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Metabolic surgery in patients with diabesity: A review of the historical backgrounds and scoring systems

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ABSTRACT

Diabesity is a modern term that describes the coexistence of adverse health effects of diabetes mellitus and obesity and indicates a causal pathophysiological relationship between the two phenomena. The progression of diabesity leads to a deterioration of multiple organs and systems. Effective intervention for patients with diabesity must include optimal obesity therapy to prevent secondary complications. Metabolic surgery is the most effective and sustainable therapy for severe obesity and the elimination or prevention of many associated diseases, including type 2 diabetes mellitus, hypertension, sleep apnea, heart disease, and certain cancers. This review provides an up-to-date overview of surgical interventions for obesity, particularly the development of metabolic surgery. It evaluates different scoring systems for evidence-based selection of metabolic surgery based on disease severity. We reviewed different predictive scoring systems for better evidence-based selection of the best metabolic surgery for patients with diabesity. We found that medication type, fasting insulin level, and C-peptide influence the outcomes of different types of metabolic surgery and heterogeneous remission rates. There are different predictive scoring systems for evidence-based selection of the best metabolic surgery, either sleeve or mini-bypass, that will ensure the highest chance of diabetes remission. Using the metabolic score calculator is a useful tool to help medical specialists determine the optimal treatment strategy for a particular patient. More research is needed before we can agree on the ideal bariatric procedure that offers the highest chance of remission with the lowest incidence of hypoglycemia.

Keywords: diabesity, metabolic surgery, scoring, complications, obesity, diabetes mellitus

INTRODUCTION

Obesity is the leading risk factor for diabetes melltus, a disease characterized by insulin hyposecretion and/or resistance and hyperglycaemia [1]. The risk escalates by twentyfold with obesity, and according to published evidence, the number of patients with diabetes is expected to increase globally to 642 million by 2040 [2]. The socioeconomic impact of type 2 diabetes mellitus and/or its health-related consequences are a substantial burden on individuals and the public burden [3]. Due to the close relationship between obesity and diabetes, the term “diabesity” was coined in the 1970s [4]. The term describes the coexistence of adverse health-related effects of diabetes mellitus and obesity, suggesting a causal pathophysiological association between both phenomena [5, 6].

The progression of both disorders (obesity and diabetes) leads to multiple organ and systems deterioration, as summarized in **Figure 1**. In particular, it is directly related to an elevated risk for many serious, life-threatening macrovascular and microvascular complications [7, 8], heamodynamic and vitamin disturbances [9], obstructive sleep apnoea, element alteration [10], cancer [11], depression [8], the bone changes [12], metabolic-associated fatty liver disease [13] and further increase in mortality, morbidity, as well as health-related quality of life [8]. Therefore, effective intervention for patients with diabesity is an important strategy and must include optimal obesity therapy [14]; such effective management would help prevent secondary complications of diabesity. The current management strategies for managing diabetes often ignore these crucial approaches by simply targeting glycemic control. Moreover, it is uncertain which type of metabolic intervention is superior in a patient with diabesity to provide long-term remission with less relapse.

This review provides an up-to-date overview of diabesity in surgical intervention, particularly the history of developing metabolic surgery. It evaluates different scoring systems for evidence-based selection of metabolic surgery based on disease severity.

HISTORICAL DEVELOPMENT OF METABOLIC SURGERY

Since the advent of the 1990s, the surgical community has believed it had a potent tool that can effectively address numerous health conditions if utilized appropriately [15]. So,

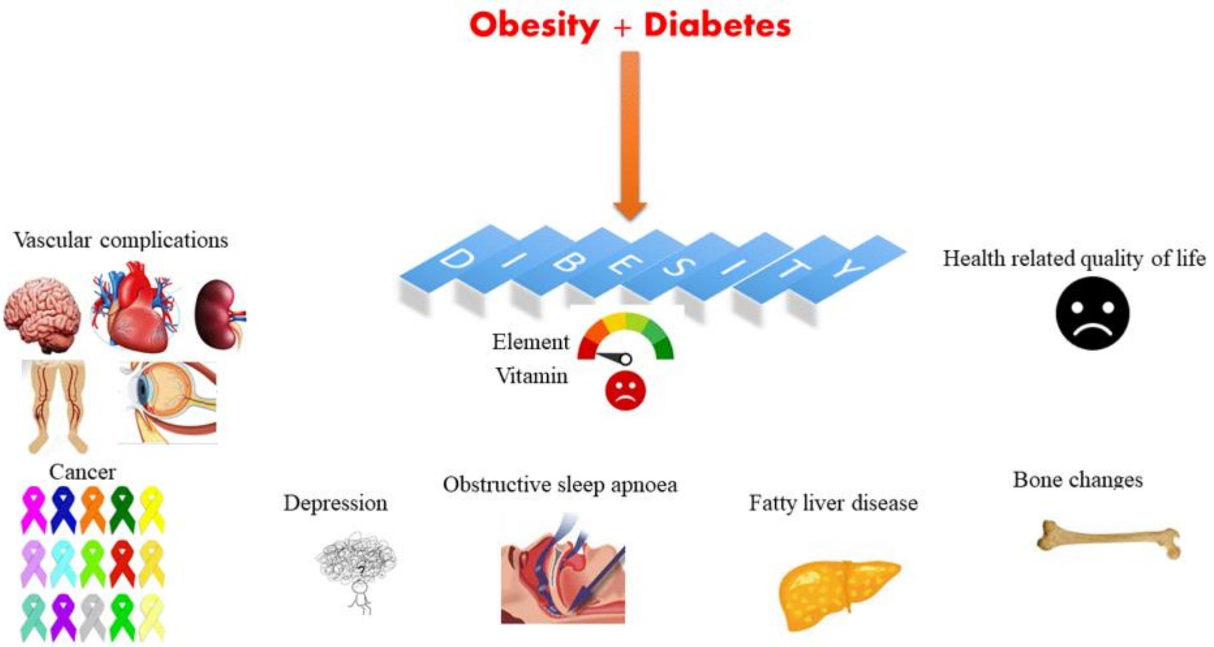

Figure 1. Diabesity complications (Source: Authors' own elaboration)

efforts have been made to improve access and reduce waiting times and the churn of potentially eligible patients. The evidence for the superior efficacy and durability of even the least successful surgery compared to any other modality overwhelms [16].

In 1991, we witnessed the birth of a new era in managing obesity. The first National Institutes of Health guidelines for the surgical treatment of obesity were established. Individuals with a body mass index (BMI) between 35 and 40 kg/m^2 without comorbidities or BMI<35 kg/m^2 are non-eligible for bariatric surgery [17]. The guidelines were written to restrict access to bariatric surgery. The remaining group of patients eligible for surgery had to go through multiple assessment steps by multidisciplinary teams, and patients had to overcome the preoperative losses required by the insurance company, among many other hurdles, to qualify for surgery [18].

There was concern in the medical community that many patients would not prefer the easy route of surgery over non-surgical options, including lifestyle changes, and that such surgical treatments carried a high risk of morbidity. Surgeons realized they needed to reduce the procedure's invasiveness, and laparoscopy seemed the best approach [19]. Therefore, much of the work over the last two decades has focused on improving the safety profile of the laparoscopic surgical approach and identifying the procedures with the best outcome and least morbidity.

The surgical approach is mature, as evidenced by the predominance of vertical sleeve gastrectomy (SG) as an easy-to-perform primary procedure with excellent weight loss [20]. Accordingly, several consensus meetings have been held, and standard for this approach is relatively well established [21].

Bypass surgery, on the other hand, dates back to the era of conventional surgery, has undergone several modifications in the laparoscopic era, and was first described in [22]. Many subtypes of gastric bypass surgery have been described. Nevertheless, Roux-en-Y gastric bypass (RYGB) remains the reference and gold standard procedure on which most studies have been performed and other bypass procedures compared. The single anastomosis gastric bypass has recently become the third most common procedure in the United States of America and the second most common in Europe [23].

Primary bypass procedures have reached such a level of maturity that a consensus has been reached when such operations are performed as primary procedures. However, when bypass surgeries are performed as revision procedures for complications or weight gain, there is a lack of consensus although there is a growing body of evidence to guide most surgeons on the size, length, and volume of the pouch as well as the various small bowel limb lengths [24].

Initially, it was difficult for the surgical community to convince referring physicians of the safety profile of commonly performed bariatric procedures. Despite the relatively high costs associated with bariatric patient morbidity, heavy investment in developing specialized instrumentation for each procedure, including intelligent vessel sealing and stapling technology and comprehensive training, are important to improve outcomes and minimize complications.

Overall, these measures have convinced the medical community that the risk has become minimal, and that bariatric surgery is safer than other forms of surgery, in part because it is performed by only the most qualified surgeons with superior skills, in part because much is invested in high-tech products that automate much of each procedure, and most importantly because, unlike other procedures, it results in an immediate improvement in the metabolism of most organs. Bariatric surgery has been extended to extreme age groups [25], extreme BMI [26], patients with organ failure [27], and transplant patients [28], among many others.

Bariatric surgery began as weight loss surgery. Therefore, it became associated with BMI, which is the most convenient rather than the most accurate measure of obesity [29]. It soon became apparent that bariatric surgery provides sustained improvement and, in many cases, permanent remission of most chronic diseases, including advanced diabetes, hypertension, hypercholesterolemia, hyperlipidemia, ischemic heart disease, and metabolic syndrome, among many others [30, 31].

Surgeons who have taken note of the metabolic and hormonal effects of bariatric surgery have decided to replace the term "weight loss surgery" with "metabolic surgery." American Society of Bariatric Surgery has become American Society for Bariatric and Metabolic Surgery (ASMBS) [32]. The antidiabetic effect of metabolic surgery was the cornerstone of most research. The multicenter, randomized control trial surgical treatment and medications potentially eradicate diabetes efficiently showed that bariatric surgery results were better than those of intensive medical therapy, with remission lasting over five years [33].

The surgical community knew that their next task was to extend the benefits of this treatment to as many patients as possible, including those deemed ineligible in the 1991 guidelines. BMI restriction was the obstacle, and the surgical community organized many multidisciplinary meetings to get the entire medical community to remove or at least reduce BMI restrictions [34]. Given the strength of the evidence, several non-surgical professional societies have softened their stance. Initially, American Diabetic Association recommended bariatric surgery for adults with a BMI >35 and type 2 diabetes when lifestyle and pharmacotherapy did not provide relief. Nevertheless, the 2019 Diabetes Surgery Summit, where 75.0% of attendees were non-surgeons, recommended bariatric surgery as an option for poorly controlled diabetics with a BMI>30. In the Asian population, the threshold was even lowered to 27.5% [35].

The recent joint ASMBS/International Federation for the Surgery of Obesity and Metabolic Disorders statement on the indication for metabolic surgery, published in 2022, is a further attempt to remove BMI as a restriction and not limit surgery to uncontrolled chronic disease. The new guidelines recommend surgery for diabetes with a BMI>30, even if the diabetes is adequately controlled by medical therapy [36].

The rearrangement of the small intestine and food detour was hypothesized to mediate the early metabolic effects of bariatric surgery in diabetes. Two main hypotheses were based on either loss of inhibitory signaling or loss of an unknown direct effect on insulin (foregut theory) [37] or rapid delivery of nutrients to L-cells in the distal intestine that stimulated the release of incretins such as glucagon-like peptide-1 (GLP-1) (hindgut theory) [38, 39]. Proponents of the foregut theory pushed for surgery for diabetes, even in non-obese individuals, by performing duodenojejunal bypass. However, the results were disappointing, and the mixed reactions led surgeons to refrain from such procedures. But, in Southeast Asia, responses to such procedures in overweight, non-obese individuals were more favorable, but variations were also noted [40].

The surgical community needed to study these phenomena and develop prognostic indicators to identify those with low BMI who might benefit from metabolic surgery. Some authors recommended alternative measures of fat percentage in low BMI patients to predict metabolic response, including waist-to-height ratio and relative fat mass. Other work focused on the difference between hormonally active central visceral fat in the portal circulation as the strongest predictor of response [41].

The literature review provides insight into the work done in this regard. However, there is still a lack of reliable evidence for identifying these topics and their ideal procedure. Such a procedure would have to be one with the highest success rate in metabolic cure, and the trade-off of getting rid of diabetes is worthwhile in terms of the risk and adverse events associated with such a procedure.

Scoring Systems

Previous research has focused on finding a reliable scoring system to identify those likely to relapse in the event of an intervention. Several scoring systems described in the literature claim to be able to predict the likelihood of diabetes remission. Even if this information is accurate, it falls short of the expectations of patients and the medical community. Patients and referring physicians want a scoring system that can predict the likelihood of remission for different procedures and provide a decision support system that allows patients to make an informed decision based on each intervention's desirable and undesirable effects. What makes this system difficult is the speed with which new bariatric procedures have been introduced and the frequent changes these procedures have undergone. In some cases, procedures have been abandoned or withdrawn from use, making conclusions from previous decades barely relevant [42]. Furthermore, due to the differences between procedures, it is unlikely that a conclusion drawn for one procedure is transferable to others. The mechanism of vertical SG for weight loss and the metabolic effect differs from all forms of gastric bypass [43]. Such conclusions are also not transferable for bypass procedures, whether simple or RY configuration, long or short limb [44]. Nevertheless, there is relatively sufficient data to draw simple conclusions about standard procedures such as vertical SG and RYGB [45].

Currently, only the individualized metabolic surgery (IMS) score [46] and the diabetes remission (Ad DiaRem) score [47], when applied, can suggest the best bariatric procedure for a given patient.

This review compares the existing scoring systems in terms of the relative value of the different components of each system, the presence or absence of external validation studies and the degree of suitability in such studies; the ability of the scoring system to discriminate between bariatric procedures in terms of outcome and, finally, whether any of the systems incorporate a risk stratification or scoring system to improve a surgeon's ability to make the correct recommendation for a particular patient.

A brief look at what components were included in all scoring systems can provide insight into the applicability and limitations of existing scoring systems. Although many scoring systems have been described, and several modifications exist for each scoring system, in this review, we have limited ourselves to the scoring systems that are widely used and have been externally validated by further independent studies [48, 49].

ABCD scoring system

ABCD scoring system was first developed in a large prospective cohort study to predict the chance of diabetes remission after RYGB as a metabolic surgery [50]. It is the only scoring system with a high score indicating a higher chance of remission (**Table 1**). The maximum score is 10, meaning the patient is older than 40 years, has a BMI of over 42, has a C-peptide level of over five ng/ml (15 nmol/l), and has had diabetes for less than one year. The lowest score of zero indicates a patient who is younger than 40, has a BMI below 27, has a C-peptide below two ng/ml (six nmol/l), and has had diabetes for more than eight years. It is, thus, the only system that includes BMI in the scoring [50]. In 2015, it was published the use of ABCD score in non-obese individuals undergoing

Table 1. Predicting remission of diabetes post-metabolic surgery: ABCD score [61]

Factor	Score
Age (years)	
<40	1
≥40	0
Body mass index (kg/m^2)	
<27.0	0
27.0-34.9	1
35.0-41.9	2
≥42.0	3
C-peptide (ng/ml)	
<2.0	0
2.0-2.9	1
3.0-4.9	2
≥5.0	3
Duration of diabetes mellitus (years)	
>8.0	0
4.0-8.0	1
1.0-3.9	2
<1.0	3
Total score is calculated by adding each of four variables	0-10

Note. Patients with higher ABCD scores were predicted to have a higher probability of type 2 diabetes mellitus remission after surgery; kg/m^2: Kilogram per square meter; & ng/ml: Nanograms per milliliter

bariatric surgery and reported a 23.0% complete remission rate compared to a 49.0% rate in individuals with a BMI between 30 and 35 and 79.0% in individuals with a BMI>35 [51].

Measurement of C-peptide may limit its application in day-to-day practice. The choice of two ng/ml as a cut-off was arbitrary [52]. It was measured fasting C-peptide levels in 56 diabetics who underwent RYGB and reported complete remission in 74.0% and partial remission in 16.0% of patients at a much lower C-peptide level>1 nmol/l (0.3 ng/ml), but no other studies shared that suggested cutoff point [53]. The study in [54] agreed with the study in [53] that the best cut-off point for C-peptide would be three ng/ml (nine nmol/ml). It was conducted a meta-analysis and documented the value of C-peptide in predicting remission but also showed that BMI had no impact on disease remission [55]. There was a partial remission in 82.0% of those above three ng/dl (nine nmol/l) and 44.0% in those below that level [52].

Age was given less weight in ABCD score compared to DiaRem [56], and Ad DiaRem scores [57], whereas it was not considered in IMS score. Older age was considered a poor prognostic sign, and in ABCD score, 40 years was the cutoff point. Research has shown that beta cell mass and low apoptosis rate are relatively well preserved with age and may not be responsible for diabetes. Still, an altered or absent adaptation of beta cell proliferation in response to decreased insulin sensitivity at the peripheral tissue level has been observed in both human and animal studies and in in vivo and in vitro experiments [58]. Most studies report non-significant physiological changes in most patients before 60, with 40 as the cut-off point for scientific merit. Several external validation studies showed the best area under the curve (AUC) receiver operator characteristics (ROC) for ABCD score is at a cutoff point of four, so in those with a score≥5, the area under the receiver-operating characteristic curve (AUC-ROC) was 0.85. It was conducted a comparative study between his ABCD score and DiaRem score [59]. It was concluded that the score was better than identifying the intermediate and poor risk groups [59], supported by [46], where IMS score was developed.

Table 2. Predicting remission of diabetes post-metabolic surgery: Comparison DiaRem & Ad DiaRem scores [61]

Factor	Score
DiaRem	
Age (years)	
<40	1
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 diabetic drugs	
No sulfonylureas/insulin-sensitizing agents not metformin	0
Sulfonylureas & insulin-sensitizing agents not metformin	3
Treatment with insulin	
No	0
Yes	10
Total score is calculated by adding each of four variables	0-22
Ad DiaRem	
Age (years)	
30-60	1
<30 or >60	2
Body mass index (kg/m^2)	
>27	1
≤27	2
Duration of type 2 diabetes mellitus (years)	
<10	1
≥10	2
Microvascular complications	
No	1
Yes	2
Macrovascular complications	
No	1
Yes	2
Pre-operative insulin use	
No	1
Yes	2
Stimulated C-peptide (ng/ml)	
≥4	1
<4	2
Total score calculated by adding each of the seven variables	7-14

Note. Lower scores indicate a higher probability of achieving remission after surgery; kg/m^2: Kilogram per square meter; & ng/ml: Nanograms per milliliter

DiaRem & Ad DiaRem scores

DiaRem and Ad DiaRem scores were first developed in 2013 to predict diabetes remission post-RYGB [60]. Near 45.0% of the score's weight is in the use of insulin, and if medication use is added, the relative weight reaches 59.0%, and HbA1C control carries 27.0% of the score weight. The remainder is related to age (14.0%). In the original DiaRem study on RYGB patients, patients were grouped into two good score groups of zero-two and three-seven with remission rates of 88.0%-99.0% and 64.0%-88.0%, respectively. A moderate score group of eight-12 with a remission rate of 23.0%-49.0% and two high-risk groups, 12-17 and 18-22, with remission rates of 11.0%-33.0% and 2.0%-16.0%, respectively [60].

ABCD score was compared (**Table 1**) against DiaRem and Ad DiaRem scores (**Table 2**) in one anastomosis gastric bypass patients [61, 62]. It was concluded that DiaRem score had the highest AUC, followed by ABCD and Ad DiaRem scores [61, 62].

Table 3. Characteristics of patients by diabetes severity stage & bariatric surgical technique [46]

Preoperative patient characteristics	Mild stage		Moderate stage		Sever stage	
	RYGB	SG	RYGB	SG	RYGB	SG
Duration of diabetes (years)	1.4±0.7	1.4±0.8	5.1±3.1	6.3±3.4	14.5±6.7	13.2±5.3
Insulin use percentage (%)	0.0	0.0	15.0	19.0	85.0	84.0
Body mass index (kg/m^2)	47.9±6.3	50.8±10.3	46.7±8.9	46.8±12.3	44.7±7.2	44.6±10.9
Glycemic control (HbA1c<7.0%)	97	95	42	35	12	8

Note. RYGB: Roux-en-Y-gastric bypass; SG: Sleeve gastrectomy; & kg/m^2: Kilogram per square meter

A main critique of DiaRem score is the influence of the practice pattern on the score, where socioeconomic factors often play a role in prescribing preference from the physician's perspective and compliance on the patient's side. A patient who is non-compliant with diet or medication may receive a high initial score, even if he had a good pancreatic reserve, and probably would be mislabelled as a poor risk because he was prescribed insulin earlier.

Attempts at modifying DiaRem score included Ad DiaRem score, which was suggested, where much of the weight of insulin use was shifted to the duration of illness to improve the positive predictive value and negative predictive value of the scoring system [57]. A major drawback against the duration of illness is that in many patients, it may not differentiate between many years of mild diabetes in a patient with a high BMI and preserved beta cell function from a patient whose diabetes was severe from the time of inception with rapid deterioration of the illness. It was suggested the duration of insulin use is more appropriate in detecting the high-risk group unlikely to remit [63].

Furthermore, contrary to expectation, it was shown no benefit in adding the beta cell reserve measurement to Ad DiaRem and ABCD scores in improving AUC-ROC of the remission prediction [64]. Yet, a major critique of such a study is the group's heterogeneity in which low and high-score patients were analyzed together, and no differentiation was made between patients who underwent RYGB or SG, two distinct procedures with different metabolic effects.

It was examined DiaRem score discriminating capability among different ethnicities and procedures [65]. While white patients did not differ from Hispanic patients, RYGB had the highest AUC-ROC curves (0.85) instead of SG (0.69). The mechanism by which SG works is mostly weight-loss dependent via ameliorating peripheral insulin resistance. Hence, preoperative BMI greatly influences insulin resistance, which is not a component of DiaRem score, which explains the low AUC-ROC in SG under this score [65].

From this study, as well as from the work of [66], it is clear that the results are diluted if most patients belong to the low to medium-risk group. No significant conclusions can be drawn that could influence practice, which explains why scoring systems often predict a lower remission rate than is case [66].

IMS score

IMS score was first described as the first tool to suggest the procedure of choice for a particular patient [46]. The decision-making is not solely based on the remission rate in each risk group but on the interpretation of the difference in remission when comparing SG vs. RYGB (**Table 3**). A normogram was made in which four predictors were included–duration of illness, number of medications, glycemic control, and insulin use–making it quite similar to Ad DiaRem score. Still, the weight of each factor was different. Half of the weight of the score is related to the duration of illness, but it used a duration of up to 40 years, and a third of the weight went to the number of medications.

Glycemic control had a very low impact on the score (8.0%) only, and BMI had no bearing on the score, which probably explains why it was skewed against SG towards choosing RYGB in both <25 low risk and the 25-95 intermediate-risk groups. The argument for selecting SG in the high-risk group was not a result of better remission in SG but rather because, in the author's opinion, RYGB is unlikely to offer additional remission benefit over the sleeve.

This argument is flawed in our opinion because it will direct many patients in the low-risk group to RYGB when the majority of patients would like to undergo a less demanding procedure such as SG, which would probably produce similar remission results in the low-risk patients and does not factor the potential unique side effects of RYGB, such as an undesirable hyperinsulinemic neuroglycopenia.

Furthermore, in the absence of any form of evaluation of the secretory capacity of the pancreas, some patients with a prolonged history of non-insulin-treated mild diabetes on multiple drug therapy may fall into the high-risk group and hence would be denied the chance for a higher remission rate associated with the proinsulinemic effect of RYGB in patients with preserved beta cell function (**Table 3**).

Ad Diarem or Ad DiaRem score is the closest to IMS score as it shares the same factors of IMS score with different relative weights because it added the age with a relative weight of 29.0% at the expense of duration of illness and gave more. Ad DiaRem score had a better AUC-ROC when compared to IMS. It showed a relative increase in remission rate when comparing RYGB to SG across all risk groups. The difference was highest (a 120.0% improvement) in the highest-risk group as opposed to a 15.0% marginal improvement in the low-risk group, which goes against IMS philosophy of selecting SG in the high-risk groups and RYGB in the low-risk groups.

Furthermore, IMS score was applied to Swiss multicenter bypass or sleeve study and sleeve vs. bypass diabetic patients [67]. Similar conclusions were come up to what we predicted. It was shown that the remission scores were almost identical in the low- and intermediate-risk groups between those who underwent RYGB vs. sleeve (88.0% vs. 86.0% and 44.0% vs. 46.0%, respectively). The only difference he was able to demonstrate was the fact in the high-risk group, 18.0% of those who underwent RYGB had complete remission as opposed to 0.0% in SG group. In their conclusion, RYGB is of value in the high-risk groups to give the highest chance for those at risk of complications [67].

WHO BENEFITS FROM WHICH PROCEDURE?

Several published reports have shown the efficacy of metabolic surgery in treating diabesity and/or its related

Table 4. Post-metabolic randomized controlled clinical trials show remission rates for diabesity [68]

Study design	PBMI (<35 kg/m^2)	Study design	F-P (months)	n (R)	Remission or change in HbA1c (%)	Remission criteriaa	p-value
AGB vs. control	22.0%	AGB vs. control	24	60	73.0% vs. 13.0%	HbA1c<6.2%	<.0010
RYGB vs. SG vs. control	36.0%	RYGB vs. SG vs. control	36	150	22.0% vs. 15.0% vs. 0.0%	HbA1c≤6.0%	<.0500
RYGB vs. BPD vs. control	0.0%	RYGB vs. BPD vs. control	60	60	42.0% vs. 68.0% vs. 0.0%	HbA1c≤6.5%	.0030
RYGB vs. control	59.0%	RYGB vs. control	24	120	44.0% vs. 9.0%	HbA1c<6%	<.0010
RYGB vs. control	100%	RYGB vs. control	12	101	90.0% vs. 0.0%	HbA1c<6.5%[b]	<.0001
RYGB vs. control	34.0%	RYGB vs. control	12	38	58.0% vs. 16.0%	HbA1c<6.5%	.0300
RYGB vs. AGB vs. control	43.0%	RYGB vs. AGB vs. control	36	69	40.0% vs. 29.0% vs. 0.0%	HbA1c<6.5%	.0040
AGB vs. control	100%	AGB vs. control	24	51	52.0% vs. 8.0%	FBG<7.0 mmol/L	.0010
RYGB/AGB/SG vs. control	100%	RYGB/AGB/SG vs. control	6	57	65.0% vs. 0.0%	HbA1c<6.5%	.0001
AGB vs. control	34.0%	AGB vs. control	12	45	33.0% vs. 23.0%	HbA1c<6.5%[c]	.4600
RYGB vs. control	25.0%	RYGB vs. control	12	43	60.0% vs. 5.9%	HbA1c<6.0%	.0020
RYGB vs. control	85.0%	RYGB vs. control	24	80	60.0% vs. 2.5%	HbA1c<6.5%	<.0010

Note. BPD: Biliopancreatic diversion; AGB: Adjustable gastric banding; RYGB: Roux-en-Y gastric bypass; FBG: Fasting blood glucose; SG: Sleeve gastrectomy; BMI: Body mass index; PBMI: Patients with BMI; F-P: Follow-up; R: Randomized; n: Number of patients; [a]Remission was a primary or secondary endpoint (raching HbA1c value without diabetes medication unless otherwise specified); [b]Remission not precisely defined (HbA1c<6.5% by extrapolation); & [c]On/off diabetes medications

complications [68, 69]. Remission of type 2 diabetes mellitus is often defined as a decrease in the HbA1c levels<6.5% without hypoglycemic agents. Improvement denotes normalization of HbA1c with a decrease in dosage of glucose-lowering medications [69]. In a prospective study (a follow-up of 15 years) among Swedish obese patients with impaired fasting glucose, the risk reduction was reduced by 87.0%, and the incidence of type 2 diabetes mellitus was reduced by 78.0% with metabolic surgery [70].

A systematic review and meta-analysis that included 4,070 patients with diabesity in 19 studies found that improvement was 87.0% and remission of type 2 diabetes mellitus was 78.0% during two or more years after metabolic surgery [69]. Unfortunately, there are very few randomized controlled trials that have compared surgical and non-surgical interventions in patients with diabesity. Overall, the results of all these studies support a significant improvement in glycemic control for surgery, as summarized in **Table 4** [68].

High-Risk Diabetic Patients

Undoubtedly, most low and intermediate-risk patients would respond to SG and RYGB. The discrepancy in response is mainly in the high-risk group. However, the problem is defining who belongs to the responders and the non-responders in the high-risk group. The scoring systems have significant flaws that make conclusions at the end of this review difficult and probably inaccurate.

Put simply, patients with a high BMI are less likely to be in high-risk group if one simply understands the pathophysiology of diabetes in these patients. Most of these patients develop increased peripheral resistance to the action of insulin and may have preserved pancreatic secretory capacity. These patients have been categorized as an intermediate risk group in DiaRem score as opposed to ABCD score, which may explain the better fitness of AUC-ROC for the poor risk group under DiaRem score compared to ABCD score.

A score that considers the duration of insulin use or microvascular or macrovascular complications in a diabetic patient might give better agreement [71]. Also, fasting C-peptide levels might be important in low BMI groups. However, the cutoff point needs to be re-evaluated. The fact that other forms of bypass, including gastric bypass with anastomosis, have become more popular than RYGB outside North America needs to be studied before extrapolating results.

The fact that the length of the biliopancreatic limb is two to three times longer in gastric bypass with an anastomosis than in RYGB deserves special evaluation if we assume that the weight-independent incretin/decretin effect, as postulated by the foregut and hindgut theory to play a major role in the superior effect of RYGB over other procedures. In the Western world, practice guidelines can eliminate the bias of physicians in prescribing or introducing insulin, and endocrinologists must consider that many patients suffer from the combination of obesity and diabetes or diabesity. Treatment has shifted to more liberal use of GLP-1 and glucose-dependent insulinotropic polypeptide agonists, and these drugs were not present when risk scoring systems were developed. Response to such agents should be considered a positive predictor of preserved secretory capacity despite low C-peptide levels.

Low- & Intermediate-Risk Patients

Low-risk patients may not need to undergo the strongest metabolic procedure without being warned of the potential for exaggerated proinsulin response with disabling hypoglycemia or neuroglycopenia. The use of grading of recommendation, assessment, development, and evaluation allows patient to participate in decision-making process for a procedure, as most suggestions in grading systems are on low evidence and are likely to be weak or conditional recommendations. Unlike strong recommendations, where there is no need to discuss the alternatives, a weak recommendation involves the patient in the decision-making process based on their values and preferences, especially if there is a balance between each option's desirable and undesirable effects. The scoring system has not evaluated any systems; we believe it is necessary today.

CONCLUSIONS

In conclusion, there are different predictive scoring systems for a better evidence-based selection of the best metabolic surgery, either sleeve or mini-bypass, for each patient, ensuring the highest chance of diabetes remission. Using the metabolic score calculator is a useful tool to help medical specialists determine optimal treatment strategy for a particular patient. More research is needed before we agree on ideal bariatric procedure and select only those patients who will benefit from bariatric surgery to achieve the highest chance of remission with lowest incidence of hypoglycemia.

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