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REVIEW

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International expert consensus on surgery for type 2 diabetes mellitus

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Abstract

Introduction Metabolic and bariatric surgery (MBS) has been an established treatment option for patients with Type 2 diabetes mellitus (T2DM), but there is a relative paucity of evidence-based guidelines on preoperative, operative, and postoperative considerations concerning metabolic surgery for T2DM patients. To address this gap, we initiated a Delphi consensus process with a diverse group of international multidisciplinary experts.

Method We embarked on a Delphi consensus-building exercise to propose an evidence-based expert consensus covering various aspects of MBS in patients with T2DM. We defined the scope of the exercise and proposed statements and surveyed the literature through electronic databases. The literature summary and voting process were conducted by 52 experts, who evaluated 44 statements. The quality of evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria.

Results Consensus, defined as > 80% agreement, was reached for 43 out of 44 statements. The experts reached an agreement on the nature, terminology, and mechanisms of action of MBS. The currently available scores for predicting remission of T2DM after surgery are not robust enough for routine clinical use, and there is a need for further research to enable more personalized treatment. Additionally, they agreed that metabolic surgery for T2DM is cost-effective, and MBS procedures for treating T2DM vary in their safety and efficacy.

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Conclusion This Delphi expert consensus statement guides clinicians on various aspects of metabolic surgery for T2DM and also grades the quality of the available evidence for each of the proposed statements.

Keywords Metabolic Surgery, Bariatric Surgery, Type 2 diabetes mellitus

Introduction

Metabolic and Bariatric surgery (MBS) is an established treatment for patients with type 2 diabetes mellitus (T2DM) [1, 2]. Obesity is one of the most important risk factors for T2DM [1, 3], and significant weight loss achieved through MBS or other approaches can lead to improvement and remission of T2DM [1, 4]. Improvements in T2DM post-MBS, however, may also be mediated through non-weight-loss dependent mechanisms [4]. Both weight loss and T2DM improvement show considerable variation after MBS [5]. The most commonly performed surgical procedures, Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG), are increasingly incorporated into treatment algorithms for T2DM [6, 7]. Despite this, there is a relative lack of evidence-based and clear guidelines on perioperative considerations concerning MBS for patients with T2DM.

The modified Delphi methodology is a recognized process for developing consensus amongst experts on topics that require additional high-quality evidence to inform current practice [8]. Since no consensus statement covers various aspects of MBS in patients with T2DM, we embarked on a Delphi consensus-building exercise. This work aimed to achieve a consensus amongst a multidisciplinary, international group of experts on multiple aspects of metabolic surgery for T2DM.

Methods

We established a multidisciplinary group of 52 experts, including metabolic and bariatric surgeons, endocrinologists, GPs with specialist interest, dietitians, psychologists, anaesthesiologists, and a patient representative from 23 countries (Supplementary Material 1), to carry out this consensus-building exercise. The selection of experts was based on their expertise, academic qualifications, proficiency in the English language, and willingness to participate in the exercise. Of 61 experts invited to join the project, 52 (85.0%) accepted the invitation. The Delphi methodology was shared with the group in advance, and two moderators (MK and KM) moderated all communication.

This adopted methodology has been used previously [8]. As the first step, experts were invited to submit statements covering various aspects of MBS for T2DM. These were then compiled by the moderators and presented to the group for further discussion. Group members were advised to only communicate through moderators to prevent any influence on opinions. Communication was through emails and online meetings with the moderators. The levels of agreement/disagreement were classified using a six-point Likert scale. Moderators assigned 2–3 statements to each expert in their areas of expertise to compile the evidence.

This work was further supplemented by a core study team of non-voting members (IO, SP, SS, and SK), who summarised the relevant literature. The core team researched literature and focused on high-quality evidence from levels 1 and 2. The moderators then reviewed the list of publications. This summary of evidence was then graded using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) guideline criteria [9] (Table 1). The summary and the evidence grade were then shared with the consensus-building team.

The committee discussed the proposed statements and went through several rounds of modifications. Ultimately, the committee agreed on a set of statements to vote on using the SurveyMonkey® platform. The first round of voting took place between July 17, 2022, to August 20, 2022. An agreement of ≥80% of experts was regarded

Table 1 GRADE criteria

Code	Quality of Evidence	Definition
A	High	Further research is very unlikely to change our confidence in the estimate of effect; the statement can be supported by several high-quality studies with consistent results or, in special cases, by one large, high-quality multicentre trial
B	Moderate	Further research is likely to have an important effect on our confidence in the estimate of effect and might change the estimate; the statement can be supported by one high-quality study or several studies with some limitations
C	Low	Further research is very likely to have an important effect on our confidence in the estimate of effect and is likely to change the estimate; the statement can be supported by one or more studies with severe limitations
D	Very Low	Any estimate of effect is very uncertain; the statement can be supported by expert opinion or one or more studies with very severe limitations, or there might be no direct research evidence

as consensus. The results of the voting were then shared with the consensus building team.

The whole process was then repeated for the statements that the committee did not reach a consensus on after the first round of voting. During the second round, committee members were also able to add new statements, modify previous statements, or eliminate statements where no consensus was possible. After discussion over several rounds, a set of statements was proposed for second-round voting between October 21, 2022 and October 30, 2022.

Results

Fifty-two experts agreed on 43 statements, yielding 27 recommendations (Table 2) on MBS for T2DM after two rounds of the Delphi methodology. Figure 1 shows the study flowchart.

The statements and recommendations covered nine different aspects (Table 2), namely I-Nature, Terminology and Mechanisms of Action, II-Predictors of Remission, III-Preoperative Diabetic Control, IV-Perioperative Care, Monitoring and Special Considerations, V-Care Pathways and Logistics of Service, VI- Accurate Classification of Diabetes Mellitus, VII-Surgical Considerations, VIII-Communication with Primary Care and Extended Follow-up, and IX-Remission and Recurrence.

Ninety-five per cent agreed that surgery has a strong evidence-based role in treating some patients with T2DM, and 94% agreed that metabolic surgery for T2DM works through both weight-loss-dependent and weight-loss-independent mechanisms. The expert panel recommended using the term"Metabolic Surgery for T2DM" as a common descriptor for surgery aimed at treating people with T2DM. Ninety-six per cent of the panel agreed that the beneficial impact of metabolic surgery for T2DM depends on many factors. Additionally, 86% agreed that metabolic surgery for T2DM only has a role in individuals with obesity, and the currently available scores for predicting remission of T2DM after surgery are not robust enough for routine clinical use. However, 92% agreed on the need to optimize glycemic control to an HbA1c level of $\leq$69 mmol/mol ($\approx$ 8.5%), and 83% agreed that HbA1c >69 mmol/mol should not be considered an absolute contraindication for patients undergoing surgery for T2DM.

The experts agreed on six statements related to perioperative care and monitoring and recommended that patients undergoing metabolic surgery for T2DM should be reviewed by a diabetologist for perioperative management of diabetes. Additionally, they recommended frequent glucose and blood pressure monitoring in the early postoperative phase.

There was complete consensus (100%) on the barriers that prevent patients from accessing surgery for diabetes, including insufficient awareness of the benefits and risks of surgery amongst many healthcare professionals, insufficient awareness amongst patients on the safety and efficacy of surgery, lack of funding or insurance coverage for surgery, mandatory weight loss targets, lack of capacity for delivering surgery to eligible patients, weight bias towards access to healthcare, stigma, and shame of obesity.

A complete consensus was achieved that the referral criteria for surgery should not be based on BMI alone, and the patient's other obesity-associated medical and mental health conditions and quality of life should be considered.

Accurate diagnosis of the type of diabetes was an important domain of the consensus, and the panel recommended considering alternative diagnoses for T2DM, such as T1DM or Maturity Onset Diabetes of Young (MODY), before referring patients for surgery. Additionally, surgery can be an option in selected patients with T1DM or Latent Autoimmune Diabetes in Adults (LADA) who also meet BMI criteria for MBS.

Regarding the surgical considerations, 86% agreed that gastric balloons have no role for patients seeking metabolic surgery for T2DM apart from being used as a bridge to facilitate surgery, and 83% agreed that there is currently insufficient evidence to suggest a role for endoscopic sleeve gastroplasty in these patients.

Ninety-four per cent agreed that the patients should be followed up in a multidisciplinary environment for the first two years after surgery. The panel recommends that remission is defined as an HbA1c of <48 mmol/mol (< 6.5%) for at least three months in the absence of glucose-lowering pharmacotherapy.

Discussion

Nature, terminology, and mechanisms of action

Surgery performed primarily for T2DM may differ from bariatric surgery; it has different goals from bariatric surgery. There is now a large body of literature, including randomized studies [10, 11] focusing on surgery for patients with T2DM. It may, therefore, be necessary to differentiate between bariatric surgery and metabolic/diabetes surgery [12]. Both terms"metabolic surgery"and"diabetes surgery"have been used in previous consensus-building exercises on this topic [6, 7]. However, the use of the term "Type 2 Diabetes Surgery" did not reach a consensus in this exercise.

Level 1 evidence supports the role of surgery in treating patients with T2DM [2, 13] and international diabetes and obesity organizations have recommended it [7]. Further, high-quality evidence confirms that surgery is

Table 2 Statements and recommendations

	Statement	First Round	Second Round	Grade	Relevant Recommendations
I	**Nature, Terminology, and Mechanisms of Action**				
1	Surgery for Type 2 Diabetes Mellitus (T2DM) is largely similar to bariatric surgery, the only difference being the primary focus, which is diabetes improvement/remission and prevention of complications of diabetes in this case, with weight loss being considered a secondary benefit. This allows patients with diabetes to be considered for surgery at a lower BMI than historically recommended thresholds for bariatric surgery and may influence the choice of surgical procedure. Care must, however, be taken to ensure that this does not result in stigmatization and under-treatment of people with other serious obesity-associated conditions	96% Agree (Consensus)	-	Grade A	Surgery for Type 2 Diabetes Mellitus (T2DM) is similar to bariatric surgery, but allows patients with diabetes to be considered for surgery at a lower BMI
2	The term "Type 2 Diabetes Surgery" should be used as a common descriptor for surgery aimed at treating people with T2DM	57% Agree (No -Consensus)	61% Agree (Non-Consensus)	Grade D	The term "Metabolic Surgery for T2DM" should be used as a common descriptor for surgery aimed at treating people with T2DM
3	The term "Metabolic Surgery for T2DM" should be used as a common descriptor for surgery aimed at treating people with T2DM	77% Agree (No-Consensus)	84% Agree (Consensus)	Grade D	
4	Surgery has a strong evidence-based role in the treatment of some patients with Type 2 Diabetes Mellitus	95% Agree (Consensus)		Grade A	Surgery has a strong evidence-based role in the treatment of patients with T2DM that works through both weight-loss dependent and weight-loss independent mechanisms and changes multiple signals (metabolic, biliary, neural, hormonal)
5	Surgery for T2DM works through both weight-loss-dependent and weight-loss-independent mechanisms	94% Agree (Consensus)		Grade B	
6	The surgery alters how the gut communicates with the rest of the body by changing multiple signals (metabolic, biliary, neural, hormonal)	92% Agree (Consensus)		Grade A	
II	**Predictors of Remission**				
7	The beneficial impact of surgery for T2DM depends on factors such as age, preoperative Body Mass Index (BMI), diabetes duration, preoperative glycaemic control, pancreatic beta-cell reserve, waist circumference, and the presence of other obesity-associated conditions	96% Agree (Consensus)		Grade A	The beneficial impact of surgery for T2DM depends on factors such as younger age, higher baseline BMI, shorter diabetes duration, and better preoperative glycaemic control represented by higher c-peptide level, lower HbA1c, and less insulin usage. Surgery for T2DM ONLY has a role in individuals with a Body Mass Index of ≥ 30 kg/m2, or 27.5 kg/m2 in some Asian populations Despite some existing scores such as ABCD score and DiaRem, It seems that there is an essential need for more accurate predicting scores
8	Surgery for T2DM ONLY has a role in individuals with obesity (i.e., Body Mass Index of ≥ 30 kg/m2, or 27.5 kg/m2 in some Asian populations)	86% Agree (Consensus)		Grade A	
9	Those with a longer duration of T2DM or on insulin are less likely to benefit from surgery in terms of remission but will benefit from improvement in glycaemic control, obesity, and other associated conditions	92% Agree (Consensus)		Grade A	
10	Currently, available scores for predicting remission of T2DM after surgery are not robust enough for routine clinical use, and there is a need for greater research for more personalization of treatment	86% Agree (Consensus)		Grade B	
III	**Preoperative Diabetic Control**				

Table 2 (continued)

	Statement	First Round	Second Round	Grade	Relevant Recommendations
11	HbA1c > 69 mmol/mol (≈ 8.5%) should not be considered an absolute contraindication for patients undergoing surgery for T2DM because of the effect of preoperative diet and surgery on glycemic control	69% Agree (No- Consensus)	83% Agree (Consensus)	Grade B	HbA1c levels matter but all efforts should be made to optimize glycaemic control to an HbA1c level of ≤ 69 mmol/mol (≈ 8.5%) but surgery should not be delayed unduly to achieve this
12	All efforts should be made to optimize glycaemic control to an HbA1c level of ≤ 69 mmol/mol (≈ 8.5%), but surgery should not be delayed unduly to achieve this	92% Agree (Consensus)		Grade A	
13	Patients undergoing surgery for T2DM should be reviewed by a diabetologist (or an appropriately trained healthcare professional supported by them) for the formulation of a plan for perioperative and postoperative glycaemic management of diabetes (including the period covering any preoperative liver-reducing diet)	92% Agree (Consensus)		Grade B	
IV	**Perioperative Care, Monitoring, and Special Considerations**				
14	Preoperative liver-reducing diets are safe for these patients with adequate supervision and support from dietitians, pharmacists, and diabetologists as needed. Patients should receive appropriate advice regarding glucose and blood pressure-lowering medications and monitoring	96% Agree (Consensus)		Grade B	Patients undergoing surgery for T2DM should be reviewed by a diabetologist for perioperative and postoperative glycaemic management of diabetes (including preoperative liver-reducing diet and adjustment of dosage of glucose and blood pressure-lowering agents after surgery)
15	Doses of glucose and blood pressure-lowering agents may need further adjustment after surgery in consultation with diabetologists (or an appropriately trained healthcare professional supported by diabetologists)	98% Agree (Consensus)		Grade A	
16	Frequent capillary/interstitial glucose and blood pressure monitoring (in those on antihypertensives) are advised in the early postoperative phase to allow for titration of doses of medications used for these conditions	94% Agree (Consensus)		Grade A	Frequent capillary/interstitial glucose and blood pressure monitoring (in those on antihypertensives) are advised in the early postoperative phase to allow for titration of doses of medications
17	Postprandial hypoglycemia (also known as reactive hypoglycemia) is a mostly mild complication of foregut surgery. It is more common after diversionary procedures, not more common in patients with T2DM, and can be serious	87% Agree (Consensus)		Grade A	Postprandial hypoglycemia (also known as reactive hypoglycemia) is more common after diversionary procedures, is no more common in patients with T2DM, and can be serious. These patients should be referred to diabetologists for further investigation and management
18	Patients with suspected postprandial hypoglycemia should be referred to diabetologists for further investigation and management	90% Agree (Consensus)		Grade A	
19	Sodium-Glucose Co-Transporter 2 Inhibitors (SGLT2i) should be stopped before surgery or before starting a preoperative low-energy diet to reduce the risk of ketoacidosis. The risk will persist for several months after surgery, and the decision to restart these drugs in the long term should only be made after a careful discussion of the pros and cons with the patient	83% Agree (Consensus)		Grade A	Based on the evidence we suggest stopping SGLT2 inhibitors 48 h prior to surgery to reduce the risk of ketoacidosis
V	**Care Pathways and Logistics of Service**				

Table 2 (continued)

	Statement	First Round	Second Round	Grade	Relevant Recommendations
20	Some of the barriers that prevent patients from accessing surgery for diabetes include (Insufficient awareness of the benefits and risks of surgery amongst many healthcare professionals, Insufficient awareness amongst patients on the safety and efficacy of surgery, Lack of funding or insurance coverage for surgery, Mandatory weight loss targets, Lack of capacity for delivering surgery to eligible patients, Weight bias towards access to healthcare, Stigma toward people with obesity, Shame amongst patients because of obesity) There is a need for targeted measures such as advocacy and evidence-based campaigns to address this issue	100% Agree (Consensus)		Grade A	There is a need for targeted measures to address barriers that prevent patients from accessing surgery for diabetes include (Insufficient awareness of the benefits and risks of surgery amongst many healthcare professionals and patients, Lack of funding or insurance coverage for surgery and Stigma toward people with obesity, Shame amongst patients because of obesity)
21	All patients with T2DM meeting the criteria for surgery should be offered a choice of energy deficit diets (including meal replacement products) and/or available pharmacological options (if not used previously) with a full discussion of benefits, risks, and duration of treatment in comparison with surgery by a healthcare professional expert in weight management before referral for surgery. Evidence on comparative durability of effect should be specifically provided to ensure fully-informed decision-making	88% Agree (Consensus)		Grade A	While surgery is the most effective and durable, patients have a right to be informed about treatment options such as dietary and lifestyle interventions and pharmacological therapy with a full discussion of benefits, risks, and duration of treatment in comparison with surgery by a healthcare professional to make their own decisions about their preferred treatment
22	Referral criteria for surgery should not be based on BMI alone and also consider the patient's other obesity-associated medical and mental health conditions and quality of life	100% Agree (Consensus)		Grade C	Referral criteria for surgery should not be based on BMI alone and also consider the patient's other obesity-associated medical and mental health conditions, and quality of life
23	Mandatory medical weight management should not be a prerequisite for surgery for T2DM, but patients should have seriously attempted to lose weight in the past with the help of appropriate lifestyle/dietary education and available pharmacological interventions	88% Agree (Consensus)		Grade B	Medical weight management it's not necessary for surgery for T2DM but patients should have seriously attempted to lose weight in the past with the help of appropriate lifestyle/dietary education and available pharmacological interventions
24	Patients should receive comprehensive dietetic assessment and education, information about the risks and benefits of surgery, and education on living with surgery as part of routine preoperative assessment and planning	100% Agree (Consensus)		Grade A	Patients should receive comprehensive dietetic assessment and education, information about the risks and benefits of surgery, and access to a peer support group and MDT including dietitians, psychologists, and diabetologists both before and after surgery.
25	Patients should have access to a peer support group and multidisciplinary team, including dietitians, psychologists, and diabetologists, both before and after surgery	98% Agree (Consensus)		Grade A	Patients not eligible for surgery on the grounds of mental health contraindications should be referred for appropriate mental health treatment and support
26	Mental health contraindications of surgery include conditions such as unstable major affective or psychotic disorders; active substance/alcohol abuse; self-harm or suicidal attempts in the previous 12 months; severe, untreated eating disorder; and severe learning disability (without adequate family/social support making it difficult to cope with demands of surgery). Patients not eligible for surgery on the grounds of mental health contraindications should be referred for appropriate mental health treatment and support	96% Agree (Consensus)		Grade B	
VI	**Accurate Classification of Diabetes Mellitus**				
27	Consider alternative diagnoses for T2DM, such as T1DM or Maturity Onset Diabetes of Young (MODY), before referring patients for surgery	90% Agree (Consensus)		Grade B	Consider alternative diagnoses for T2DM such as T1DM or Maturity Onset Diabetes of Young (MODY) before referring patients for surgery

Table 2 (continued)

	Statement	First Round	Second Round	Grade	Relevant Recommendations
28	Surgery can be an option in selected patients with T1DM who also meet BMI criteria for bariatric surgery and may thus benefit from better glycaemic control and weight loss, but the decision for surgery should not be taken without consulting a diabetologist in these patients	84% Agree (Consensus)		Grade A	Surgery can be an option in selected patients with T1DM or Latent Autoimmune Diabetes in Adults (LADA) who also meet BMI criteria for bariatric surgery and may thus benefit from better glycaemic control and weight loss but the decision for surgery should not be taken without consulting a diabetologist in these patients
29	Surgery can be an option in selected patients with Latent Autoimmune Diabetes in Adults (LADA) who also meet BMI criteria for bariatric surgery and may thus benefit from better glycaemic control and weight loss, but the decision for surgery should not be taken without consulting a diabetologist in these patients	90% Agree (Consensus)		Grade A	
30	Routine antibody/C peptide level testing to rule out T1DM is unnecessary before surgery for diabetes. This should be left to the discretion of the diabetologists	83% Agree (Consensus)		Grade C	Antibody/C-peptide level can help to increase the accuracy of preoperative diabetes classification and rule out T1DM but it is unnecessary before surgery for diabetes
VII	**Surgical Considerations**				
31	Patients undergoing surgery do not routinely need to be admitted to the hospital before the day of surgery	98% Agree (Consensus)		Grade D	Patients undergoing surgery do not routinely need to be admitted to the hospital before the day of surgery, but should be prioritised as the first case of the day if they are on drugs that can cause hypoglycaemia
32	Patients undergoing surgery should be prioritized as the first case of the day if they are on drugs that can cause hypoglycemia	88% Agree (Consensus)		Grade D	
33	Gastric Balloons have no role for patients seeking surgery for T2DM (except when they are used as a bridge to facilitate surgery)	86% Agree (Consensus)		Grade B	Gastric Balloons have no role for patients seeking surgery for T2DM (except when they are used as a bridge to facilitate surgery). Additionally, there is insufficient evidence to suggest a role for Endoscopic Sleeve Gastroplasty for patients seeking surgery for T2DM
34	Currently, there is insufficient evidence to suggest a role for Endoscopic Sleeve Gastroplasty for patients seeking surgery for T2DM	83% Agree (Consensus)		Grade B	
35	Surgery for T2DM is a treatment option for adolescent patients who meet the criteria for surgery but should only be carried out in specialized centers with an appropriate multidisciplinary team, including pediatricians, bariatric physicians (or diabetologists), psychologists, and dietitians	96% Agree (Consensus)		Grade A	Surgery for T2DM is a treatment option for adolescent patients who meet the criteria for surgery but should only be carried out in specialized centers with an appropriate MDT including pediatricians, bariatric physicians (or diabetologists), psychologists, and dietitians
36	Surgery for T2DM is cost-effective	98% Agree (Consensus)		Grade A	Surgery for T2DM seems to be cost-effective over 10-year and lifetime horizons
37	Surgical procedures aimed at treating T2DM vary in their safety and efficacy	96% Agree (Consensus)		Grade A	Surgical procedures aimed at treating T2DM vary in their safety and efficacy. The more weight loss, the better the effect in terms of T2DM remission/improvement: BPD > OAGB > RYGB > LSG. Regarding safety, LSG is safer than RYGB > OAGB > BPD
VIII	**Communication with Primary Care and Extended Follow-up**				
38	Patients and their General Practitioners should be given clear written as well as verbal information at the time of discharge regarding the nature of the surgical procedure, post-discharge medications/supplements, diabetes management post-surgery, and any changes in the management of diabetes and other associated health conditions	100% Agree (Consensus)		Grade D	Patients and their General Practitioners should be given clear written as well as verbal information at the time of discharge regarding the nature of the surgical procedure, post-discharge medications/supplements, and changes in the diabetes management post-surgery to decrease the incidence of preventable medication-induced complications

Table 2 (continued)

	Statement	First Round	Second Round	Grade	Relevant Recommendations
39	Post-surgery for T2DM, patients should have their HbA1c levels checked every 3 months for the first year or until stable and annually after that	90% Agree (Consensus)		Grade D	Post-surgery for T2DM, patients should have their HbA1c levels checked every 3 months for the first year or until stable, and annually after that (this strategy may significantly help to monitor the changes in serum glucose after surgery accurately and modify the dosage of the antidiabetic agents)
40	Patients should be followed up in a multidisciplinary environment for the first two years after surgery with close input from a diabetologist as needed	94% Agree (Consensus)		Grade A	Patients should be followed up in a MDT environment for the first two years after surgery with close input from a diabetologist as needed. Stable patients can be discharged to primary care after 2–3 years of surgery where they should have an annual follow-up including aspects of surgery and diabetes management
41	Stable patients can be discharged to primary care after 2–3 years of surgery, where they should have an annual follow-up, including aspects of surgery and diabetes management. There should be clear pathways of care for patients to be referred back to the surgical teams for surgical, dietetic, or mental health issues that may arise later in the course of a patient's life. Such follow-up should be properly funded	76% Agree (No-Consensus)	94% Agree (Consensus)	Grade A	
IX	**Remission and Recurrence**				
42	Remission is defined as an HbA1c of < 48 mmol/mol (< 6.5%) for at least three months in the absence of glucose-lowering pharmacotherapy. When HbA1c is determined to be an unreliable marker of chronic glycaemic control (for example, because of anemia related to surgery), Fasting Plasma Glucose (FPG) < 7.0 mmol/l (< 126 mg/dl) or Estimated Glycosylated Haemoglobin (eA1c) < 6.5% calculated from continuous glucose monitoring values can be used as alternative criteria	88% Agree (Consensus)		Grade A	Remission is defined as an HbA1c of < 48 mmol/mol (< 6.5%) for at least 3 months in the absence of glucose-lowering pharmacotherapy. Furthermore FPG < 7.0 mmol/l (< 126 mg/dl) or eA1c < 6.5% calculated from continuous glucose monitoring values can be used as alternative criteria Patients in remission should continue to receive the usual diabetes care for screening and management of diabetes complications (retinopathy, nephropathy, neuropathy, and macrovascular disease) and early detection of recurrence
43	Patients in remission should continue to receive the usual diabetes care for screening and management of diabetes complications (retinopathy, nephropathy, neuropathy, and macrovascular disease) and early detection of recurrence	92% Agree (Consensus)		Grade A	
44	The risk of recurrence is multifactorial and depends on variables such as preoperative duration of diabetes, type of surgery, weight regain, and time after surgery	98% Agree (Consensus)		Grade A	Restrictive procedures, longer duration of T2DM, higher preoperative HbA1 C level, less postoperative weight loss, female sex, and insulin treatment prior to surgery are risk factors for T2D relapse after initial remission

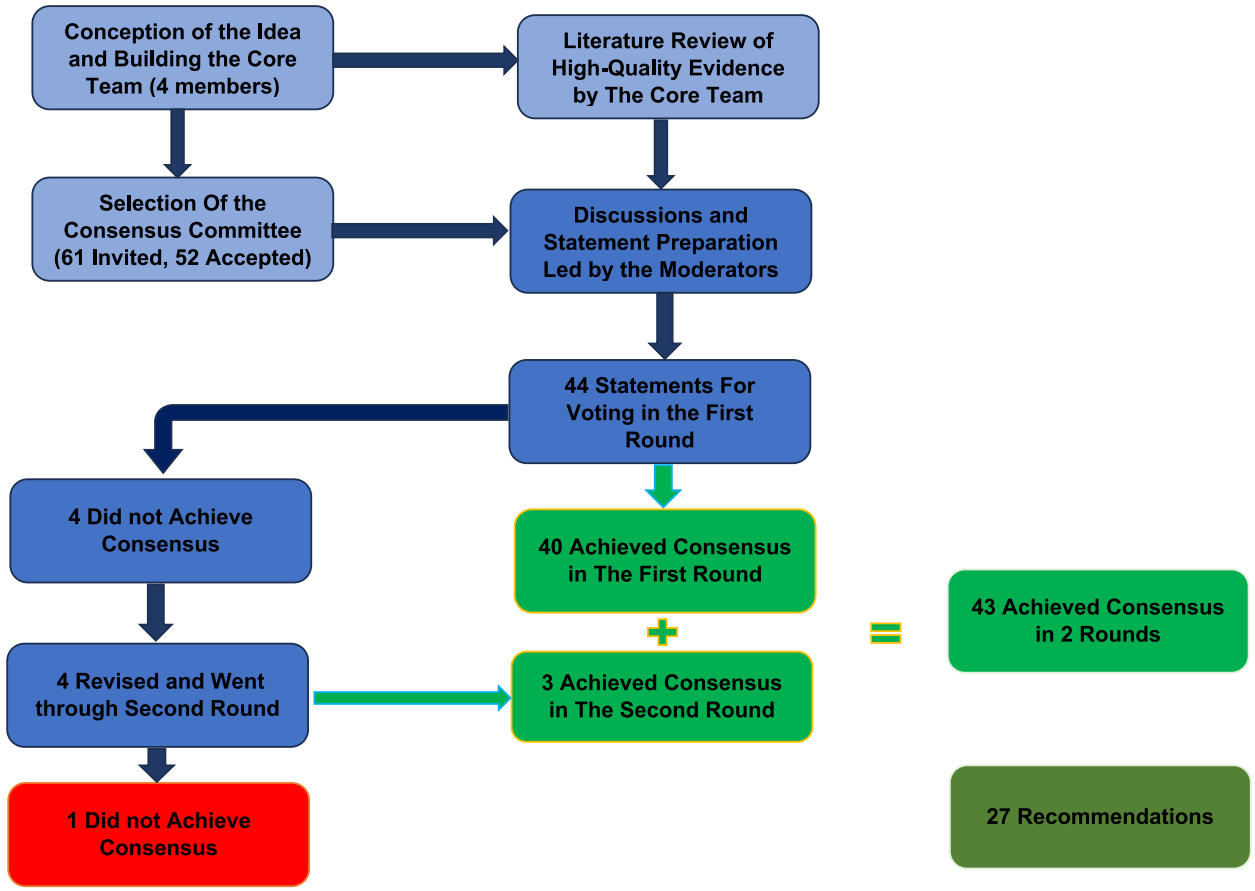

Fig. 1 Study flowchart

an effective treatment of T2DM in patients with obesity [14]. MBS is more likely to achieve resolution of T2DM compared with medical management [15]. The latest version of the American Diabetes Association Standards of Care in Diabetes (2023) incorporates MBS in the management algorithm of T2DM with a lower BMI cut point for patients of Asian ethnic origin [16]. At the same time, evidence suggests that a combination of treatment strategies (i.e., surgery with medication) often yields better outcomes than any single treatment [17, 18].

Weight loss and glycemic effects of MBS for T2DM were traditionally thought to be mediated by "restriction" and/or "malabsorption" of ingested nutrients. Recent studies have challenged this paradigm, and many have suggested that malabsorption by itself is not a sustained mechanism of action, even after RYGB [19]. An increasing body of evidence indicates that neuro-hormonal and other physiological factors affecting hunger, appetite, satiety, and energy expenditure are responsible for the beneficial effects of MBS for T2DM [20, 21].

Predictors of remission

Surgery has variable effectiveness among patients. Several factors have been identified that can help identify individuals who are likely to respond better to surgical treatment, and clinical scores have been developed [22, 23] to predict that response. Younger age, higher BMI, better pancreatic islet beta-cell reserve, shorter duration of diabetes, and better glycemic control before surgery seem to be associated with better clinical outcomes [24].

A nationwide study of the Scandinavian obesity surgery registry [25] included 8,057 patients who had RYGB and showed that increasing age, higher HbA1c levels, and longer diabetes duration decreased the chance of reaching T2DM remission, while there was a positive linear association with postoperative weight loss. However, even those patients who do not achieve T2DM remission after surgery can derive significant benefits through better glycemic control, weight loss, and improvement in other associated health conditions [26].

A nationwide register-based cohort study [26] from Sweden, which included 8,546 patients, showed that the chance of no longer requiring T2DM medication was lower in patients with a longer preoperative diabetes duration at both two and five years after surgery. The chance of achieving sustained T2DM remission correlated negatively with diabetes duration, insulin treatment, age, and HbA1c levels at baseline. T2DM remission was greater among males and those with higher BMI at baseline. Although studies have also shown benefits in those who are living with overweight [27] rather than obesity, there is currently a lack of randomized evidence to inform practice in this area. However, recent evidence with a long-term follow-up period suggests that the accuracy of the available scores in predicting T2D remission in the long term is still suboptimal [28].

Preoperative diabetic control

Hyperglycaemia leads to immune dysfunction and cellular damage, which could potentially lead to perioperative complications [29]. There is no level 1 evidence available on the effect of preoperative HbA1 C levels on the outcomes of MBS. However, attention to glycemic control minimizes the potential risk for adverse outcomes similar to other surgical procedures.

The evidence from large-scale cohort studies showed conflicting results on the association between HBA1 C levels and the complications or mortality rates after MBS or other surgical interventions [30, 31]. This was probably the basis for the American Society for Metabolic and Bariatric Surgery (ASMBS) conclusion that the current evidence does not support delaying or withholding bariatric surgery to achieve specific HbA1 C targets [32].

Hart A et al. [33] studied 31,060 patients who had SG and 13,754 patients who had RYGB. They found that patients with elevated HbA1c levels had a significantly higher rate of composite overall morbidity and mortality rates but did not have a significant difference in 30-day mortality. Unplanned intubation, superficial surgical site infection, postoperative pneumonia, and postoperative sepsis were all higher in patients with high HbA1c.

More recently, Pina L et al. [34] analyzed the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) database, which included 42,181 patients who had RYGB and SG. They found that there was no significant association between HbA1c levels and 30-day major complications (Clavien-Dindo III/IV). Both the American Diabetes Association (ADA) [16] and the European Association for the Study of Obesity (EASO) [35] recommend that MBS should be performed by multidisciplinary teams with appropriate experience in managing obesity and diabetes to formulate and oversee the diabetes management plans.

Perioperative care, monitoring, and special considerations

Preoperative energy restriction

Preoperative energy restriction regimens have been adopted by Upper Gastrointestinal (UGI) surgeons to reduce liver volume before major UGI surgical procedures [36, 37]. Different regimens have been described, which could be collectively categorized as a very low-energy diet (VLED) with 450–800 kcal per day or a low-energy diet (LED) with 800–1500 kcal per day.

A systematic review [38] including 849 patients from nine studies (three randomized clinical trials and six observational studies) found that while a VLED resulted in liver size reduction (5%—20%), it did not significantly reduce perioperative complications. However, one study (n = 273) reported a protective effect 30 days after surgery. A recent study [39] included 120 candidates for MBS who received a VLED for eight days only and observed a 5% reduction in body weight primarily due to loss of body fat. A recent systematic review by Romeijn MM et al. [40] included eight studies with 251 patients and showed that LED reduced liver volume (12–27%) and achieved a 4–17% weight loss. They concluded that LED had acceptable patient adherence and could be used instead of a VLED for 2 to 4 weeks preoperatively. Besides the technical feasibility of a"liver-shrinking"diet, these regimens have proven to significantly improve liver histological features, including steatosis, inflammation, and hepatocellular ballooning [41]. Dietary modification and nutritional support should be achieved under supervision by experienced teams specialized in managing patients with obesity and T2DM [16].

Blood pressure changes

Recent studies [42, 43] have shown a significant decrease in mean arterial blood pressure (MAP) within ten days to two weeks after MBS in both hypertensive and normotensive patients, with a substantial reduction of blood pressure 6—12 months after MBS [43, 44]. These changes are more pronounced after RYGB [45]. Orthostatic intolerance post-MBS has been reported and can present as light-headedness, dizziness, syncope, and palpitations [46]. These findings highlight the need for early monitoring and management of blood pressure after MBS.

Post-MBS hypoglycaemia

Post-MBS hypoglycaemia has been reported and could be attributed to faster gastric emptying after MBS and rapid circulating glucose surge with consequent excessive postprandial insulin secretion leading to a sharp drop in blood glucose levels. It has been reported in up to 10% of patients after gastric bypass procedures. Patients may present with sweating, tachycardia, hunger, tremor, impaired cognition, loss of consciousness, and seizures.

This should be differentiated from dumping syndrome due to intra-intestinal osmotic effects, which usually occur soon after surgery and improve over time. Post-MBS hypoglycaemia usually occurs > 1 year after surgery. The management options include dietary modification, exclusion of surgical complications, and pharmacological management [47, 48].

A recent meta-analysis [49] of 8 studies including 280 patients found that the total weighted mean prevalence (WMP) of post-MBS hypoglycemia (PMH) was 54.3%, and the WMP of nocturnal PMH was 16.4%, with a comparable rate of PMH after RYGB and SG. However, RYGB was associated with a higher glycemic variability than SG. The time elapsed from surgical intervention was positively associated with a higher rate of both total PMH and nocturnal PMH. Another study from the USA [50] included 6,024 patients who had MBS and showed that 118 patients (2.0%) had a postoperative glucose level ≤ 70 mg/dL, and 83 (1.4%) developed symptomatic hypoglycemia.

Early monitoring of glucose levels and adjustment of diabetes medications have been emphasized in the latest guidelines for perioperative care after MBS by the Enhanced Recovery After Surgery (ERAS) Society [51]. More detailed recommendations have been proposed by the Task Force of the European Association for the Study of Obesity for the post-bariatric surgery medical management, including target glucose levels and frequency of blood glucose testing [35]. Also, the latest ADA guidelines recommend a long-term medical review and monitoring of metabolic status. Continuous glucose monitoring has been recommended in cases with suspected post-MBS hypoglycaemia [16].

Sodium-glucose co-transporter-2 inhibitors and MBS

SGLT-2i are increasingly prescribed due to their cardio-renal protective benefits in patients with and without T2DM [52]. However, euglycemic and hyperglycemic diabetic ketoacidosis (DKA) have been reported in patients using these medications. The Food and Drug Administration (FDA) issued a warning on this in 2015, and the British Obesity and Metabolic Surgery Society (BOMSS) patient safety committee released an alert in 2022 highlighting these risks and outlining specific recommendations before and after MBS [53, 54]. The National Institute for Health and Care Excellence (NICE) recommends assessing the risk of DKA before commencing SGLT2i [55].

Care pathways and logistics of service

Utilization of the service and barriers

Despite the safety profile and clear benefits of MBS in treating obesity and related complications and its superiority over the alternatives, MBS has been significantly underutilized in many parts of the world [56, 57]. This has been attributed to a variety of reasons, including patient and public misperceptions [58, 59], ineffective referral pathways [60, 61], logistics, and medical insurance-related issues [62, 63]. Of particular concern is the disparity in bariatric service access related to ethnicity [64, 65].

Dietary modification

Dietary and physical activity modifications are associated with clinically significant weight loss and improvement in weight-related comorbidities, including glycaemia and hypertension [66–68]. LED has demonstrated efficacy over the other alternatives in terms of T2DM remission without significant adverse consequences [69, 70]. The ADA guidelines [16] recommend a short-term LED (800–1,000 kcal/day) for selected individuals by trained staff. Additionally, they advised nutritional modification and physical activity to achieve and maintain at least 5% weight loss for people with T2DM with overweight or obesity. These options should be explored and discussed with patients with T2DM as alternatives to MBS as part of informed consent for the agreed treatment plan.

Referral criteria

Despite being the most commonly used anthropometric measure for obesity, BMI has limitations in assessing body composition and distinguishing between muscle and fat distribution. Other more accurate parameters to diagnose obesity and predict associated risks and comorbidities have been explored [71, 72]. Despite the paucity of evidence around referral criteria apart from BMI, there is a growing body of evidence on the efficacy and safety of MBS in treating T2DM in patients with BMI ≤ 35 kgs/m^2 [73, 74]. The ADA [16] recommendations addressed this clearly and identified lower BMI cut points for consideration of MBS in patients with T2DM of Asian origin. The latest guidelines of ASMBS and the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) recommended surgery for patients with T2DM and BMI ≥ 30 kg/m^2 [74].

Preoperative weight loss

Preoperative weight loss of 5% – 10% of total body weight was recommended [51, 75] and even considered mandatory for obtaining insurance or state coverage in some healthcare settings. However, currently available evidence would challenge such practices. While some studies have shown a positive association between preoperative and postoperative weight loss, reduction of complications, and mortality, others have not found these associations [76]. In addition, the majority of the candidates for MBS

have a long history of weight loss attempts. Therefore, forcing them to repeat these treatments, which have previously not resulted in achieving durable outcomes, may be considered an unnecessary barrier to MBS and, therefore, morally indefensible as such practices may exclude those most in need.

Comprehensive assessment and MDT approach

As part of the informed consent process, the different perioperative considerations should be discussed in detail with the patients. Moreover, providing access to support groups can help the patients through their treatment journey [75]. MBS results in fundamental anatomical changes to the patient's alimentary tract. In addition to reducing intake, they can also affect the absorption of macro/micronutrients. Prevention, early detection, and correction of nutritional and micronutrient deficiencies is imperative for this patient group at high risk of nutritional deficiencies. Different national societies have released dedicated practice guidelines on perioperative biochemical monitoring and micronutrient replacement, such as BOMSS perioperative and postoperative biochemical monitoring and micronutrient replacement guidelines [77], ASMBS Integrated Health Nutritional Guidelines [78] and the more recent French expert consensus guidance on post-MBS nutritional support [79].

Mental health and MBS

The MDT approach and psychological support are paramount and have been emphasized in the NICE [80, 81] and BOMSS guidelines [82] as an integral part of the surgery provided by the UK National Health Service (NHS) and private and public insurers in the United States.

Although MBS in patients with stable psychiatric illnesses is safe [83], mental health disorders may lead to lower adherence to follow-up reviews and postoperative care plans [84], worsening of psychiatric disorders after surgery [85], and the emergence of new mental health and behavioural disorders after MBS in some patients, including maladaptive eating, substance use disorders, self-harm behaviour, and suicidal ideation [86].

A recent nationwide cohort study [87] identified 9,480 patients with psychiatric illnesses within 22,539 who had gastric bypass. The disease spectrum includes bipolar disorder, schizophrenia, depression, neurotic disorders, attention deficit hyperactivity disorder (ADHD), substance use disorder, eating disorder, personality disorder, and self-harm. The authors found that the presence of psychiatric illness was associated with delayed discharge and higher reoperation rates. Another study has linked psychiatric disorders to early readmission and increased length of hospital stay [88]. Moreover, a scoping review of fifty-eight studies [89] reported that substance use history does not influence weight loss after MBS. However, it could be associated with increased substance use after surgery.

All the relevant guidelines emphasize the preoperative psychological assessment and postoperative psychological support as part of the MDT approach for patients with mental health conditions rather than excluding them from surgery on these grounds [16, 80, 81, 90].

Accurate classification of diabetes mellitus

MBS has a demonstrated positive impact on patients with Type 1 Diabetes Mellitus (T1DM) by reducing insulin requirements [91] and reducing the risks of cardiovascular disease, stroke, and mortality. However, it is associated with some risks, including that of postoperative hypoglycaemia and diabetic ketoacidosis (DKA) [92, 93].

Despite the proven benefit of MBS in reducing insulin requirements and resolving comorbidities, its benefit in achieving glycemic control is debatable [91, 93]. The most commonly performed procedures for T1DM are RYGB and SG [93], with no significant differences in the weight loss outcomes or reduction of insulin requirements between both procedures [94]. Studies comparing the outcome of MBS in patients with T2DM and T1DM showed significant differences in the outcomes in favour of T2DM [95]. Accordingly, a clear distinction should be sought for better management of patient expectations and consenting.

The latest guidelines of the American Association of Clinical Endocrinology define diagnostic criteria for different types of diabetes. T1DM is characterized by insulin deficiency, hyperglycaemia, and positive autoantibody tests to glutamic acid decarboxylase (GAD65), pancreatic islet b cells (tyrosine phosphatase IA-2), and IA-2b zinc transporter (ZnT8), and/or insulin [96]. An accurate diagnosis in liaison with the endocrinologist or diabetes specialist team is an essential preliminary step before considering the surgical option in this patient group.

Latent Autoimmune Diabetes in Adults (LADA) and Maturity Onset Diabetes of Young (MODY) are unique variants of glycemic metabolic derangements with different pathophysiological characteristics and genetic and molecular basis [97–99]. Few studies have been conducted on the effect of MBS in patients with these forms of DM. However, it seems that the response of these disease types and T1DM to MBS is less favourable than that of T2DM [100, 101].

Surgical considerations

Day case or regular preoperative admission?

There has been a significant shift in the perioperative care setting across different surgical specialities, with an inclination towards shortening preoperative and postoperative hospitalization. This trend has been driven by the benefits of reducing bed occupancy, avoiding perioperative nosocomial infections, and achieving cost-effective medical care. This idea formed the basis for the concept of Perioperative Anaesthesia and Surgical Home (PASH) [102]. The concept of ambulatory MBS with or without telemonitoring has been investigated and shown to be safe in selected patients [103, 104] with comparable results in terms of patient satisfaction and greater cost-effectiveness [105, 106]. The latest Guidelines for Perioperative Care in Bariatric Surgery of the (ERAS) Society [51] detailed the evidence-based recommendations for preoperative care, which can be implemented on the day of surgery without admitting the patient. However, inadequate diabetes management in the perioperative period after or before MBS has been reported [107]. Great caution should be exercised to prevent fluctuation of blood glucose levels in the perioperative period, including listing patients with diabetes at the top of the list to limit the time of preoperative fasting.

Metabolic endoscopy

Recent technological advances in gastrointestinal endoscopy have led to the evolution of bariatric and metabolic endoscopy (BME) as a less invasive option compared to MBS. Gastric balloons (GB) and endoscopic sleeve gastroplasty (ESG) are the most common applications of BME [108].

Evidence from different studies on various types of gastric balloons confirms the achievement of acceptable short-term weight loss results [109, 110] and the feasibility of utilizing gastric balloons as a bridge to definitive MBS [111]. Despite the promising initial results, the long-term efficacy of gastric balloons has yet to be confirmed [112, 113], and there is a need for more well-designed studies to evaluate long-term outcomes to support it. A recent meta-analysis [114] of 17 studies that included 1,198 patients showed a significant reduction in HbA1c levels six months after inserting an intragastric balloon (IGB). It was concluded that IGB is associated with improvements in insulin resistance and other obesity-related metabolic derangements.

ESG has been introduced as a less invasive variant of sleeve gastrectomy. Current evidence supports its safety, efficacy in achieving weight loss, and some improvement in metabolic parameters [115]. Additionally, it has been proposed as a revisional procedure after sleeve gastrectomy [116]. A recent prospective cohort study of 612 patients who had ESG showed the resolution of T2DM in 51.2% of the cases [117]. A non-inferiority propensity score-matched comparative study [118] showed a resolution of diabetes in 64% of the patients after EGS compared to 82% after LSG. Moreover, a recent systematic review and meta-analysis of 35 studies, including 7,525 patients, showed diabetes resolution in more than 55% of patients who had EGS [119]. Based on the current evidence, NICE recommended EGS as a treatment option in adults with obesity [120].

Surgery for adolescents with T2DM

T2DM in the adolescent population with obesity poses a significant risk for the early development of diabetes complications, poor quality of life, and mortality. Adolescents with T2DM will have a faster decline in pancreatic islet beta-cell function and earlier deterioration of renal function, in addition to worsening retinopathy, hypertension, and neuropsychiatric complications [121, 122]. The landmark study, Teen Longitudinal Assessment of Bariatric Surgery (Teen-LABS) [123], showed that adolescents with T2DM had better glycemic control after MBS compared to adults without the use of diabetes medications. The same observation has been reproduced in subsequent studies [124, 125], which led to increased utilization and an overall uptrend of MBS in the adolescent age group [126]. Both the European Society of Endocrinology and the Pediatric Endocrine Society guidelines [127] and ASMBS pediatric metabolic and bariatric surgery guidelines [128] emphasize the role of MBS in the adolescent population based on clear criteria for referral and the MDT approach.

Costs and burden

Given the high cost of the intervention and management of subsequent potential complications of MBS, cost-effectiveness is a key issue. Different cost-effectiveness analyses of MBS for T2DM have been conducted in different parts of the world with varying healthcare settings; all have reported that MBS is cost-saving in the long run due to reduction of the costs of diabetes medication as well as postoperative medical care and management of T2DM and its related complications [129, 130]. A recent systematic review of economic evaluations [131] included 30 studies and found that MBS for patients with T2DM and obesity is cost-effective in the long term.

Procedure choice

The resolution of T2DM after MBS is multifactorial and achieved through weight loss-dependent and weight loss-independent mechanisms [132]. The most commonly performed procedures include SG, One Anastomosis Gastric Bypass (OAGB), RYGB, and

Biliopancreatic Diversion (BPD). A recent systematic review included five RCTs [133] that compared OAGB and SG and found that T2DM remission with OAGB was more efficient at one and five years. Another systematic review and meta-analysis of RCTs compared RYGB to SG [134] and found that the remission rate of T2DM at one year was higher with RYGB than with SG. However, at 2–5 years, there was no significant difference. A network meta-analysis of 20 RCTs [135] included 1,803 patients and showed greater T2DM remission with either RYGB or OAGB compared to SG. However, perioperative complications were higher with RYGB compared to either SG or OAGB.

Another RCT with a 10-year follow-up [136] showed that after SG and RYGB, there was no significant difference in T2DM remission. A recent systematic review [137] compared the safety and efficacy of RYGB, OAGB, and Single Anastomosis Duodeno-Ileal bypass with Sleeve gastrectomy (SADI-S). The review included 18 studies and showed that SADI-S was associated with better resolution of T2DM. However, the early complications and mortality were higher with SADI-S, and late complications were more frequent with RYGB. OAGB was associated with fewer complications.

Communication with primary care and extended follow-up

Postoperative care after MBS requires close collaboration of the specialist MDT in tertiary healthcare facilities with primary care to guarantee continuity of care and safety. Also, patient education and involvement are of paramount importance. This shared-care model of management has been emphasized in the NICE guidance [80, 81]. Documentation of the discharge process and follow-up care arrangements, including detailed written discharge summaries and liaising with primary care, are integral roles of the surgical teams [138].

Postoperative monitoring of the nutritional status and glycemic control is an important phase of the treatment journey [77, 78, 81, 139]. The ADA guidance [139] recommends assessing glycemic status at least quarterly and as needed in patients whose therapy has been recently changed. As MBS induces a dramatic effect on glucose metabolism, there should be regular monitoring, and HBA1c levels should be checked regularly till stabilization of glucose levels and cessation or adjustment of diabetes medications. The NICE guidelines recommend two years of follow-up under bariatric services and MDT, followed by at least annual monitoring of nutritional status in the long term in primary care after discharge from the bariatric service [81].

Remission and recurrence

Remission

Monitoring glycemic control to determine remission can be achieved by measuring HbA1c levels, fasting plasma glucose (FPG), 2-h plasma glucose after an oral glucose challenge, or mean daily glucose from continuous glucose monitoring (CGM). HbA1c is the most practical and commonly used method. However, conditions exist that may interfere with the reliability of HbA1c and include haemoglobin variants, differing rates of glycation, or alterations in erythrocyte survival. Iron deficiency, which is common after MBS, could potentially complicate the picture further by affecting HBA1c levels. Oral glucose tolerance tests may not be feasible or accurate in patients post-MBS [140, 141].

The most used criterion for remission is HbA1c < 6.5% (48 mmol/mol), as used in the DIADEM-I trial [140] and recommended by an expert consensus group [4]; this is consistent with the cut-off value for DM diagnosis [141]. If HbA1c is deemed inaccurate for remission determination, FPG lower than 126 mg/dL (7.0 mmol/L) could be used as an alternative criterion. Testing for remission should be done at least three months after the procedure and three months after cessation of glucose-lowering medications [140].

Diabetes-related complications

MBS reduces, but does not eliminate, the risk of diabetes-related complications, including retinopathy, nephropathy, or neuropathy [142, 143]. A recent meta-analysis [144] included 32,756 participants in 12 studies and showed that MBS reduced the incidence of microvascular complications, diabetic nephropathy, and neuropathy compared with nonsurgical treatments in obesity with T2DM. These findings support the regular follow-up of diabetes-related complications even after T2DM remission.

Recurrence

Recurrence of T2DM after initial remission secondary to MBS has been reported [145]. The PCORNet [14] study showed that T2DM remission rates of patients who had RYGB and SG were 59.2% and 55.9%, respectively, at one year and 86.1% and 83.5% at five years after surgery. Among 6,141 patients who experienced T2DM remission, the estimated relapse rates for those who had RYGB and SG were 8.4% and 11.0% at one year and 33.1% and 41.6% at five years postoperatively. A recent meta-analysis reproduced the same with more favourable results with RYGB compared to SG in terms of relapse of T2DM after initial remission [146]. A registry-based Swedish study [147] included 2,090 patients in complete remission two years after surgery who were followed for a

Table 3 Recommendations from the Delphi consensus on surgery for type 2 diabetes mellitus

Recommendations	Grading level
Surgery for Type 2 Diabetes Mellitus (T2DM) is similar to bariatric surgery but allows patients with diabetes to be considered for surgery at a lower BMI	Grade A
The term "Metabolic Surgery for T2DM" should be used as a common descriptor for surgery aimed at treating people with T2DM	Grade D
Surgery has a strong evidence-based role in the treatment of patients with T2DM that works through both weight-loss dependent and weight-loss independent mechanisms and changes multiple signals (metabolic, biliary, neural, hormonal)	Grades A and B
The beneficial impact of surgery for T2DM depends on factors such as younger age, higher baseline BMI, shorter diabetes duration, and better preoperative glycaemic control represented by higher c-peptide level, lower HbA1c, and less insulin usage. Surgery for T2DM ONLY has a role in individuals with a Body Mass Index of ≥ 30 kg/m2, or 27.5 kg/m2 in some Asian populations. Despite some existing scores such as ABCD score and DiaRem, It seems that there is an essential need for more accurate predicting scores	Grades A and B
HbA1c levels matter, but all efforts should be made to optimize glycaemic control to an HbA1c level of ≤ 69 mmol/mol (≈ 8.5%), but surgery should not be delayed unduly to achieve this	Grades A and B
Patients undergoing surgery for T2DM should be reviewed by a diabetologist for perioperative and postoperative glycaemic management of diabetes (including preoperative liver-reducing diet and adjustment of dosage of glucose and blood pressure-lowering agents after surgery)	Grades A and B
Frequent capillary/interstitial glucose and blood pressure monitoring (in those on antihypertensives) are advised in the early postoperative phase to allow for titration of doses of medications	Grade A
Postprandial hypoglycemia (also known as reactive hypoglycemia) is more common after diversionary procedures, no more common in patients with T2DM, and can be serious. These patients should be referred to diabetologists for further investigation and management	Grade A
Based on evidence, we suggest stopping SGLT2 inhibitors 48 h prior to surgery to reduce the risk of ketoacidosis	Grade A
There is a need for targeted measures to address barriers that prevent patients from accessing surgery for diabetes, including (Insufficient awareness of the benefits and risks of surgery amongst many healthcare professionals and patients, Lack of funding or insurance coverage for surgery, and Stigma toward people with obesity, Shame amongst patients because of obesity)	Grade A
While surgery is the most effective and durable, patients have a right to be informed about treatment options such as dietary and lifestyle interventions and pharmacological therapy with a full discussion of benefits, risks, and duration of treatment in comparison with surgery by a healthcare professional to make their own decisions about their preferred treatment	Grade A
Referral criteria for surgery should not be based on BMI alone and should also consider the patient's other obesity-associated medical and mental health conditions and quality of life	Grade C
Medical weight management is not necessary for surgery for T2DM, but patients should have seriously attempted to lose weight in the past with the help of appropriate lifestyle/dietary education and available pharmacological interventions	Grade B
Patients should receive comprehensive dietetic assessment and education, information about the risks and benefits of surgery, and access to a peer support group and MDT, including dietitians, psychologists, and diabetologists both before and after surgery. Patients not eligible for surgery on the grounds of mental health contraindications	A and B
Consider alternative diagnoses for T2DM, such as T1DM or Maturity Onset Diabetes of Young (MODY), before referring patients for surgery	Grade B
Surgery can be an option in selected patients with T1DM or Latent Autoimmune Diabetes in Adults (LADA) who also meet BMI criteria for bariatric surgery and may thus benefit from better glycaemic control and weight loss, but the decision for surgery should not be taken without consulting a diabetologist in these patients	Grade A
Antibody/C-peptide level can help to increase the accuracy of preoperative diabetes classification and rule out T1DM, but it is unnecessary before surgery for diabetes	Grade C
Patients undergoing surgery do not routinely need to be admitted to the hospital before the day of surgery but should be prioritized as the first case of the day if they are on drugs that can cause hypoglycemia	Grade D
Gastric Balloons have no role for patients seeking surgery for T2DM (except when they are used as a bridge to facilitate surgery). Additionally, there is insufficient evidence to suggest a role for Endoscopic Sleeve Gastroplasty for patients seeking surgery for T2DM	Grade B
Surgery for T2DM is a treatment option for adolescent patients who meet the criteria for surgery but should only be carried out in specialized centers with an appropriate MDT, including pediatricians, bariatric physicians (or diabetologists), psychologists, and dietitians	Grade A
Surgery for T2DM seems to be cost-effective over 10-year and lifetime horizons	Grade A
Surgical Procedures aimed at treating T2DM vary in their safety and efficacy. The more weight loss, the better the effect in terms of T2DM remission/improvement: BPD > OAGB > RYGB > LSG. Regarding safety, LSG is safer than RYGB > OAGB > BPD	Grade A
Patients and their General Practitioners should be given clear written as well as verbal information at the time of discharge regarding the nature of the surgical procedure, post-discharge medications/supplements, and changes in the diabetes management post-surgery to decrease the incidence of preventable medication-induced complications	Grade D
Post-surgery for T2DM, patients should have their HbA1c levels checked three monthly for the first year or until stable, and annually after that (this strategy may significantly help to monitor the changes in serum glucose after surgery accurately and modify the dosage of the antidiabetic agents)	Grade D

Table 3 (continued)

Recommendations	Grading level
Patients should be followed up in an MDT environment for the first two years after surgery with close input from a diabetologist as needed. Stable patients can be discharged to primary care after 2–3 years of surgery, where they should have an annual follow-up, including aspects of surgery and diabetes management	Grade A
Remission is defined as an HbA1c of < 48 mmol/mol (< 6.5%) for at least three months in the absence of glucose-lowering pharmacotherapy. Furthermore, FPG < 7.0 mmol/l (< 126 mg/dl) or eA1c < 6.5% calculated from continuous glucose monitoring values can be used as alternative criteria Patients in remission should continue to receive the usual diabetes care for screening and management of diabetes complications (retinopathy, nephropathy, neuropathy, and macrovascular disease) and early detection of recurrence	Grade A
Restrictive procedures, longer duration of T2DM, higher preoperative HbA1 C level, less postoperative weight loss, female sex, and insulin treatment prior to surgery are risk factors for T2D relapse after initial remission	Grade A

median of 5.9 years. They reported a cumulative T2DM relapse rate of 20.1%. Duration of diabetes, preoperative HbA1c level and preoperative insulin treatment were associated with higher rates of relapse. Other predictors of relapse have been reported and included preoperative insulin use, a lower percentage of total body weight loss at one year, and a greater percentage of total body weight regained after one year [148]. Clear information on T2DM remission and recurrence would formulate the patient's expectations and should be an integral part of the informed consenting process.

Recommendations

According to the results of this expert consensus, the recommendations around metabolic surgery for T2DM are summarised in Table 3.

Strengths and limitations

This is the first consensus-building exercise on metabolic surgery for T2DM involving experts from 23 countries with significant experience and expertise in the field. The experts followed a robust Delphi methodology.

Several limitations of this work need to be highlighted. The selection of expert clinicians can be considered arbitrary, but due care was taken to represent those with the appropriate international expertise, including contributors to the major national and international obesity and diabetes guidelines. The threshold of 80% for consensus can also be considered arbitrary but has been used in several prior consensus-building exercises [8].

Some of the statements achieved consensus with a low margin of agreement. The lack of high-quality evidence on these recommendations limited the expansion of the relevant discussion section. These areas need more research to enrich the decision-making process and fill the gaps in knowledge.

Moreover, we appreciate the variability in the scope of service provision and the availability of resources. Given the variable resources and expertise in different parts of the world, one of the challenges of these recommendations is their generalisability.

Finally, although very valuable for day-to-day clinical practice, a consensus statement amongst experts is still opinion, and these statements need further confirmation by adequately designed studies.

Conclusion

This Delphi expert consensus statement provides guidance to clinicians on various aspects of metabolic surgery for T2DM and also grades the quality of the contemporary evidence for each of the proposed statements.

Abbreviations

MBS	Metabolic and Bariatric surgery
T2DM	Type 2 Diabetes Mellitus
MDT	Multidisciplinary Team
BMI	Body Mass Index
HbA1c	Glycated haemoglobin
ASMBS	American Society for Metabolic and Bariatric Surgery
SG	Sleeve Gastrectomy
RYGB	Roux-en-Y Gastric Bypass
MBSAQIP	Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program
ADA	American Diabetes Association
EASO	European Association for the Study of Obesity
GI	Gastrointestinal
UGI	Upper Gastrointestinal
VLED	Very Low-Energy Diet
LED	Low-Energy Diet
MAP	Mean Arterial Blood Pressure
SGLT-2	Sodium-Glucose Transport Protein 2
GLP-1	Glucagon-Like Peptide-1
WMP	Weighted Mean Prevalence
PBH	Post-Bariatric Hypoglycaemia
ERAS	Enhanced Recovery After Surgery
DKA	Diabetic ketoacidosis
FDA	Food and Drug Administration
BOMSS	British Obesity and Metabolic Surgery Society
NICE	The National Institute for Health and Care Excellence
NHS	National Health Service
ADHD	Attention Deficit Hyperactivity Disorder
T1DM	Type 1 Diabetes Mellitus
LADA	Latent Autoimmune Diabetes in Adults
MODY	Maturity Onset Diabetes of Young
GAD65	Glutamic Acid Decarboxylase
ZnT8	IA-2b Zinc Transporter
PASH	Perioperative Anaesthesia and Surgical Home

GB	Gastric Balloons
ESG	Endoscopic Sleeve Gastroplasty
IGB	Intragastric Balloon
Teen-LABS	Teen Longitudinal Assessment of Bariatric Surgery
OAGB	One Anastomosis Gastric Bypass
BPD	Biliopancreatic Diversion
SADI-S	Single Anastomosis Duodeno-Ileal Bypass with Sleeve Gastrectomy
DIADEM-I	Effect of Intensive Lifestyle Intervention on Body Weight and Glycaemia in Early Type 2 Diabetes
FPG	Fasting Plasma Glucose
eA1c	Estimated Glycosylated Hemoglobin
CGM	Continuous Glucose Monitoring
PCORnet	Bariatric Study funded through a Patient-Centred Outcomes Research Institute (PCORI)

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