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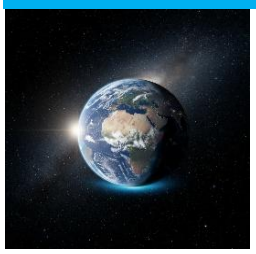

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Metabolic and Bariatric Surgery - a Review of Available Surgical Procedures

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Abstract:

Introduction: The aim of this review is to provide an overview of currently available bariatric and metabolic surgical procedures. Obesity has become a global health problem, significantly increasing the risk of cardiovascular disease, type 2 diabetes, malignancies, and other chronic conditions. In patients with severe obesity, conservative treatment often fails to achieve sustained weight loss. Bariatric surgery represents the most effective therapeutic option, offering durable weight reduction and improvement of obesity-related comorbidities. Currently, sleeve gastrectomy and Roux-en-Y gastric bypass are the most commonly performed procedures, while other established and emerging techniques differ in efficacy, risk profile, and level of supporting evidence.

Aim: The purpose of this review is to present a comprehensive overview of metabolic and bariatric surgical methods used in the treatment of obesity. It outlines patient qualification criteria and reviews both established procedures with proven long-term efficacy and newer surgical and endoscopic techniques with limited follow-up data.

Materials and methods: A comprehensive review of the literature was conducted using the PubMed and Google Scholar databases using keywords: “obesity”, “bariatric surgery”, “weight loss surgery”, metabolic and bariatric surgery”, “obesity treatment”. References cited in the included articles were also screened to identify additional relevant sources.

Conclusion: Bariatric and metabolic surgery remains a key component in the management of severe obesity. Given the diversity of available procedures, surgical strategy should be individualized based on patient characteristics and treatment goals. Further long-term studies are needed to better define the role of newer techniques and optimize outcomes in bariatric surgery.

Key words: BMI, bariatric surgery, obesity, sleeve gastrectomy, Roux-en-Y gastric bypass

Content

1. Introduction
2. Criteria for patient qualification for surgery
3. Review of surgical techniques

    3.1 Standard bariatric procedures with proven efficacy

        3.1.1. Sleeve gastrectomy (SG)

        3.1.2. Roux-en-gastric bypass (RYGB)

        3.1.3. Adjustable gastric banding (AGB)

        3.1.4. Biliopancreatic diversion (BPD) and Biliopancreatic diversion-duodenal switch (BPD-DS)

        3.1.5. Mini gastric bypass/one-anastomosis gastric bypass (MGB/OAGB)

    3.2 Bariatric surgery techniques lacking long-term follow-up data

        3.2.1. Laparoscopic gastric greater curvature plication (LGGCP)

        3.2.2. Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S)

        3.2.3. Ileal interposition

    3.3 Endoscopic methods for the treatment of obesity

        3.3.1. Intragastric balloon (IGB)

4. Conclusion
5. Disclosure

    Author's Contribution

    Funding

    Institutional Review and Board Statement

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1. Introduction

The term „globesity" refers to the global epidemic that currently impacts both developed and developing nations. Obesity rates have surged dramatically across the WHO European Region since the 1980s, increasing threefold in numerous countries. Currently, about half of the population in most European countries is either overweight or obese [1]. If these patterns continue, projections indicate that by 2030, roughly 60% of people worldwide – around 3.3 billion individuals – will be overweight (2.2 billion) or obese (1.1 billion) [2].

Obesity is linked to persistent mild inflammation and impaired immune function. It is suspected that this ongoing inflammatory condition disrupts the body's regulatory balance, resulting in metabolic complications typically seen with obesity. These changes happen through complex, not yet completely clarified mechanisms that include various signaling molecules such as cytokines, adipokines, hormones, and inflammatory markers [3-5]. Carrying extra weight significantly increases the likelihood of developing various chronic diseases, including diabetes, hypertension, stroke, dyslipidaemia, sleep apnoea, cancer, non-alcoholic steatohepatitis and other severe health complications. Furthermore, excess weight also contributes to numerous other disabling health issues such as osteoarthritis, lung function impairment, gallbladder disease, infertility, psychological challenges [6,7]. These conditions decrease both lifespan and overall well-being while creating substantial economic burdens through lost productivity and increased healthcare utilization [7].

According to the World Health Organization (WHO) individuals are classified as overweight when their body mass index reaches 25.0 kg/m2 or higher, while obesity is defined as a BMI of 30.0 kg/m2 or above[8]. Multi-faceted treatment strategies are presently considered the optimal approach, combining behavior modification, dietary restriction, medications and surgical management. Even though non-surgical methods are recommended as the initial treatment, they typically lead to poor compliance and limited success in achieving satisfactory outcomes for individuals with obesity[9]. Surgical weight loss procedures offer the best long-term outcomes for individuals with morbid obesity and type-2 diabetes mellitus. The metabolic

and bariatric surgery (MBS) field has expanded significantly in recent years, with procedural safety improving considerably[10].

2. Criteria for patient qualification for surgery

For many years, the criteria for qualifying patients for bariatric surgery were based on the 1991 National Institutes of Health guidelines[11]. Clinical practice standards for metabolic and bariatric surgery underwent revisions in later years. According to these regulations, the criteria for qualifying for bariatric surgery are based on BMI [1,12]. In 2022 the American Society of Metabolic and Bariatric Surgery (ASMBS) and the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) released updated joint guidelines on surgical eligibility. The procedure is indicated for people whose BMI is above 35 kg/m2, with or without related medical complications. For those with type 2 diabetes, the threshold is lowered to a BMI over 30 kg/m2. Additionally, surgical intervention may be warranted for patients with a BMI below 35 kg/m2 when conservative approaches have failed to achieve meaningful weight reduction or alleviate obesity-associated health problems. Surgery may also serve as preparation for subsequent procedures, including joint replacement, abdominal wall hernia repair and organ transplantation[13].

3. Review of surgical techniques

Worldwide, there has been an increase in the number of bariatric surgery procedures performer [14]. Furthermore, bariatric surgical procedures rank as the most frequently conducted operations within the field of general surgery[15]. Traditionally, bariatric surgeries were categorized into malabsorptive techniques – which reroute portions of the gastrointestinal system to limit nutrient absorption – and restrictive techniques – which decrease gastric capacity to promote earlier fullness. A third type combines both malabsorptive and restrictive elements[16]. This classification is a significant oversimplification that does not account for the neural and hormonal signaling pathways involved in the feelings of satiety and hunger, Recent research emphasizes the fact that anatomical alterations of the gastrointestinal tract have implications for the physiology of digestion and nutrient absorption[17].

The types of surgeries performed have also changed over time. Outdated procedures have given way to safer and more successful alternatives. In 1991, the NIH Consensus Statement identified vertical banded gastroplasty (VBG) and Roux-en-Y gastric bypass (RYGB) as the primary techniques used clinically. Presently, sleeve gastrectomy (SG) and RYGB have

emerged as the leading procedures, collectively comprising about 90% of bariatric operations performed around the world. Other surgical options include adjustable gastric banding (AGB), biliopancreatic diversion with duodenal switch, and single-anastomosis gastric bypass. The VBG has been phased out and is merely a historical reference, and AGB usage has dropped substantially in recent years. Today, MBS is typically performed using less invasive methods, including laparoscopic and robot-assisted techniques [18]. Laparoscopy has transformed the field by improving perioperative outcomes, such as faster recovery, reduced postoperative pain, shorter hospital stays, lower rates of wound complications and incisional hernias, and decreased mortality. It also offers superior cosmetic results and a quicker return to normal activities compared with open surgery [19].

3.1 Standard bariatric procedures with proven efficacy

3.1.1. Sleeve gastrectomy (SG)

Since 2013, sleeve gastrectomy (SG) has emerged as the most frequently performed bariatric surgery, according to the American Society for Metabolic and Bariatric Surgery (ASMBS) [20]. Currently, laparoscopic vertical sleeve gastrectomy is the most commonly performed primary bariatric procedure in the United States, accounting for 61,4% of all bariatric surgeries in 2018, compared with 17,8% in 2011 [21].

SG was first introduced in 1998 as a modification of biliopancreatic diversion (BPD) with duodenal switch [22]. Unlike the BPD originally described by Scopinaro et al. which involved a horizontal gastrectomy, SG preserves the pylorus and duodenum, thereby reducing the incidence of dumpling syndrome and marginal ulceration. Furthermore, SG provides a predominantly restrictive effect, with a diminished malabsorptive component and fewer nutrition-related sequelae. Although originally performed as an open procedure, Ren et al. first described the laparoscopic approach in the late 1990s [23].

SG is performed as a pylorus-preserving subtotal vertical gastrectomy, with longitudinal resection of the fundus, body, and antrum to form a tubular stomach along the lesser curvature, removing approximately 80% of the gastric volume [23]. SG as a restrictive procedure, reduces gastric volume, thereby promoting earlier satiety. Initially considered purely restrictive purely restrictive, SG also triggers hormonal changes. Removal of the fundus lowers ghrelin levels, reducing hunger and potentially improving insulin sensitivity. SG also enhances production of glucagon-like peptide-1 (GLP-1), which suppresses appetite and slows gastric emptying, and increases levels of peptide YY and pancreating polypeptide, further decreasing food intake

[21,24]. The incidence of major complications following laparoscopic sleeve gastrectomy ranges from 0% to 6%. Early complications may include gastric leak, hemorrhage, symptomatic stenosis, deep vein thrombosis or pulmonary embolism – with a particular risk of portomesenteric venous thrombosis – and dehydration. Late complications can include strictures, weight regain, and nutritional deficiencies[25].

Vertical sleeve gastrectomy in an effective and safe option for weight loss. It not only promotes significant weight reduction but also improves obesity-related comorbidities and is technically straightforward. Nevertheless, careful consideration of patient – and surgery-specific factors is essential. When appropriately applied, SG is a highly effective tool in addressing obesity and its associated health risk[21].

3.1.2. Roux-en-Y gastric bypass (RYGB)

Roux-en-Y gastric bypass (RYGB) remains a highly important and effective primary bariatric surgical procedure with excellent clinical outcomes[20]. Laparoscopic RYGB is the second most commonly performed bariatric surgery, accounting for 17% of procedures in 2018, a decline from 36.7% in 2011[21].

A seminal moment in the history of MBS occurred in 1967, when Dr. Edward Mason performed the first gastric bypass (GBP) for weight loss[26]. Mason and Ito initially described the procedure as a horizontal gastric division with loop gastrojejunostomy[27]. Over the next tree decades, several modifications were developed, including the Roux-en-Y gastric bypass introduced by Griffen et al. in 1977, which replaced the loop gastrojejunostomy with a vertically oriented gastric pouch[28]. Originally considered both restrictive and malabsorptive, the standard RYGB is now understood to act primarily through gastric restriction, as well as hormonal and neuronal mechanisms, rather than true malabsorption[19].

RYGB involves division of the stomach to create a small gastric pouch formed from cardia and fundus. The jejunum is transected distal to the ligament of Treitz, and the distal segment, referred to as the Roux limb, is anastomosed to the gastric pouch, allowing ingested food to bypass the proximal biliopancreatic limb, which consists of the gastric remnant, duodenum, and associated pancreaticobiliary structures. The biliopancreatic limb is subsequently anastomosed to the Roux limb approximately 100 cm distally, where the two limbs merge to form a common channel[29,30]. While these anatomical modifications reduce caloric intake and contribute to weight loss, growing evidence indicates that endocrine and metabolic changes play a central

rôle in the remission of diabetes following RYGB. Notably, significant improvements in glucose homeostasis often occur before substantial weight los sis achieved [31].

Gastric bypass is associated with complications such as staple-line failure, anastomotic leaks, delayed gastric emptying, stomal stenosis, herias, and intestinal obstruction. Dumpling syndrome may occur after intake of refined sugars and can contribute to weight loss through aversive symptoms. Nutritional deficiencies, including calcium, vitamin D, vitamin B12, and iron, require lifelong monitoring and supplementation [30,32].

3.1.3. Adjustable gastric banding (AGB)

Gastric banding was first introduced in 1978 by Wilkinson and Peloso as a nonadjustable device placed around the proximal stomach. A major advancement occurred in 1986 when Kuzmak developed a laparoscopically placed adjustable silicone gastric band [19]. The device incorporates an inflatable ballon connected to a subcutaneous access port, similar to those used for chronic central venous access, allowing the band to be tightened or loosened by injecting saline through the port, typically located on the abdominal wall or sternum [33].

Adjustable gastric banding initially gained widespread acceptance, particularly with the advent of laparoscopic techniques, contributing to a marked increase in bariatric procedures. However, its modest long-term efficacy and relatively high complication rates – including band prolapse, esophageal dilatation, erosion, strictures, and dysphagia – have led to a substantial decline in its use in favor of alternative bariatric procedures [27,34].

3.1.4. Biliopancreatic diversion (BPD) and Biliopancreatic diversion – duodenal switch (BPD-DS)

Scopinaro et al. introduced a surgical technique known as biliopancreatic diversion (BPD) in 1976, which combined removal of the lower portion of the stomach with an extended intestinal rerouting. This approach was specifically designed to overcome several limitations associated with traditional intestinal bypass procedures [22,35]. Jejunoileal bypass achieved weight loss by surgically creating short bowej syndrome with severe malabsorption. Despite its efficacy in weight reduction, it carried a high risk of severe, life-threatening complications [36,37].

In Canada in 1993, Maceau et al., followed by Hess and Hess in the United States in 1998, independently created a modified version of BPD that replaced the distal gastric resection with

a sleeve gastrectomy, also reffered to as the duodenal switch (DS). This adaptation lowered the likelihood of dumpling syndrome and marginal ulceration [19].

The BPD-DS procedure is performed through either an open or laparoscopic approach and involves three essential surgical elements: pylorus-preserving sleeve gastrectomy, distal ileoileal anastomosis, and proximal duodenoileal anastomosis. Sleeve gastrectomy involves mobilization of the greater curvature from approximately 4-5 cm distal to the pylorus to the angle of His using an energy-based sealing and cutting device, while preserving lesser curvature blood supply and vagal innervation. The goal is to create a tubular stomach with a volume of 150-250 mL. For the bypass, the small bowel is divided 250 cm proximal to the ileocecal valve, and the biliary limb is anastomosed to the common channel 100 cm proximal to the ileocecal valve. The duodenal-ileal anastomosis may be constructed using various techniques, including circular or linear stapling, hand-sewn laparoscopic methods, or robotic assistance. The alimentary limb may be positioned in either an antecolic or retrocolic fashion [22,38,39].

Both procedures exhibit substantial efficacy in promoting weight reduction [36,40]. Nevertheless, they carry a considerable risk of complications, predominantly malnutrition. Consequently, their adoption remains limited, representing only approximately 1% of all bariatric surgical interventions globally [39].

3.1.5. Mini gastric bypass/one-anastomosis gastric bypass (MGB/OAGB)

The mini-gastric bypass (MGB), also known as one-anastomosis gastric bypass (OAGB), was first performed by Rutledge in 1997 [41]. OAGB has emerged as a safe and effective revisional option for patients who have previously undergone primary restrictive bariatric procedures. Ihe International Federation for the Surgery of Obesity (IFSO) formally recognized OAGB as a bariatric and metabolic procedure in 2021, and the American Society for Metabolic and Bariatric Surgery (ASMBS) subsequently endorsed the procedure in 2023 [42]. It was developed as a simplified alternative to the RYGB, offering comparable efficacy with a technically easier procedure and shorter operative time [43].

MGB involves creating a long, narrow gastric pouch along the lesser curvature of the stomach. This pouch is then anastomosed in a loop fashion to a jejunal segment approximately 150-200cm distal to the ligament of Treitz, forming a single gastrojejunostomy. The excluded portion of the stomach and proximal small intestine carries bile and pancreatic secretions, which mix with ingested food further downstream in the common channel. Unlike RYGB, MGB

involves only one anastomosis, which simplifies the procedure and reduces operative time [44,45].

Long-term weight loss following OAGB has been shown to be highly effective. Meta-analyses of randomized controlled trials demonstrate that OAGB is associated with significant reductions in HbA1c, accompanied by substantial decreases in BMI. Furthermore, OAGB achieves a 28% higher 5-year remission rate of type 2 diabetes mellitus compared with RYGB and SG [46-48].

3.2 Bariatric surgery techniques lacking long-term follow-up data

3.2.1 Laparoscopic gastric greater curvature plication (LGGCP)

LGGCP is a restrictive bariatric procedure that reduces gastric volume without gastric resection or intestinal bypass. The concept of gastric plication was first described in an open approach by Tretbar et al. in 1976 [49], while the laparoscopic technique was later introduced by Telebpour and Amoli in 2006 [50]. The procedure involves laparoscopic mobilization of the greater curvature of the stomach followed by inward folding and fixation with sutures to create a tubular gastric configuration. LGGCP preserves gastric anatomy, avoids stapling, and is potentially reversible. Weight los sis achieved primarly through restriction, with limited hormonal effects [50,51].

Long-term outcomes have demonstrated a high revision surgery rate, largely attributable to weight regain Although conversion to SG after LGGCP is technically feasible and can achieve additional, predictable weight loss, revision surgery may be technically challenging due to the need to dismantle gastric plication [52]. Given the substantial long-term risk of weight recurrence and the associated morbidity of revisional procedures, LGGCP should be selected with caution as a primary bariatric intervention, and patients must be thoroughly counseled regarding its long-term limitations and revision risk [52-54].

3.2.2. Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S)

SADI-S was introduced by Sánchez-Pernaute and Torres in 2007 as simplified modification of BPD-DS. The procedure combines sleeve gastrectomy with transection of the duodenum 2-3cm distal to the pylorus and end-to-side anastomosis to the ileum, typically 200 cm proximal to the ileocecal valve, creating a single duodeno-ileal anastomosis [55]. Weight loss and metabolic improvement result from gastric restriction, significant malabsorption, and

hormonal modulation, while pyloric preservation promotes more physiologic gastric emptying [56].

Compared with classic duodenal switch, SADI-S offers reduced technical complexity, shorter operative time, and lower risk of internal hernias, while achieving substantial and durable weight loss and high rates of type 2 diabetes remission [56,57]. However, the procedure carries a risk of protein-calorie malnutrition and micronutrient deficiencies, requiring lifelong supplementation and close follow-up. SADI-S is increasingly used in selected patients with severe obesity or as a revisional option after sleeve gastrectomy, primarily in high-volume bariatric centers [58,59].

3.2.3. Ileal interposition

Intestinal interposition combined with sleeve gastrectomy represents an innovative procedure that promotes metabolic improvement and body weight reduction without causing significant malabsorption [60]. This technique was first described by Koopmans in 1982 in a rat model [61].

The procedure is performed laparoscopically under general anesthesia using six ports. A 170 cm ileal segment, 30 cm from the ileocecal valve, is interposed into the jejunum 20-50 cm distal to the ligament of Treitz. Three side-to-side anastomoses are created and closed in two layers, and mesenteric defects are sutured to prevent internal herniation. SG is performed along the greater curvature with gastric calibration, and resection is completed. In nonobese patients, only a fundectomy is performed to preserve gastric volume [60].

As a result of the intestinal transposition, the ileum is exposed early to undigested nutrients, stimulating the release of anorexigenic peptides such as peptide YY (PYY) and glucagon-like peptide-1 (GLP-1). Reduced levels of ghrelin, an orexigenic hormone, are achieved through the sleeve gastrectomy, which serves as the restrictive component of the procedure. Consequently, patients experience decreased food intake and significant body weight loss [62]. While this procedure demonstrates efficacy, it is not yet recommended for widespread clinical application, and long-term studies are necessary to validate its outcomes and assess potential complications in larger patient cohorts [63].

3.3 Endoscopic methods for the treatment of obesity

3.3.1. Intragastric balloon (IGB)

The intragastric balloon was first introduced in 1982, and the Garren-Edwards gastric bubble received US FDA approval for obesity treatment in 1985. IGB induces weight loss primarily by reducing stomach volume and delaying gastric emptying, which sustains gastric distension and triggers early satiety via vagal nerve stimulation. Gastric mechanoreceptors activated by distension, along with gastric accommodation and hormonal signals, contribute to the satiety effect[64].

IGB placement offers an alternative for weight loss in patients who do not respond to lifestyle modification, dietary measures or pharmacotherapy. IGB can serve as a temporary intervention for obesity, with or without associated comorbidities and may also be used as a bridge to bariatric surgery in patients with obesity[65-67].

Endoscopic procedures and pharmaceutical interventions are gaining attention as alternatives, they have not yet demonstrated the sustained success rates seen with surgical methods [68].

4. Conclusions

The prevalence of obesity has risen sharply in recent years, representing a significant public health concern. Obesity is associated with multiple comorbidities and substantially diminishes both life expectancy and quality of life. Given its nature as a civilization-associated disease, considerable efforts have been directed toward identifying effective therapeutic strategies. In cases of severe obesity, conventional conservative management often fails to achieve satisfactory outcomes, positioning bariatric surgery as a critical intervention. Among the most commonly performed procedures are sleeve gastrectomy and Roux-en-Y gastric bypass, both of which have demonstrated well-established efficacy and safety profiles, thereby representing standard approaches in contemporary bariatric practice. Biliopancreatic diversion with duodenal switch has also shown high efficacy, although further studies are warranted to optimize its safety.

For patients in whom conventional bariatric procedures do not produce the desire outcomes, the development and evaluation of alternative techniques remain necessary. Procedures such as laparoscopic greater curvature plication and intestinal transposition warrant

further prospective investigation to assess their clinical utility and potential integration into routine practice. Future research should particularly address the capacity of bariatric interventions to modulate hormonal pathways governing hunger and satiety, while simultaneously managing obesity and its associated comorbidities.

5. Disclosure

Author's Contribution:

Conceptualization: KDW, MW, BC, JC, ZC, NT, DP, ML, AC, KD

Methodology: NT, JC, ZC

Formal analysis: MW, BC, DP, ML

Investigation: AC, KD, MW, BC

Supervision: JC, DP

Writing-rough preparation: KDW, ZC, NT

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