Surgical Results of Laparoscopic Loop Duodenojejunal Bypass with Sleeve Gastrectomy (LDJB-SG) in Obese Asians (BMI ≥ 27.5 kg/m^2) with Type 2 Diabetes Mellitus (T2DM): A New Promising Bariatric and Metabolic Surgery

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ABSTRACT

Objective: To demonstrate surgical outcomes, safety and complications in obese Asians (BMI > 27.5 kg/m^2) who underwent LDJB-SG in our center.

Methods: We retrospectively reviewed ninety-one patients who underwent LDJB-SG from October 2011 to March 2014. One-year surgical outcomes regarding the efficacy of weight loss, safety as well as complications of this procedure were demonstrated. Remission of T2DM and co-morbidities resolution after one year were also analyzed.

Results: The median duration of T2DM was 60 months and the median operative time was 140 min. Interestingly, the mean/median preoperative BMI, HbA1C and FPG levels dropped significantly from 30.7 kg/m^2, 8.9%, and 139.0 mg% to 23.7 kg/m^2, 6.2%, and 95.0 mg% respectively at 1 year after operation ($p<0.001$). Furthermore, 61.5% of patients who had completed 1 year follow-up showed complete diabetic remission and 92.3% experienced glycemic control (HbA1c<7% without any medication). The postoperative complications were intra-abdominal bleeding (4.4%), leakage (1.1%), stricture (3.3%) and port site hernia (2.2%).

Conclusion: LDJB-SG is a safe and feasible bariatric and metabolic surgery, which has demonstrated excellent outcomes in terms of weight reduction, co-morbidities resolution as well as glycemic control in short-term follow-up.

Keywords: Loop duodenojejunal bypass with sleeve gastrectomy; type 2 diabetes mellitus; Obese Asians (Siriraj Med J 2018;70: 103-113)

INTRODUCTION

Currently, changes in lifestyle, particularly overeating and less exercise, economic and social factors have mainly contributed to the increase in obesity around the world. It is estimated that about 2 billion individuals are encountering this problem.[1] Moreover, obesity is associated with an increased risk of death, and carries a significant risk of life-threatening complications such as type 2 diabetes mellitus (T2DM), coronary artery disease, hyperlipidemia, hypertension, obstructive sleep apnea and several cancers.[2]

According to WHO 1998 classification of weight status in adults, the definition of obesity [body mass index (BMI) >30 kg/m^2] is based on criteria derived from studies that involved European populations.[3] It has been proposed that there are differences between European and Asian populations in terms of the associations of BMI with body composition and health outcomes. Furthermore,

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Asian populations have also been manifested to have an elevated risk of serious co-morbidities at a relatively low level of BMI. Regarding these observations, it has been suggested that the BMI cut-off points for obesity should be lower for Asians than Europeans. The suggested BMI cut-off points for obese Asians is ≥ 27.5 kg/m^2.[3]

Type 2 diabetes mellitus has become the most serious life-threatening condition which is apparently related to obesity. Diet control, increased physical activity, weight loss and anti-diabetic medications are the basical standard treatment for T2DM. Nevertheless, many studies have shown that the results of these non-surgical treatments are ineffective in long-term observation. [4-7] On the contrary, several reports have demonstrated that the majority of obese diabetic patients who received bariatric surgery resulted in T2DM remission and/or improvement which was significantly more than patients who did medical therapy alone.[8-10]

Many bariatric and metabolic surgical procedures such as Laparoscopic Roux-en-Y Gastric Bypass (LRYGB) and Biliopancreatic Diversion with Duodenal Switch (LBPD-DS) have shown impressive weight loss and comorbid diseases resolution particularly in T2DM in both severely obese and mild to moderate obese patients from many recent studies.[11-16,20-22] However, the drawbacks of these procedures are the long-term complications including marginal ulcer, intractable dumping syndrome, internal hernia, malnutrition and even mortality in some patients. Regarding these eventful complications, we were the first group who invented a novel bariatric procedure called "Laparoscopic Loop Duodenojejunal Bypass with Sleeve Gastrectomy (LDJB-SG)" in October 2011. This procedure is theoretically more physiological and carries less surgical related complications. In addition, we previously reported our preliminary result of this novel procedure since March 2013, which was demonstrated to be safe, feasible and achieved excellent weight loss and glycemic control in T2DM patients at 6 months of follow-up.[23] The objective of this study is to demonstrate two-year surgical outcomes regarding the efficacy of weight loss, safety and complications as well as one-year surgical results of diabetic remission and co-morbidities resolution in obese Asians (BMI ≥ 27.5 kg/m^2) with T2DM who underwent LDJB-SG in our center.

MATERIALS AND METHODS

This study was approved by the Medical Ethics Committee and Institutional Review Board of E-Da Hospital. We retrospectively reviewed, from prospectively maintained database, ninety-one patients who underwent LDJB-SG in our hospital from October 2011 to January 2014. All of the patients underwent a routine preoperative work-up and were assessed by a specialized team including a surgeon, gastroenterologist, anesthetist, psychiatrist and dietician. The inclusion criteria was based on The Consensus Statement of International Federation for Surgery of Obesity and Metabolic Disorders-Asia Pacific Chapter Meeting 2011 (IFSO-APC 2011)[24] and The International Diabetes Federation (IDF) statement in the treatment of Obese Patients with T2DM[25] (age of 18-65 years and body mass index (BMI) ≥ 27.5 kg/m^2 with inadequately controlled T2DM). The patients who were younger than 18 or older than 65 years, BMI < 27.5 kg/m^2, psychiatric illness, liver cirrhosis, active malignancy condition, addiction to either drugs or alcohol, severe gastroesophageal reflux disease (grade C and D by Los Angeles Classification[27] base on endoscopic finding) and any duodenal ulcer or lesion from preoperative upper endoscopic evaluation were excluded from receiving this surgery.

The prospectively collected data included preoperative patient demographics such as gender, age, body weight (BW), BMI, waist circumference (WC), hip circumference (HC), waist/hip ratio (WHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), obesity-related co-morbidities (diabetes mellitus, hypertension, hyperlipidemia, hyperuricemia, steatohepatitis), duration of diabetes, insulin or oral hypoglycemic agents (OHA) usage, fasting plasma glucose (FPG), glycosylate hemoglobin (HbA1C), C-peptide level, total cholesterol (CHOL), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), aspartate aminotransferase (AST), alanine aminotransferase (ALT), complete blood count (CBC) and uric acid (UA). Intra- and postoperative complications, operative time (OT) as well as length of hospital stay (LOS) were also recorded. Furthermore, preoperative esophagogastroduodenoscopy (EGD) and upper abdominal ultrasound (US) were performed in every patient. The concomitant cholecystectomy with LDJB-SG was done when the patient had gallstone from preoperative US and the hiatal hernia repair was also performed simultaneously when we found any hiatal hernia from preoperative EGD.

All the patients were followed up routinely at 1, 3, 6, 9 and 12 months after surgery. The postoperative collected data were BW, BMI, weight loss percentage (%EWL), WC, HC, WHR, blood pressure as well as the levels of FPG, HbA1C, C-peptide, CHOL, TG, HDL-C, LDL-C, AST, ALT, CBC, and UA. Moreover, EGD and US were also performed additionally at 12 months postoperatively in every patient.

The surgical outcomes in our study included

the efficacy of weight loss and co-morbidities resolution after operation. Additionally, we also demonstrated the remission of T2DM, which was based on the criteria of the American Diabetes Association (ADA) 2012.[26] Complete remission was stated if HbA1c < 6% and FPG < 100 mg/dl and partial remission was considered when HbA1C < 6.5% and FPG 100-125 mg/dl for at least 1 year's duration with the absence of anti-diabetic medication. If HbA1C < 7% without any anti-diabetic medication, it could be determined that glycemic control was achieved. When the FPG decreased more than 25 mg/dl or HbA1C decreased more than 1%, it was considered as glycemic improvement. In contrast, failure of diabetic control after operation was defined as no significant improvement or worsened glycemic indices or a requirement for additional diabetic medication. Hypertension resolution was documented if blood pressure < 130/80 mmHg without medication and the level of TG < 150 mg/dl and LDL-C < 100 mg/dl without medication were considered as hyperlipidemia resolution.[28]

Finally, we also analyzed the side effects, complications, morbidity and mortality of this operation. Early complications were described as those, which occurred within the 30 days after operation. Major complications were life threatening or required surgical intervention treatment. Furthermore, diagnosis and grading of erosive esophagitis were determined endoscopically based on the Los Angeles (LA) classification.[27]

Operative technique

LDJB-SG was performed laparoscopically under general anesthesia. The patient was placed in the supine position with both arms abducted. The surgeon and assistants position were on the right and left side of patient, respectively (Fig 1). Pneumoperitoneum was created using a long Veress needle technique and intra-abdominal pressure was maintained at 17 mmHg. We used five-port laparoscopic surgery to access the abdominal cavity. (Fig 2) The liver was retracted superiorly using T-shape liver suspension tapes in order to achieve good exposure of both stomach and duodenal area. Complete devascularization of the greater curvature of the stomach was done, 4 cm., from pylorus up to the left crus of the diaphragm, using 5 mm., LigaSure vessel sealing (Tyco, New Haven, CT, USA) followed by sleeve gastrectomy (SG) procedure over a 36-Fr., orogastric tube calibrator using 60 mm., laparoscopic linear tri-stapler ENDO GIA (Covidien, Mansfield, MA, USA). Black reloads were used for the first two firings while purple reloads were used for the subsequent firings toward the gastric fundus. After ensuring hemostasis, a stay suture was done at distal

Fig 1. Patient and Surgeon positioning.

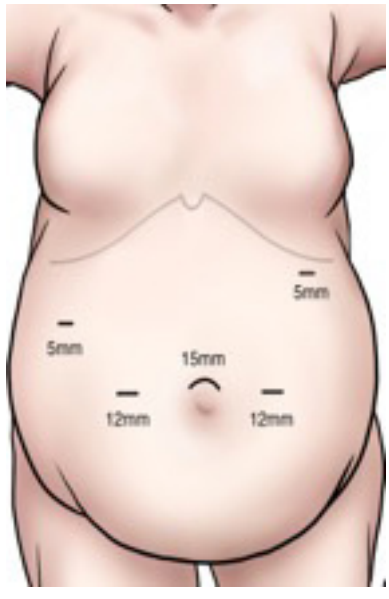

Fig 2. Ports position.

end of SG for counter-traction and better visualization of the first part of duodenum. The transection of the first part of duodenum was performed at 2 cm., away from pylorus using 45 mm., laparoscopic linear white stapler ENDO GIA (Covidien, Mansfield, MA, USA) then a 1.5 cm., side to side, antecolic, loop duodenojejunal anastomosis (totally hand-sewn continuous suture with 3-0 Monocryl, single-layer technique) was created at 200-300 cm., from the ligament of Treitz. The limb tailoring for duodenojejunostomy bypass depended on the patient's preoperative C-peptide level as follows: the limb length for any patient who had preoperative C-peptide level more than 2, between 1 and 2 and less

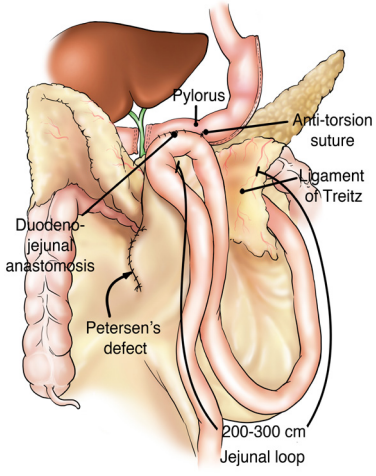

Fig 3. Laparoscopic Loop DuodenoJejunal Bypass with Sleeve Gastrectomy (LDJB-SG).

than 1 ng/ml were 200, 250 and 300 cm., respectively. An anti-torsion suture between proximal jejunum and antrum (2 cm., proximal to pylorus) was made then the Peterson's defect was closed with continuous suture. (Fig 3) A Jackson-Pratt drain was placed behind the duodenojejunal anastomosis and stapler line of SG.[23]

Early postoperative care

All the patients were extubated and transferred to the surgical ward after surgery. Deep-breathing exercises, early mobilization and adequate pain control administration were given in order to avoid postoperative pulmonary complications. A clear-liquid diet was started once patients were fully conscious. The patients were discharged when they could tolerate oral fluid, passed flatus and had no sign of tachycardia, which was usually by postoperative day 2-3. Patients were scheduled for follow-up in the outpatient clinic 1 week after discharge. They advanced to soft diet intake by the third week and solid diet intake after 1 month. Subsequent routine follow-ups were scheduled as mentioned previously.

Statistical Analysis

Patient data were collected prospectively and verified retrospectively. Descriptive results for categorical variables were presented as frequency and percentage (%) of subjects affected. Normally distributed continuous variables were demonstrated as means ± standard deviation (SD), whereas those variables without a normal distribution were showed as the median (interquartile range, IQR). The changes in general medical parameters and laboratory values were compared pre- and postoperatively using pair t-test, the Wilcoxon signed rank test and McNemar test when appropriate. Categorical variable frequencies were compared using Chi-square or Fisher exact test if small expected frequencies had been found. All statistical tests were calculated with SPSS statistical software (version 22.0; SPSS Inc., Chicago, IL). A p-value < 0.05 was considered statistically significant.

RESULTS

A total of ninety-one patients (64 female, 27 male) with T2DM were enrolled in this study and the overall patient's preoperative demographics, co-morbidities and operative data have been summarized in Table 1. The mean age was 46.6 years (SD=9.5 years, range 27-65 years). The preoperative median BMI was 32.0 kg/m^2 (range 27.5-47.3 kg/m^2). The median duration from the onset of T2DM was 60 months (range 1-240 months). There were 67 patients (73.6%) who had oral hypoglycemic agents (OHA) usage only, 2 patients (2.2%) had insulin injection usage only and 15 patients (16.5%) had both OHA and insulin injection usage. However, there were 7 patients (7.7%) who did not use any glucose-lowering medication. Regarding patient's co-morbidities, 43 patients (45.7%) had hypertension, 73 patients (80.2%) had hyperlipidemia, 74 patients (81.3%) had steatohepatitis, and 16 patients (17.6%) had hyperuricemia. The mean preoperative HbA1C was 8.7% (SD=1.9%) and the median preoperative FPG and C-peptide level were 146.0 mg% (range 64-400 mg%) and 2.5 ng/ml (range 0.4-12.3 ng/ml), respectively.

All of the patients underwent LDJB-SG successfully without any conversion to open surgery. The median operative time was 140 minutes (range 73-265 minutes) and duration of hospitalization was 2 days (range 1-7 days). There was no mortality in our study. Nevertheless, the postoperative complications (both early and late complications) were found as follows: 4 patients (4%) had intra-abdominal bleeding, 1 patient (1%) had sleeve gastrectomy (SG) leakage, 3 patients (3%) had SG stricture, 2 patients (2%) had port site hernia and 1 patient (1%) developed acute uncomplicated calculous cholecystitis. There was no dumping syndrome, internal hernia or marginal ulcer in our study.

In this study, all of the patients had at least 3 months of follow-up. Thirty-nine patients had completed one-year follow up. The comparison between preoperative and postoperative one-year surgical outcomes of these 39 patients, have been demonstrated in Table 2. The median % EWL was 82.3% (range 45.1-150.4%). The median BMI decreased significantly from 30.7 kg/m^2 (range 27.6-43.6 kg/m^2) preoperatively to 23.7 kg/m^2 (range 18.0-28.6 kg/m^2) at 1 year postoperatively (p=<0.001). The changes in mean/median WC, HC, WHR, SBP and DBP at 1 year in comparison to the preoperative data were also significant (p=<0.001). The mean/median preoperative

TABLE 1. The overall patient's preoperative demographics, co-morbidities and operative data.

Parameters	Mean (±SD) / Median (range)	N (%)
No. patients		91
Age (years)	46.6 (9.5)	
Gender (F/M)		64/27
Body Height (cm.)	163.7 (10.2)	
Body weight (kg.)	87.4 (16.3)	
BMI (kg/m^2)	32.0 (27.5-47.3)	
Co-morbidities		
Diabetes		91 (100%)
OHA only		67 (73.6%)
Insulin only		2 (2.2%)
OHA and insulin		15 (16.5%)
No OHA or insulin		7 (7.7%)
Hypertension		43 (45.7%)
Hyperlipidemia		73 (80.2%)
Steatohepatits		74 (81.3%)
Hyperuricemia		16 (17.6%)
Duration of Diabetes (months)	60.0 (1-240)	
HbA1C (%)	8.7 (1.9)	
FPG (mg/dl)	146.0 (64-400)	
C-peptide (ng/dl)	2.5 (0.4-12.3)	
Operative time (minutes)	140.0 (73-265)	
Hospital stay (days)	2.0 (1-7)	
Intraoperative complication		0
Conversion to open		0
Early postoperative complication		
Intra-abdominal bleeding		4
Leakage (SG part)		1
Infection		0
Late postoperative complication		
Port site hernia		2
Acute calculous cholecystitis		1
Stricture (SG part)		3
Dumping syndrome		0
Internal hernia		0
Marginal ulcer		0
Mortality		0

Abbreviations: BMI: Body Mass Index, OHA: Oral Hypoglycemic Agent, FPG: Fasting Plasma Glucose, SG part : Sleeve Gastrectomy part.

TABLE 2. One-year surgical outcomes after LDJB-SG in 39 patients who had completed one-year follow up.

Parameters	Preoperative Mean (±SD) / Median (range)	One year Mean (±SD) / Median (range)	p-value
General medical parameters			
Body weight (kg)	83.8 (15.3)	62.0 (10.9)	<0.001
BMI (kg/m^2)	30.7 (27.6-43.6)	23.7 (18.0-28.6)	<0.001
EWL (%)	-	82.3 (45.1-150.4)	<0.001
WC (cm.)	100.5 (11.5)	81.8 (8.3)	<0.001
HC (cm.)	108.7 (10.1)	94.0 (8.2)	<0.001
WHR	0.91 (0.15-1.03)	0.87 (0.78-0.98)	<0.001
SBP (mmHg)	133.4 (15.3)	120.0 (14.9)	<0.001
DBP (mmHg)	83.5 (11.0)	70.6 (12.1)	<0.001
Laboratory values			
FPG (mg/dl)	139.0 (102-317)	95.0 (78-211)	<0.001
HbA1c (%)	8.9 (1.8)	6.2 (0.9)	<0.001
C-peptide (ng/ml)	2.5 (0.4-11.3)	1.4 (0.6-3.4)	<0.001
TG (mg/dl)	149.0 (51-825)	81.0 (25-316)	<0.001
CHOL (mg/dl)	183. 0 (40.1)	170.4 (30.9)	0.119
HDL-C (mg/dl)	45.0 (32-180)	52.0 (39-94)	0.002
LDL-C (mg/dl)	96.3 (31.9)	90.3 (27.5)	0.547
AST (U/L)	30.0 (14-96)	28.0 (14-55)	0.879
ALT (U/L)	35.0 (10-150)	32.5 (13-63)	0.986
Uric acid (mg/dl)	6.4 (2.1)	4.9 (1.5)	<0.001
Hb (g/dl)	13.8 (9.9-17.3)	12.9 (8.0-15.7)	0.003
Hct (%)	40.0 (4.7)	37.3 (5.4)	0.001
WBC (x 10^3 cell/mcL)	7.2 (2.1)	7.4 (7.5)	0.867
Plt (x 10^3 cell/mcL)	245.5 (61.3)	229.5 (67.7)	0.130

Abbreviations: BMI: Body Mass Index, EWL: Excess Weight Loss, WC: Waist Circumference, HC: Hip Circumference, WHR: Waist-Hip Ratio, SBP: Systolic Blood Pressure, DSP: Diastolic Blood Pressure, FPG: Fasting Plasma Glucose, TG: Triglyceride, CHOL: Cholesterol, HDL-C: High Density Lipoprotein Cholesterol, LDL-C: Low-Density Lipoprotein Cholesterol, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, UA: Uric Acid, Hb: Hemoglobin, Hct: Hematocrit, WBC: White Blood Cell count, Plt: Platelet count

FPG, HbA1C and C-peptide level dropped significantly from 139.0 mg% (range 102-317 mg%), 8.9% (SD=1.8%) and 2.5 ng/ml (range 0.4-11.3 ng/ml) to 95.0 mg% (range 78-211 mg%), 6.2% (SD=0.9%), and 1.4 ng/ml (range 0.6-3.4 ng/ml), respectively at 1 year after operation (p=<0.001).

We found the mean/median of TG and UA level decreased significantly from 149.0mg/dl (range 51-825 mg/dl) and 6.4 mg/dl (SD=2.1 mg/dl) preoperatively to 81.0mg/dl (range 25-316 mg/dl) and 4.9 mg/dl (SD=1.5 mg/dl), respectively at 1 year postoperatively (p=<0.001). The level of HDL-C increased significantly from 45.0 mg/dl (range 32-180 mg/dl) preoperatively to 52.0 mg/dl (range 39-94 mg/dl) at 1 year postoperatively (p=0.002). In addition, the level of Hb and Hct preoperatively decreased significantly from 13.8 g/dl and 40.0% to 12.9 g/dl and 37.3%, respectively at 1 year after operation (p=0.003 and p=0.001 respectively). However, there were no significant changes in LDL-C, AST and ALT level at 1 year in comparison to preoperative data (p>0.05).

Regarding the result of co-morbidities resolution, the overall complete diabetic remission rate (CR) was 61.5%

(24/39 patients), partial diabetic remission rate (PR) was 20.5% (8/39 patients), glycemic control rate (GC) was 10.3% (4/39 patients) and glycemic improvement rate (GI) was 7.7% (3/39 patients). There was no failure of treatment in our study. (Table 3) Additionally, in subgroup analysis of these patients, we found that the CR was 80.0% (12/15 patients), PR was 6.7% (1/15 patients), GC was 6.7% (1/15 patients) and GI was 6.7% (1/15 patients) in the patients who had BMI ≥ 32.5 kg/m^2 (Group A). In the patients who had BMI < 32.5 kg/m^2 (Group B), the CR was 50% (12/24 patients), PR was 29.2% (7/24 patients), GC was 12.5% (3/24 patients) and GI was 8.3% (2/24 patients). (Table 4) Also, we found that the rate of hypertension and hyperlipidemia resolution were 69.2% (27/39 patients) and 89.7% (35/39 patients), respectively at 1 year after operation. (Table 3)

TABLE 3. The results of co-morbidities resolution at 1 year postoperatively.

Co-morbidities resolution (1 year postoperatively)	N (%)
Total of patients (completed follow-up)	39
Diabetic remission	
Complete remission (CR)	24/39 (61.5%)
Partial remission (PR)	8/39 (20.5%)
Glycemic control (GC)	4/39 (10.3%)
Glycemic Improvement (GI)	3/39 (7.7%)
Failure of treatment	0/39 (0%)
Hypertension resolution	27/39 (69.2%)
Hyperlipidemia resolution	35/39 (89.7%)

TABLE 4. Subgroup analysis of diabetic remission in both Group A and B.

Diabetic remission 1 year after surgery (Total 39 patients)	Group A (15 patients)	Group B (24 patients)	P value
Complete remission (CR)	12/15 (80.0%)	12/24 (50.0%)	0.686
Partial remission (PR)	1/15 (6.7%)	7/24 (29.2%)	
Glycemic control (GC)	1/15 (6.7%)	3/24 (12.5%)	
Glycemic Improvement (GI)	1/15 (6.7%)	2/24 (8.3%)	
Failure of treatment	0/15 (0%)	0/24 (0%)	

Group A: BMI ≥ 32.5 kg/m^2, Group B: BMI<32.5 kg/m^2

DISCUSSION

Bariatric surgery has been shown to be the most effective treatment for morbid obesity in terms of long-term weight loss and co-morbidities resolution compared to non-surgical treatment. The impact on the resolution of co-morbidities such as T2DM after bariatric surgery besides weight loss has contributed to the increasing use of the term "Metabolic Surgery". The improvement of glucose homeostasis experienced before weight loss occurs has drawn attention and proposed an expansion of the traditional indications for bariatric surgery to the lower BMI obese patients.[29,30] Interestingly, many studies have shown the excellent short- term results in regards to glycemic improvement and co-morbidities resolution in non-severely obese patients (BMI 30-35 kg/m^2) after bariatric surgery.[16-22] Generally, Asian populations have a higher percentage of body fat than do Europeans, and also have been shown to have an elevated risk of T2DM, hypertension, and hyperlipidemia at a relatively low level of BMI.[1] Regarding these concepts, presently, The International Diabetes Federation (IDF) statement in the treatment of Obese Patients with T2DM and The

consensus of International Federation for Surgery of Obesity and Metabolic Disorders-Asia Pacific Chapter Meeting 2011 (IFSO-APC 2011) suggest that Bariatric/GI Metabolic Surgery should be considered for the treatment of T2DM or metabolic syndrome for patients who are inadequately controlled by lifestyle alternations. Medical treatment for acceptable Asian candidates with BMI 30-35 kg/m^2 and Metabolic Surgery may be considered as a non-primary alternative to treat inadequately controlled T2DM, or metabolic syndrome, for suitable candidates with BMI ≥ 27.5 kg/m^2.[24,25]

In recent years, many bariatric and metabolic surgeries such as BPD-DS and LRYGB, have demonstrated impressive weight loss and comorbid diseases resolution in severely obese patients and excellent long-term glycemic control in mild to moderate obese patients with T2DM from many recent studies.[11-16,20-22] However, the drawbacks of these procedures are the long-term complications including marginal ulcer, intractable dumping syndrome, internal hernia, and malnutrition. Therefore, Laparoscopic Loop Duodenojejunostomy Bypass with Sleeve Gastrectomy (LDJB-SG) has been developed in our center in order to overcome these long-term eventful complications as well as demonstrate the surgical outcomes in regards to efficacy of weight loss and co-morbidities resolution, which are comparable to other bariatric and metabolic surgeries.[23]

Theoretically, LDJB-SG offers many advantages. The pyloric preservation may decrease the dumping phenomenon as well as the chance of marginal ulcer. The acid and intrinsic factor secretion would be maintained. Thus, iron, vitamin and protein deficiency should be less because some parts of the antrum are preserved. Moreover, one anastomosis and only Petersen's defect should have some advantages in decreasing the probability of postoperative anastomotic leakage and internal hernia as compared to LRYGB and BPD-DS.

LDJB-SG can result in weight loss and glycemic improvement through multiple mechanisms. The partial vertical sleeve gastrectomy in this procedure can produce efficient weight loss by reducing food/calorie intake (restrictive mechanism) and reducing the ghrelin, orexigenic hormone, level by removing the fundus of stomach which led to increase satiety.[31-34] Also, the glycemic improvement can be explained by hindgut hypothesis by 200-300 cm., jejunal bypass and foregut hypothesis by exclusion of the second part of duodenum. The hindgut hypothesis claims that the surgical rerouting of nutrients to the distal part of the small intestine results in increasing secretion and concomitant glucose-lowering effects of GLP-1[35,36] and the foregut hypothesis states that surgical bypass of foregut prevents the release of unidentified materials that induce a diabetogenic signal in susceptible individuals.[37,38]

This procedure has demonstrated excellent results in weight loss and is comparable to other bariatric procedures. Many studies have reported that the patients who undergo LRYGB, LSG, LAGB and BPD-DS typically experience an EWL of 60-70%, 33-85%, 40-50% and 60-76.7%, respectively at 1 year postoperatively. In our study, the overall median BMI preoperatively was significantly dropped from 31.2 kg/m^2 to 23.7 at 1 year postoperatively (p=<0.001). Furthermore, the median % EWL at 1 year after operation was 82.3% (range 45.1-150.4%) (Table 2), which were comparable to other studies. [11-16,20-22] Additionally, regarding IDF statement in the treatment of Obese Patients with T2DM, it states that surgery should be an acceptable option in people who have BMI ≥ 35 kg/m^2 with T2DM and BMI action points may be reduced by 2.5 kg /m^2 in Asians. Therefore, we aim to demonstrate the changes in BMI and % EWL in both patients who had BMI ≥ 32.5 kg/m^2 (15/39 patients, Group A) and BMI < 32.5 kg/m^2 (24/39 patients, Group B). In this subgroup analysis, we found that the median BMI of Group A and Group B were significantly decreased from 34.2 kg/m^2 (range 33.1-43.6 kg/m^2) and 29.3 kg/m^2 (range 27.6-32.1 kg/m^2) preoperatively to 23.9 kg/m^2 (range 18.0-28.6 kg/m^2) and 23.7 kg/m^2 (range 18.9-25.6 kg/m^2), respectively at 1 year after operation (p=0.018 and p<0.001, respectively). There was no statistical difference in median BMI between group A and B (p=0.152) at 1 year after operation (Fig 4). Furthermore, the median % EWL for Group A and Group B were 84.3 % (range 51.3-136.3%) and 81.4 % (range 45.1-150.4%), respectively at 1 year postoperatively without any significant difference between these two groups (p=0.658). Interestingly, these results have shown that although preoperative median BMI in Group A was higher than Group B initially, the postoperative median BMI at 1 year in Group A and B were ultimately almost equal (23.9 Vs. 23.7 kg/m^2).

In our study, LDJB-SG had also shown magnificent results in terms of glycemic control and diabetic remission. We found that the overall mean/median level of preoperative FPG, HbA1C and C-peptide were significantly decreased from 139.0 mg%, 8.9% and 2.5 ng/ml to 95.0 mg%, 6.2% and 1.4 ng/ml at 1 year postoperatively (p=<0.001). (Table 2) The overall diabetic complete remission rate (CR) was 61.5% (24/39 patients), partial remission rate (PR) was 20.5% (8/39 patients), glycemic control (GC) was 10.3 % (4/39 patients) and glycemic improvement (GI) was 7.7% (3/39 patients). There was no failure of treatment in our study. (Table 3) Additionally, in Group A analysis, we found that the diabetic complete remission rate (CR) 6

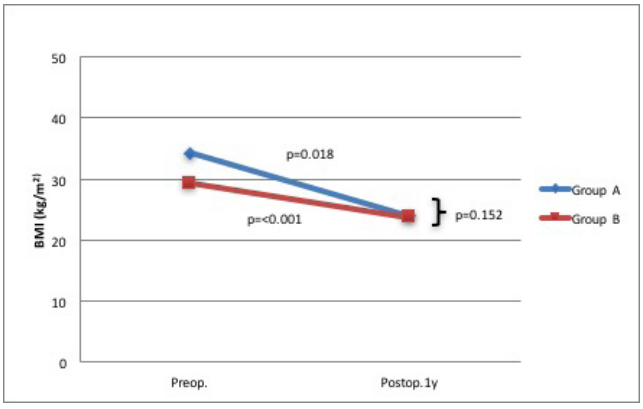

Fig 4. Change in median BMI of the patients who had preoperative BMI ≥ 32.5 kg/m² (Group A) and BMI < 32.5 kg/m² (Group B) at 1 year after operation.

80.0% (12/15 patients) (Table 4), which was comparable to other procedures.[11,14] Many studies had been reported the diabetic CR of LRYGB and LBPD with DS were 40-88% and 97-100%, respectively in the patients who had mean BMI ≥32.5 kg/m².[11-13,40,41] Furthermore, in Group B analysis, our results were also comparable to other procedures. Camilo et al.,[42] and Lee et al.,[16] reported the diabetic CR was 55.3% and 57%, respectively at 1 year after LRYGB in T2DM patients who have median/mean BMI<32.5 kg/m². Also, in regards to our previous study, LRYGB achieved 63.6% diabetic CR after 1 year in patients with mean BMI<32.5 kg/m².[17] Scopinaro et al.,[22] showed diabetic CR rate was 30% after LBPD in the T2DM patients with mean BMI<32.5 kg/m². We found that the diabetic CR was 50.0% (12/24 patients), PR was 29.2% (7/24 patients), GC was 12.5% (3/24 patients) and GI was 8.3% (2/24 patients) in Group B (Table 4). Interestingly, all of these findings meant there were 91.7% of T2DM obese patients (BMI<32.5kg/m²) who achieved glycemic control after LDJB-SG. These results have shown better outcome than another DJB-SG study. Navarrete et al., reported 4 (40%) patients who achieved glycemic control after Roux-en-Y DJB-SG in T2DM patients with an average BMI <32.5 kg/m².[43] Although the patients in group B achieved lesser CR rate than group A, their PR rate was higher than group A. Furthermore, there was no significant difference of overall diabetic remission (CR and PR) between groups A and B. (p=0.686) (Table 4) However, in our subgroup analysis of CR, group B had lower preoperative C peptide level than group A. This could elucidate that CR rate in group B was lesser than group A because they had poorer pancreatic endocrine reserve.

The excellent improvements of hypertension and hyperlipidemia after bariatric surgery, have been reported in many studies. The average of hypertension and hyperlipidemia resolution after LRYGB vs. LSG vs. BPD-DS were 75.4%, 93.6% vs. 71.7%, 61.0% vs. 81.3%, 99.5%, respectively.[11-14] These results were comparable to our study, in which we found the hypertension resolution rate was 69.2% and hyperlipidemia resolution rate was 89.7% at one-year after operation. (Table 3)

Regarding early postoperative complications in our study, we found that there were 5 patients (5.5%) who had early postoperative complications as follows: 4 patients (4.4%) had intra-abdominal bleeding, although only 1 out of these 4 patients underwent re-laparoscopy due to persistent dropping of her hematocrit despite the numbers of pack red cell replacements. Nevertheless, we found only old blood clot without any bleeding point could be detected intraoperatively. Postoperatively, the patient was stable and could be discharged 2 days after operation. One patient (1.1%) had leakage at sleeve gastrectomy part (near EG junction), which was treated initially by endoscopical stent placement. Unfortunately, the leakage still continued after the procedure. Thus, conversion to Roux-en-Y gastric bypass was performed in order to treat this problem. Postoperatively, the patient's clinical signs were improved and she was discharged without any further complication.

Late postoperative complications were found in 6 patients (6.6%) in this series, 2 patients (2.2%) developed incisional hernia at 1 year postoperatively at umbilical port (15 mm.), 1 patient (1.1%) developed uncomplicated acute calculous cholecystitis at 8 months postoperatively and 3 patients (3.3%) developed stricture at incisura angularis of the remnant stomach. Two of them, who had only mild to moderate stricture, were managed successfully by laparoscopic stricturoplasty and the last patient, who had severe stricture, was corrected successfully by conversion to LRYGB. There was no dumping syndrome, internal hernia, marginal ulcer or mortality in our study. Surprisingly, although anemia resulting from LDJB-SG should theoretically be less, we found the mean level of both Hb and Hct were significantly decreased from 13.8 g/dl and 40.0% preoperatively to 12.9 g/dl and 37.3%, respectively at 1 year postoperatively (p=0.003 and 0.001, respectively). Long-term close follow up is necessary in order to manage this anemic problem after LDJB-SG.

Thirty patients in our study completed upper abdominal U/S and EGD at 1 year postoperatively. We found 2/30 patients (6.6%) developed asymptomatic gallstone after LDJB-SG and watchful follow up was done in these patients. Additionally, in regards to Los Angeles (LA) classification for the endoscopic grading of reflux esophagitis, we found 22 patients (73.3%) had no reflux esophagitis and 8 patients (26.7%) had reflux esophagitis

grade A preoperatively. Postoperatively, we found 16 patients (53.5%) had no change of reflux esophagitis grading (14 patients for grade 0 to 0 and 2 patients for grade A to A). Meanwhile, there were 14 patients (46.5%) who had the alterations of reflux esophagitis grading after operation. Moreover, we discovered that there were 7 patients (23.3%) who developed reflux esophagitis grade B and 2 patients (6.7%) who had reflux esophagitis grade C at 1 year after operation. However, there was no reflux esophagitis grade D in this study. (Table 5) All of these patients did not have any severe reflux esophagitis symptom, while their symptoms could be controlled efficiently by oral proton-pump inhibitor medication. Furthermore, we also found 8/30 patients (26.6%) developed hiatal hernia at 1 year after operation. One out of eight patients had hiatal hernia preoperatively and despite repairing it intra-operatively, the patient still developed hiatal hernia postoperatively. Long-term close follow up is needed to clarify these problems after LDJB-SG.

TABLE 5. The results of EGD at 1 year after LDJB-SG.

EGD finding (Total 30 patients)	Preoperative N (%)	Postoperative N (%)
Hiatal hernia	1 (3.3%)	8 (26.6%)
Grading of reflux esophagitis		
0	22 (73.3%)	14 (46.7%)
A	8 (26.7%)	7 (23.3%)
B	0	7 (23.3%)
C	0	2 (6.7%)
D	0	0

EGD: esophagogastroduodenoscopy, Los Angeles (LA) classification for grading of reflux esophagitis (0= normal, A= One or more mucosal breaks < 5 mm in maximal length, B= One or more mucosal breaks > 5 mm, but without continuity across mucosal fold, C= Mucosal breaks continuous between > 2 mucosal folds, but involving less than 75% of the esophageal circumference, D= Mucosal breaks involving more than 75% of esophageal circumference)

CONCLUSION

Laparoscopic Loop Duodenojejunostomy Bypass with Sleeve Gastrectomy (LDJB-SG) is a safe and feasible bariatric and metabolic surgery for obese Asians with T2DM, which has demonstrated excellent surgical outcomes in terms of weight reduction, co-morbidities resolution as well as glycemic control after one-year follow up.

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Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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