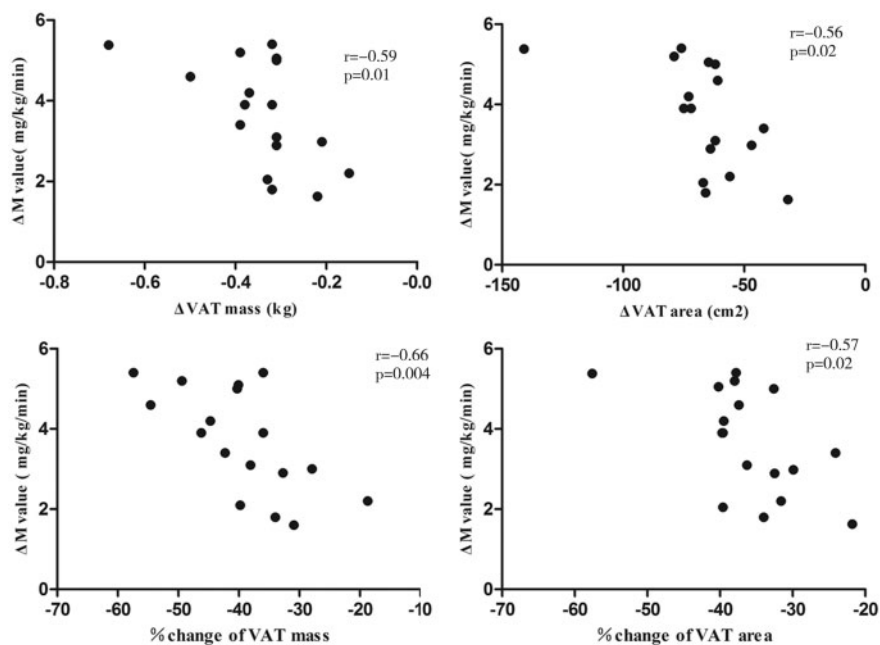


Figure 1. Correlation between changes in glucose-disposal rate (M value) and visceral adipose tissue (VAT) at 3 months after Roux-en-Y gastric bypass. Δ M value or Δ VAT mass/area: variables from post-operative to pre-operative of M value or VAT mass/area. %Change of VAT mass/area: percentage of Δ M value or Δ VAT mass/area in variables of pre-operative M value or VAT mass/area.

greater omentum is removed, other intra-abdominal depots with adverse effects may still be present.

Compared to VAT, no significant relationship was observed between changes in SAT and improved insulin sensitivity after surgery in this study. Furthermore, accumulation of VAT was closely associated with insulin resistance, rather than with SAT [29]. Therefore, VAT, rather than SAT, can reflect insulin sensitivity. However, the reduction in subcutaneous fat-cell volume, rather than fat mass, is markedly associated with increased insulin sensitivity in women with morbid obesity and without diabetes before and after RYGB [30].

The pre-operative BMI is regarded as the most important criterion for metabolic surgery [31]. Unlike American investigations, most Chinese T2DM patients have central obesity with mild obesity or overweight. Therefore, BMI is relatively less useful in predicting diabetes variables in the Chinese population after RYGB [32]. The data in this study clearly showed that VAT loss is highly related to improved peripheral insulin sensitivity, which is the key target of diabetic control. As such, VAT evaluation with dual-energy X-ray absorptiometry may be an important pre-operative predictor of the benefits of metabolic surgery for Chinese patients with mild and central obesity. In addition, the VAT area may be a new predictor of diabetic remission after gastric bypass in Chinese patients with a BMI <35 kg/m² [33].

Chinese patients with a low BMI and T2DM showed a marked improvement in glycemic control [34]. RYGB was an effective option to improve metabolic diseases for Chinese patients with mild obesity in this study. Such data support recent recommendations for metabolic surgery in Asian patients with a BMI >27.5 kg/m², according to the latest guidelines of multiple international diabetes organizations [35].

Although the current study produced interesting results, it has some limitations. First, we only collected post-operative data at 3 months post surgery. Subsequent investigations should collect data over a longer follow-up period. Second, only a small sample of patients were enrolled in this study. Third,

radioisotope-labeled glucose clamp measures were not included in this study; therefore, metabolic pathway changes in sugar, lipids and protein were not investigated. In addition, all participants underwent RYGB. Future studies may benefit from comparisons across surgical procedures, such as laparoscopic sleeve gastrectomy.

In conclusion, a strong correlation exists between increased peripheral insulin sensitivity and decreased VAT following RYGB in Chinese patients with mild and central obesity. RYGB significantly decreased VAT and SAT along with improving insulin sensitivity. VAT mass should be considered as an indication of gastric bypass during patient selection.

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