



# Roux-en-Y gastric bypass for the treatment of Asian type II diabetes

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**Abstract:** Since the development of gastric bypass 50 years ago by Mason and Ito, Roux-en-Y gastric bypass (RYGB) gradually become the most durable and commonly performed bariatric surgery. RYGB has been shown to be effective in achieving significant and durable long-term weight loss as well as improving medical co-morbidities in morbidly obese patients, and currently regarded as a gold standard bariatric/metabolic procedure. Recently, RYGB became the most commonly performed metabolic surgery for the treatment of type 2 diabetes mellitus (T2DM). Many reports about metabolic surgery are coming from this region because of the characters of Asian T2DM patients. In this review, the current literature evidence about the long-term result of RYGB on weight control and diabetic remission in Asian T2DM patients will be analyzed.

**Keywords:** Roux-en-Y gastric bypass (RYGB); type 2 diabetes mellitus remission (T2DM remission); bariatric surgery; metabolic surgery

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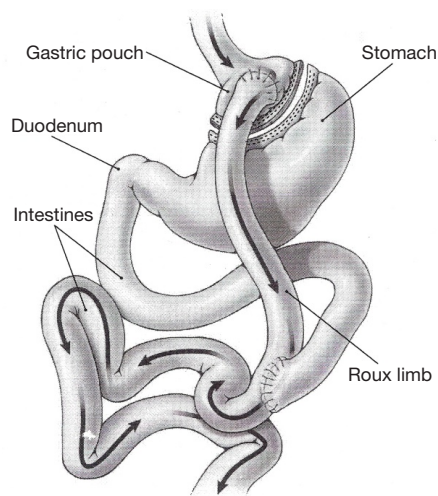
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## Introduction

Gastric bypass surgery was invented by Mason and Ito at 1966 to replace intestinal bypass as a bariatric procedure (1). The procedure consisted by a proximal transverse gastric pouch and a loop gastroenterostomy. Because a loop bypass close to esophgo-gastric junction would cause intractable bile reflux, the procedure was then modified to Roux-en-Y (RY) gastroenterostomy, so called Roux-en-Y gastric bypass (RYGB), by Griffen at 1977 (2,3). At 1991, vertical banded gastroplasty (VBG) and RYGB are the only two procedures approved by the NIH (4). Because gastric bypass has been demonstrated to result in a better weight reduction than VBG in several randomized trials (5-8), RYGB gradually become the most commonly performed surgical procedures for obesity treatment and regarded as a gold standard bariatric/metabolic procedure (9,10). Laparoscopic RYGB (LRYGB) was then developed in 1993 by Wittgrove and Clark (11). Although the learning curve is very long,

LRYGBP was rapidly adopted and emerged as the preferred bariatric procedure worldwide (12,13).

Traditional RYGB has been shown to be effective in achieving significant and durable long-term weight loss as well as improving medical co-morbidities in morbidly obese patients. The initiation of using bariatric surgery for the treatment of T2DM started from the report by Pories *et al.* in 1987 (14). Strong evidences have shown that RYGB is an effective treatment for severe obesity (BMI >35 kg/m<sup>2</sup>) and result in marked improvement of T2DM control (15-17). Recently, several randomized control trial have demonstrated the feasibility and efficacy using LRYGB as a metabolic surgery for the treatment of T2DM in low BMI patients (BMI <35 kg/m<sup>2</sup>) (18-23). However, data of the results for the treatment of T2DM in Asian is less known. The aim of this study is to analyze the update results of RYGB on weight reduction and the efficacy on T2DM treatment in Asian.



**Figure 1** Schema of laparoscopic Roux-en-Y gastric bypass: A small proximal gastric pouch is created by stapling and transecting the lesser curvature side of stomach. The jejunum was divided at around 75cm below the ligament of Treitz. The gastric pouch is anastomosed to the alimentary or Roux limb of jejunum. Proximal bilio-pancreatic limb is anastomosed to the alimentary limb approximately 100 cm below the gastrojejunostomy site.

### Technical aspects

The operation consisted of two components, including, first, a small proximal gastric pouch, usually less than 50 cc, second, a Roux-en-Y gastrojejunostomy with a 75 to 150 cm alimentary or Roux limb and 50 to 100 cm bilio-pancreatic limb (Figure 1). The gastro-jejunostomy is recommended to be smaller than 2cm in diameter (13). The anastomosis can be created using circular stapler, linear stapler or pure hand sewn techniques (11-13). The alimentary bring up was started from retro-colic and retro-gastric to ante-colic and ante-gastric. However, omentum bivalve was recommended in ante-colic and ante-gastric way to avoid the tension of gastro-jejunal anastomosis. The most specific and notorious complication of LRYGB was the development of internal hernia (24). Closure of mesenteric defects can markedly reduce the incidence of internal hernia after LRYGB and should be routinely performed (25,26).

### Operative risk

LRYGB is regarded as one of the most technically demanding advanced laparoscopic surgeries with a very steep learning curve (27-31). The estimated learning curve period of LRYGB is stated to be 100 to 500 cases

(27,32). The reported conversion rate of LRYGB varied from 0.8% to 11.8%, the major complication rate from 3.3% to 15% and the late complication rate from 2.2% to 27%. Although bariatric surgery, especially performed by laparoscopic surgery, is one the most common complex laparoscopic operations, the safety of laparoscopic bariatric surgery improved very rapidly. The 30-day operation mortality of LRYGB was reported to be 2% in 2004 and decreased to 0.2% in 2009 through the program of high quality bariatric center program in USA (33, 34). Well experienced surgeons, fully trained in laparoscopic technique and proctorship, team work and adequate volume are important for a high quality bariatric surgical center (35). Improvement of technology, operative technique, results of clinical trials and accumulation of experience all contributed to this progress (36). In the most recently publication, the 30-day mortality of LRYGB from European center of excellence program was reported to be only 0.012% (37). In conclusion, LRYGB is the leading bariatric/metabolic surgery in the past decade but the operation is one hundred times safer now.

### Weight loss outcome

LRYGB has been shown to be effective in achieving significant and durable long-term weight loss. The Long-term (>10 years) weight loss after LRYGB was reported to be around 25–30 % total weight loss (%TWL) and 55 to 70 % excess weight loss (%EWL) (38-43). Table 1 showed the long-term outcome of LRYGB at different reports. The mean %WL at 10-y are 28.8% and %EWL are 60.9%. Up to 20% of RYGB patients may require a revision surgery for various complications or weight regain. The most commonly reoperation indication is intestine obstruction, including internal herniation. Weight regain was common after RYGB and usually related to dilatation of gastric pouch and anastomosis (44,45). Endoscopic treatment was developed recently and was recommended for the first-line treatment for those with weight regain after RYGB (46). Other options included band replacement, converting to distal gastric bypass or duodenal switch (47-49).

### Remission of T2DM

T2DM remission rate was reported up to 82.9% during 10- to 14-year follow-up in the historical landmark article by Pories *et al.* (15). Another meta-analysis by Buchwald

**Table 1** Ten-year weight loss after LRYGB

Author	Case no	Age (years)	BMI (Kg/m <sup>2</sup> )	%TWL	%EWL	Revision rate %
Higa (38)	65	41.5	47.8	–	57.1	32.0
Lee (39)	46	35.4	38.5	26.7	60.1	5.1
Angrisani (40)	24	34.7	43.8	29.6	69	28.6
Edholm (41)	40	37.9	44.5	NR	67.3	2.1
Obeid (42)	134	42.9	46.6	31.6	58.9	23.5
Mehaffey (43)	651	41.4	53.3	27.3	52.5	–
Mean	160	39.0	45.8	28.8	60.9	18.3

Data are presented in mean (SD). LRYGB, Laparoscopic Roux-en-Y gastric bypass; –, not reported; BMI, body mass index; TWL, total weight loss; EWL, excess weight loss.

**Table 2** T2DM remission rate after LRYGB in randomized trial

Author	Year	No	Pre-op BMI [range]	Pre-op HbA1c%	F/u year	Post HbA1c%	T2DM 1-y CR	T2DM 1-y PR	T2DM 5-y PCR	T2DM 5-y PCR
Schauer (18,51)	2017	50	36 [28–42]	9.4%	5	7.3%	42%	–	26.4%	–
Ikramuddin (19,52)	2017	60	34.6 [30–40]	9.6%	5	6.7%	44%	–	27%	–
Mingrone (53,54)	2015	20	48.7 [>35]	8.7%	5	6.7%	–	75%	37%	42%
Liang (20)	2013	31	30 [28–35]	10.5%	1	6.0%	90%	–	–	–
Courcoulas (21)	2014	21	35.5 [30–40]	7.9%	1	6.4%	27%	50%	–	–
Halperin (22)	2014	19	36.3 [30–40]	8.5%	1	6.7%	–	58%	–	–
Cummings (23)	2016	15	37.8 [30–45]	7.5%	1	6.4%	60%	60%	–	–
Mean	–	–	–	–	–	–	42%	66.6%	30.1%	42%

T2DM, type 2 diabetes mellitus; LRYGB, laparoscopic Roux-en-Y gastric bypass; CR, complete remission A1c <6.0%; PR, partial remission A1c <6.5%; PCR, prolog complete remission: CR more than 5 years; –: no data.

*et al.* reported RYGB achieved a high T2DM remission rate up to 80.3% (81.6% in less than 2 years and 70.9% in more than 2 years) but these data generally used loose and heterogeneous criteria (50). *Table 2* listed the reported T2DM remission rate in randomized clinical trial (RCT) (19–23,51–54). The prolong T2DM complete remission (5-y) rate was less than 50% in RCT trials. Generally speaking, T2DM remission rate was higher in morbid obese patients (BMI >35 Kg/m<sup>2</sup>) than in low BMI group (BMI <35 Kg/m<sup>2</sup>). Complete T2DM remission rate (HbA1c <6% without medication) usually sit at 50% in low BMI patients and might decrease to less than 30% after 5-y [prolong remission (55)]. However, studies from Asia usually reported a higher T2DM remission rate that those from Western countries (56–74). *Table 3* listed the reported T2DM remission rate from Asia. The reason

might be the patients in Asia were relatively young with shorter duration of T2DM than in other part of the world (73).

### Recurrence of T2DM

Studies have illustrated some patients whose T2DM remission after RYGB experienced a recurrence of their disease over times (75–77). DiGiorgi *et al.* have shown that beyond 3 years after RYGB, 24% of patients with initial remission of their T2DM had re-emergence of diabetes (76). Recurrence was related to weight regain and longer duration of T2DM. The variance of T2DM remission rate and high recurrent rate of T2DM highlights the importance of patient selection and understanding the mechanism of T2DM remission by metabolic surgery. We

**Table 3** T2DM remission rate after LRYGB in Asian studies

Author	Year	No	Pre-op BMI	Pre-op HbA1c%	F/u year	Post HbA1c%	T2DM 1-y CR	T2DM 1-y PR	T2DM 5-y PCR	T2DM 5-y PCR
Kim (56)	2011	50	34.5	8.6%	1	–	68%	–	–	–
Huang (57)	2011	221	30.8	9.2%	1	6.4%	63.6%	50%	–	–
Lee (58)	2012	205	40.7	8.3%	1	–	78%	–	–	–
Zhu (59)	2012	30	26.2	8.2%	1	5.6%	30.0%	–	–	–
Dixon (60)	2013	154	37.2	9.1	1	6.7%	69.5%	75%	–	42%
Lee (61)	2013	176	36.7	8.6%	1	6.0%	65.3%	NA	–	–
Yan (62)	2013	99	26.3	9.1%	1	6.7%	NA	80%	–	–
Lakdawalab(63)	2013	52	32.6	8.8%	5	6.2%	NA	73.1%	–	57.7%
Malapan (64)	2014	29	24.4	10.0%	1	6.4%	37.9%	60%	–	–
Yang (65)	2015	30	32.3	8.9%	3	–	–	–	85.2%(3-y)	92.6%(3-y)
Tang Q (66)	2015	38	37.8	7.4%	2	–	38.6%	57.6%	–	–
Liang (67)	2015	86	24.7	6.8%	1	–	23.3%	–	–	–
Park (68)	2016	134	37.9	8.0%	1	6.1%	46.1%	61.8%	–	–
Wang (69)	2016	78	28.3	8.2	2	7.1%	–	43.8%	–	–
Zhang (70)	2017	120	33.9	8.3%	3	–	76.4%	–	62.2%(3-y)	–
Du (71)	2017	64	31.2	9.3%	3	NA	–	75%	–	59.5%(3-y)
Haruta (72)	2017	13	42	NA	1	NA	92%	–	–	–
Chong (30)	2017	14	31.9	9.6	2	6.4%	29%	57%	–	–
Lee (74)	2017	157	34.5	8.6%	5	6.5%	55.4%	–	39.4%	–
Mean	–	–	–	–	–	–	55.2%	60.7%	62.3%	62.9%

T2DM, type 2 diabetes mellitus; LRYGB, laparoscopic Roux-en-Y gastric bypass; CR, complete remission A1c <6.0%; PR, partial remission A1c <6.5%; PCR, prolog complete remission: CR more than 5 years; –: no data.

need information of pre-operative predictors to identify the best candidates to achieve this goal, durable or prolonged T2DM remission. A simple scoring system combined age, BMI, C-peptide and duration of disease to become an ABCD score which is a very useful in selecting suitable patients for metabolic surgery (60). Studies have shown this multi-dimension scoring system ABCD score, is the only predictor of prolonged T2DM remission after metabolic surgery (69,71,78).

### Comparison of RYGB with other procedures

RYGB had a better weight loss than pure restrictive bariatric procedures, including VBG and adjustable gastric banding (5-8,40). However, weight loss after LRYGB was

found to be similar or slightly better than LSG in many RCTs but with more nutritional deficiencies in LRYGB (79-82). That's why that LSG is becoming the leading bariatric/metabolic procedure now (83,84). However, LRYGB still have a better glycemic and lipid control than LSG, probably because of the duodenum exclusion effect (85-87). On the other hand, mal-absorptive procedures including bilio-pancreatic diversion/duodenal switch (BPD/DS), laparoscopic single anastomosis (Mini-) gastric bypass (LSAGB) and single anastomosis duodeno-ileostomy (SADI), had a better weight loss and glycemic control than RYGB but had higher incidence of malnutrition (39,50,53,54,88). Therefore, the surgeon should counsel the patients for metabolic surgery and choice of surgical procedure to construct a personalized

treatment according to individual situation and update evidence.

## Conclusions

LRYGB is a safe and durable primary bariatric procedure with overall 28.8% TWL and 60.9%EWL at 10 years and satisfactory resolution of obesity related co-morbidities. LRYGB has become the most favorable metabolic procedure for T2DM treatment and resulted in a better glycemic control than intensive medical control. However, prolong complete T2DM remission rate was less than 50% 5-y after LRYGB. We need to understand the mechanism of metabolic system and more information of pre-operative predictor in order to identify the best candidates from T2DM patients for this procedure.

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