

Prediction of Diabetes Remission after Bariatric or Metabolic Surgery

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Bariatric surgery has evolved from the surgical measure to treat morbid obesity into the epochal remedy to treat metabolic syndrome as a whole, which is represented by type 2 diabetes. Numerous clinical trials have unanimously advocated bariatric or metabolic surgery over the non-surgical interventions, demonstrating markedly superior metabolic outcomes not only in morbidly obese patients who satisfy traditional criteria for bariatric surgery (body mass index [BMI] >35kg/m²) but also in less obese or even in simply overweight patients. Nevertheless, not all the diabetic patients can achieve the most desirable outcomes, that is, diabetes remission, after metabolic surgery and candidates for metabolic surgery should be selected carefully based on the comprehensive preoperative assessment of the risk-benefit ratio. Predictors for diabetes remission after metabolic surgery can be largely classified into 2 groups based the mechanism of action; 1) indices for the preserved pancreatic beta-cell function, such as younger age, shorter duration of diabetes, and higher C-peptide level, and 2) those represent the potential reserve for reduction in insulin resistance, such as higher baseline BMI, and visceral fat area. Several prediction models for diabetes remission have been suggested by merging these predictors to guide clinicians and patients' joint decision-making process. Among them, 3 models, DiaRem, ABCD, and Individualized Metabolic Surgery (IMS) scores provide intuitive scoring systems which can be simply utilized in the routine clinical practice and have been validated in the independent external cohort. These prediction models need further validation in the various different ethnicities to ensure the universal applicability.

Key Words: Metabolic surgery, Bariatric surgery, Diabetes, Remission, Predictor

INTRODUCTION

Type 2 diabetes (T2D) is an expanding pandemic affecting more than 400 million people around the world at present [1]. Unfortunately, approximately one-third of these diabetic patients are living in Asia-Pacific area. Obese Asians are at higher risk to develop T2D than Caucasians with the same body mass index (BMI) because of the higher proportion of body fat and prominent abdominal obesity [2].

The prevalence of T2D is increasing in Korea as well. Among adults aged ≥30 years, diabetes prevalence has

increased from 8.6% to 11.0% in 2001 and 2013, respectively, according to the Korean National Health and Nutrition Examination Surveys (KNHANES) [3]. Despite the rapidly increasing diversity of the pharmaceutical options, however, there has been minimal improvement in the diabetes control over the last decade in Korea. According to the Korean national survey including 1,341 diabetic patients of age over 30, the proportion of well-controlled diabetes meeting HbA1c goal of <6.5% was 27% and only 45.6% succeeded to achieve HbA1c <7% in 2012; the figures showed little change from those in 2005 [4]. This indicates

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that a breakthrough is required in the fight against this chronic disease.

The efficacy of bariatric surgery on remarkable and sustained weight loss has been well demonstrated in the numerous previous studies and it is no longer disputable that the surgical measures induce distinctly superior outcomes in terms of weight loss compared to any medical treatments. Along with the sustained weight loss, bariatric surgery is known to achieve a marked improvement in obesity-related comorbidities such as T2D. Since Dr. Pories provoked a concept of metabolic surgery in 1995, which suggested the potential for cure of diabetes by surgical treatment [5], growing number of studies have been focused on the metabolic effect of the bariatric surgery [6-9]. This trend resulted in the gradual paradigm shift from bariatric surgery, which simply aimed at body weight reduction, toward “metabolic surgery” which primarily intends to treat metabolic diseases, particularly T2D. Based on the extensive evidence, the international diabetes organizations encompassing over 50 medical and surgical societies have released a joint statement in 2016 to endorse metabolic surgery within the T2D treatment algorithm in patients with uncontrolled T2D in spite of optimal medical management, even for those with class I obesity (BMI 27.5-32.5 for Asians) [10]. This indirectly reflects that consensus has been reached on the fact that improvement in diabetes mellitus after bariatric surgery is related to various mechanisms other than simple weight loss alone, although they are not completely understood yet [11].

Nevertheless, not all the diabetic patients can achieve desirable outcomes, that is, diabetes remission, after surgical treatment and surgery might inevitably pose nutritional risks requiring long-term monitoring and supplementation to the patients. Candidates for metabolic surgery should be selected carefully based on the comprehensive preoperative assessment of the risk-benefit ratio. Although many studies have shown that baseline BMI *per se* does not adequately predict the outcomes of metabolic surgery [12], most of the currently available evidence is based on the studies complying with the conventional eligibility criteria of BMI >35 kg/m² for bariatric surgery. It is inevitable to select patients based on BMI criteria at present. However, investigators have consistently argued

that more robust diabetes-specific parameters other than BMI should be established to identify suitable patients for metabolic surgery and to predict postoperative outcomes.

DEFINITION OF DIABETES REMISSION

There has been great heterogeneity in defining remission of diabetes across the previous literature. The rate of diabetes remission following bariatric and metabolic surgery can be largely affected by how we define remission. Mas-Lorenzo et al. [13] revealed that the remission rate dropped from 92.7% to 43.6% along with the adoption of more stringent remission in the 55 diabetic patient cohort undergoing Roux-en-Y gastric bypass (RYGB) or sleeve gastrectomy (SG). Blackstone et al. [14] reviewed 505 patients who underwent RYGB and also demonstrated that the prevalence of diabetes remission at 14 postoperative months varied from 43.2% to 59.4% depending on the definition of remission, although they concluded that the independent predictors for the remission were consistent regardless of how remission was defined.

So far, the most commonly used definition for remission is based on a consensus statement released in 2009 by a panel of expert endocrinologists [15]. They defined remission as achieving glycemia below the diabetic range in the absence of active pharmacological or surgical therapy. Partial remission was defined as sub-diabetic hyperglycemia (HbA1c $<6.5\%$, fasting glucose 100-125 mg/dl) of at least 1 year's duration, and complete remission as a full return to normal measures of glucose metabolism (normal HbA1c, fasting glucose <100 mg/dl) for the same duration. Prolonged remission was considered when complete remission is attained and lasts for more than 5 years.

However, this rather strict definition has not been uniformly adopted in the previous studies even after the statement was publicly released. Most studies have used simple HbA1c criteria at a single time point during the follow-up to define diabetes remission without considering sustained remission status for a given period of time. One of the reasons might be that the researchers are inclined to release the best possible outcomes. This strict definition with additional time frame renders metabolic surgery seemingly less effective than the initial expectation; the

previous studies, the stricter the criteria, the poorer the remission rate with the same study cohort. Furthermore, according to this definition, patients who keep taking preventive medication after surgery, such as metformin, are not regarded to have attained diabetes remission in spite of excellent glycemic control after surgery by the reason that those patients do not discontinue oral hypoglycemic agents.

It is necessary to clarify the standard criteria of diabetes remission for the ready usage in the real clinical practice as well as for the scientific purpose to gather objective evidence across the different studies.

PROBABILITIES OF DIABETES REMISSION

The efficacy of bariatric or metabolic surgery on T2D has been extensively investigated in the previous studies and well-recognized in morbidly obese patients. The Swedish Obese Subject (SOS) study prospectively observed 343 and 260 diabetic patients in the bariatric surgery group and matched control group, respectively, and the patients were followed up for 12 to 25 years. Surgical procedures used in this study were gastric bypass, gastric banding, and vertical banded gastroplasty. They reported that diabetes remission rate was 72.3% in surgery group compared to 16.4% in control group at 2 years after surgery. At 15 years, the diabetes remission rate decreased to 30.4% for surgical patients and to 6.5% for controls. They concluded that bariatric surgery was associated with more frequent diabetes remission and significantly reduced diabetes-related complications in obese patients with T2D, although some of the patients experienced diabetic relapse over time [16].

According to the previous meta-analysis published in 2009 which involved 3188 diabetic patients, Buchwald et al. [17] reported an overall 78.1% of complete diabetes remission rate after bariatric surgery, achieving normal fasting blood glucose (<100 mg/dl) or HbA1c <6% without diabetic medications. The diabetes resolution was greatest for patients undergoing biliopancreatic diversion/duodenal switch (95.1%, resolved), followed by gastric bypass (80.3%), gastroplasty, which has been discarded in recent years (79.7%), and gastric banding (56.7%). This

gradient was significantly correlated to the BMI loss achieved following the different bariatric procedures.

Another recent meta-analysis carried out in the U.K. involving 569 patients with T2D and BMI >35 kg/m² who underwent bariatric surgery and matched them to 1881 diabetic patients without bariatric surgery for age, sex and baseline BMI. They have demonstrated that the 94.5 diabetes remissions per 1000 person-years were found in who underwent bariatric surgery compared with 4.9 diabetes remission in matched control patients; patients who underwent bariatric surgery had an 18-fold increase chance for diabetes remission compared with matched controls [18]. Consistent with other studies, the effect size was greatest in patients undergoing gastric bypass (adjusted relative rate [RR], 43.1), followed by sleeve gastrectomy (adjusted RR, 16.6), and gastric banding (adjusted RR, 6.9).

It appears apparent that the anti-diabetic effect is better in the surgical procedures inducing malabsorption compared to the purely restrictive procedures such as gastric banding or sleeve gastrectomy in morbidly obese patients, along with the better weight loss outcomes.

Then, will metabolic surgery work for the diabetic patients with much lower BMI? Many researchers have argued that anti-diabetic effect of metabolic surgery results not only from weight loss-related changes in the glucose homeostasis but also from diverse weight loss-independent mechanisms of glycemic control. Although not fully understood, these include favorable changes in the gut hormones, bile acid signaling, intestinal nutrient sensing, gut microbiota, increased glucose metabolism in the small intestine and so on [11]. However, most of these specific mechanisms have only been demonstrated in animals so far, and the evidence in human is still lacking and under investigation at present.

Admittedly, the evidence supporting the metabolic surgery for those with BMI less than 35 kg/m² is still limited. Nevertheless, several studies, albeit with relatively small sample size, have investigated the efficacy of metabolic surgery in non-morbidly obese diabetic patients with BMI <35 kg/m². One thing to note is that majority of them employed procedures including intestinal bypass rather than purely restrictive procedures.

Rao et al. [19] conducted a meta-analysis to investigate

the effect of gastric bypass (including both traditional RYGB and mini-gastric bypass) in T2D in patients with BMI < 35 kg/m² in the minimum follow-up period of 12 months. They included 269 participants from 9 articles; the mean BMI decreased from 31.0 ± 2.1 kg/m² to 25.3 ± 3.4 kg/m² and HbA1c level from 8.3 ± 1.8% to 5.8 ± 0.8%. The overall diabetes remission rate was 57% (range, 23–93%)

Baskota et al. [20] evaluated the results from even lighter patients with BMI < 30 kg/m² in the meta-analysis including 291 diabetic patients from 10 studies. Most of them were preliminary studies with very small sample size less than 30 as well as short follow-up period and more than a half of the patients were from Asia-Pacific region. The pooled results demonstrated weight loss of 9.7 kg and diabetes remission rate of 42.4%. The study by Dixon et al. [21] is one of the biggest series thus far, which reported the outcomes of gastric bypass (RYGB or mini-gastric bypass) in 103 diabetic patients with BMI < 30 kg/m² (mean, 25.9 ± 3.0 kg/m²). The participants were either Korean or Taiwanese. Excellent glycemic control with HbA1c < 6.0% was achieved only in 30% of the patients at 1 year, which appears to be considerably lower than the figures from the studies based on the higher BMI population. The surgical efficacy on diabetes resolution seems less prominent in the less or non-obese patients compared to the results from morbidly obese patients.

Meanwhile, Panunzi et al. [12] conducted meta-analyses with 94 previously published studies comprised of 4944 patients with T2D. They categorized the patients into two subgroups based on their preoperative BMI (BMI < 35 or > 35 kg/m²) to compare the surgical effect on the T2D. The rate of diabetes remission was similar in two subgroups, which was 71% and 72%, respectively, and they concluded that preoperative BMI does not predict the postoperative outcome of T2D.

PREDICTIVE FACTORS OF DIABETES REMISSION FOLLOWING BARIATRIC OR METABOLIC SURGERY

Several studies have investigated the outcomes of bariatric surgery in patients with T2D to identify predictive factors of diabetes remission following surgery (Table 1)

[9,14,22–28]. The remission rate ranged from 24% to 84% according to the type of surgery and to the baseline characteristics of the patients as well. As shown in Table 1, these studies were heterogeneous in terms of sample size, follow-up duration, and even in the definition of remission used in the literature.

Interestingly though, some factors emerged as a common denominators of diabetes remission across these studies in spite of different surgical types and remission criteria; these include younger age, higher baseline BMI, shorter duration of diabetes, better glycemic control before the surgery which could be represented by lower HbA1c or FPG and no preoperative insulin use, as shown in Table 1. Some studies suggested that lower baseline C-peptide level was associated with a poor response in diabetes control after bariatric surgery [24]. The study from Korean patients demonstrated that similar result with other studies; baseline C-peptide level of more than 2.6 ng/ml was a prerequisite for diabetes remission and preoperative BMI, younger age, lower HbA1c with no insulin use before the surgery independently predicted diabetes remission among those who underwent RYGB [27].

These previously proposed predictors can be largely classified into 2 subgroups. One group stands for the preserved or less deteriorated pancreatic beta-cell function to secrete insulin after glucose challenge; these include higher preoperative C-peptide level, shorter duration of diabetes, younger age, and good glycemic control without insulin use. The other group stands for the potential reserve for a reduction in insulin resistance. This can be indirectly represented by preoperative higher BMI, higher visceral fat area, and a larger amount of weight loss following the surgery.

PREDICTION MODELS OF DIABETES REMISSION

Most of the previously published studies have focused on identifying factors *per se* to predict postoperative diabetes remission and the results were based the retrospective analyses of data retrieved from a single-center cohort of a relatively small population. In the meantime, recently introduced 3 prediction models of diabetes remission

Table 1. Predictors of diabetes remission after bariatric or metabolic surgery

	N	Type of surgery	Baseline BMI (kg/m ²)	Baseline HbA1c (%)	Duration of diabetes (years)	Remission rate (%)	Definition of diabetes remission	Predictors of diabetes remission
Hayes et al. (2011) [22]	127	RYGB	46.8±9.4	7.7±1.7	4.5±5	84% at 12 month	HbA1c < 6% without medication	Preoperative BMI, HbA1c, FPG presence of hypertension diabetic status
Hamza et al. (2011) [23]	74	LAGB & RYGB	51.6±8.2	LAGB 7.5±1.8 RYGB 7.9±1.9	< 5 (n=34) ≥ 5 (n=30)	LAGB 24% RYGB 50% at 17 months	HbA1c < 6.5% & FPG < 100 without medication	Age, %EWL (type of surgery, female, follow-up duration)
Balckstone et al. (2012) [14]	505	RYGB	48.7±8.1	7.5±1.6	Median 4	43.2% at 14 months	HbA1c < 5.7%, FPG < 100 without medication	Preoperative FPG, HbA1c Preoperative insulin use
Aarts et al. (2013) [24]	56	RYGB	48.1±6.3	7.4±1.5	4.8±5.0 (OHA), 8.7±6.1 (insulin)	74%	HbA1c ≤ 6.5% without medication	Duration of diabetes < 4 years Recent T2D diagnosis lower preoperative HbA1c Lower daily doses of metformin
Schauer et al. (2014) [9]	99	RYGB & LSG	36±3.5	9.3±1.5	8.3±5.1	RYGB 46% LSG 29% at 3 years	HbA1c < 6.5% without medication	Lower daily doses of insulin Reduction in BMI (OR 1.33) Duration of diabetes < 8 years (3.3)
Bhasker et al. (2015) [25]	106	RYGB	45±7.8	8.7±2.1	8.2±6.2	NA (HbA1c 6.2±1.3 at 5 years)	HbA1c < 6% & FPG < 100 without medication for 6 months	C-peptide levels ≥ 3 Duration of T2DM ≤ 5 years BMI ≥ 40 kg/m ²
Yu H et al. (2015) [26]	68	RYGB	31.5±3.6	8.6±2.1	7	75.5% at 1 year	HbA1c < 6.5% without medication	no preoperative insulin use Shorter diabetes duration C-peptide VFA
Park and Kim (2016) [27]	134	RYGB	37.9±5.2	8.0±1.5	4.6±5.8	46.1% at 12 month	HbA1c < 6% without medication	C-peptide > 2.6 Age. preoperative BMI, HbA1c, insulin use
Scopirano et al. (2017) [28]	135	BPD	27.0±9.6	9.2±1.7	11.1±7.8	60.7% at 5 years	HbA1c < 6.5% without medication	Preoperative BMI Preoperative insulin use

BMI = body mass index; RYGB = Roux-en-Y gastric bypass; LAGB = laparoscopic adjustable gastric banding; LSG = laparoscopic sleeve gastrectomy; FPG = fasting plasma glucose.

might serve as more intuitive and practical tools to use in clinical practice with a simple scale. They were driven from a relatively large number of patients and externally validated to verify their general applicability in other population.

1. DiaRem score

DiaRem Score was proposed by Still et al. [29] based on the retrospective review of 690 patients with T2D who underwent Roux-en-Y gastric bypass. They reported complete or partial remission rate of 63%. They used 259 clinical variables to identify independent predictive factors and to develop a prediction model. They found out that the patients who required insulin for glycemic control before the surgery was 7.25 times less likely to achieve either complete or partial remission after the surgery, which was the strongest indicator to predict diabetes remission after bariatric or metabolic surgery. Additionally, age at operation, baseline HbA1c level, and the type of antidiabetic medications used before the surgery appeared to be predictors irrespective of insulin use. Based on this result, a scoring system ranging from 0 to 22 was established by weighing each variable based on the probability of diabetes remission (Table 2). The scores were classified into 5 groups according to the probability of diabetes remission, and the higher score indicated a higher probability of remission. This scoring system was externally validated in the independent population and several subsequent studies [30, 31].

2. ABCD score

ABCD score was devised by Wei-Jei Lee and other representative bariatric surgeons from Asia [32]. They initially reviewed 63 patients who underwent RYGB or single-anastomosis gastric bypass (previously known as mini-gastric bypass) and identified 4 factors, including age at operation (A), baseline BMI (B), C-peptide level (C), and diabetes duration (D). They were used to construct a simple scaling system ranging from 0 to 10 and patients with a higher score are more likely to achieve diabetes remission after surgery. This original scoring system went through some modification to enhance the predictive power with very low scores, particularly reflecting the results from the

lower BMI population (Table 3) [33]. The modified ABCD scoring system has been tested in the 510 patients from the different hospital across Asia and demonstrated very good predictability of diabetes remission from 5.9 % to 93.3% along with the score increase [34]. The system was also tested in the SG patient and showed good correlation to the diabetes remission rate as well, although with lower remission rate compared to those of gastric bypass patients in the original cohort [35]. This indicates that the type of surgery has a significant influence on the glycemic control after metabolic surgery.

3. Individualized metabolic surgery score

Aminian et al. [36] came up with the individualized metabolic surgery (IMS) score to guide procedure selection based on the long-term (>5 years) glucose control in

Table 2. Calculation of DiaRem score and probability of diabetes remission after Roux-en-Y gastric bypass

	Score
Age (years)	
< 40	0
40-49	1
50-59	2
≥ 60	3
HbA1c (%)	
< 6.5	0
6.5-6.9	2
7.0-8.9	4
≥ 9.0	6
Other diabetes drugs	
No sulfonylureas or insulin-sensitizing agents other than metformin	0
Sulfonylureas and insulin-sensitizing agents other than metformin	3
Treatment with insulin	
No	0
Yes	10
Overall score (sum of the four components)	0-22
Probability of remission in each DiaRem score subgroup*	
0-2	87% (83-90)
3-7	66% (61-70)
8-12	32% (24-40)
13-17	16% (12-21)
18-22	5% (0-9)

*Including both partial and complete remission. Data are presented as probability (%) with 95% confidence interval. Adopted from Still CD et al. Preoperative prediction of type 2 diabetes remission after Roux-en-Y gastric bypass surgery: a retrospective cohort study. *Lancet Diabetes Endocrinol* 2014;2:38-45 [29].

Table 3. Modified ABCD scoring system and the probability of diabetes remission after gastric bypass

	Points on ABCD index			
	0	1	2	3
Age (years)	≥40	<40		
BMI (kg/m ²)	<27.0	27.0-34.9	35.0-41.9	≥42.0
C-peptide (mg/L)	<2.0	2.0-2.9	3.0-4.9	≥5.0
Duration of diabetes (years)	<8	4-8	1-3.9	<1

ABCD score	Probability of diabetes remission*	
	Complete remission	Partial remission
0	5.9%	5.9%
1	5.0%	20.0%
2	26.3%	38.6%
3	31.9%	42.0%
4	52.5%	67.8%
5	55.4%	75.0%
6	61.7%	78.3%
7	77.0%	92.3%
8	85.2%	96.3%
9	87.1%	87.1%
10	93.9%	93.3%
Overall	52.2%	64.7%

*According to the analysis of 510 patients of Asian Diabetes Surgery Study (ADSS).

Adopted from Lee WJ et al. The effect and predictive score of gastric bypass and sleeve gastrectomy on type 2 diabetes mellitus patients with BMI <30 kg/m². *Obes Surg* 2015;25:1772-8 [33].

patients with T2D. They retrospectively collected data from 659 patients with T2D who underwent RYGB or sleeve gastrectomy at a single center in the United States and had completely documented glycemic follow-up of at least 5 years after surgery. A nomogram was constructed to generate the IMS score based on 4 independent predictors of long-term remission, which included preoperative number of diabetes medications, insulin use, duration of diabetes, and glycemic control (HbA1c <7%, Fig. 1); the user-friendly IMS score calculator is available online [37]. The patients were categorized into 3 stages of diabetes severity according to the calculated IMS score and the probability of diabetes remission in each stage after RYGB and SG were provided, respectively. The authors went one step further, providing recommendations on the procedure of choice (RYGB or SG) for each severity stage based on the efficacy and risk-benefit ratio of 2 procedures; RYGB for those with mild disease (IMS score ≤25), RYGB for moderate disease (IMS score 25-95), and SG for severe disease (IMS score >95). The prediction model was externally validated in the independent cohort of 241 patients.

DISCUSSION

Traditionally, diabetes care has been led by endocrinologists and the relevant medical team, particularly in Korea. As the era of metabolic surgery has begun, surgeons are more likely to be involved in the treatment of diabetes and need to provide an active effort to achieve glycemic control with surgical measures.

Optimal outcomes following metabolic surgery would be achieving diabetes remission without antidiabetic medication. However, not all diabetic patients can achieve diabetes remission and we should select patient carefully to avoid those who might least benefit from surgical procedures.

There is no doubt that the bariatric/metabolic surgery is a far better option to improve glucose homeostasis along with the remarkable and sustained weight loss in morbidly obese patients with T2D. However, the inconsistent results from different studies in lower BMI population indirectly suggest that the BMI criterion does not adequately predict the probability of diabetes remission in the non-morbidly

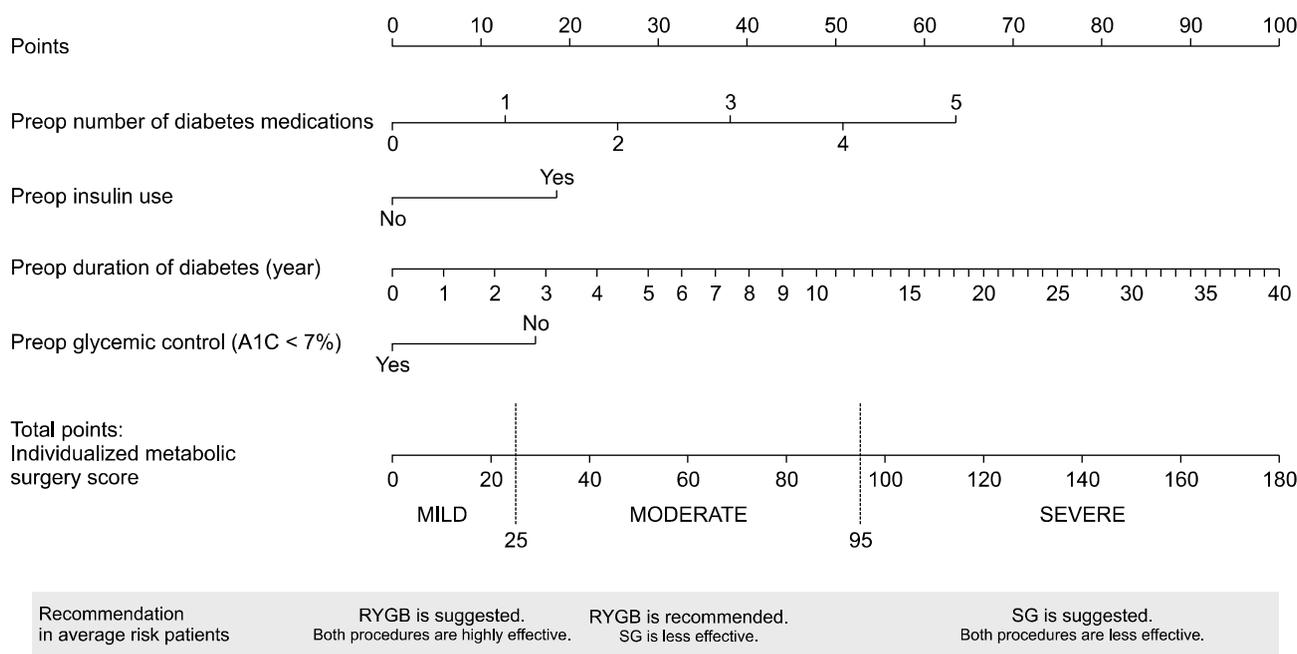


Fig. 1. Nomogram for the individualized metabolic surgery (IMS) score. Adopted from Ali Aminian et al. Individualized Metabolic Surgery Score: Procedure Selection Based on Diabetes Severity. *Ann Surg* 2017 Jul 24 [38].

obese patients undergoing metabolic surgery. Although several randomized controlled studies unanimously advocated metabolic surgery over conventional management even in patients with BMI less than 35 kg/m², the debate is ongoing over whether the anti-diabetic effect of surgery is attenuated in the lower BMI population. In general, patients seeking surgery for the primary purpose of diabetes treatment would be older, with lower BMI and poorer glycemic control, the pathophysiology of diabetes might be different in these patients from the beginning. Understanding this potential difference would further facilitate the process to identify more robust parameters relevant to diabetes and consequently to select the best-suited patients for metabolic surgery in clinical practice. It is particularly more important in Asia where people are more vulnerable to T2D even in relatively low BMI compared to Caucasians.

An ideal prediction model for diabetes remission after metabolic surgery will guide clinicians and patients to make the optimal decision for the diabetes treatment by balancing the surgical risks against the potential benefit. It should be accurate enough to discriminate the candidate for metabolic surgery among those with diabetes and

should be consistent and reproducible in patients with different baseline characteristics. Thus far, aforementioned 3 prediction models (DiaRem, ABCD, and IMS scores) were the only models that have been externally validated in the relatively large independent population and they are easy-to-use and intuitive scoring systems, which assess the possibility of diabetes remission based on the baseline patient characteristics. However, there was a considerable difference in the geographic origin of the derivation cohorts (DiaRem and IMS scores from the USA, ABCD score from Asian population) as well as in the baseline characteristics of the patients (particularly in the baseline BMI) between the scoring systems. Lee et al. compared ABCD score with DiaRem score, and then with IMS score using the data from Taiwanese patients [38,39]. They suggested that ABCD score might be better at predicting T2D remission after metabolic surgery than both DiaRem and IMS scores. DiaRem score and ABCD score were also tested in the Korean patient who underwent RYGB [40]. Although the overall trend in both scoring systems correlated to the actual diabetes remission rates, ABCD score appeared to be more discriminating in Korean patients. It seems that the ABCD score predicts better of the

diabetes remission or improvement after surgery in the Asian population with relatively lower BMI. These prediction models with the scoring system should be further validated in the various different ethnicities to ensure the universal applicability before implementation into clinical practice.

As the second Diabetes Surgery Summit made an official announcement that metabolic surgery is recommended as a standard option for the T2D treatment [10], more and more studies will enthusiastically focus on the therapeutic effect of the metabolic surgery in terms of complete cure, i.e. "remission", of this complex chronic disease which formerly believed to inevitably worsen over time. Nonetheless, one thing to be cautious is that the remission of diabetes should not be considered as the only goal of metabolic surgery. Most investigators agree that the surgical outcome of metabolic surgery with the primary intent to treat T2D should be considered in the continuum of the improved glucose homeostasis and failure to achieve complete diabetes remission should not be considered as "failure" of surgical treatment. Majority of patients still can benefit from the improved glycemic control after metabolic surgery, although the degree might not be enough to satisfy the criteria of remission. Remission of diabetes based on the current definition, although desirable, should not be regarded as the only goal of metabolic surgery or the only measure of success and it is necessary to establish a universally accepted goal and definition of successful treatment of metabolic surgery in the larger context of diabetes care to facilitate judicious patient selection for surgery.

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