Metabolic and bariatric surgery: Surgical options and outcomes

Clinical Practice Guideline for the Management of Obesity in Adults in South Africa

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SOUTH AFRICAN METABOLIC MEDICINE AND SURGERY SOCIETY

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KEY MESSAGES FOR HEALTHCARE PROVIDERS

- Metabolic and bariatric surgery (MBS) is recommended for individuals with a body mass index (BMI) >35 kg/m^2, regardless of the presence, absence or severity of comorbidities.[1]
- MBS should be considered for individuals with metabolic disease and a BMI of 30 - 34.9 kg/m^2.[1]
- The choice of surgical procedure should be tailored to patients' needs, in collaboration with a multidisciplinary team (MDT) and based on the discussion of risks, benefits and side-effects.
- Several procedures are currently performed in South Africa, but variations exist.
- For patients with severe obesity, surgery offers superior outcomes compared with best medical management in terms of quality of life (QoL), long-term weight loss and resolution of obesity-related diseases, especially type 2 diabetes (T2DM), sleep apnoea, metabolic dysfunction-associated steatotic liver disease (MASLD) and hypertension.
- A laparoscopic surgical approach should be standard and is associated, for most patients, with a low mortality rate (<0.1%) and low serious complication rate (<5%).
- MBS improves life expectancy.
- Novel surgical and endoscopic approaches are being used and developed and can represent an option for selected patients.

KEY MESSAGES FOR PEOPLE LIVING WITH OBESITY

- If you live with obesity (when the amount or location of adipose or fat tissue in your body causes health problems), you should enquire about metabolic and bariatric surgery. Behavioural interventions and medical therapies are often not effective enough to obtain significant long-term weight loss and remission of obesity-related diseases.
- Metabolic and bariatric surgery combined with healthy behaviours can result in significant long-term weight loss (20% to 40% of your body weight) and improvement of obesity-related diseases, including type 2 diabetes, sleep apnoea, fatty liver disease and hypertension.
- Different surgical options exist with different levels of effectiveness. You should have an extensive discussion with your multidisciplinary team before deciding which surgical option may provide the greatest benefit to you.
- All surgeries have some adverse effects and potential risks and require lifelong follow-up to monitor mineral and vitamin levels, adjust supplementation, and support healthy behaviours.

RECOMMENDATIONS

1. MBS is recommended for individuals with a BMI >35 kg/m^2, regardless of the presence, absence or severity of comorbidities,[1]* to:
   a) reduce long-term overall mortality (Level 2b, Grade B)[2,3]
   b) induce significantly better long-term weight loss compared with medical management alone (Level 1a, Grade A)[4]
   c) induce control and remission of T2DM, in combination with best medical management, over best medical management alone (Level 2a, Grade B)[5,6]
   d) significantly improve QoL (Level 3, Grade C)[7]

e) induce long-term remission of most obesity-related diseases, including dyslipidaemia (Level 3, Grade C),[8] hypertension (Level 3, Grade C)[9] and MASLD (Level 3, Grade C).[10]

2. MBS should be considered for individuals with metabolic disease and a BMI of 30 - 34.9 kg/m^2*.[1]
3. We suggest that the choice of metabolic and bariatric procedure be decided according to the patient's need, in collaboration with an experienced MDT (Level 4, Grade D, Consensus).
4. We suggest that adjustable gastric banding should not be offered owing to unacceptable complications and long-term failure (Level 4, Grade D).[11]
5. We suggest that one-anastomosis gastric bypass should not be routinely offered owing to long-term complications in comparison with standard Roux-en-Y gastric bypass (Level 4, Grade D).[12]

*Recommendation 1 (Level 5, Grade D) and Recommendation 2 (Level 2a, Grade B).[13]

Introduction

For most individuals with severe obesity, health behaviour interventions, perhaps effective in inducing short-lived weight loss, are frequently ineffective for long-term weight loss maintenance and durable metabolic recovery. For example, the vast majority (74%) of individuals living with severe obesity undergoing intensive behavioural intervention in the Look AHEAD (Action for Health in Diabetes) study did not maintain a weight loss greater than or equal to 10% of initial body weight after 4 years.[14] Accordingly, few benefits were observed in this study subgroup from the cardiovascular risk standpoint.[14] Compared with best medical management, metabolic and bariatric surgery (MBS) consistently provides better weight loss and long-term improvement in medical complications, such as type 2 diabetes mellitus (T2DM).[5,6,15] It is also associated with a reduction in cardiovascular disease and metabolic dysfunction-associated steatotic liver disease (MASLD).[16,17]

Which patients should be offered metabolic and bariatric surgery?

MBS has become an integral part of the management of patients with severe obesity.[18]

The 1991 indications for the surgical management of obesity were updated in 2022 by the American Society for Metabolic and Bariatric Surgery (ASMBS) and the International Federation for the Surgery and Other Therapies for Obesity (IFSO), to include all individuals with a body mass index (BMI) >35 kg/m^2, regardless of the presence, absence or severity of comorbidities.[1] In addition, surgical management of obesity should be considered for individuals with metabolic disease and a BMI of 30 - 34.9 kg/m^2 who do not achieve substantial or durable weight loss or comorbidity improvement using non-surgical methods.[1] BMI thresholds should be adjusted in the Asian population such that a BMI >25 kg/m^2 suggests obesity, and individuals with a BMI >27.5 kg/m^2 should be offered MBS.[1]

Individual patient selection for MBS should be discussed in a multidisciplinary team (MDT) meeting to consider patient-specific health benefits and perioperative risk. When a patient is selected for surgical treatment, the patient should understand the risks, benefits and alternatives, including obesity medications. The need for lifelong medical surveillance to prevent and correct potential long-term nutritional deficiencies after surgery should be emphasised.

Relative contraindications to MBS include active or recent substance abuse (alcohol, drugs), non-stable or untreated psychiatric conditions (i.e. changes in psychiatric medications in the past 6 months), a limited life expectancy, and any contraindication to general anaesthesia.[19]

There is a paucity of evidence to support an age cut-off for patients seeking surgical management of their obesity, and patients should not be denied MBS because of age alone. A recent systematic review identified and summarised 26 articles encompassing 8 149 patients to evaluate the role of age in outcomes after MBS.[20] Pooled 30-day mortality was 0.01% and the overall complication rate was 14.7%. At 1-year follow-up, mean excess weight loss (EWL) was 53.8%, diabetes resolution was 54.5%, hypertension resolution was 42.5% and lipid disorder resolution was 41.2%. The authors concluded that outcomes and complication rates of MBS in patients older than 60 years are comparable to those in a younger population, independent of the type of procedure performed. Because frailty rather than age alone is an independent indicator of increased risk for complications after surgery, a careful assessment of frailty is recommended in the older surgical candidate, and a procedure with less perioperative risk may be opted for.[21]

Literature supporting MBS in adolescents has been summarised in the recent ASMBS paediatric MBS guidelines.[22] Surgery in adolescents does not adversely affect pubertal development or bone growth, and therefore no cut-off Tanner stage or bone age should be used to determine candidacy for surgery in the paediatric population.[23] (NB: These references are given for information only, and are outside the purpose of this guideline.)

Which bariatric surgery should be offered?

A number of surgical procedures have emerged over the past 40 years, including Roux-en-Y gastric bypass (RYGB) in 1971, adjustable gastric banding in 1980, duodenal switch (DS) in 1989, and sleeve gastrectomy (SG) in 2000 (Fig. 1).[24]

Laparoscopic SG and laparoscopic RYGB are the most common bariatric operations performed worldwide. The fourth IFSO Global Registry Report revealed they make up 92% of all bariatric procedures (46% each).[25] Other MBS procedures such as single-anastomosis duodenal-ileal bypass with SG (SADI-S), one-anastomosis gastric bypass (OAGB), endoscopic sleeve gastroplasty (ESG) and intragastric balloon (IGB) are becoming more popular and are discussed in the 'New surgical and endoscopic approaches' section of this chapter.

The decision regarding the type of surgery is made in collaboration with an MDT and based on the patient's medical condition, including weight and obesity-related diseases, expected adherence with supplementation and follow-up, and the patient's personal goals and preferences in terms of expected weight loss and resolution of comorbidities and side-effects. The goal is to decrease the complications and risk of mortality associated with obesity, improve the patient's quality of life (QoL), and reduce obesity-related diseases while aiming for acceptable short- and long-term complications and side-effects of the surgery.[25]

- **Adjustable gastric banding** has evolved from a non-adjustable gastric band placed at laparotomy to laparoscopic adjustable gastric banding. An adjustable silicone band is placed at the level of the cardia, creating a small stomach pouch above the band, with the rest of the stomach below the band. The gastric band is connected by a silicone tube to a subcutaneous reservoir. The

band can be inflated or deflated via the access port to control the amount of restriction. Even though this procedure has the lowest short-term complication rate, it is associated with a high long-term complication rate and weight regain, which has led to its progressive replacement by SG.
- **Sleeve gastrectomy** was originally the first step in a staged approach to reduce perioperative complications in high-risk patients.[26] Its relative technical simplicity and good outcomes led to a worldwide surge in popularity as a stand-alone procedure, starting around 2008. The surgeon divides the omentum and short gastric vessels along the greater curve of the stomach to excise 70% of the patient's stomach, leaving a narrow gastric tube that remains in continuity with the gastrointestinal tract and without disruption of the pylorus. It promotes weight loss through reduced meal volume and reduced appetite. It has become the most frequently performed surgical approach, representing 45.9% and 58.3% of all surgeries in the world and in North America, respectively.[27] In addition, SG is typically easier to revise in the case of weight regain compared with RYGB.
- **Roux-en-Y gastric bypass** involves the creation of a small gastric pouch at the level of the cardia. The first 75 - 150 cm of small bowel from the duodenojejunal flexure is measured and then transected (the biliopancreatic limb). The distal small bowel is brought up to the pouch and anastomosed, after which approximately 100 - 150 cm of the alimentary limb is measured, and the biliopancreatic limb is anastomosed. Short- and long-term metabolic and hormonal effects and outcomes have been studied extensively in numerous studies, making it the gold standard in MBS.[11,28]
- **Duodenal switch** combines moderate restrictive and hypoabsorptive mechanisms by creating a wider SG, while the duodenum is transected distal to the pylorus and anastomosed to a 250 cm alimentary limb, leaving a 100 cm common channel for nutrient absorption. According to a 2016 worldwide IFSO survey, and in stark contrast to the rest of the world, 21% of surgeries performed in South Africa (SA) were biliopancreatic diversions.[27] In a recent report with 30-year follow-up in 199 patients undergoing biliopancreatic diversion, a nutritional complication was diagnosed in 73 of 122 patients (60%) at 20 years and in 28 of 38 (74%) at 30 years.[29] Twelve patients (6%) needed surgical revision and 4 (2%) died of liver failure. The technical complexity of a DS and the risk of long-term nutritional deficiencies associated with the procedure have led to it now representing fewer than 1.1% of the total number of MBS procedures worldwide.[27]

Risks
A systematic review and meta-analysis published in 2014 reported a mortality rate within 30 days of 0.08% (95% confidence interval [CI] 0.01 - 0.24); the mortality rate after 30 days was 0.31% (95% CI 0.01 - 0.75).[30] The overall complication rate ranged from 10% to 17%, and the reoperation rate was 7%. Perioperative mortality and complication rates were highest for RYGB and lowest for adjustable gastric banding, while SG was placed in between. A recent network meta-analysis confirmed the higher postoperative complication rate associated with RYGB compared with SG.[31]

The most common complications after bariatric surgery are bleeding, venous thromboembolism (VTE) and wound infection; each is associated with a <1% risk. Bleeding and leakage are associated with the greatest impact on reoperation rates and length of stay, and VTE can be targeted for prevention using extended thromboprophylaxis.[32] In a large analysis of MBS registries in the USA (*N*=134 142), SG was associated with half the risk-adjusted odds of death (0.1% v. 0.2%), serious morbidity (5.8% v. 11.7%) and leak (0.8% v. 1.6%) during the first 30 days compared with RYGB.[33] A recent systematic review and meta-analysis evaluated the safety and efficacy of MBS in the elderly population (>55 years), and concluded that high-risk elderly patients should be considered for SG given the lesser morbidity and comparable efficacy with RYGB.[21] This finding is supported by a recent umbrella review including six meta-analyses.[34]

Specific risk associated with RYGB and SG was clearly defined in two recent randomised controlled trials (RCTs), now with 5-year and 10-year follow-up.[35-37] RYGB was associated with internal herniation, kinking or obstruction of the jejunal-jejunal anastomosis, marginal ulceration and nutritional deficiencies. SG was associated with worsening or *de novo* reflux.

Table 1 summarises the risks and benefits of the four different surgeries.

Metabolic effects of metabolic and bariatric surgery
What is the quality of life after metabolic and bariatric surgery?
Patients living with severe obesity have lower perceived health across

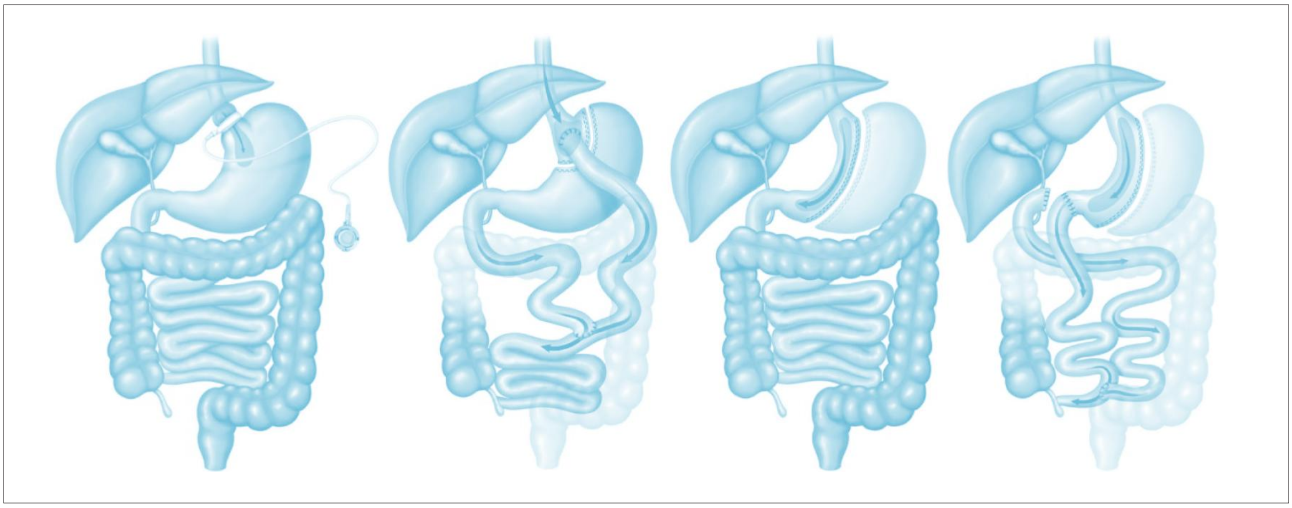

Fig. 1. Left to right: Adjustable gastric banding, Roux-en-Y gastric bypass, sleeve gastrectomy, and biliopancreatic diversion with duodenal switch. (Copyright: Graphics department, Quebec Heart and Lung Institute, Laval University. Reprinted with permission.)

Table 1. Weight loss and resolution of comorbidities after metabolic bariatric surgery[4]

	Adjustable gastric banding	Sleeve gastrectomy	Roux-en-Y gastric bypass	Duodenal switch
Total weight loss, %	20	25	30	40
Resolution rate of T2DM, %	20	30	40	80
Resolution rate of hypertension, %	20	30	40	60
Resolution rate of OSA, %	30	40	50	70
Mortality rate, %	0.01	0.01	0.01	0.02
Serious adverse event rate, %	2	3	3	5
Common side-effects	Dysphagia, vomiting	Vomiting, constipation	Dumping syndrome	Increased bowel movements, bloating
Long-term risks	Band erosion, band intolerance, weight regain	Gastro-oesophageal reflux, Barrett's oesophagus, weight regain	Anastomotic ulcer, internal hernia, small-bowel obstruction	Protein malnutrition, vitamin deficiency, small-bowel obstruction, internal hernia

T2DM = type 2 diabetes; OSA = obstructive sleep apnoea.

all dimensions of QoL.[38] For most patients, MBS has a significant positive influence on QoL. The impact varies considerably across studies, with MBS showing a significantly greater positive influence on physical QoL compared with mental QoL. Improvement in health-related QoL (HRQoL) is typically correlated with weight loss.

Improvement in HRQoL tends to correlate with weight loss, and in patients randomised to RYGB versus intensive behavioural therapy, operated patients reported significant improvement in HRQoL.[39] Meta-analyses of short-term (1 year) and long-term (≥5 years) HRQoL following MBS versus non-surgical management in patients with Class 2 or 3 obesity showed evidence of a substantial and significant improvement in physical and mental health favouring the surgical group compared with controls, spanning 5 to 25 years after surgery.[40,41]

A 2025 report of HRQoL in 228 individuals randomised to MBS versus medical and lifestyle intervention confirmed significant improvement in the physical component score with no significant change in the mental component score.[42] A 2015 meta-analysis reported a positive effect on QoL, especially when looking at physical wellbeing after MBS.[7] In a more recent systematic review comparing MBS with medical treatment in adults with obesity (BMI >30 kg/m^2), MBS resulted in greater improvements in QoL than other treatments.[43] Significant differences in QoL improvements were found between different types of MBS procedures, and greater improvements in physical QoL than mental QoL were evident.

What is the impact on weight?

One of the largest prospective trials in MBS, called the Swedish Obese Subjects (SOS) study,[2,44] involved 4 047 individuals living with obesity who underwent MBS (n=2 010) or conventional treatment (n=2 037) in a matched control group. The SOS study is a prospective controlled trial with one of the longest periods of follow-up in MBS literature. The average weight change in control subjects was less than 2% during the period of follow-up to 15 years. After 10 years, the total weight loss (TWL) was 25% after gastric bypass, 16% after vertical banded gastroplasty and 14% after adjustable gastric banding. A meta-analysis of studies comparing surgery with non-surgical interventions included a total of 22 RCTs, representing altogether 1 496 patients allocated to surgery and 302 to non-surgical interventions.[4] Outcomes were similar between RYGB and SG, and both of these procedures had better outcomes than adjustable gastric banding. For people with a very high BMI, biliopancreatic diversion with DS resulted in greater weight loss than RYGB.

A series of 250 patients with an initial BMI of 45 - 60 kg/m^2 were randomised to RYGB or laparoscopic adjustable gastric banding.[11] At 10-year follow-up, the mean (standard deviation [SD]) total body weight (TBW) loss was –42 (20) kg for gastric bypass versus –27 (15) kg for gastric banding (p<0.05). Late reoperation was significantly higher after gastric banding compared with the gastric bypass group (31% v. 8%; p<0.01). At 10 years and compared with gastric banding, RYGB was associated with better long-term weight loss, a lower rate of late reoperation and improved remission of comorbidities.

EWL was assessed after SG in a systematic review.[45] SG was furthermore compared with RYGB in two RCTs with 5-year outcomes.[35,36] Both procedures resulted in equivalent, long-standing QoL improvement. RYGB resulted in more stable weight loss (75% v. 65% EWL at 5 years; p=0.017) but was associated with higher readmission rates. Similar improvements in QoL were found in the second RCT and EWL was 49% after SG versus 57% after RYGB, but the difference did not reach significance. Overall morbidity was 19% for SG and 26% for RYGB (p=0.19). The Finnish group published their outcomes in 193 patients who reached 10 years of follow-up.[37] They reported 43.5% EWL after SG and 50.7% EWL after RYGB. Mean estimated %EWL was not equivalent between the procedures; %EWL was 8.4 (95% CI 3.1 - 13.6) higher after RYGB.

What are the effects on type 2 diabetes?

The prevalence of T2DM continues to increase, and it now affects 11.3% (95% CI 4.6 - 12.4) of adults aged 20 - 79 years in SA.[46] In 80% of cases T2DM develops as a result of excess or dysfunctional adiposity, and it has become the leading cause of macro- and microvascular disease, including diabetic nephropathy, retinopathy and limb ischaemia. MBS has consistently proven more effective than best medical treatment and psychological/behavioural interventions to induce durable control and remission of T2DM.[47]

The SOS study reported remission rates for T2DM of 72% and 36% at 2 and 10 years, respectively, in the surgical group. Reductions in glucose, insulin and homeostatic model assessment for insulin resistance increased with increasing weight loss, and changes were typically related to weight change in each surgery group.[47]

Several RCTs have specifically studied T2DM response to different surgical procedures versus medical treatment.[48]

Mingrone *et al*.[5] reported 75% remission of T2DM at 3 years after RYGB, compared with no response with medical intervention alone. At 5 years, remission was maintained in 37% of the RYGB patients and 63% of the DS patients.[15] Schauer *et al.*[6] reported remission of T2DM in 42% and 37% after RYGB and SG, respectively, compared with 12% achieved with medical therapy (N=50). At 5 years, the criterion for the primary endpoint was met by 5% of patients who received medical treatment alone, compared with 29% who underwent RYGB and 23% who underwent SG. The mean reduction in glycated haemoglobin (HbA1c) was 2.1% versus 0.3% (p=0.003) in the surgery versus medical group. Change in TBW was −23%, −19% and −5% in the RYGB, SG and medical therapy groups, respectively; triglyceride levels were −40%, −29% and −8%; high-density lipoprotein cholesterol (HDL-C) levels were 32%, 30% and 7%; use of insulin was −35%, −34% and −13%; and QoL measures were significant (p<0.05) for all comparisons. Three-year follow-up of a large cohort of randomised patients confirmed that MBS is more effective and durable than medical/lifestyle intervention in remission of T2DM, including among individuals with Class 1 obesity.[49] Superior glycaemic control is maintained in patients randomised to surgery at 12-year follow-up.[50] Five- to 20-year remission rates after DS are even higher, with observational studies showing complete remission in the range of 93% and discontinuation of insulin therapy in 97%.[51]

All studies comparing MBS with a non-surgical group consistently show superior control and remission of T2DM in the surgical arms,[52-54] including superior weight loss and lower HbA1c.[55] Variations in reported outcomes are multifactorial and include differences in study design, surgical technique, duration of follow-up and patient characteristics, such as higher pre-surgical BMI and shorter duration of T2DM (both of which may confer a higher likelihood of remission).[56] Metabolic improvement is less impressive after adjustable gastric banding than after more invasive surgical intervention.[57] Continued postoperative monitoring of glycaemia is warranted, as the effect of surgery may diminish over time with relapse of hyperglycaemia.[53]

The place of MBS in the management of T2DM was ultimately recognised by the International Diabetes Federation (IDF) in 2011[58] and by the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA) in 2017,[59] both stating that surgery should be considered as an alternative treatment option in patients with a BMI between 30 and 35 kg/m^2 when diabetes cannot be adequately controlled by optimal medical regimens. The South African Obesity Guideline Committee support MBS as treatment option in patients with a BMI ≥35 kg/m^2 and in patients with a BMI ≥30 kg/m^2 when glucose levels are not controlled despite best efforts with medications and lifestyle modification.

What is the impact on other comorbidities?

Hypertension

A meta-analysis of the effect of MBS on hypertension included 57 studies.[9] Thirty-two studies reported improvement of hypertension in 64% of patients (odds ratio [OR] 13.24; 95% CI 7.7 - 22.7; p<0.00001), and 46 studies reported resolution of hypertension in 50% of patients (OR 1.7; 95% CI 1.1 - 2.6; p=0.01). A systematic review and meta-analysis on the early impact of MBS on T2DM, hypertension and dyslipidaemia reported a reduction in cardiovascular risk, with a BMI reduction of 5 kg/m^2 after surgery corresponding to reduced T2DM in 33% of patients, reduced hypertension in 27%, and reduced dyslipidaemia in 20%.[60] The impact of SG on hypertension was assessed in a systematic review including 33 studies and 3 997 patients.[61] There was resolution of hypertension in 58% of patients and improvement or resolution in 75%.

Obstructive sleep apnoea

There is emerging evidence regarding the impact of MBS on obstructive sleep apnoea (OSA).

A meta-analysis including 15 studies (11 RCTs) and 636 patients showed a significant improvement in nocturnal hypoxaemia, although significant inter-study heterogeneity was noted.[62] A large cohort study from the National Bariatric Surgery Register of UK and Ireland demonstrated nearly 60% remission after bariatric surgery, with the greatest chance of remission after RYGB (64.5%), followed by SG (56.1%) and adjustable gastric banding (31.2%).[63]

A more recent systematic review including six studies (two RCTs) found that a comprehensive weight loss programme conferred no clinically significant effects, while MBS was associated with more robust weight loss, a reduction in OSA severity (18 - 44% reduction of the apnoea-hypopnoea index), and improvement in gas exchange (17 - 20% reduction in partial pressure of carbon dioxide in the arterial blood), ultimately leading to the resolution of obesity hypoventilation syndrome.[64]

The American Thoracic Society (ATS) recently released a clinical practice guideline on the management of OSA.[65] Their conditional recommendation for patients with OSA and a BMI ≥35 kg/m^2, whose weight has not improved despite participating in a comprehensive behavioural intervention programme and who have no contraindications, is to refer patients for MBS evaluation.

Dyslipidaemia

MBS improves serum lipids, but changes vary widely. A literature review including 178 studies and 25 189 patients reported significant reductions in total cholesterol (TC) (−0.7 mmol/L), LDL cholesterol (LDL-C) (−0.6 mmol/L) and triglycerides (−0.7 mmol/L), and a significant increase in HDL cholesterol (HDL-C) (0.2 mmol/L), at 1 year postoperatively (p<0.00001 for all).[8] The magnitude of this change was significantly greater than that seen in non-surgical control patients (e.g. LDL-C −0.6 mmol/L v. −0.1 mmol/L). When assessed separately, the magnitude of changes varied greatly by surgical type (p-interaction <0.00001; e.g. LDL-C: DS −1.1 mmol/L, RYGB −0.6 mmol/L, gastric band −0.2 mmol/L, SG −0.2 mmol/L). In the case of adjustable gastric banding (TC and LDL-C) and SG (LDL-C), the response at 1 year following surgery was not significantly different from non-surgical control patients.

Urinary incontinence

In a series of 470 patients undergoing MBS, the prevalence of urinary incontinence was 66%.[66] Other pelvic floor disorders are also frequent. A meta-analysis of the effects of MBS on pelvic floor disorders included 11 cohort studies in which a total of 784 patients were assessed with a variety of questionnaires, before and after MBS.[67] MBS was associated with a significant improvement in pelvic floor disorders, specifically with regard to urinary incontinence and pelvic organ prolapse. There was no significant improvement in faecal incontinence or sexual function. In a prospective analysis of 140 patients undergoing MBS, surgery was associated with an improvement in stress urinary incontinence (40% at baseline v. 15.5% at 1 year), urge incontinence (37% at baseline v. 8%), dysuria (20% at baseline v. 3.4%) and QoL related to urinary symptoms (all p<0.0001).[68] In addition, a reduction in the prevalence of urinary incontinence correlated significantly with weight loss (p=0.01).[69]

Metabolic dysfunction-associated steatotic liver disease

The MASLD spectrum ranges from hepatic steatosis to more severe non-alcoholic steatohepatitis and fibrosis that can progress to cirrhosis, end-stage liver disease and hepatocellular carcinoma (HCC). MASLD is strongly associated with components of the metabolic syndrome, including obesity, T2DM and hypertension.[70] MASLD prevalence is estimated to be around 25% globally and over 80% in patients with complicated obesity.[71] Prevalence/incidence data for all liver disease in sub-Saharan Africa are severely limited, and the estimated general population MASLD incidence of 13.5% is likely to be a gross underestimation.[72] Steatohepatitis develops in about a quarter of patients with MASLD, and it is set to become the leading cause of liver transplantation ahead of hepatitis C and alcoholic liver disease.[71,73] With the background of a high prevalence of hepatitis viral infection and alcoholic liver disease in sub-Saharan Africa, MASLD diagnosis and treatment will have to become a priority for the region.[74]

There is growing evidence to show improvement of MASLD after MBS, and a large meta-analysis showed 66% and 50% improvement in steatosis and fibrosis, respectively, after surgery.[75] Both SG and RYGB seem effective, without a significant difference between the procedures. In a systematic review, the pooled proportion of patients with improvement or resolution in steatosis was 91.6%, 81.3% in steatohepatitis, 65.5% in fibrosis and 69.5% for complete resolution of non-alcoholic steatohepatitis.[10]

Lassailly *et al.*[76] showed that 84% of patients had resolution of steatohepatitis without worsening fibrosis 5 years after surgery. There was a 70% improvement in fibrosis and a 50% resolution rate. A proportion of patients had persistent steatohepatitis, seen in patients with a suboptimal clinical response or weight regain after surgery. In patients with non-cirrhotic MASLD, surgery reduced the risk of developing a major liver event by 88% compared with a non-surgical group.[17] The risk of a major surgical complication was 9.5%.

Renal function

Obesity is an independent risk factor for the development and progression of chronic kidney disease (CKD). A systematic review and meta-analysis including 30 observational studies found a significant reduction in hyperfiltration, albuminuria and proteinuria after MBS.[77] In another systematic review of 29 studies incorporating 18 172 patients (including 4 RCTs, 5 cohort studies and 20 before-and-after studies), there was a significantly lower proportion of albuminuria (difference −21.2%; 95% CI −28.8 - −13.5) and reductions in 24-hour urine albumin excretion rate (weighted mean difference −48.78 mg/24 hours; 95% CI −75.32 - −22.24) and urine albumin-to-creatinine ratio (uACR) (weighted mean difference −16.10 mg/g; 95% CI −22.26 - −9.94) after surgery.[78] Compared with non-surgical treatment, MBS was associated with a statistically lower uACR and lower risk of new-onset albuminuria (OR 18; 95% CI 0.03 - 0.99 from RCTs). Low-quality evidence suggests that MBS improves albuminuria and uACR in patients with T2DM. However, the effect on other outcomes is uncertain.

Malignancy

MBS is increasingly recognised as a tool for reducing cancer risk.[79-81] In the SOS trial, the number of first-time cancers after inclusion was lower in the surgery group (n=117) than in the control group (n=169) (hazard ratio [HR] 0.67; 95% CI 0.53 - 0.85; p=0.0009).[82] This effect appears to be more profound for women than for men. Evidence is particularly strong for ovarian, endometrial and breast cancer, with a recent meta-analysis demonstrating a 49%, 67% and 53% reduction in risk, respectively.[83] MBS may be used to induce weight loss and reduce the amount of oestrogen in the active management of obesity-related endometrial dysplasia or early-stage endometrial carcinoma.[84] Data show a reduction in HCC and skin cancers, including melanoma, after MBS.[85-87] There is increasing evidence to support a reduction in colorectal cancer risk.[81,88] In contrast, limited data suggest that changes in bile salt absorption after RYGB may increase the risk of rectal cancer.[89] RYGB can lead to regression of Barrett's oesophagus and can prevent progression to advanced disease.[90] However, results from two RCTs confirm that gastro-oesophageal reflux is worsened in up to 60% of patients after SG, and concerns regarding the development of oesophageal adenocarcinoma therefore remain.[36,37,91,92] In the light of an estimated 11.6% prevalence of Barrett's oesophagus after SG, it seems prudent to offer patients postoperative endoscopic surveillance initially at 3-year and later at 5-year intervals, even if asymptomatic.[93]

Does metabolic and bariatric surgery decrease long-term mortality risk?

A large observational cohort study has shown that MBS significantly decreases overall mortality.[94] Patients who underwent MBS had significant reduction in risk of developing cardiovascular, cancer and endocrine conditions (including T2DM), as well as infectious, psychiatric and mental disorders, compared with the control group. The mortality rate in the MBS cohort was 0.68% compared with 6.17% in controls, translating to a reduction in the relative risk of death by 89%.

In the SOS study, MBS reduced the incidence of total and fatal cardiovascular events over 20 years compared with matched non-surgical controls.[2] There were 129 deaths in the control group and 101 deaths in the surgery group. The HR adjusted for age, sex and risk factors was 0.71 in the surgery group (p=0.01) compared with the control group. The most common causes of death were myocardial infarction and cancer. Analyses of the SOS data failed to demonstrate an association between initial BMI and postoperative health benefits. Weight loss did not correlate with cardiovascular events in the surgical cohort, suggesting weight loss-independent beneficial mechanisms.

A 2017 meta-analysis reported a reduction of 41% in all-cause mortality (HR 0.59; 95% CI 0.52 - 0.67; p<0.001) after MBS.[3] A more recent meta-analysis including 16 matched cohort studies and 174 772 patients demonstrated a 49% reduction in HR of death and a median increase in life expectancy of 6.1 years.[95] This effect was particularly profound for patients with pre-existing diabetes, who gained a median of 9.3 years' life expectancy after MBS compared with the non-surgical cohort.

Metabolic and bariatric surgery in patients with Class 1 obesity (BMI 30 - 35 kg/m^2)

Evidence supporting the updated IFSO/ASMBS indications for MBS, and especially evidence supporting surgery in patients with a BMI of 30 - 34.9 kg/m^2 in the presence of a metabolic disease, was recently summarised.[13]

A meta-analysis by Cohen *et al.*[96] evaluated patients with T2DM and a BMI of 30 - 40 kg/m^2 undergoing RYGB versus medical treatment. Five RCTs were identified; 43.3% of the patients had a BMI below 35 kg/m^2. RYGB significantly improved total and partial remission of T2DM (OR 17.48; 95% CI 4.28 - 71.35 and OR 20.71; 95% CI 5.16 - 83.12, respectively). HbA1c was also reduced at longest follow-up in the surgery group (−1.83; 95% CI 2.14 - 1.51).

Other metabolic outcomes are also improved in patients with mild to moderate obesity. Ikramuddin *et al.*[97] randomised 120 patients with a BMI 30 - 40 kg/m^2 to RYGB or medical management and looked at a composite main endpoint of hyperglycaemia, hypertension and dyslipidaemia resolution. At 12 months, the primary endpoint was reached in 49% of the RYGB group versus 19% of the medical group (95% CI 10 - 32). Participants in the RYGB group required on average three fewer medications and lost 26.1% versus 7.9% of their TBW compared with the medical management group. Regression analyses indicated that achieving the composite endpoint was primarily attributable to weight loss.

New surgical and endoscopic approaches

MBS is one of the fastest-evolving fields of general surgery. Surgical procedures are being modified, and new concepts emerge over time; however, only some withstand the test of time and scientific evaluation. The most common surgical modifications performed around the world are described below.

Single-anastomosis duodenal-ileal bypass with sleeve gastrectomy

This simplified DS technique was first described by Sánchez-Pernaute *et al*.[98] It involves the creation of an SG, then the duodenum is transected and connected to an omega-shaped loop of small bowel. This procedure requires only one intestinal anastomosis instead of two as used in the traditional DS. The length of the common intestinal channel allowing digestion and absorption (250 - 300 cm) is more than doubled compared with the standard DS (100 cm), which could attenuate side-effects related to dietary fat and fat-soluble vitamin malabsorption. SADI-S is emerging as an option for SG weight regain or T2DM recurrences. As a primary MBS procedure, SADI-S is endorsed by the IFSO based on its similarities to and commonly accepted decreased risk compared with the standard DS.[99,100] However, high-level evidence in the form of randomised comparison with RYGB is limited, and surgeons performing SADI-S are advised to input their data into national registries.

One-anastomosis gastric bypass

The OAGB was initially described in 2001 by Rutledge and consists of creating a long and narrow gastric pouch (10 cm v. 3 - 5 cm in RYGB) and bypassing approximately 150 - 200 cm of small bowel from the duodenojejunal flexure, then creating a loop anastomosis between the gastric pouch and the jejunum. This technique is increasingly popular in Europe and Asia and has been endorsed by the IFSO.[101,102] Long-term benefits of OAGB compared with standard RYGB are still questioned with regard to the risk of bile reflux and long-term risk of oesophageal and gastric cancer associated with chronic exposure to bile acids. An RCT compared OAGB with RYGB and SG (200 patients in each group).[103] The authors reported superior weight loss (98% v. 76% v. 77% in the OAGB, SG and RYGB groups, respectively) and similar remission rates of metabolic syndrome, including remission of T2DM (94% v. 87% v. 90% after OAGB, SG and RYGB, respectively). However, the long-term risk associated with bile acid exposure has not yet been clearly addressed and remains a concern, and surgeons offering OAGB are therefore advised to input their data into national registries.

Gastric plication

Laparoscopic gastric plication was first described by Talebpour *et al*.[104] This procedure imbricates the greater curvature of the stomach with two layers of non-absorbable sutures. The overall goal is to duplicate the effects of an SG, while avoiding any gastric stapling or resection. The procedure is associated with significant postoperative nausea and food intolerance and does not seem to reduce the risk of gastric leaks. A systematic review of 14 studies and 1 450 patients[105] reported EWL ranging from 32% to 74%, with follow-up from 6 to 24 months. No mortality was reported in these studies, and the rate of major complications requiring reoperation ranged from 0% to 15.4% (average 3.7%).

Two-year outcomes were assessed in an RCT comparing SG with gastric plication.[104] At 2 years, the TWL and complication rates were not significantly different between the two groups. Additional comparative trials and long-term follow-up are needed to further define the role of laparoscopic gastric plication in the surgical management of obesity.

Current endoscopic therapies

It is conservatively estimated that approximately 70% of SA adult women and 40% of SA adult men have a BMI of more than 25 kg/m^2, this in a population of over 63 million people. (See the chapter 'Epidemiology of obesity'.) Only a fraction of South Africans seek surgical intervention for obesity, and only 587 MBS procedures were performed in SA in 2017.[27] Many patients may favour less invasive procedures in view of concerns about postoperative complications, hospitalisation and risks of micronutrient deficiencies typically associated with standard surgical therapies. A number of endoscopic approaches have emerged over time and are placed between medical therapy and surgical therapy in terms of effectiveness, risks and side-effects.

Endoscopic sleeve gastroplasty

Endoscopic procedures have been developed to reduce gastric volume.

ESG employs a full-thickness endoscopic suturing device to create apposition of the anterior and posterior gastric wall. Suturing starts distally at the transition from body to antrum and passes proximally through the greater curvature. The fundus is partially reduced with the preservation of a small pouch to allow accommodation. It therefore tubularises the gastric body, altering satiety and satiation.

Abu Dayyeh *et al*.[106] randomised 209 patients with Class 1 or Class 2 obesity to ESG with lifestyle modification or lifestyle modification alone. At 52 weeks, mean (SD) EWL was 49.2% (32.0%) for the ESG group and 3.2% (18.6%) for the control group (p<0.0001). Mean TBW loss was 13.6% (8.0%) for the ESG group and 0.8% (5.0%) for the control group (p<0.0001). ESG-related serious adverse events occurred in three (2%) of 131 patients, without mortality or need for intensive care or surgery.

A 2024 IFSO systematic review including 44 articles and 15 714 patients undergoing ESG reported TBW loss up to 18% at 2.5 years' follow-up.[107] The Federation endorses ESG as an effective treatment for obesity, particularly beneficial for patients with Class 1 and 2 obesity, as well as for those with Class 3 obesity who are not suitable candidates for MBS.

Intragastric balloons

IGBs were first described in 1982 by Nieben *et al*.[108] and represent the oldest endoscopic procedure for weight loss. Modifications have improved tolerability, risk of perforation, and ease of placement and retrieval. Most IGBs still require upper gastrointestinal endoscopy with sedation or general anaesthesia and need to be retrieved after 6 to 12 months. Patients may experience side-effects such as nausea (24%), vomiting (2.7%), abdominal fullness (6.3%) or pain (14%), deflation (6%) and gastric ulcer (12.5%).[109] Rare complications including gastric or oesophageal perforation, small-bowel obstruction and hypoxia at the time of extraction have been reported.

A contemporary meta-analysis including 13 RCTs and 1 523 patients showed a significant difference in weight (4.4%, 6.1 kg) and BMI (2.13 kg/m^2) between the IGB and control groups.[110]

Table 2. Enhanced recovery after bariatric surgery[25]

Preoperative	Intraoperative	Postoperative
• Extensive education by multidisciplinary team	• Avoidance of fluid overload	• Postoperative analgesia, antiemetics and laxatives
• Encouraged to increase activity	• Bariatric anaesthetic protocol	• Early mobilisation
• Preoperative weight loss	• Laparoscopic approach	• Thromboprophylaxis (extended to 3 weeks)
• Preoperative anaesthetic assessment	• Intermittent pneumatic compression devices	• Early postoperative feeding
• Shortened (2-hour) fluid fasts	• Omission of urinary catheterisation	• Incentive spirometry
• Day-of-surgery admission	• Avoidance of surgical drains and nasogastric tubes	

The latest IGB modifications allow the balloon to be swallowed[111] and even self-excreted.[112] Initial studies have demonstrated its safety and short-term efficacy. The role of IGB therapy as bridging therapy to a stapled bariatric procedure is emerging.

Endoscopic bypass

A number of endoscopic procedures have recently been developed to mimic the metabolic effect of RYGB. The most advanced endoscopic bypass (EndoBarrier®, or duodenojejunal endoscopic bypass) involves the placement of a one-metre plastic sleeve in the duodenum to prevent contact of food with bile acids and to bring undigested food into the proximal jejunum. The sleeve is placed endoscopically under sedation and is retrieved after 6 months. A small RCT reported an EWL of 32.0% (22.0 - 46.7%) versus 16.4% (4.1 - 34.6%) in the control group ($p<0.05$).[113] A meta-analysis identified 151 patients who underwent an endoscopic bypass, with TWL of –5.1 kg (95% CI –7.3 - –3.0) and EWL of 12.6% (95% CI 9.0 - 16.2).[114] The procedure is associated with a risk of serious adverse events, such as acute pancreatitis in 3% of patients, device migration, early explant, gastrointestinal bleeding and liver abscess.[115-117] This device is currently licensed for investigational use only.

Aspiration therapy

A percutaneous gastrostomy device (AspireAssist®) has been described to treat patients with a BMI >35 kg/m^2. The procedure is performed under sedation and consists of placement of a gastrostomy tube and an external device to facilitate drainage of about 30% of the calories consumed in a meal, in conjunction with behavioural modifications. Thompson *et al*.[118] randomised 207 patients in a 2:1 ratio to treatment with AspireAssist® plus behavioural counselling (n=137) or behavioural counselling alone (n=70). At 52 weeks, participants in the AspireAssist® group had lost significantly more weight (12.1 ± 9.6% TBW) than in the counselling group (3.5 ± 6.0% TBW). Adverse events included abdominal pain (38%), nausea/vomiting (17%), and peristomal bacterial infection (13.5%). Serious adverse events were reported in 3.6% of participants, including severe abdominal pain, peritonitis, gastric ulcer and tube replacement. Medium-term results are starting to appear, with studies confirming the maintenance of weight loss, at 19 ± 13% weight loss, up to 4 years.[119] Even though results seem promising, patients' and physicians' acceptability of the procedure, the need for long-term nutritional surveillance, lack of long-term data, and multiple effective and safe alternative therapies severely limit the adoption of this procedure.

Perioperative care[25]

Enhanced recovery after bariatric surgery

Enhanced recovery after bariatric surgery (ERABS) protocols mitigate surgical stress and are associated with reduced length of stay, without increasing readmission rates.[120] Typical interventions undertaken in the perioperative care period are outlined in Table 2.[25] Some preoperative interventions take place weeks or months before surgery. Comprehensive Enhanced Recovery After Surgery (ERAS) Society guidelines have been published by the *World Journal of Surgery*, incorporating the best available evidence for all aspects of perioperative care.[121]

Bariatric anaesthesia

Patients undergoing bariatric surgery present challenges in each phase of anaesthesia. Guidelines recommend that a lead for anaesthesia for the patient with obesity be appointed in each department.[122] Experienced anaesthetic staff should manage patients presenting for bariatric surgery, as they represent a higher-risk patient population. The Society for Obesity and Bariatric Anaesthesia UK (SOBAUK) has published comprehensive guidance on all aspects of anaesthetic management for this patient group.[122] The SOBAUK single-sheet guidance on anaesthesia consent for the patient with obesity is a valuable resource when discussing perioperative risks with patients in an individualised, non-stigmatising manner.[123-125] The recent ERAS Society guidance is an additional valuable source of information.[121]

General considerations for anaesthesia for the patient with obesity

Specific equipment includes larger-size non-invasive blood pressure cuffs, a head-elevating laryngoscopy position pillow or similar, high-flow nasal oxygen (HFNO), equipment for managing a difficult airway, and an inflatable mattress to facilitate positioning.

It is advisable to induce anaesthesia in the operating theatre rather than the anaesthesia induction room. Patients should be positioned while awake in the ramped position, ideally using a wedged pillow designed for this purpose. Preoperative sedation poses risks in a patient with OSA and is not generally required. Lean body weight and TBW should be calculated and used to prepare appropriate drug doses. Intravenous access is more difficult in a patient with obesity, and ultrasound should be available if possible. Invasive arterial blood pressure monitoring is advisable only in those patients with significant cardiovascular comorbidities or when non-invasive cuffs are deemed inaccurate owing to body habitus. The use of quantitative neuromuscular monitoring is of particular importance in this patient group, both intraoperatively to ensure adequate muscle relaxation to facilitate surgical access, and postoperatively to confirm the full reversal of paralysis before tracheal extubation.

Airway management

Patients with obesity have a reduced functional residual capacity (FRC) owing to cephalad displacement of the diaphragm. Patients with coexisting OSA have increased fat deposition in the upper airway and reduced pharyngeal cross-sectional area.[126] These factors predispose this patient population to more rapid oxygen desaturation during periods of apnoea. Moreover, reduction in pharyngeal tone on induction of anaesthesia reduces the cross-sectional area of the upper airway, further making mask ventilation more challenging. Careful planning and meticulous attention to detail are vital in approaching airway management of this patient group.

Preoxygenation in the ramped or semi-sitting position improves respiratory dynamics by increasing the FRC and is the optimal position for airway management. Wedge pillows ease bag-mask ventilation (BMV) and improve the laryngoscopic view by aligning the pharyngeal, laryngeal and oral airway axis compared with a neutral position.[127] Predicting the most challenging airways is essential. Obesity alone is not necessarily predictive of difficult tracheal intubation.[128] Neck circumference greater than 50 cm, the ratio of neck circumference to thyromental distance, male gender, Cormack-Lehane classification >2 and American Society of Anesthesiologists physical status classification >2 are risk factors for difficult tracheal intubation.[129,130] The prediction of difficult mask ventilation is arguably of greater importance. Factors predictive of difficult BMV are the presence of a beard, Mallampati classification 3 or 4, severely limited mandibular protrusion, and a history of snoring.[131] If difficult airway management is predicted, relevant planning must be done, including consideration of awake fibre-optic tracheal intubation.

HFNO for apnoeic oxygenation during laryngoscopy and airway management in the anaesthetised patient has been demonstrated to be an effective method for reducing the time to oxygen desaturation in patients with obesity. An RCT of 40 patients with a BMI >40 kg/m^2 undergoing MBS compared HFNO at 40 - 60 L/min with standard preoxygenation and found significantly longer safe apnoea times (average 76 seconds) and higher minimum oxygen saturation during anaesthesia induction in the HFNO group compared with the control group.[132]

Venous thromboembolism

People living with obesity are at increased risk of developing VTE.[133] Symptomatic deep-vein thrombosis (DVT) and pulmonary embolism are encountered in up to 6.4% of bariatric patients.[134,135] The incidence of venous thrombotic events in the literature is variable, with DVT accounting for up to 2.2% of complications after MBS. Formal recommendations for prophylaxis include the use of intermittent compression devices and early mobilisation along with chemoprophylaxis with both low-molecular-weight heparin (LMWH) and unfractionated heparin (UH). A systematic review of 30 publications, mostly uncontrolled retrospective studies including open and laparoscopic bariatric procedures, reported variable anticoagulation dosing regimens. In the absence of RCTs and high-level evidence to guide the choice, dose and duration of anticoagulation after MBS, reviews and guidelines agree about the need for a risk-stratified prophylaxis approach.[136] The most recent American and European guidelines suggest a combination of mechanical and chemical prophylaxis, making use of LMWH (rather than UH or direct-acting oral anticoagulants), at a BMI-adjusted dose and for at least 10 days following surgery.[137,138]

Opioid-free anaesthesia

Opioid-free or opioid-sparing anaesthetic techniques are part of ERABS protocols.[139] They reduce the incidence of opioid-induced respiratory depression, postoperative nausea and vomiting (PONV), constipation and urinary retention. Drugs commonly used include paracetamol, non-steroidal anti-inflammatory drugs, ketamine, magnesium sulphate, intravenous lidocaine infusions and alpha-2-agonists.[140]

A systematic review and meta-analysis of 21 RCTs including 1 039 patients and comparing intraoperative administration of remifentanil and dexmedetomidine demonstrated the superiority of dexmedetomidine, with improved postoperative pain scores for up to 24 hours, and a lower incidence of hypotension, shivering and PONV compared with remifentanil.[141] In a meta-analysis of trials, a dexmedetomidine infusion group had lower postoperative morphine consumption, lower PONV incidence and lower pain scores postoperatively compared with conventional analgesia.[142]

Lidocaine has been found to reduce opioid consumption and the duration of postoperative ileus following laparoscopic abdominal surgery. Recent studies demonstrate that an initial bolus of lidocaine 1.5 mg/kg followed by an intraoperative infusion of 2 mg/kg/h, calculated on adjusted body weight, results in serum lidocaine concentrations in the accepted safe range.[143] Regional anaesthesia is technically challenging in this patient population. There is moderate to low-level evidence that transversus abdominus plane block improves analgesia after bariatric surgery up to 24 hours postoperatively.[144]

Drug dosing in bariatric anaesthesia

Blood pressure, cardiac workload and cardiac output are increased in patients with obesity, with variable impacts on hepatic and renal perfusion. T2DM, CKD and MASLD make dosing of anaesthetic agents challenging.[145] Current guidance advocates using lean body weight for optimal dosing of hydrophilic drugs, such as neuromuscular blocking agents, opioids, local anaesthetics and paracetamol. TBW is considered appropriate for suxamethonium given the increased plasma cholinesterase activity.[122] Actual body weight is advised when calculating the dose of sugammadex. An RCT of 207 patients with a BMI >40 kg/m^2 revealed a 1.5 minutes faster recovery time when 2 mg/kg sugammadex was dosed on actual body weight compared with ideal body weight.[146]

Total intravenous anaesthesia (TIVA) is associated with a reduction in postoperative nausea and vomiting; however, the Marsh and Schnider pharmacokinetic propofol TIVA models may not be accurate in the patient with obesity. The maximum weight accepted by the Marsh model is 150 kg. Newer algorithms are emerging that address this limitation. The Eleveld propofol model allows for accurate target concentrations for patients with BMIs below 52.9 kg/m^2.[147] Applicability, broad clinical availability, and incorporation in clinical practice are yet to be established.[148]

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