




Experience of the First 100 OAGB in China: OAGB In Situ Technique

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Abstract

Background One anastomosis gastric bypass (OAGB) is gradually accepted worldwide but still new in China.

Materials and Methods Retrospective review of the patients who received OAGB in a new bariatric/metabolic surgical center in China and compared the data with a center of excellence in Taiwan. All in-patient and outpatient follow-up data were analyzed. The main outcome measures were (1) operation risk (2) weight loss (3) diabetes remission.

Results Between August 2019 and October 2021, 100 consecutive patients who received OAGB in situ in China and 225 patients who received OAGB with the same technique were recruited from Taiwan. Taiwan patients were older (39.2 ± 10.6 vs. 33.3 ± 8.8 years old, $p < 0.001$), and to have more diabetes (32.4% vs. 20.0%, $p = 0.022$) comparing to the patients of China. Operation time was significantly longer for Taiwan patients (172.4 ± 36.9 vs. 128.5 ± 29.8 , $p < 0.001$). Taiwan patients lost more blood during the operation (35.5 ± 25.2 vs. 22.4 ± 15.6 , $p < 0.001$) but patients in China need more time to post-operative flatus passage (1.3 ± 0.5 vs. 2.0 ± 0.5 , $p < 0.001$). There was no major surgical complication in this study, minor complication rates were similar low for both groups (1.0% vs. 1.8%, $p = 0.891$). At 1 year after surgery, %TWL and %EWL of both centers were similar ($33.9 \pm 7.43\%$ vs. $32.6 \pm 11.2\%$, $p = 0.91$; 81.9 vs. 19.8 vs. 85.4 ± 13.2 , $p = 0.798$). T2DM remission (HbA1c $< 6.5\%$) was 100% for patients of China and 95.9% for patients of Taiwan ($p = 0.836$).

Conclusions OAGB in situ is a safe and effective bariatric/metabolic surgery. With proper training and proctorship, these results are reproducible in a new bariatric/metabolic surgical center in China.

Keywords Metabolic surgery · One anastomosis gastric bypass · China · First 100

Key Points

- The clinical results of the first 100 consecutive patients received the OAGB in situ procedure in a new bariatric/metabolic surgical center of China were compared with another 225 patients with same technique in a center of excellence of Taiwan.
- Patients in the new center of China were younger and with less comorbidities than patients in the center of Taiwan.
- Major surgical complication was 0% in both centers. Minor complication was 1% in China and 1.8% in Taiwan.
- %TWL 1 year after OAGB for patients at China and Taiwan were similar ($32.6 \pm 11.25\%$ vs. $33.9 \pm 7.4\%$, respectively).
- T2DM remission rate at 1 year was similar high (100% at China and 95.9% at Taiwan).

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Introduction

Bariatric/metabolic surgery is the most effective therapy for patients with morbid obesity and type 2 diabetes mellitus (T2DM) today [1, 2]. Along with the obesity epidemic, the number of bariatric/metabolic surgery increased rapidly worldwide but the types of operation are still in evolving [3]. One-Anastomosis Gastric Bypass (OAGB), as a simplified procedure of standard Roux-en-Y gastric bypass (RYGB), has been gradually accepted [4–13]. OAGB account for 4.7% of all bariatric procedures worldwide in 2017 according to the statistic of International Federation of Surgery for Obesity (IFSO) [3]. However, there was no report data from China which has the largest population in the world. From August 2019, we launched a OAGB program in a new bariatric/metabolic surgical center of a tertiary hospital of China under the proctorship of Professor A. This program was identical with the program of the world renowned OAGB center at the hospital in Taiwan lead by Professor A

at Taiwan [4, 5, 14]. However, the program was performed by another team lead by Professor B at China. In this study, we sought to compare the characteristics, peri-operative outcomes, and outcomes of the first 100 OAGB patients in China with the data of the original center in Taiwan.

Patients and Methods

The study was conducted in the bariatric/metabolic surgical center of the hospital, Suzhou, China, and Department of Surgery of the hospital, Taiwan. Prior approval for performance of the study was obtained from the ethics committee of the Hospital. From August 2019 to October 2021, consecutive 100 morbid obese Chinese subjects who received laparoscopic OAGB for the treatment of their obesity and accompanying comorbidities were recruited. Professor A and Professor B were the surgeons in charge of the operation in the hospital, China. Professor A demonstrated and guided B to perform the operation. Then, Professor B performed the surgery independently. Because of the Covid-19 epidemic, the surgeries were performed by two different teams in Taiwan and China. The only overlap person was A who had visited and mentored the program of China several very short periods. At the same period, 225 patients who received the OAGB at the hospital in Taiwan were recruited as a control group. Professor A, Doctor C and D were the surgeons in charge of the operation in Taiwan. The inclusion criteria were morbidly obese patients ($BMI \geq 32 \text{ kg/m}^2$) [14] or not well controlled T2DM patients ($HbA1c > 7.5\%$) with their $BMI \geq 25 \text{ kg/m}^2$ [15] whom had been well informed about this procedure and agreed to receive it. The inclusion criteria are specific for Asians and especially modified for diabetic Asian patients. Patients with previous bariatric operations were excluded. Age limitation was from 16 to 74 years old. The baseline characteristic, surgical outcome, weight loss, and comorbidity resolutions at follow-up were included in the analysis. Patient follow-up was scheduled on the 1st, 3rd, 6th, and 12th months of the first year and then annually. Patients were instructed to receive twice daily multi-vitamin supplementation and calcium 1200 mg elementary calcium (preferably as calcium citrate)/vitamin D3 8000 IU (since 2016 the recommended dose becomes 3000 IU) supplementation as recommendation for gastric bypass [16]. Body weight loss and laboratory evaluation of nutritional status were recorded during every visit. All the follow-up data as well as the pre-operative and peri-operative data of every bariatric patient in both centers were recorded in a prospectively maintained database. Safety end points were defined by the 30 days peri-operative minor and major complications. Complication was graded according to Clavien-Dindo Classification [17]. Effectiveness end points include

BMI, percentage of total weight loss (*%TWL*), percentage of excess weight loss (*%EWL*), and resolution of T2DM.

Diagnosis and classification of T2DM were based on a fasting plasma glucose concentrations $\geq 7 \text{ mmol/L}$ or positive history of that and under the current use of antidiabetic medications [18]. In this study, diabetes remission was defined as $HbA1c < 6.5\%$ for at least 1 year without anti-diabetes medications according to the new recommendation from American Diabetes Association (ADA) [19].

Surgical Technique

Our surgical technique of OAGB has evolved over the years [20]. The current technique was matured since 2016 and was called OAGB in situ. Important surgical techniques were briefly described. OAGB was performed first by creating a long sleeve gastric tube approximately 24 cm long and 2.0 cm wide using a 36 Fr size bougie along the lesser curvature from the antrum to the angle of His. The long gastric staple line was reinforced with seromuscular sutures to avoid the leakage and bleeding. Then, a Billroth II type loop gastroenterostomy about 3 cm in size was created at the posterior wall of gastric tube. The bypassed jejunum was tact proximal 8–10 cm to the anastomosis to the lateral edge of the gastric sleeve, to prevent the food stream go proximally and hope to reduce the chance of bile reflux. The length of the biliopancreatic (BP) limb is decided according to the *BMI* value, a 150-cm bypass limb for patients with $BMI < 35 \text{ kg/m}^2$ with 10 cm increase for each *BMI* point above 35 kg/m^2 [21]. The whole length of small bowel was routinely measured, and we keep at least 400 cm common channel (CC) to reduce the incidence of protein calories deficiency [22]. Then, the gastroenterostomy was anchored to gastric antrum to prevent the loop rotation and form the technique image we called “OAGB in situ” (Fig. 1). Many of the techniques were similar to the techniques proposed by Carbajo et al. [10] but with some modifications. No nasogastric drainage tube or drain tube was left. We did not routinely close the mesentery defect in our loop bypass for experience very few internal herniation up to now. Figure 2 shows the image of original loop anastomosis technique of mini-gastric bypass (MGB) proposed by Rutledge [23, 24].

Statistical Analysis

All statistical analyses were performed using SPSS version 25 (SPSS Inc., Chicago, Illinois). A baseline comparison was done using chi-squared tests and two-sample t-tests. Continuous variables were expressed as the mean (standard deviation). The differences between patient characteristics were established with the use of t test for independent samples. A 2-sided *p* value of less than 0.05 was considered statistically significant.



Fig. 1 Upper gastrointestinal series showing the “OAGB in situ” technique. The image showing the gastric tube fixed at right upper quadrant and food stream directly into the efferent loop

Results

Participants

Overall, 325 patients (100 in the hospital in China and 225 in the hospital in Taiwan) were evaluated. As shown in Table 1, the patients in China were younger (33.3 ± 8.8 vs. 39.2 ± 10.6 , $p < 0.001$), with similar BMI (35.5 ± 6.1 vs. 36.6 ± 7.8 kg/m², $p = 0.769$), and were less likely to have diabetes (20.0% vs. 32.4%, $p = 0.022$). The patients of Taiwan also had a borderline higher prevalence of hypertension (41.3% vs. 30.0%; $p = 0.052$).

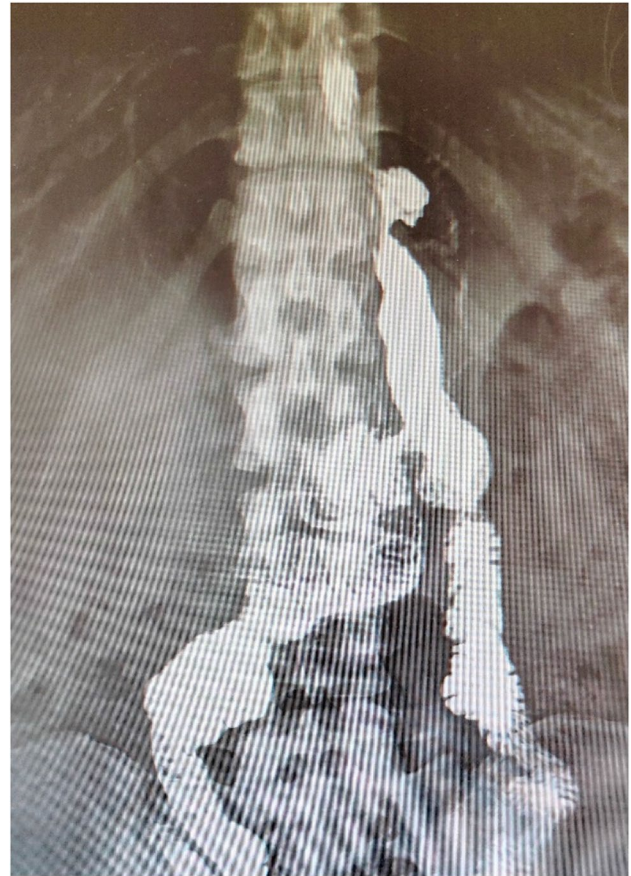


Fig. 2 Upper gastrointestinal series showing a loop anastomosis of original OAGB (mini-gastric bypass) technique

Operative Outcome

The surgical time was significantly shorter for the patients of China than the patients of Taiwan (128 ± 29.8 min vs. 172 ± 36.9 min, $p < 0.001$). The patients of China also had a lower intraoperative blood loss (22.4 ± 15.6 vs. 35.5 ± 25.2 ; $p < 0.001$) but a longer postoperative flatus passage compared with the patients of Taiwan (2.0 ± 0.5 vs. 1.3 ± 0.5 , $p < 0.001$) (Table 2). The 30-day surgical complication was similar low between the two groups (1.0% vs. 1.8%, $p = 0.891$), all minor complication. One (1.0%) of the patients of China had mild complication (intraluminal bleeding at postoperative 21st day requiring admission). Four (1.8%) of the patients of Taiwan had grade 2 complication, 2 with transient stenosis and 2 with intraluminal bleeding. All the patients improved after conservative treatment.

The bypass limb was about 30% of total bowel length in both groups. Although patients of China had a slightly longer bypass limb length than patients of Taiwan, both groups had a similar common channel length (523 cm vs. 547 cm; $p = 0.093$).

Table 1 The clinical characteristics of bariatric and diabetes patients of two centers prior to bariatric/metabolic surgery

	The Hospital in China (n = 100)	The Hospital in Taiwan (n = 225)	p value
Age (mean ± SD)	33.3 ± 8.8	39.2 ± 10.6	< 0.001*
Sex (female) %	77(77.0%)	165(73.3%)	0.484
Body weight (kg)	97.6 ± 20.6	98.8 ± 25.5	0.549
Body height (cm)	165.9 ± 7.7	163.7 ± 8.2	0.044*
BMI (kg/m ²)	35.5 ± 6.1	36.6 ± 7.8	0.768
Waist circumference (cm)	117.1 ± 13.8	113.9 ± 17.5	0.103
Hypertension n (%)	30(30.0%)	93(41.3%)	0.052
Dyslipidemia n (%)	54(54.0%)	109(48.4%)	0.355
AST (U/L)	33.6 ± 25.4	34 ± 25.4	0.918
Albumin (g/dL)	4.6 ± 0.5	4.4 ± 0.3	< 0.001*
Hemoglobin (g/dL)	14.1 ± 1.7	14.2 ± 1.8	0.296
WBC (10 ⁹ /l)	6.94 ± 1.74	8.6 ± 3.4	< 0.001*
Creatinine (umol/L)	57.7 ± 13.5	70.9 ± 17.5	< 0.001*
Uric acid (umol/L)	433.8 ± 114.1	569.3 ± 158.1	< 0.001*
Patients with T2DM (%)	20(20.0%)	73(32.4%)	0.022*
Duration of T2DM (year)	0.5 ± 2.0	2.8 ± 4.5	< 0.001*
C-peptide (ng/ml)	3.6 ± 1.0	4.1 ± 2.1	0.147
HbA1c %	6.3 ± 1.3	6.7 ± 1.5	0.419
Glucose (mmol/L)	6.0 ± 2.2	6.6 ± 2.3	0.075
Insulin usage (case)	3(3.0%)	8(11.0%)	0.798

BMI, body mass index; AST, asparagines transaminase; WBC, white blood cell; T2DM, type 2 diabetes mellitus; **p* < 0.05

Table 2 A comparison of perioperative parameters in patients of the 2 centers

	The Hospital in China (n = 100)	The Hospital in Taiwan (n = 225)	p value
Mean operative time(min)	128.5 ± 29.8	172.43 ± 36.9	< 0.001*
Intra-operative blood loss (ml)	22.4 ± 15.6	35.5 ± 25.2	< 0.001*
Postoperative flatus passage(day)	2.0 ± 0.5	1.3 ± 0.5	< 0.001*
Complication#			
Minor	1(1%)	4(1.8%)	0.891
Grade 1			
Grade 2	1	4	
Grade 3a	0		
Major	0	0	
Grade 3b			
Grade 4			
Grade 5			
Total small bowel length (cm)	797.2 ± 117.1	796 ± 113.3	0.535
Bypass length (cm)	273.3 ± 76.5	219.6 ± 58.3	< 0.001*
Bypass percentage	33.9 ± 5.6%	27.5 ± 5.6%	< 0.001*
Common Channel length (cm)	523.9 ± 70.6	547.8 ± 87.6	0.093

Data are presented as the mean ± (standard deviation); BMI, body mass index; T2DM, type 2 diabetes mellitus; # defined by Clavien-Dindo Classification [17]; **p* < 0.05

Weight Loss Outcome and Nutrition Status

The mean follow-up time was 14 months. At follow-up, the weight loss was similar between the two groups (Table 3). Post-operatively, the mean BMI at 1 year was 24.2 ± 2.4 kg/m², with a mean %EWL of 85.4 ± 13.2%, and % TWL of 32.6 ± 11.2% for patients of China. The case hospital in Taiwan had similar data (26.4 ± 3.6 kg/m², 81.9 ± 19.8%, 33.9 ± 7.4%, respectively). The change of clinical and nutritional parameters after surgery of both groups was shown in Table 3. There was significantly improvement of cardiovascular risk related metabolic parameters and decrease of liver enzymes and uric acid in both groups. However, there were slightly reduction of hemoglobin and albumin level in both groups.

Remission of T2DM

Before surgery, the hospital in China had 20 (20%) patients with T2DM; the mean duration with T2DM was 0.5 ± 2.0 years (range 0–8 years). Oral hypoglycemic agents (OHA) were used in all patients (100%) and insulin therapy was acquired in 3 patients (3.0%) before operation. The mean HbA1c before operation was 6.3 ± 1.3% (range 6–11%). Remission of T2DM (HbA1c < 6.5%) was achieved in 100% of the patients at the 1-year follow-up. The hospital in Taiwan had 73 (32.4%) patients with T2DM; the mean duration with T2DM was 2.8 ± 4.5 years. OHA were used in all patients (100%) and insulin therapy was acquired in 8 (11.0%) patients. Remission of T2DM (HbA1c < 6.5%) was achieved in 95.9% of the patients at 1-year follow-up.

Table 3 A comparison of clinical characteristics of patients of the 2 centers 1 year after bariatric surgery

Variable	The Hospital in China	The Hospital in Taiwan	<i>p</i> value
<i>BMI</i> at 6 months (kg/m ²)	26.3±4.5	27.1±4.4	0.18
At 12 months	24.2±2.4	26.4±3.6	0.056
%Excess body weight loss at 1 year	85.4±13.2	81.9±19.8	0.798
%Total Weight loss at 3 m	19.7±3.8	19.1±6.3	0.23
At 6 m	26.8±5.8	27.2±6.1	0.31
At 12 m	32.6±11.2	33.9±7.4	0.91
AST (U/L)	31.85±28.9	24.8±7.2	0.659
Albumin (g/dL)	4.34±4.53	4.1±0.4	0.162
Hemoglobin (g/dL)	12.7±11.3	11.5±3.1	0.644
WBC (10 ⁹ /L)	4.11±0.42	6.9±2.0	0.002*
Creatinine (umol/L)	55.67±13.86	47.6±11.9	0.192
Uric acid (umol/L)	346.67±72.97	386.7±261.8	<0.001*
Remission of T2DM at 1 year	20/20(100%)	70/73(95.9%)	0.836
C-peptide (ng/ml)	1.23±0.25	1.6±0.4	0.012
HbA1c %	5.20±0.23	5.3±0.5	0.143
Glucose (mmol/L)	4.55±0.26	5.4±1.1	<0.001*
Insulin usage (case)	0(0%)	0(0%)	—

Data are presented as the mean ± (standard deviation); *BMI*, body mass index; *T2DM*, type 2 diabetes mellitus; **p* < 0.05

At the 1-year follow-up, both hospitals had similar HbA1c levels (5.2±0.23% vs. 5.3±0.5%; *p*=0.143) (Table 3). No patient required insulin treatment after OAGB at follow-up.

Revision Surgery

At follow-up, there was only one (1.0%) patient of the new center in China underwent revision surgery for hypoalbuminemia at 14 months after OAGB. This is a 51-year-old male, pre-operative *BMI* 40.1 kg/m² with multiple comorbidities underwent OAGB with a bypass limb of 5 m and common channel 5 m (total bowel length 10 m). The patient developed hypoalbuminemia lower to 2.67 g/dL and intractable diarrhea 9 months after operation. The patients finally received a revision surgery with shorting the bypass limb to 2.5 m and recovered uneventfully. The albumin level was 4.24 g/dL, and the stool passage frequency was 3 times a day at the latest follow-up.

In the control group, there was one (0.44%) patient received revision surgery. This 32-year-old lady received revision 8 months after OAGB and was converted to normal anatomy because of intolerance due to personal worry. Another 2 patients received re-operation for ventral hernia repair. Both hernias are related to the periumbilical trocars used in the primitive OAGB. Both are female patients, and one patient has a history of laparoscopic surgery. For better aesthetic postoperative appearance, we used the original surgical incision, which may be one of the main causes of ventral hernia. The other was a young woman with no prior surgical history. One year after surgery, the patient developed

ventral hernia due to increased intra-abdominal pressure after pregnancy. In addition, the weakness of abdominal muscles after weight loss was also one of the reasons.

At follow-up, three patients had marginal ulcer with bleeding: one (1%) in China and 2 (0.9%) in Taiwan. Intractable bile reflux or small bowel ileus was not detected yet in this series.

Discussion

Although OAGB is gradually gaining accepted worldwide and was recognized by IFSO as a standard bariatric/metabolic procedure since 2015 [11], this procedure is still new for many areas of the world. This study reported the experience of transplanting a maturing gastric bypass procedure, OAGB in situ, into a new bariatric/metabolic center of China. The result confirmed that OAGB is a very safe and effective treatment for morbid obesity. In our previous report, OAGB was continually evolved in the past 20 years with a major complication rate decreasing from 1–2% to 0.4% [20]. In this study, the major complication rate was 0% for 325 patients in a period of 2 years and revision rate was 1% which is compatible or superior to the results from experienced centers of excellence for OAGB [5–13]. This study also demonstrated that this excellent result can be successfully reproduced by a new surgical team of a new bariatric center in a big country without a significant learning curve by careful preparation and mentoring.

There were significant differences in patient characters between the two centers which can be attributed to the difference of patient recruitment between new and experienced referral center. Severe obesity patients with many comorbidities or high risk were more likely to be referred to well-known experienced center than to a new center.

There was a dramatic evolution of OAGB technique in the past 20 years [20]. One of the important evolutions was to measure the whole bowel length during operation which may prevent the possibility of short common channel in patients with short total length of bowel [22]. The major disadvantage of OAGB was the nutrition deficiencies and serious nutrition adverse events which were reported in 20 to 30% of the OAGB patients [7, 16]. In this study, only 1% of the patients required a revision surgery because of severe malnutrition, which is lower than the 3% in our previous reports [20, 25]. Measuring the whole bowel length and bypassing 30% of the total bowel can be a recommended state of art for OAGB, to maintain the efficacy and avoid the malnutrition [22, 26].

Another important disadvantage of OAGB is the possibility of bile reflux. By shifting the anastomosis to posterior wall and anchoring the afferent loop to higher part of the gastric tube, we may help the smooth passage of the food stream into the efferent loop and preventing the bile reflux [20]. A similar technique was first described by Carbajo et al. and was named “anti-reflux technique” [10]. The major differences of the techniques between this study and Carbajo et al. included (1) a longer gastric pouch (24 cm vs. 18 cm) started from antrum, (2) a longer common channel (> 400 cm vs. > 250–300 cm), (3) post wall anastomosis vs. side anastomosis, and (4) fixation of the gastric pouch to antrum vs. fixation of small bowel (efferent limb) to stomach. In this study, no patient experienced intractable bile reflux and only intolerance which is much lower than the incidence in our previous reports [20, 25–27].

The most important advantage of OAGB was the avoidance of the problems from entero-enterostomy of the Roux-en-Y gastric bypass which was regarded as the Archil’s heel of RYGB [28]. The reported incidences of intestinal obstruction following RYGB were around 4% [4, 13, 25, 27, 29–31]. In this study, no intestinal obstruction had been experienced although the follow-up is not long enough.

Another important advantage of OAGB was the good weight loss and high efficacy for T2DM remission. The good weight loss after OAGB was attributed to the long narrow gastric tube which might provide a good satiety and a long bilio-pancreatic limb. Recent studies also suggested that a longer bilio-pancreatic limb had some weight loss independent mechanisms on T2DM remission [13, 32–35]. In this study, the weight loss and T2DM remission were satisfactory and compatible to other reports [7–13].

There were many limitations in this study. First, this is a retrospective study with a selective group of patients which

may have many biases included. However, this study presented a promising result of introducing a new procedure in a big country. The results of this study supported the continuing usage of this procedure in a more widely condition. Second, the follow-up of bariatric patients is relative short. However, the follow-up rate of the new center was nearly 100% which is compatible or better than the previous reports of long-term follow-up. Third, this included a single ethic of Asian with a relatively low *BMI* of 35 which is not representative of the patient population in a country such as the USA. Thus, the results may not be applicable and should be tested on other ethics as well.

In conclusion, laparoscopic OAGB is becoming a well-established bariatric/metabolic surgery with mature technique. The advantages of OAGB are safety and efficacy; however, the patients should be closely monitored for the appearance of malnutrition. This study demonstrated that the good result of OAGB can be reproduced in a new bariatric/metabolic center of a big country through a well-prepared program. However, the outcomes of OAGB in China may not transferable and should be tested in other ethnics.

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Declarations

Conflict of Interest The authors declare no competing interests.

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