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RESEARCH ARTICLE

Laparoscopic Roux-en-Y Gastric Bypass for Morbidly Obese Chinese Patients: Learning Curve, Advocacy and Complications

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Abstract
Background Laparoscopic Roux-en-Y gastric bypass (LRYGB) involves a combination of both restrictive and mal-absorptive mechanisms and has become the procedure of choice for patients with morbid obesity in Western countries. However, its efficacy remains uncertain in Asian populations. We report our pilot experience with LRYGB in a Chinese population.
Methods Between August 2005 and February 2007, 100 morbidly obese patients received LRYGB. We evaluated the learning curve for the operation, its efficacy in weight reduction, and its postoperative complications.
Results Surgical time reached a plateau after about 50 cases, decreasing from 216 min for the initial 50 patients to 105 min for the final 50. The conversion rate from laparoscopic to open surgery was 2%. The mean percent body mass index loss was 33.9% after 12 months. Twenty-four complications occurred in 18 patients, but most resolved with conservative treatment without mortality. Patients with advanced age (P=0.04) or hypertension (P=0.03) were at increased risk for complications leading to prolonged surgical times and hospital stays. The complication rate declined as technical expertise increased.
Conclusion In Chinese patients with morbid obesity, LRYGB is promising procedure because of its acceptable learning curve, good efficacy, and low complication rate.

Keywords Bariatric surgery · Laparoscopy · Roux-en-Y gastric bypass · Morbid obesity

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Introduction

Morbid obesity, defined as a body mass index (BMI) >40 kg/m^2, affects about 3% of the Western population and leads to substantial morbidity and mortality [1]. For morbidly obese patients, nonsurgical methods, including diet, exercise, and behavioral modification rarely result in sustained weight loss [2]. Therefore, bariatric surgeries such as gastric bypass, vertical banded gastroplasty (VBG), and gastric banding with biliopancreatic diversion are considered more effective than nonsurgical therapies in the maintenance of long-term efficacy [3, 4].

Roux-en-Y gastric bypass (RYGB) is a relatively new approach that emphasizes the dual mechanisms of restriction and mal-absorption. Regarding its efficacy, most investigators have reported a 60–70% loss of excess body weight, with effects maintained for >10 years [5–7]. However, open bariatric surgery has been associated with a risk of cardiopulmonary, thromboembolic, and incision-related complications. Therefore, an alternative procedure is warranted [8, 9].

First reported by Wittgrove et al. in 1994 [10], laparoscopic Roux-en-Y gastric bypass (LRYGB) includes the creation of a gastric pouch, a Roux limb, and two anastomosis, as well as the closure of mesenteric defects [11]. Despite its complexity, LRYGB substantially decreases procedure-specific morbidities without losing efficacy in weight reduction.

In Taiwan, the prevalence of obesity is increasing, and the need for bariatric surgery is rapidly expanding [12]. In this study, we evaluated LRYGB in a Chinese population, with special attention on the initial learning curve for the procedure, its efficacy in weight reduction, and its potential complications.

Materials and Methods

Eligible Patients

Consecutive patients with morbid obesity (BMI≥40 kg/m^2) or morbid obesity (≥35 kg/m^2) with comorbidity whose conservative treatment failed were evaluated by a multidisciplinary team consisting of dietitians, endocrinologists, psychiatrists, and surgeons for LRYGB. The patients' anthropometric information, including their age, sex, laboratory data, and comorbidities, were recorded before surgery.

Surgical Technique for LRYGB

A senior surgeon who had 4 years of experience in laparoscopic surgery performed all of the operations. Before surgery, elastic bandages were applied to compress both of the patients' lower legs to help prevent deep venous thrombosis. A pneumoperitoneum was created by puncturing the peritoneal cavity with a Veress needle in the left periumbilical area. Five ports were routinely created. A liver retractor was introduced at the subxiphoid area.

The proximal jejunum were transected 40 cm distal to the ligament of Treitz. The alimentary limb was measured at 100 cm, and a side-to-side jejunojejunostomy was performed by using a 60-mm linear cutter and 3.5-mm stapler (Endo-GIA, Tyco, Connecticut, USA). The jejunojejunostomy was closed with manually placed polyglactin (2-0 Vicryl, Ethicon, Somerville, USA) sutures. Mesenteric defects were closed with nylon (2-0 Ethibond, Ethicon, UK) suture. Then, we created a 25-ml proximal gastric pouch with the 60-mm linear cutter and the 3.5-mm stapler. We performed gastrojejunostomy with a 30-mm linear cutter and a 2.5-mm stapler (Endo-GIA, Tyco) at the antecolic position. The gastrojejunostomy was 2.5 cm long. The gastrojejunostoma was closed with manual sutures (2-0 Vicryl, Ethicon). Finally, a Penrose drain was placed near gastrojejunostomy around the right upper quadrant.

Learning Curve for Surgery

Parameters to assess the learning curve for LRYGB were surgical times, conversion rates to open surgery, complication rates, lengths of hospital stay, and overall mortality rates. Early complications were defined as those occurring within 30 days after the operation, whereas late complications occurred 30 days or longer after the operation. Major complications were defined as life-threatening events or a need for a repeat operation.

Efficacy in Weight Reduction

Efficacy in weight loss was assessed on the basis of percent BMI loss (%BMIL). It was defined by the following formula [13]: [(operative BMI-follow-up BMI) / operative BMI] × 100. Percent BMIL was assessed every 3 months in the postoperative follow-up period.

Statistical Analysis

Descriptive results regarding continuous variables are presented as the mean±standard deviation (SD), and categorical variables are given as percentages. To evaluate the influence of the learning curve on therapeutic outcomes, we performed a post hoc analysis in which we stratified the patients into two groups: the first 50 and the last 50. This cutoff was selected because surgical times reached a plateau around the 50th patient; the remaining patients were considered to have undergone a mature technique.

We compared patients with and those without complications. Differences were analyzed with an unpaired t test or a χ^2 test when appropriate. A $P<0.05$ indicated a statistically significant difference. All statistical analyses were performed by using software (SAS version 9.1, SAS Institute, Cary, NC).

Results

Baseline Characteristics of the Patients

Between August 2005 and February 2007, 100 morbidly obese patients underwent LRYGB at our academic institute. Table 1 summarizes their demographic, and anthropometric data are summarized. Five patients had undergone previous

Table 1 Demographic and anthropometric characteristics of 100 patients

Characteristics	Mean±SD (Range) or No.
Age (years)	31.2±7.2 (17–58)
Weight (kg)	120.4±26.4 (80–211)
Excess weight (%)	102.3±34.8 (61.3–191.2)
BMI (kg/m^2)	43.0±7.5 (35–63.3)
Gender (M/F)	34:66
Comorbidities	
Hypertension	38
Hyperglycemia	36
Hyperlipidemia	29
Abnormal liver function	54
Sleep apnea	38

SD=standard deviation.

bariatric surgery (two VBG, two open RYGB, and one laparoscopic gastric banding procedures), with poor results.

Learning Curve for Surgery

The mean operation time was 161 min (range 52–324 min) for the 100 patients. As technical expertise increased, operation times decreased and reached a plateau around the 50th case. Mean operating times significantly differed between the first 50 patients and the last 50 (216.5±50.9 vs. 105.2±37.8 min, $P<0.01$). Two patients in the early group had undergone a conversion to open surgery during the laparoscopic procedure, but none in the late group did.

Overall, the mean length of stay was 5.6 days. Hospital stays were shortened among the last 50 patients, although the difference was barely significant (6.4±5.6 vs. 4.8± 4.3 days, $P=0.1$).

Efficacy in Weight Reduction

Follow-up ranged 4 to 22 months. At 12 months after surgery, mean %BMIL was 33.9%. For three patients, efficacy for weight loss was poor, or they even regained weight. One patient with an initial 16.9% of %BMIL at 6 months regained 7.3% at month 9, and another two patients had a %BMIL of only 10.8% and 12.9% at 6 months.

Postoperative Complications

Table 2 shows the early and late complications, treatment methods, and final outcomes. A total of 24 complications occurred in 18 (18%) of 100 patients, and the rate of major complications was 8%. Thirteen early complications happened in 11 patients, and 11 late complications in 10 patients. The complication rate was significantly higher in the first 50 patients than in the last 50 (15 vs. 3%; $P<0.05$). Most complications could be treated with medication, endoscopy, or laparoscopic surgery. Only two patients required laparotomy.

Table 3 shows the result of our post hoc comparison between patients with and those without complications. The risk of complications rose in older patients ($P=0.04$), those with hypertension ($P=0.03$), and those treated early in the

Table 2 Postoperative complications and therapeutic methods in 18 patients

Complications	No.	Treatment	Outcome
Early complications			
Stenosis of the jejunojejunostomy	2	Laparoscopic revision in 1, open revision in 1	Resolved
Stenosis of the gastrojejunostomy	2	Endoscopic balloon dilation	Perforation in 1, healed after conservative treatment
Leakage of the gastrojejunostomy	3	Percutaneous drainage and antibiotics	Resolved
Leakage of the gastric pouch	1	Laparoscopic repair	Resolved
Peroneal nerve palsy	2	Rehabilitation	Resolved
Marginal ulcer with hemorrhage	1	Proton-pump inhibitor and angiography	Resolved
Intraabdominal infection	1	Percutaneous drainage and antibiotics	Resolved
Acute cholecystitis	1	Percutaneous cholecystostomy	Resolved
Late complications			
Stenosis of gastrojejunostomy	5	Endoscopic balloon dilation	Resolved
Stenosis of jejunojejunostomy	1	Open revision	Resolved
Marginal ulcer with hemorrhage	2	Proton-pump inhibitor	Resolved
Enlarged gastric pouch	3	Laparoscopic resizing	Fistula formed in 1 patient then laparotomy; success in 2

Table 3 Comparison of patients with and those without complications*

Characteristics	Mean±SD or No. (%)		*P* value
	Complication+(*n*=18)	Complication—(*n*=82)	
Age (years)	37.1±13.2	29.9±8.8	0.04†
Gender (M:F)	9:9	30:52	0.29
Weight (kg)	130.6±33.9	118.2±24.2	0.16
EWL (%)	70.1±29.1	59.1±1.1	0.06
BMI (kg/m^2)	45.7±8.6	42.6±7.0	0.12
Consecutive operations (no.)	34.4±27.7	54.0±28.2	<0.01†
Operation time (min)	202.6±97.0	153.6±83.4	<0.01†
Length of hospital stay (days)	10.7±10.3	4.5±1.2	0.02†
Comorbidities			
Hypertension	11 (61.1)	27 (32.9)	0.03†
Hyperglycemia	8 (44.4)	28 (34.1)	0.41
Hyperlipidemia	9 (50)	44 (53.7)	0.78
Abnormal liver function	12 (66.7)	42 (51.2)	0.23

*Quantitative data were tested with unpaired *t* test, and categorical data were compared with the χ^2 test.
†Statistically significant difference.

recruitment period ($P<0.01$). For these patients, surgical times and lengths of stay were also prolonged ($P<0.01$ and $P=0.02$, respectively).

Discussion

Laparoscopic gastric banding and gastric bypass are the two common approaches for bariatric surgery in Asia [12]. In contrast to gastric banding surgery, which produces solely a restrictive effect, LRYGB also takes advantage of malabsorption and thus improves efficacy. Although the technique for LRYGB is complicated, our results revealed an acceptable learning curve, good efficacy, and a lowered complication rate in our Chinese population.

Also recruiting Chinese patients like we did, Lee et al. compared the results of laparoscopic vertical banded gastroplasty (LVBG, $n=40$), LRYGB ($n=40$), and laparoscopic minigastric bypass (LMGBP, $n=40$) [14, 15]. LRYGB prolonged operation times (209 vs. 126 min) and complication rates (27.8 vs. 7.5%) compared with LVBG, although LRYGB was more effective than LVBG for weight reduction with 1-year percent excess weight loss of 62.9 vs. 55.4% [13, 14]. Compared with LMGBP, LRYGB increased the operation time (205 vs. 148 min, $P<0.05$) and the complication rate (27.5 vs. 15%, $P<0.05$), despite similar efficacies (1- and 2-year percent EWLs of 58.7% and 60.0% for LRYGB, and 64.4% and 64.9% for LMGBP) [15].

These operation times and complication rates for LRYGB, however, were similar to ours only in the learning stage. With growing technical expertise and with modifications in the surgical procedures, our operation times and complication rates substantially declined, without a loss of efficacy in weight reduction.

Completion of the learning stage can be evaluated on the basis of the following indicators: operation time of <2 h, conversion rate of 1–3%, mortality rate of <1%, major morbidity rate of <5%, and major leakage rate of <2% [16–19]. We required approximately 50 cases to complete the learning phase, and all indicators rapidly improved after this stage. The mean %BMIL of 33.9% at 12 months, equivalent to 65% in percent EWL, indicated that LRYGB was safe and effective after the surgical technique was mastered. Reports from Western countries also showed that 50–100 cases were needed for the learning stage. The reported percent EWLs of 60–80% at 1 year after operation and complication rates of 20–30% were similar to our results.

In the present study, older patients and those with hypertension tended to have an increased risk for complications. These results were concordant with the findings of Perugini et al. [20] and O'Rourke et al. [21]. Anastomotic strictures, including gastrojejunostomy and jejunojejunostomy, were the most common complications in our series ($n=10$, 10%). Seven patients had stenosis of the gastrojejunostomy; this 7% rate was similar to reported data [22, 23]. All of stenosis of the gastrojejunostomy occurred within 3 months after surgery, and six of the affected patients were among the first 50 who were treated. The reason was assumed to be an anastomosis of improper diameter, in keeping with the theory by Nguyen et al. [24]. Another potential reason was the use of the Endo-GIA stapler to create the gastrojejunostoma; with this device, we might have stapled more tissue than expected. Three

patients (3%) had stenosis of the jejunojejunostomy, a result that was also thought to result from mechanical closure with this stapler [25]. To decrease these aforementioned complications, the width of gastrojejunostomy was enlarged to 2.5 cm from 2.0 cm, and we adopted a hand-suturing method for both the gastrojejunostoma and the jejunojejunostomy. These complications did not happen after we made these technical modifications.

Endoscopic diagnosis and therapy are important for preventing postoperative complications because of the high rate of stenosis (7%) and hemorrhage (3%) [24, 26]. We performed endoscopic balloon dilation to treat stenosis of the gastrojejunostomy in six patients, but one perforation occurred. Despite this, the patient was successfully treated with nothing per oral and supplemental intravenous fluids. In three patients, ulcer-related hemorrhage was diagnosed with endoscopy; two patients were treated with proton-pump inhibitors, but massive bleeding occurred in one. Angiography with embolization successfully achieved hemostasis.

Leakage happened in four patients (4%); one case involved the proximal gastric pouch, and three the gastrojejunostomy. Parental antibiotics and adequate drainage were usually effective. One leak in the proximal gastric pouch needed laparoscopic repair.

Two patients with complications of peroneal palsy deserved special attention. Weakness and numbness of the lower extremities manifested soon after their operations. The cause was assumed to be prolonged immobility during intensive care. With rehabilitation, the patients gradually recovered 3 months later. We did not encounter this complication after we encouraged patients to exercise early after surgery.

In the three patients with insufficient weight loss or even weight gain, the cause was considered to be enlarged gastric pouches. Two patients had a remnant greater curvature of the stomach, and one received delayed treatment of a stenosis of the gastrojejunostomy. Resizing of the laparoscopic pouch and dilatation of the gastrojejunal anastomosis solved this problem in two patients [27], but delayed fistula formation occurred in one patient, who needed another operation.

In conclusion, we report findings from a series of morbid obese patients who underwent LRYGB in Taiwan. We reached a plateau in the learning curve after 50 cases. Efficacy in weight reduction was satisfactory. Increasing experience together with technical modifications could reduce operation times and complication rates. Further studies are warranted to determine the long-term efficacy of LRYGB compared with that of other surgical modalities.

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