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Surgical management of obesity

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ABSTRACT

Weight loss surgery is the most effective intervention for addressing obesity and related metabolic disorders such as diabetes. We describe common surgical procedures as well as emerging and investigational procedures in terms of their capacity to induce weight reduction and their risk profiles. We then discuss the impact of weight loss surgery on important obesity related disorders including diabetes, cardiovascular disease, and non-alcoholic fatty liver disease. The question of operative choice is discussed with respect to benefits and risks of common procedures. Reoperative weight loss surgery, an increasingly common element of weight loss surgical practice, is reviewed. We briefly discuss the metabolic mechanism of action of weight loss surgery. Lack of access to and under-utilization of weight loss surgery represent important challenges to adequate obesity treatment, and we review these topics as well.

Contents

Abbreviations: ASMBS, American Society for Metabolic and Bariatric Surgery; BMI, body mass index; CT, computed tomography; GB, gastric banding; GERD, gastroesophageal reflux disease; MBSAQIP, Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program; NAFLD, non-alcoholic fatty liver disease; NASH, non-alcoholic steatohepatitis; NSAID, non-steroidal anti-inflammatory drug; OSA, obstructive sleep apnea; SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; VTE, venous thromboembolism; WLS, weight loss surgery.

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1. Introduction

Obesity is a modern illness associated with weight-related mortality, cardiovascular disease, diabetes, liver disease, obstructive sleep apnea (OSA), malignancy, functional impairment, as well as many other disorders [1]. The medical costs of obesity exceed $100 billion per year [2]. Over one third of American adults are obese, and obesity rates continue to increase [3].

Weight loss surgery (WLS) is the most effective intervention to reduce body weight and obesity-associated diseases among obese patients and has become a widely accepted approach to treating these disorders [4].

1.1. BMI Criteria

Joint guidelines from the American Association of Clinical Endocrinologists, the Obesity Society, and the American Society for Metabolic and Bariatric Surgery advise that WLS should be considered for patients whose BMI is over 40 regardless of comorbidities, for patients with BMI of 35–40 in the presence of a severe obesity-related comorbidity, and for patients with BMI 30–35 in the presence of a severe obesity-related comorbidity such as diabetes [5]. Recent guidelines recommend WLS for any diabetic patient with BMI over 40 or with BMI 35–40 and poor glycemic control despite aggressive medical therapy. They advise consideration of WLS for those with poorly controlled diabetes in patients with a BMI between 30 and 35. These guidelines also suggest lowering the BMI thresholds by 2.5 points for Asian populations [6].

1.2. Improvement of Comorbidities

WLS reliably induces rapid, marked, and durable weight loss among obese patients [7], and reduces the burden of multiple obesity-associated comorbidities including diabetes [8], cardiovascular disease including hypertension [9], stroke, coronary artery disease [10], and heart failure [11]. WLS is also effective in improving OSA [12]. Excess weight and diabetes are associated with risk of multiple primary cancers [13,14], and WLS may protect against malignancy [15,16].

1.3. Improved Survival with Bariatric Surgery

Multiple large observational analyses strongly suggest that WLS improves survival compared to non-surgical management over the course of long-term follow up [17–20]. In the Swedish Obese Subjects study, in which 2010 WLS patients were prospectively matched to a control group of 2037 patients who underwent standard medical therapy, the risk-adjusted hazard ratio for mortality was 0.71 after a mean follow up of 10.9 years [18]. A retrospective analysis that matched 2500 WLS patients to 7462 matched controls in the United States Veterans Affairs system found that surgical patients had significantly decreased mortality after one year of follow up, with a hazard ratio of 0.47 after five years [20]. In a recently reported retrospective Israeli cohort of over 8000 WLS patients, the adjusted hazard ratio for mortality among 25,000 matched controls was 2.02 after four years [17].

2. Procedures and Outcomes

The two most commonly performed procedures for weight loss are the sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), which together account for the vast majority of initial bariatric surgical procedures in the United States [21]. We discuss these procedures below. Less commonly utilized procedures are enumerated and briefly discussed as well.

2.1. RYGB

RYGB was traditionally regarded as the standard of care and until 2013 was the most popular bariatric operation [21]. RYGB involves dividing the stomach to create a small pouch composed of cardia and fundus known as the “gastric pouch.” The jejunum is divided distal to the ligament of Treitz. The distal “roux limb” is anastomosed to the gastric pouch such that food bypasses the proximal “biliopancreatic limb,” composed of the remnant stomach, duodenum, and associated pancreaticobiliary structures. Meanwhile, the biliopancreatic limb is anastomosed to the roux limb at about 100 cm along its length such that the two limbs converge and empty into a “common channel” [22].

2.1.1. Weight Loss

RYGB induces loss of about 25% [23] of total and 60% of excess body weight [24–26] as well as excess BMI reduction of approximately 65% [23,25]. Weight decreases substantially in the initial 1–2 years following surgery [23,27], followed by a period of erosion [27] that diminishes over time [7]. Weight loss is durable in cohorts with long-term follow up of ten years or longer [28–30]. Within these general trends, the significant variability in weight loss over time among WLS patients [27] is due at least in part to behavioral factors [31].

2.1.2. Complications

2.1.2.1. Short Term Complications. The overall 30-day morbidity rate for RYGB is about 3.4% for serious complications and 8.3% for any complication [32]. The most important perioperative complications are bleeding, gastrointestinal leak, wound complications, and bowel obstruction, each with an incidence on the order of 1–2% [32,33]. A recent large database analysis places contemporary venous thromboembolism (VTE) risk at 0.04% [34] in an era when most bariatric centers use routine VTE chemoprophylaxis in accordance with ASMBS guidelines [35].

Risk factors for short-term morbidity include patient age [36], male sex, and low institutional case volume [32]. The overall mortality rate is very low. In one large study of over 25,000 patients who underwent RYGB from a Scandinavian database, the perioperative 30-day mortality after RYGB was 0.04% [32]. In another study of over 128,000 RYGB patients from an American database, mortality rates within 30 days and at one year following surgery were 0.13% and 0.23% respectively [37]. The safety of WLS, including RYGB, appears to be improving significantly over time [37].

2.1.2.2. Long Term Complications

2.1.2.2.1. Abdominal Pain. RYGB patients can complain of abdominal pain that may be acute or chronic in nature. Nearly half of these patients require CT imaging to evaluate the pain [38]. Causes of abdominal pain are variable and workup should exclude problems related specifically to RYGB such as internal hernias, marginal ulcers, dumping syndrome, gastric remnant distension, bowel obstruction, intussusception, and cholecystitis. Often, the etiology is not identified [39].

2.1.2.2.2. Marginal Ulcer. About 0.6–7.6% of patients can develop ulceration of the gastrojejunal anastomosis, though some studies report higher rates. The etiology of a marginal ulcer is unclear, but possible factors include large pouch size, smoking, NSAID use, anastomotic tension, corticosteroid use, foreign suture material used at anastomosis, and anticoagulation. In most cases, marginal ulcers present as epigastric pain, nausea, vomiting, or reflux-like symptoms and are confirmed endoscopically. These symptoms can usually be treated medically with proton pump inhibitors plus or minus sucralfate and avoidance of risk factors such as smoking or NSAIDs. Less frequently, marginal ulcer can present with gastrointestinal bleeding, perforation, or fistula, occasionally prompting reoperation [40,41].

2.1.2.2.3. Internal Hernia. RYGB patients are at risk for herniation of small bowel through mesenteric defects. The incidence in the literature is approximately 1–10% [42]. Internal hernias can present any time after RYGB, but are commonly seen 2–3 years post-operatively in patients who have lost significant amounts of weight. Patients often complain of diffuse, episodic, severe abdominal pain that is not predictably postprandial [43]. The presentation can frequently be atypical and demands a high index of suspicion [43,44].

Serum elevations in amylase and lipase may be helpful, being elevated in 48% of patients with obstruction [45]. CT can be useful in identifying internal hernias especially if mesenteric swirling is visualized, but is often non-revealing. If clinical suspicion for internal hernia is high based on symptoms, a surgical consultation and operative exploration is warranted given the high risk of progression to bowel necrosis absent prompt intervention [43,44].

2.1.2.2.4. Nutritional Complications. WLS patients must be monitored for adherence to taking multivitamins, as there can be exacerbation and onset of various micro- and macro-nutritional disorders [46]. Important among these are B12 deficiency [46], iron deficiency, anemia [47], and hypovitaminosis D [48]. Bone mineral density decreases following surgery [49,50], placing patients at increased risk for fractures [51]. Other micronutrient deficiencies such as folate, zinc, copper and selenium have been reported [46]. Patients who undergo RYGB should have periodic surveillance of important micro- and macronutrient levels [52].

2.1.2.2.5. Dumping Syndrome. Dumping syndrome applies to uncomfortable symptoms that result from rapid passage of chyme into the small intestine. Early dumping manifests within 30 min of food ingestion as combined gastrointestinal and systemic symptoms due to osmotic fluid shifts and hormonal responses to food; late dumping describes a reactive hypoglycemia that occurs on the order of hours postprandially [53]. Early dumping occurs in 10–20% and late dumping in 5–10% of RYGB patients [54,55]. Though dumping symptoms have been associated with decreased quality of life [56], they may influence eating behaviors that contribute to post-operative weight loss [57] (Fig. 1).

2.2. SG

SG involves resection of the greater curvature of the stomach, leaving a tubular remnant with markedly restricted capacity. Initially used to bridge high risk patients to biliopancreatic diversion, SG was ultimately accepted as a standalone alternative [59]. In 2013, it became the most frequently used procedure in the United States [21].

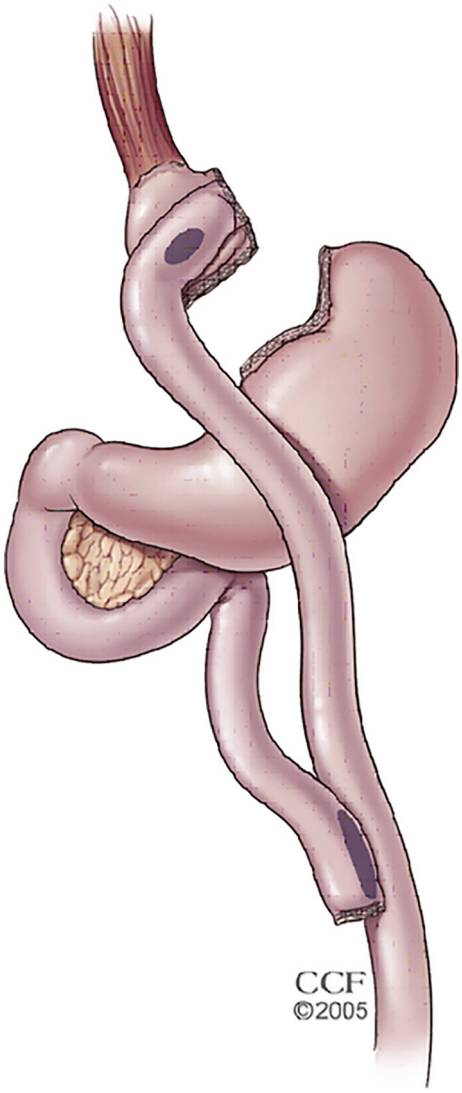

Fig. 1. Roux-en-Y gastric bypass [58].

2.2.1. Weight Loss

Randomized controlled trials comparing RYGB and SG, including the recent SLEEVEPASS and SM-BOSS trials, demonstrate the procedures are comparable in terms of excess weight reduction [23–25,60]. However, some data from large, long-term cohort studies suggest RYGB is probably more effective than SG in reducing excess weight beyond five years [28,61]. The weight loss trajectory experienced by SG patients is similar to that of RYGB patients discussed above [62].

2.2.2. Complications

Important short-term complications specific to SG include staple line bleed and gastrointestinal leak, each occurring in <1% of patients [63,64]. The incidence of gastrointestinal leak is lower among SG as compared to RYGB patients [33]. Oxygen dependence, hypertension, OSA, oxygen dependence, hypoalbuminemia, diabetes, and GERD may increase risk [33,64]. Many of these complications can be treated endoscopically [65]. Surgeons continue to debate the relative importance of surgical technique versus patient factors in the risk of leak [63,64].

SG patients are at risk for vitamin D deficiency and loss of bone mineral density changes [48,50] but may have lower fracture risk than RYGB patients [51]. Anemia, iron, folate, vitamin B12, and vitamin D deficiencies are seen [66] and require frequent surveillance and adherence to daily multivitamins, B12 and calcium supplementation [5].

The rate of early dumping symptoms after SG is similar to that following RYGB, but SG patients seem to experience less late dumping [54].

A recent ASMBS position paper characterized the risk of GERD following SG as a topic of considerable controversy and did not take a strong position on whether GERD constitutes a relative contraindication to SG [67]. However, in the recent SM-BOSS trial, of patients with mild GERD who underwent SG, 32% had worsening symptoms. Furthermore, 9 of 121 SG patients underwent conversion to RYGB for severe GERD [23] (Fig. 2).

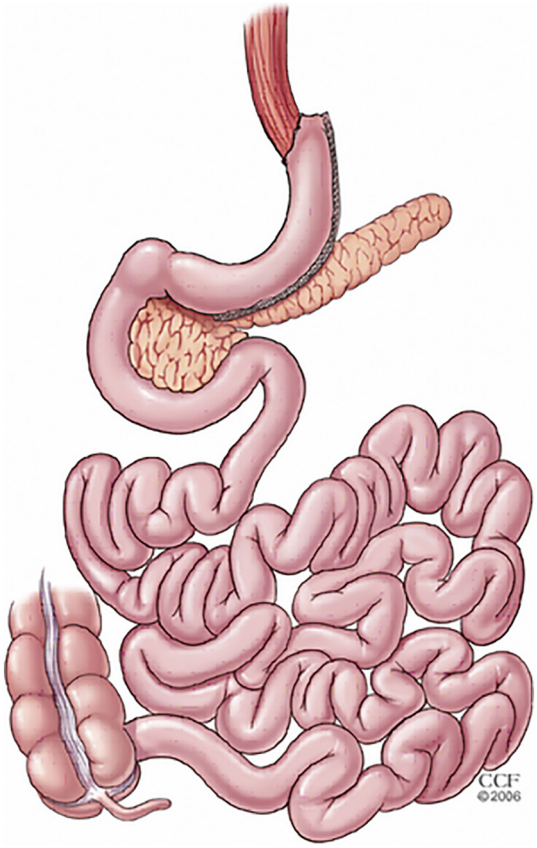

Fig. 2. Sleeve gastrectomy [58].

2.3. Gastric Banding (GB)

GB uses an inflatable band around the gastric fundus and cardia to restrict food intake and stomach compliance. Evidence in favor of GB includes one major longitudinal cohort that reported durable weight loss over an extended follow up period [29] and a randomized controlled trial demonstrating effectiveness versus medical therapy in achieving diabetes remission [68]. However, GB is associated with a high rate of reoperation at an unacceptable cost to payers [69]. Although some authors advocate for its continued utility in selected patients [62], its use has declined precipitously over the last decade [70] and has been nearly abandoned in favor of RYGB and SG [21]. At academic medical centers, procedures to remove gastric bands now outnumber placements [21].

2.3.1. Weight Loss

In one large observational cohort, GB patients lost about half of their excess weight within four years of surgery and the result was durable in patients with follow up over ten years [29]. However, a randomized trial comparing RYGB to GB, patients who underwent RYGB lost a significantly higher proportion of their initial body weight ten years after surgery [71]. In a systematic review comparing WLS procedures, GB was ruled inferior to RYGB in weight loss induction as excess weight loss was <50% after 2–5 years in 69% of studies [26]. Weight loss among GB patients appears to be inferior to that of SG as well [62].

2.3.2. Complications

Perioperative and late mortality following GB is very low [29]. Although the 30-day morbidity rate is about 1% and lower than that of RYGB, GB patients are much more likely to suffer major adverse events or reoperation in the years following surgery [71,72]. Complications that commonly prompt surgery include erosion of the band into the gastric mucosa, slippage of the band, obstruction, food intolerance, reflux symptoms, pouch dilation, infection, and complications related to tubing [71,73]. In a large database analysis that included over 25,000 patients who underwent GB with mean follow up of 4.5 years, about 20% of patients underwent an average of nearly four reoperations [69] (Fig. 3).

2.4. Biliopancreatic Diversion

Typically discussed in the context of super-obesity (BMI over 50), biliopancreatic diversion consists of a partial gastrectomy in combination with a Roux-en-Y gastro-ileostomy [78]. A variant of this procedure is duodenal switch, which includes sleeve gastrectomy [22]. Both procedures are thought to minimize fat absorption more than other bariatric surgical interventions [78].

2.4.1. Weight Loss

These procedures are highly efficacious in weight loss induction with an effect size larger than that of RYGB. In an RCT comparing RYGB to duodenal switch among patients with BMI from 50 to 60, BMI reduction in RYGB patients was 13.6 as compared to 22.1 among duodenal switch patients [79]. Similarly, in a 20-year follow up data from a cohort of over 2000 open duodenal switch patients at a single institution, patients lost an average of 70% of excess weight, corresponding to a mean 20-unit BMI reduction [78].

2.4.2. Complications

This efficacy comes at the expense of complications. It is perhaps due to surgical risk that utilization of these procedures is low and has been estimated at 1% of bariatric operations worldwide [22]. In the randomized controlled trial mentioned above, about 10% of RYGB patients as compared to nearly 50% of duodenal switch patients required reoperation after five years of follow up. Furthermore, over 10% of duodenal

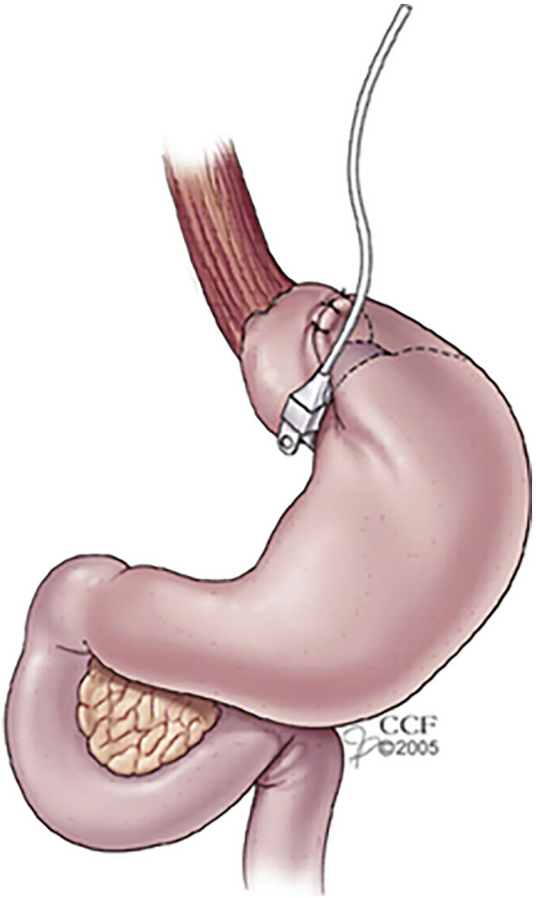

Fig. 3. Gastric band [58].

switch patients required hospital admission for malnutrition [79] (Fig. 4).

2.5. Vagal Nerve Blocker

This is a relatively new intervention in which laparoscopically-placed electrodes, powered via a rechargeable subcutaneous source, are used to intermittently inhibit the vagal signaling near the gastro-esophageal junction. An American Society for Metabolic and Bariatric Surgery (ASMBS) position statement from 2016 recognizes the technique as measurably efficacious with a reasonable safety profile and calls for further investigation [74].

2.5.1. Weight Loss

ReCharge and EMPOWER are randomized, sham-controlled trials evaluating vagal blockade. They demonstrated significant weight loss that is durable in up to two years of follow up [75,76]. The effect size appears to be relatively lower than that of RYGB and SG. In the first open-label study of vagal blockage for diabetes among adults with BMI between 30 and 40, excess weight loss was 22% and glycemic control was improved with a glycosylated hemoglobin reduction of 0.6% after two years of follow up [77].

2.5.2. Complications

In the ReCharge study, the rate of Clavien-Dindo grade III–IV adverse events was 3.7% after two years [75]. The EMPOWER study did not report graded adverse events. Further research is needed to quantify the long-term risks of vagal inhibition.

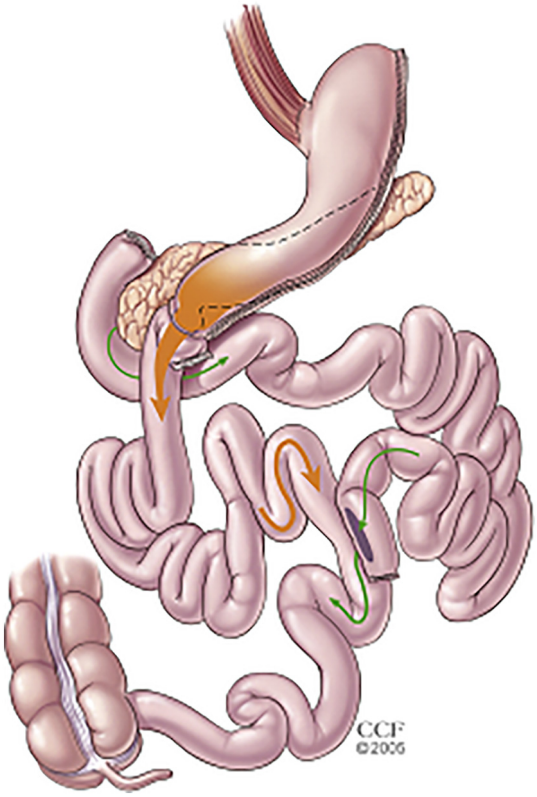

Fig. 4. Biliopancreatic diversion (including duodenal switch) [58].

2.6. Gastric Imbrication

Gastric imbrication, also commonly referred to as gastric plication, is a relatively new procedure that attempts to create the restrictive functional anatomy of SG through imbrication of the greater curvature of the stomach. Patients are spared gastric resection and foreign body placement, leading to hypothesized safety benefits [80]. The procedure remains under active investigation.

2.6.1. Weight Loss

A recent meta-analysis of prospective trials comparing gastric imbrication to SG found improved excess weight reduction among SG patients through 18 months of follow up. At the 24 and 36-month time points, there was no detectable difference between SG and gastric imbrication patients in terms of weight loss, but results exhibited a high degree of heterogeneity, highlighting the importance of collecting additional data on long-term follow up [81].

2.6.2. Complications

In the same meta-analysis, safety was comparable between gastric imbrication and SG patients on all important measures [81].

3. Emerging and Endoscopic Approaches

3.1. Endoluminal RYGB Analogues

Endoluminal RYGB analogues are tubular devices that are anchored endoscopically in the proximal GI tract and act to separate ingested nutrients from the intestinal lining and pancreaticobiliary secretions through the jejunum at the termination of the tube [82].

In a meta-analysis, subjects treated with one such device, the duodenal-jejunal bypass liner, lost about 10% more excess weight than controls. However, glycemic control was not significantly improved

[83]. Data from a systematic review specifically focused on safety of the duodenal-jejunal bypass liner show a serious adverse event rate of about 3%; among these, 85% were attributed to design of the device anchor [84].

3.2. Robotic Surgery

While the vast majority of WLS is performed by conventional laparoscopy, the use of robotic surgery increased about tenfold in the decade prior to 2015 [85]. A meta-analysis of studies comparing robotic to laparoscopic sleeve gastrectomy found the approaches had a similar safety profile, but that robotic surgery was associated with longer operative times, longer length of stay, and higher cost [86]. In an analysis of MBSAQIP data, patients who underwent robotic RYGB were propensity-score matched to patients who underwent laparoscopic surgery. In this analysis, robotic RYGB was as safe as conventional laparoscopy on most outcomes of interest, however, robotic surgery was associated with longer operative times and increased readmission [87]. Improved safety with the robotic approach has been reported in at least one cohort [88]. Whether the robotic platform provides a good incremental value over traditional laparoscopy remains to be determined.

3.3. Intragastric Balloon

Intragastric balloons have been under development and in use around the world since the 1980s, but their use in the US has been limited. Since 2015, the FDA has approved three new intragastric balloons. Because they are intended for short term use, these devices are not an alternative to WLS [89]. A recent review of intragastric balloons meta-analyzed four controlled trials and found the devices led to mean total body weight loss of 9.7%, which is significant but small in relation to standard WLS interventions [90]. There have been multiple FDA advisories on gastric rupture and hemorrhage following intragastric balloon placement, the outcomes of which remain undetermined [91].

4. Mechanism of Action of Weight Loss and Metabolic Surgery

Researchers continue to actively investigate and debate the underlying physiology of weight loss and blood glucose homeostasis following WLS. While the precise mechanisms of action remain to be fully elucidated, they appear to be multifactorial and mediated by interrelated changes in enteroendocrine function, bile acid circulation, behavior and appetite, and intestinal microflora. Following surgery, patients experience significant changes in food preferences and eating behaviors, with decreased caloric intake lasting for years following intervention. RYGB and SG increase PYY and GLP-1, intestinal peptide hormones secreted by L cells in the distal gut that are normally increased following meals. PYY likely acts centrally and increases satiety; GLP-1 also acts centrally to increase satiety and potentiates insulin responsiveness; and its analogues are common and effective diabetes medications. Bariatric surgery also increases bile acids, which have various metabolic functions including regulation of metabolically important hormones such as GLP-1 and FGF-19. WLS induces intestinal luminal morphologic and functional changes. Malabsorption of macronutrient content appears to play a partial but relatively minor role in weight loss after surgery [57].

5. Impact of Surgery on Diabetes Type 2

Randomized controlled trials have shown that in patients with obesity associated with diabetes, WLS is highly effective in controlling hyperglycemia [92,93]. The Diabetes Surgery Study randomized 120 adults with obesity and diabetes to intensive medical management alone or in combination with RYGB. After a year, 49% of surgical patients achieved a composite endpoint combining control of blood sugar, blood pressure, and cholesterol levels as compared to 19% of the non-surgical arm, and they required significantly fewer medications [94]. After three years, 28% of RYGB patients as compared to 9% of controls met criteria for the primary endpoint, demonstrating the durability of surgical intervention. In addition, full or partial diabetes remission was seen in 36% of the surgical arm versus zero non-surgical patients [95]. Although the effect of surgery diminished over time, it remained robust after five years [96].

The STAMPEDE trial randomized 150 overweight or obese adults with diabetes to intensive medical therapy alone or in combination with RYGB or SG. After five years, 29% and 23% of patients in the RYGB and SG arms respectively had achieved a primary outcome of glycosylated hemoglobin <6% as compared to 5% of patients who received intensive medical therapy alone. Surgical patients also maintained adequate glycemic control, using significantly fewer diabetes medications as compared to medical patients [97].

Large, long-term, prospective cohort studies show improved blood sugar control and remission of diabetes among WLS patients, providing evidence for the stability of this effect over time [7,98]. In one such cohort, nearly one third of diabetic patients remained in remission fifteen years after surgery [8]. In addition, multiple studies suggest WLS decreases the burden of diabetic microvascular disease [8,99,100].

WLS has considerable efficacy in diabetes prevention as well: In a study that prospectively followed patients with obesity who sought and underwent RYGB to patients that either sought and did not undergo surgery or did not seek surgery, the incidence of diabetes in the RYGB patients was 3% as compared to 26% in the non-surgical patients after 12 years [30].

6. Impact of Surgery on Cardiovascular Risk

An emerging body of literature confirms that WLS has a significant capacity to improve cardiovascular risk. In a recent trial that randomized patients with hypertension to RYGB versus medical therapy, the primary endpoint of blood pressure control with ≥30% reduction in number of blood pressure medications was met by 83.7% of surgical patients as compared to 12.8% of medical enrollees [9]. The trial confirmed prior findings that WLS leads to reduced cardiovascular risk as measured by Framingham Risk Score [101–103]. Cardiac risk reduction may proceed through a mechanism independent of weight loss [104]. WLS appears to decrease coronary arterial calcification [105] and improve both diastolic and systolic function in obese patients with heart failure [11]. It also leads to a reduced risk of heart failure in according three large, recent observational cohort studies [106–108]. In terms of neurovascular risk, WLS appears to reduce carotid atherosclerosis [109] and atrial fibrillation [110].

Over two thousand WLS patients and a prospectively matched non-surgical control group were followed for ten years in the Swedish Obese Subjects study. Surgical patients had lower risk of cardiovascular mortality and of total first-time acute coronary syndrome or stroke [10].

7. Impact of Surgery on Non-Alcoholic Fatty Liver Disease

WLS is hypothesized to slow or reverse non-alcoholic fatty liver disease (NAFLD) by improving lipid metabolism and insulin sensitivity and by reducing the chronic inflammation of obesity [111]. WLS decreases the incidence of NASH among subjects on biochemical and histological measures [111]. In one prospective cohort, WLS induced resolution of biopsy-proven non-alcoholic steatohepatitis (NASH) in 85% of patients on biopsies taken one year after surgery [112]. Another prospective study confirmed the dramatic effect of WLS on NAFLD using serial MR imaging [113]. Resolution of NASH following WLS is seen among patients with improved insulin sensitivity [111] and increased weight loss [112]. Dedicated randomized trials to evaluate WLS as a therapy for NAFLD are unavailable at this time.

8. Operative Choice

Both recent European randomized controlled trials comparing SG to RYGB, SM-BOSS and SLEEVEPASS, suggest RYGB and SG offer similar five-year outcomes with respect to weight loss [23,24].

The SM-BOSS and SLEEVEPASS trials found SG and RYGB offer similar rates of complete diabetes remission and blood glucose control. In the former trial, rates of diabetes remission were 68% and 62% for RYGB and SG respectively; in the latter, the corresponding remission rates were 25% and 12% [23,24]. However, the STAMPEDE trial suggests RYGB may be preferable to SG as a diabetes intervention, as RYGB patients were more likely to be off glucose-lowering medications than SG patients after five years (45% versus 25%) [97].

The SM-BOSS and SLEEVEPASS trials suggest resolution of other comorbidities is similar between RYGB and SG [23,24].

Neither trial reported significant differences between RYGB and SG in operative morbidity, complications requiring operative reintervention, or mortality [23,24]. The SLEEVEPASS trial found similar quality of life between RYGB and SG at study conclusion [24].

A large meta-analysis including 1394 patients did not show any significant weight differences between RYGB and SG or resolution of comorbidities within five years. Beyond that, RYGB induced slightly more weight loss than SG without an associated advantage in comorbidity resolution [61].

Of note, the SM-BOSS trial found SG patients had a significantly higher rate of worsened (32% vs 6%) and de novo GERD (32% vs 11%), while RYGB patients had a significantly higher rate of GERD remission (60% vs 25%) [23]. Patients with GERD should be cautioned that RYGB is more likely to improve their symptoms than SG, and that SG may make mild GERD worse [114].

In comparative trials, the complication rate of SG is similar to that of RYGB [23] aside from some evidence of increased early, minor complications among RYGB patients [24,115]. However, meta-analytic data [116] and evidence from large databases [36,37,117] collectively suggest morbidity and mortality may be somewhat lower among SG patients.

In general, SG and RYGB are comparable in terms of effectiveness and safety, and providers should tailor the operative choice to individual patients' goals, values, and risk tolerances through a process of shared decision-making [114].

9. Reoperations for Weight Gain

Treatment failure in the form of weight regain or insufficient weight loss is considered an indication for reintervention by the ASMBS [118]. It is included as an indication for reoperation in many studies, but there is currently no consensus definition or guideline to define or classify weight regain after WLS [119]. Weight recidivism after WLS is multifactorial and related to type of bariatric procedure performed. Prior to contemplating revisional surgery for weight recidivism, a wide range of factors must be optimized including endocrine function, mental health, physical activity, and dietary compliance [60,118]. Revisional surgery for weight regain is performed by some bariatric surgeons; however, these procedures have modest weight loss, require redo surgery, and are associated with increased complications [118]. As a result, bariatric surgeons exhibit significant variability of opinion regarding the definition of weight regain and its optimal treatment in various clinical situations, and the decision to pursue reoperation is often driven by patient goals [120,121].

Additional research is needed to clarify appropriate clinical definitions of treatment failure, specify indications for secondary interventions, and determine the efficacy of various interventional options in clinical trials.

9.1. RYGB

Weight regain in RYGB patients is multifactorial but often attributed to post-surgical anatomical changes [122] including pouch distention and widening of the gastrojejunal anastomosis [123,124]. A recent review of interventions following weight recidivism after RYGB found that conversion to biliopancreatic diversion with duodenal switch and conversion to distal gastric bypass were both safe and effective in inducing weight loss [122]. Another review found that weight loss can be achieved through endoscopic intervention, and in particular, full thickness suturing of the gastrojejunal anastomosis combined with argon plasma coagulation [125]. Evidence regarding other salvage interventions including pouch reshaping [126] and wedge resection of the gastrojejunostomy [127] continues to emerge.

9.2. SG

A review of reoperation for weight regain after SG found that both re-sleeve gastrectomy and conversion to RYGB were effective and comparable in weight loss induction. It recommended re-sleeve gastrectomy given its relatively low technical difficulty as compared to conversion to RYGB [128]. Single anastomosis duodenoileal bypass has also produced weight loss in this context [129].

10. Delivery

WLS is highly effective, and though it may not be cost-saving [130], it is cost-effective [131]. Nevertheless, reported WLS utilization rates are well under 1% in clinically eligible populations [132,133]. Furthermore, WLS utilization varies considerably by region, and this variation is not easily explained by population epidemiology [134], or access to care [135].

Health insurance policies do not consistently cover the procedure despite the value to be gained by expanding access [132]. Publicly insured patients are relatively unlikely to undergo WLS [136], though utilization may be increasing marginally in this publication [137]. Patients belonging to racial and ethnic minority groups appear less likely than whites to undergo WLS [136], though the extent to which this is driven by racial disparities in healthcare provision is unclear and may vary by region [138,139].

A number of factors contribute to low and variable utilization rates [140]. Studies examining barriers to WLS implicate lack of knowledge and experience with bariatric surgery among referring providers, and their relative over-emphasis of complications as opposed to effectiveness of WLS as major contributors [141–143].

11. Conclusion

WLS comprises a number of procedures and interventions that have proved durably efficacious in treating a number of obesity-related diseases. Bariatric surgeries have an acceptable safety profile and continue to improve and evolve over time as existing interventions are refined and new ones are developed and incorporated into the surgical repertoire for treating obesity. The next generation of obesity treatments is likely to include weight loss surgical interventions with an emphasis on minimal intervention in conjunction with existing and emerging drugs [144]. For the foreseeable future, WLS remains the most effective option for treating obesity and related metabolic disorders and can significantly improve morbidity and mortality associated with these diseases.

Declarations of Interest

The authors have no conflict of interest.

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Author Contributions

Study conception and design: Nudel, Sanchez.
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References

[1] Heymsfield SB, Wadden TA. Mechanisms, pathophysiology, and management of obesity. N Engl J Med 2017;376:254–66. https://doi.org/10.1056/NEJMra1514009 [PMID:28099824].
[2] Kim DD, Basu A. Estimating the medical care costs of obesity in the United States: systematic review, meta-analysis, and empirical analysis. Value Health 2016;19:602–13. https://doi.org/10.1016/j.jval.2016.02.008 [PMID:27565277].
[3] Hales CM, Fryar CD, Carroll MD, Freedman DS, Ogden CL. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007–2008 to 2015–2016. JAMA 2018;319:1723–5. https://doi.org/10.1001/jama.2018.3060 [PMID:29570750].
[4] Colquitt JL, Pickett K, Loveman E, Frampton GK. Surgery for weight loss in adults. Cochrane Database Syst Rev 2014:CD003641. https://doi.org/10.1002/14651858.CD003641.pub4 [PMID:25105982].
[5] Mechanick JI, Youdim A, Jones DB, Timothy Garvey W, Hurley DL, Molly McMahon M, et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient—2013 update: cosponsored by American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic & Bariatric Surgery. Surg Obes Relat Dis 2013;9:159–91. https://doi.org/10.1016/j.soard.2012.12.010 [PMID:23537696].
[6] Rubino F, Nathan DM, Eckel RH, Schauer PR, Alberti KGMM, Zimmet PZ, et al. Metabolic surgery in the treatment algorithm for type 2 diabetes: a joint statement by international diabetes organizations. Surg Obes Relat Dis 2016;12:1144–62. https://doi.org/10.1016/j.soard.2016.05.018.
[7] Courcoulas AP, King WC, Belle SH, Berk P, Flum DR, Garcia L, et al. Seven-year weight trajectories and health outcomes in the longitudinal assessment of bariatric surgery (LABS) study. JAMA Surg 2018;153:427–34. https://doi.org/10.1001/jamasurg.2017.5025 [PMID:29214306].
[8] Sjöström L, Peltonen M, Jacobson P, Ahlin S, Andersson-Assarsson J, Anveden Å, et al. Association of bariatric surgery with long-term remission of type 2 diabetes and with microvascular and macrovascular complications. JAMA 2014;311:2297. https://doi.org/10.1001/jama.2014.5988.
[9] Schiavon CA, Bersch-Ferreira AC, Santucci EV, Oliveira JD, Torreglosa CR, Bueno PT, et al. Effects of bariatric surgery in obese patients with hypertension: the GATEWAY randomized trial (gastric bypass to treat obese patients with steady hypertension). Circulation 2018;137:1132–42. https://doi.org/10.1161/CIRCULATIONAHA.117.032130 [PMID:29133606].
[10] Sjöström L, Peltonen M, Jacobson P, Sjöström CD, Karason K, Wedel H, et al. Bariatric surgery and long-term cardiovascular events. JAMA 2012;307:56–65. https://doi.org/10.1001/jama.2011.1914 [PMID:22215166].
[11] Aggarwal R, Harling L, Efthimiou E, Darzi A, Athanasiou T, Ashrafian H. The effects of bariatric surgery on cardiac structure and function: a systematic review of cardiac imaging outcomes. Obes Surg 2016;26:1030–40. https://doi.org/10.1007/s11695-015-1866-5 [PMID:26328532].
[12] Ashrafian H, Toma T, Rowland SP, Harling L, Tan A, Efthimiou E, et al. Bariatric surgery or non-surgical weight loss for obstructive sleep apnoea? A systematic review and comparison of meta-analyses. Obes Surg 2015;25:1239–50. https://doi.org/10.1007/s11695-014-1533-2 [PMID:25537297].
[13] Avgerinos KI, Spyrou N, Mantzoros CS, Dalamaga M. Obesity and cancer risk: emerging biological mechanisms and perspectives. Metabolism 2018. https://doi.org/10.1016/j.metabol.2018.11.001 [PMID:30445141].
[14] López-Suárez A. Burden of cancer attributable to obesity, type 2 diabetes and associated risk factors. Metabolism 2018. https://doi.org/10.1016/j.metabol.2018.10.013 [PMID:30412695].
[15] Schauer DP, Feigelson HS, Koebnick C, Caan B, Weinmann S, Leonard AC, et al. Association between weight loss and the risk of cancer after bariatric surgery. Obesity (Silver Spring) 2017;25(Suppl. 2):S52–7. https://doi.org/10.1002/oby.22002 [PMID:29086527].
[16] Sjöström L, Gummesson A, Sjöström CD, Narbro K, Peltonen M, Wedel H, et al. Effects of bariatric surgery on cancer incidence in obese patients in Sweden (Swedish Obese Subjects Study): a prospective, controlled intervention trial. Lancet Oncol 2009;10:653–62. https://doi.org/10.1016/S1470-2045(09)70159-7 [PMID:19556163].
[17] Reges O, Greenland P, Dicker D, Leibowitz M, Hoshen M, Gofer I, et al. Association of bariatric surgery using laparoscopic banding, Roux-en-Y gastric bypass, or laparoscopic sleeve gastrectomy vs usual care obesity management with all-cause mortality. JAMA 2018;319:279–90. https://doi.org/10.1001/jama.2017.20513 [PMID:29340677].
[18] Sjöström L, Narbro K, Sjöström CD, Karason K, Larsson B, Wedel H, et al. Effects of bariatric surgery on mortality in Swedish obese subjects. N Engl J Med 2007;357:741–52. https://doi.org/10.1056/NEJMoa066254 [PMID:17715408].
[19] Adams TD, Gress RE, Smith SC, Halverson RC, Simper SC, Rosamond WD, et al. Long-term mortality after gastric bypass surgery. N Engl J Med 2007;357:753–61. https://doi.org/10.1056/NEJMoa066603 [PMID:17715409].
[20] Arterburn DE, Olsen MK, Smith VA, Livingston EH, Van Scoyoc L, Yancy WS, et al. Association between bariatric surgery and long-term survival. JAMA 2015;313:62–70. https://doi.org/10.1001/jama.2014.16968 [PMID:25562267].
[21] Koh CY, Inaba CS, Sujatha-Bhaskar S, Hohmann S, Ponce J, Nguyen NT. Laparoscopic adjustable gastric band explantation and implantation at academic centers. J Am Coll Surg 2017;225:532–7. https://doi.org/10.1016/j.jamcollsurg.2017.06.015 [PMID:28754410].
[22] Albaugh VL, Abumrad NN. Surgical treatment of obesity. F1000Res 2018;7. https://doi.org/10.12688/f1000research.13515.1 [PMID:29904577].
[23] Peterli R, Wölnerhanssen BK, Peters T, Vetter D, Kröll D, Borbély Y, et al. Effect of laparoscopic sleeve gastrectomy vs laparoscopic Roux-en-Y gastric bypass on weight loss in patients with morbid obesity: the SM-BOSS randomized clinical trial. JAMA 2018;319:255–65. https://doi.org/10.1001/jama.2017.20897 [PMID:29340679].
[24] Salminen P, Helmiö M, Ovaska J, Juuti A, Leivonen M, Peromaa-Haavisto P, et al. Effect of laparoscopic sleeve gastrectomy vs laparoscopic Roux-en-Y gastric bypass on weight loss at 5 years among patients with morbid obesity: the SLEEVEPASS randomized clinical trial. JAMA 2018;319:241–54. https://doi.org/10.1001/jama.2017.20313 [PMID:29340676].
[25] Kehagias I, Karamanakos SN, Argentou M, Kalfarentzos F. Randomized clinical trial of laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy for the management of patients with BMI <50 kg/m^2. Obes Surg 2011;21:1650–6. https://doi.org/10.1007/s11695-011-0479-x [PMID:21818647].
[26] Puzziferri N, Roshek TB, Mayo HG, Gallagher R, Belle SH, Livingston EH. Long-term follow-up after bariatric surgery: a systematic review. JAMA 2014;312:934–42. https://doi.org/10.1001/jama.2014.10706 [PMID:25182102].
[27] Courcoulas AP, Christian NJ, Belle SH, Berk PD, Flum DR, Garcia L, et al. Weight change and health outcomes at 3 years after bariatric surgery among individuals with severe obesity. JAMA 2013;310:2416–25. https://doi.org/10.1001/jama.2013.280928 [PMID:24189773].
[28] Maciejewski ML, Arterburn DE, Van Scoyoc L, Smith VA, Yancy WS, Weidenbacher HJ, et al. Bariatric surgery and long-term durability of weight loss. JAMA Surg 2016;151:1046. https://doi.org/10.1001/jamasurg.2016.2317.
[29] O'Brien PE, MacDonald L, Anderson M, Brennan L, Brown WA. Long-term outcomes after bariatric surgery. Ann Surg 2013;257:87–94. https://doi.org/10.1097/sla.0b013e31827b6c02.
[30] Adams TD, Davidson LE, Litwin SE, Kim J, Kolotkin RL, Nanjee MN, et al. Weight and metabolic outcomes 12 years after gastric bypass. N Engl J Med 2017;377:1143–55. https://doi.org/10.1056/NEJMoa1700459 [PMID:28930514].
[31] Mitchell JE, Christian NJ, Flum DR, Pomp A, Pories WJ, Wolfe BM, et al. Postoperative behavioral variables and weight change 3 years after bariatric surgery. JAMA Surg 2016;151:752–7. https://doi.org/10.1001/jamasurg.2016.0395 [PMID:27096225].
[32] Stenberg E, Szabo E, Agren G, Näslund E, Boman L, Bylund A, et al. Early complications after laparoscopic gastric bypass surgery: results from the Scandinavian Obesity Surgery Registry. Ann Surg 2014;260:1040–7. https://doi.org/10.1097/SLA.0000000000000431 [PMID:24374541].
[33] Alizadeh RF, Li S, Inaba C, Penalosa P, Hinojosa MW, Smith BR, et al. Risk factors for gastrointestinal leak after bariatric surgery: MBASQIP analysis. J Am Coll Surg 2018;227:135–41. https://doi.org/10.1016/j.jamcollsurg.2018.03.030 [PMID:29605723].
[34] Dang JT, Switzer N, Delisle M, Laffin M, Gill R, Birch DW, et al. Predicting venous thromboembolism following laparoscopic bariatric surgery: development of the BariClot tool using the MBSAQIP database. Surg Endosc 2018. https://doi.org/10.1007/s00464-018-6348-0 [PMID:30003351].
[35] American SFMABSCIC. ASMBS updated position statement on prophylactic measures to reduce the risk of venous thromboembolism in bariatric surgery patients. Surg Obes Relat Dis 2013;9:493–7. https://doi.org/10.1016/j.soard.2013.03.006 [PMID:23769113].
[36] Haskins IN, Ju T, Whitlock AE, Rivas L, Amdur RL, Lin PP, et al. Older age confers a higher risk of 30-day morbidity and mortality following laparoscopic bariatric surgery: an analysis of the metabolic and bariatric surgery quality improvement program. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3233-9 [PMID:29663253].
[37] Inaba CS, Koh CY, Sujatha-Bhaskar S, Silva JP, Chen Y, Nguyen DV, et al. One-year mortality after contemporary laparoscopic bariatric surgery: an analysis of the bariatric outcomes longitudinal database. J Am Coll Surg 2018;226:1166–74. https://doi.org/10.1016/j.jamcollsurg.2018.02.013 [PMID:29551698].
[38] Sandvik J, Hole T, Klöckner CA, Kulseng BE, Wibe A. High-frequency of computer tomography and surgery for abdominal pain after Roux-en-Y gastric bypass. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3223-y [PMID:29619755].
[39] Mala T, Høgestøl I. Abdominal pain after Roux-En-Y gastric bypass for morbid obesity. Scand J Surg 2018. https://doi.org/10.1177/1457496918772360 [1457496918772360; PMID:29739280].
[40] Coblijn UK, Goucham AB, Lagarde SM, Kuiken SD, van Wagensveld BA. Development of ulcer disease after Roux-en-Y gastric bypass, incidence, risk factors, and

patient presentation: a systematic review. Obes Surg 2014;24:299–309. https://doi.org/10.1007/s11695-013-1118-5 [PMID:24234733].
[41] Coblijn UK, Lagarde SM, de Castro SM, Kuiken SD, van Wagensveld BA. Symptomatic marginal ulcer disease after Roux-en-Y gastric bypass: incidence, risk factors and management. Obes Surg 2015;25:805–11. https://doi.org/10.1007/s11695-014-1482-9 [PMID:25381115].
[42] Geubbels N, Lijftogt N, Fiocco M, van Leersum NJ, Wouters MW, de Brauw LM. Meta-analysis of internal herniation after gastric bypass surgery. Br J Surg 2015;102:451–60. https://doi.org/10.1002/bjs.9738 [PMID:25708572].
[43] Greenstein AJ, O'Rourke RW. Abdominal pain after gastric bypass: suspects and solutions. Am J Surg 2011;201:819–27. https://doi.org/10.1016/j.amjsurg.2010.05.007 [PMID:21333269].
[44] Al-Mansour MR, Mundy R, Canoy JM, Dulaimy K, Kuhn JN, Romanelli J. Internal hernia after laparoscopic antecolic Roux-en-Y gastric bypass. Obes Surg 2015;25:2106–11. https://doi.org/10.1007/s11695-015-1672-0 [PMID:26037306].
[45] Spector D, Perry Z, Shah S, Kim JJ, Tarnoff ME, Shikora SA. Roux-en-Y gastric bypass: hyperamylasemia is associated with small bowel obstruction. Surg Obes Relat Dis 2015;11:38–43. https://doi.org/10.1016/j.soard.2014.04.030 [PMID:25264325].
[46] Bal BS, Finelli FC, Shope TR, Koch TR. Nutritional deficiencies after bariatric surgery. Nat Rev Endocrinol 2012;8:544–56. https://doi.org/10.1038/nrendo.2012.48.
[47] Weng TC, Chang CH, Dong YH, Chang YC, Chuang LM. Anaemia and related nutrient deficiencies after Roux-en-Y gastric bypass surgery: a systematic review and meta-analysis. BMJ Open 2015;5:e006964. https://doi.org/10.1136/bmjopen-2014-006964 [PMID:26185175].
[48] Maghrabi AH, Wolski K, Abood B, Licata A, Pothier C, Bhatt DL, et al. Two-year outcomes on bone density and fracture incidence in patients with T2DM randomized to bariatric surgery versus intensive medical therapy. Obesity (Silver Spring) 2015;23:2344–8. https://doi.org/10.1002/oby.21150 [PMID:26193177].
[49] Rodríguez-Carmona Y, López-Alavez FJ, González-Garay AG, Solís-Galicia C, Meléndez G, Serralde-Zúñiga AE. Bone mineral density after bariatric surgery. A systematic review. Int J Surg 2014;12:976–82. https://doi.org/10.1016/j.ijsu.2014.08.002 [PMID:25110331].
[50] Chakhtoura MT, Nakhoul NN, Shawwa K, Mantzoros C, El Hajj Fuleihan GA. Hypovitaminosis D in bariatric surgery: a systematic review of observational studies. Metabolism 2016;65:574–85. https://doi.org/10.1016/j.metabol.2015.12.004.
[51] Zhang Q, Chen Y, Li J, Chen D, Cheng Z, Xu S, et al. A meta-analysis of the effects of bariatric surgery on fracture risk. Obes Rev 2018;19:728–36. https://doi.org/10.1111/obr.12665 [PMID:29334691].
[52] Parrott J, Frank L, Rabena R, Craggs-Dino L, Isom KA, Greiman L. American Society for Metabolic and Bariatric Surgery integrated health nutritional guidelines for the surgical weight loss patient 2016 update: micronutrients. Surg Obes Relat Dis 2017;13:727–41. https://doi.org/10.1016/j.soard.2016.12.018 [PMID:28392254].
[53] Berg P, McCallum R. Dumping syndrome: a review of the current concepts of pathophysiology, diagnosis, and treatment. Dig Dis Sci 2016;61:11–8. https://doi.org/10.1007/s10620-015-3839-x.
[54] Emous M, Wolffenbuttel BHR, van Dijk G, Totté E, van Beek AP. Long-term self-reported symptom prevalence of early and late dumping in a patient population after sleeve gastrectomy, primary, and revisional gastric bypass surgery. Surg Obes Relat Dis 2018. https://doi.org/10.1016/j.soard.2018.04.011 [PMID:29858129].
[55] Nielsen JB, Pedersen AM, Gribsholt SB, Svensson E, Richelsen B. Prevalence, severity, and predictors of symptoms of dumping and hypoglycemia after Roux-en-Y gastric bypass. Surg Obes Relat Dis 2016;12:1562–8. https://doi.org/10.1016/j.soard.2016.04.017.
[56] Emous M, Wolffenbuttel BHR, Totté E, van Beek AP. The short- to mid-term symptom prevalence of dumping syndrome after primary gastric-bypass surgery and its impact on health-related quality of life. Surg Obes Relat Dis 2017;13:1489–500. https://doi.org/10.1016/j.soard.2017.04.028 [PMID:28624531].
[57] Mulla CM, Middelbeek RJW, Patti ME. Mechanisms of weight loss and improved metabolism following bariatric surgery. Ann N Y Acad Sci 2018;1411:53–64. https://doi.org/10.1111/nyas.13409 [PMID:28868615].
[58] American SFMABSCIC. Bariatric surgery procedures; 2018 [https://asmbs.org/patients/bariatric-surgery-procedures].
[59] Wölnerhanssen B, Peterli R. State of the art: sleeve gastrectomy. Dig Surg 2014;31:40–7. https://doi.org/10.1159/000354320 [PMID:24819496].
[60] Osland E, Yunus RM, Khan S, Memon B, Memon MA. Weight loss outcomes in laparoscopic vertical sleeve gastrectomy (LVSG) versus laparoscopic Roux-en-Y gastric bypass (LRYGB) procedures: a meta-analysis and systematic review of randomized controlled trials. Surg Laparosc Endosc Percutan Tech 2017;27:8–18. https://doi.org/10.1097/SLE.0000000000000374 [PMID:28145963].
[61] Shoar S, Saber AA. Long-term and midterm outcomes of laparoscopic sleeve gastrectomy versus Roux-en-Y gastric bypass: a systematic review and meta-analysis of comparative studies. Surg Obes Relat Dis 2017;13:170–80. https://doi.org/10.1016/j.soard.2016.08.011 [PMID:27720197].
[62] Vitiello A, Pilone V, Ferraro L, Forestieri P. Is the sleeve gastrectomy always a better procedure? Five-year results from a retrospective matched case-control study. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3161-8 [PMID:29549660].
[63] Berger ER, Clements RH, Morton JM, Huffman KM, Wolfe BM, Nguyen NT, et al. The impact of different surgical techniques on outcomes in laparoscopic sleeve gastrectomies: the first report from the metabolic and bariatric surgery accreditation and quality improvement program (MBSAQIP). Ann Surg 2016;264:464–73. https://doi.org/10.1097/SLA.0000000000001851 [PMID:27433904].
[64] Dhar VK, Hanseman DJ, Watkins BM, Paquette IM, Shah SA, Thompson JR. What matters after sleeve gastrectomy: patient characteristics or surgical technique. Surgery 2018;163:571–7. https://doi.org/10.1016/j.surg.2017.09.052 [PMID:29398036].
[65] Valli PV, Gubler C. Review article including treatment algorithm: endoscopic treatment of luminal complications after bariatric surgery. Clin Obes 2017;7:115–22. https://doi.org/10.1111/cob.12182 [PMID:28199050].
[66] Ben-Porat T, Elazary R, Goldenshluger A, Sherf Dagan S, Mintz Y, Weiss R. Nutritional deficiencies four years after laparoscopic sleeve gastrectomy-are supplements required for a lifetime. Surg Obes Relat Dis 2017;13:1138–44. https://doi.org/10.1016/j.soard.2017.02.021 [PMID:28416186].
[67] Ali M, El Chaar M, Ghiassi S, Rogers AM, American SFMABSCIC. American Society for Metabolic and Bariatric Surgery updated position statement on sleeve gastrectomy as a bariatric procedure. Surg Obes Relat Dis 2017;13:1652–7. https://doi.org/10.1016/j.soard.2017.08.007 [PMID:29054173].
[68] Dixon JB, O'Brien PE, Playfair J, Chapman L, Schachter LM, Skinner S, et al. Adjustable gastric banding and conventional therapy for type 2 diabetes: a randomized controlled trial. JAMA 2008;299:316–23. https://doi.org/10.1001/jama.299.3.316 [PMID:18212316].
[69] Ibrahim AM, Thumma JR, Dimick JB. Reoperation and Medicare expenditures after laparoscopic gastric band surgery. JAMA Surg 2017;152:835–42. https://doi.org/10.1001/jamasurg.2017.1093 [PMID:28514487].
[70] Spaniolas K, Kasten KR, Brinkley J, Sippey ME, Mozer A, Chapman WH, et al. The changing bariatric surgery landscape in the USA. Obes Surg 2015;25:1544–6. https://doi.org/10.1007/s11695-015-1764-x [PMID:26072171].
[71] Nguyen NT, Kim E, Vu S, Phelan M. Ten-year outcomes of a prospective randomized trial of laparoscopic gastric bypass versus laparoscopic gastric banding. Ann Surg 2018;268:106–13. https://doi.org/10.1097/SLA.0000000000002348 [PMID:28692476].
[72] Arterburn D, Powers JD, Toh S, Polsky S, Butler MG, Portz JD, et al. Comparative effectiveness of laparoscopic adjustable gastric banding vs laparoscopic gastric bypass. JAMA Surg 2014;149:1279–87. https://doi.org/10.1001/jamasurg.2014.1674 [PMID:25353723].
[73] Sharples AJ, Charalampakis V, Daskalakis M, Tahrani AA, Singhal R. Systematic review and meta-analysis of outcomes after revisional bariatric surgery following a failed adjustable gastric band. Obes Surg 2017;27:2522–36. https://doi.org/10.1007/s11695-017-2677-7 [PMID:28477245].
[74] Papasavas P, El Chaar M, Kothari SN. American Society for Metabolic and Bariatric Surgery position statement on vagal blocking therapy for obesity. Surg Obes Relat Dis 2016;12:460–1. https://doi.org/10.1016/j.soard.2015.12.004.
[75] Apovian CM, Shah SN, Wolfe BM, Ikramuddin S, Miller CJ, Tweden KS, et al. Two-year outcomes of vagal nerve blocking (vBloc) for the treatment of obesity in the ReCharge trial. Obes Surg 2017;27:169–76. https://doi.org/10.1007/s11695-016-2325-7 [PMID:27506803].
[76] Sarr MG, Billington CJ, Brancatisano R, Brancatisano A, Toouli J, Kow L, et al. The EMPOWER study: randomized, prospective, double-blind, multicenter trial of vagal blockade to induce weight loss in morbid obesity. Obes Surg 2012;22:1771–82. https://doi.org/10.1007/s11695-012-0751-8 [PMID:22956251].
[77] Shikora SA, Toouli J, Herrera MF, Kulseng B, Brancatisano R, Kow L, et al. Intermittent vagal nerve block for improvements in obesity, cardiovascular risk factors, and glycemic control in patients with type 2 diabetes mellitus: 2-year results of the VBLOC DM2 study. Obes Surg 2016;26:1021–8. https://doi.org/10.1007/s11695-015-1914-1.
[78] Marceau P, Biron S, Marceau S, Hould F-S, Lebel S, Lescelleur O, et al. Long-term metabolic outcomes 5 to 20 years after biliopancreatic diversion. Obes Surg 2015;25:1584–93. https://doi.org/10.1007/s11695-015-1599-5.
[79] Risstad H, Søvik TT, Engström M, Aasheim ET, Fagerland MW, Olsén MF, et al. Five-year outcomes after laparoscopic gastric bypass and laparoscopic duodenal switch in patients with body mass index of 50 to 60: a randomized clinical trial. JAMA Surg 2015;150:352–61. https://doi.org/10.1001/jamasurg.2014.3579 [PMID:25650964].
[80] Committee CI. ASMBS policy statement on gastric plication. Surg Obes Relat Dis 2011;7:262. https://doi.org/10.1016/j.soard.2011.03.004 [PMID:21621164].
[81] Barrichello S, Minata MK, García Ruiz de Gordejuela A, Bernardo WM, de Souza TF, Galvão Neto M, et al. Laparoscopic greater curvature plication and laparoscopic sleeve gastrectomy treatments for obesity: systematic review and meta-analysis of short- and mid-term results. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3330-9 [PMID:29951784].
[82] Jirapinyo P, Thompson CC. Endoscopic bariatric and metabolic therapies: surgical analogues and mechanisms of action. Clin Gastroenterol Hepatol 2017;15:619–30. https://doi.org/10.1016/j.cgh.2016.10.021 [PMID:27989851].
[83] Rohde U, Hedbäck N, Gluud LL, Vilsbøll T, Knop FK. Effect of the EndoBarrier Gastrointestinal Liner on obesity and type 2 diabetes: a systematic review and meta-analysis. Diabetes Obes Metab 2016;18:300–5. https://doi.org/10.1111/dom.12603 [PMID:26537317].
[84] Betzel B, Drenth JPH, Siersema PD. Adverse events of the duodenal-jejunal bypass liner: a systematic review. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3441-3 [PMID:30121857].
[85] Armijo PR, Pagkratis S, Boilesen E, Tanner T, Oleynikov D. Growth in robotic-assisted procedures is from conversion of laparoscopic procedures and not from open surgeons' conversion: a study of trends and costs. Surg Endosc 2018;32:2106–13. https://doi.org/10.1007/s00464-017-5908-z [PMID:29067582].
[86] Magouliotis DE, Tasiopoulou VS, Sioka E, Zacharoulis D. Robotic versus laparoscopic sleeve gastrectomy for morbid obesity: a systematic review and meta-analysis. Obes Surg 2017;27:245–53. https://doi.org/10.1007/s11695-016-2444-1 [PMID:27815863].
[87] Sharma G, Strong AT, Tu C, Brethauer SA, Schauer PR, Aminian A. Robotic platform for gastric bypass is associated with more resource utilization: an analysis of MBSAQIP dataset. Surg Obes Relat Dis 2018;14:304–10. https://doi.org/10.1016/j.soard.2017.11.018 [PMID:29276076].

[88] Stefanidis D, Bailey SB, Kuwada T, Simms C, Gersin K. Robotic gastric bypass may lead to fewer complications compared with laparoscopy. Surg Endosc 2018;32:610–6. https://doi.org/10.1007/s00464-017-5710-y [PMID:28726145].
[89] Gleysteen JJ. A history of intragastric balloons. Surg Obes Relat Dis 2016;12:430–5. https://doi.org/10.1016/j.soard.2015.10.074 [PMID:26775045].
[90] Tate CM, Geliebter A. Intragastric balloon treatment for obesity: review of recent studies. Adv Ther 2017;34:1859–75. https://doi.org/10.1007/s12325-017-0562-3 [PMID:28707286].
[91] Tate CM, Geliebter A. Intragastric balloon treatment for obesity: FDA safety updates. Adv Ther 2018;35:1–4. https://doi.org/10.1007/s12325-017-0647-z [PMID:29285708].
[92] Mingrone G, Panunzi S, De Gaetano A, Guidone C, Iaconelli A, Nanni G, et al. Bariatric-metabolic surgery versus conventional medical treatment in obese patients with type 2 diabetes: 5 year follow-up of an open-label, single-centre, randomised controlled trial. Lancet 2015;386:964–73. https://doi.org/10.1016/S0140-6736(15)00075-6 [PMID:26369473].
[93] Simonson DC, Halperin F, Foster K, Vernon A, Goldfine AB. Clinical and patient-centered outcomes in obese patients with type 2 diabetes 3 years after randomization to Roux-en-Y gastric bypass surgery versus intensive lifestyle management: the SLIMM-T2D study. Diabetes Care 2018;41:670–9. https://doi.org/10.2337/dc17-0487 [PMID:29432125].
[94] Ikramuddin S, Korner J, Lee WJ, Connett JE, Inabnet WB, Billington CJ, et al. Roux-en-Y gastric bypass vs intensive medical management for the control of type 2 diabetes, hypertension, and hyperlipidemia: the Diabetes Surgery Study randomized clinical trial. JAMA 2013;309:2240–9. https://doi.org/10.1001/jama.2013.5835 [PMID:23736733].
[95] Ikramuddin S, Korner J, Lee WJ, Bantle JP, Thomas AJ, Connett JE, et al. Durability of addition of Roux-en-Y gastric bypass to lifestyle intervention and medical management in achieving primary treatment goals for uncontrolled type 2 diabetes in mild to moderate obesity: a randomized control trial. Diabetes Care 2016;39:1510–8. https://doi.org/10.2337/dc15-2481 [PMID:27311493].
[96] Ikramuddin S, Korner J, Lee WJ, Thomas AJ, Connett JE, Bantle JP, et al. Lifestyle intervention and medical management with vs without Roux-en-Y gastric bypass and control of hemoglobin A1c, LDL cholesterol, and systolic blood pressure at 5 years in the diabetes surgery study. JAMA 2018;319:266–78. https://doi.org/10.1001/jama.2017.20813 [PMID:29340678].
[97] Schauer PR, Bhatt DL, Kirwan JP, Wolski K, Aminian A, Brethauer SA, et al. Bariatric surgery versus intensive medical therapy for diabetes — 5-year outcomes. N Engl J Med 2017;376:641–51. https://doi.org/10.1056/nejmoa1600869.
[98] Aminian A, Brethauer SA, Andalib A, Punchai S, Mackey J, Rodriguez J, et al. Can sleeve gastrectomy "cure" diabetes? Long-term metabolic effects of sleeve gastrectomy in patients with type 2 diabetes. Ann Surg 2016;264:674–81. https://doi.org/10.1097/SLA.0000000000001857 [PMID:27433906].
[99] Carlsson LMS, Sjöholm K, Karlsson C, Jacobson P, Andersson-Assarsson JC, Svensson P-A, et al. Long-term incidence of microvascular disease after bariatric surgery or usual care in patients with obesity, stratified by baseline glycaemic status: a post-hoc analysis of participants from the Swedish Obese Subjects study. Lancet Diabetes Endocrinol 2017;5:271–9. https://doi.org/10.1016/s2213-8587(17)30061-x.
[100] O'Brien R, Johnson E, Haneuse S, Coleman KJ, O'Connor PJ, Fisher DP, et al. Microvascular outcomes in patients with diabetes after bariatric surgery versus usual care: a matched cohort study. Ann Intern Med 2018. https://doi.org/10.7326/M17-2383 [PMID:30083761].
[101] Aftab H, Risstad H, Søvik TT, Bernklev T, Hewitt S, Kristinsson JA, et al. Five-year outcome after gastric bypass for morbid obesity in a Norwegian cohort. Surg Obes Relat Dis 2014;10:71–8. https://doi.org/10.1016/j.soard.2013.05.003 [PMID:24182445].
[102] Heneghan HM, Huang H, Kashyap SR, Gornik HL, McCullough AJ, Schauer PR, et al. Reduced cardiovascular risk after bariatric surgery is linked to plasma ceramides, apolipoprotein-B100, and ApoB100/A1 ratio. Surg Obes Relat Dis 2013;9:100–7. https://doi.org/10.1016/j.soard.2011.11.018 [PMID:22264909].
[103] Kligman MD, Dexter DJ, Omer S, Park AE. Shrinking cardiovascular risk through bariatric surgery: application of Framingham risk score in gastric bypass. Surgery 2008;143:533–8. https://doi.org/10.1016/j.surg.2007.10.021 [PMID:18374051].
[104] Mor A, Omotosho P, Torquati A. Cardiovascular risk in obese diabetic patients is significantly reduced one year after gastric bypass compared to one year of diabetes support and education. Surg Endosc 2014;28:2815–20. https://doi.org/10.1007/s00464-014-3550-6 [PMID:24853843].
[105] Priester T, Ault TG, Davidson L, Gress R, Adams TD, Hunt SC, et al. Coronary calcium scores 6 years after bariatric surgery. Obes Surg 2015;25:90–6. https://doi.org/10.1007/s11695-014-1327-6 [PMID:24927692].
[106] Sundström J, Bruze G, Ottosson J, Marcus C, Näslund I, Neovius M. Weight loss and heart failure: a nationwide study of gastric bypass surgery versus intensive lifestyle treatment. Circulation 2017;135:1577–85. https://doi.org/10.1161/CIRCULATIONAHA.116.025629 [PMID:28258170].
[107] Benotti PN, Wood GC, Carey DJ, Mehra VC, Mirshahi T, Lent MR, et al. Gastric bypass surgery produces a durable reduction in cardiovascular disease risk factors and reduces the long-term risks of congestive heart failure. J Am Heart Assoc 2017;6. https://doi.org/10.1161/JAHA.116.005126 [PMID:28536154].
[108] Persson CE, Björck L, Lagergren J, Lappas G, Giang KW, Rosengren A. Risk of heart failure in obese patients with and without bariatric surgery in Sweden-a registry-based study. J Card Fail 2017;23:530–7. https://doi.org/10.1016/j.cardfail.2017.05.005 [PMID:28506731].
[109] Marchesi F, Giacosa R, Reggiani V, De Sario G, Tartamella F, Melani E, et al. Morphological changes in the carotid artery intima after gastric bypass for morbid obesity. Obes Surg 2017;27:357–63. https://doi.org/10.1007/s11695-016-2279-9 [PMID:27389676].
[110] Jamaly S, Carlsson L, Peltonen M, Jacobson P, Sjöström L, Karason K. Bariatric surgery and the risk of new-onset atrial fibrillation in Swedish obese subjects. J Am Coll Cardiol 2016;68:2497–504. https://doi.org/10.1016/j.jacc.2016.09.940 [PMID:27931605].
[111] Bower G, Toma T, Harling L, Jiao LR, Efthimiou E, Darzi A, et al. Bariatric surgery and non-alcoholic fatty liver disease: a systematic review of liver biochemistry and histology. Obes Surg 2015;25:2280–9. https://doi.org/10.1007/s11695-015-1691-x [PMID:25917981].
[112] Lassailly G, Caiazzo R, Buob D, Pigeyre M, Verkindt H, Labreuche J, et al. Bariatric surgery reduces features of nonalcoholic steatohepatitis in morbidly obese patients. Gastroenterology 2015;149:379–88. https://doi.org/10.1053/j.gastro.2015.04.014 [quiz e15; PMID:25917783].
[113] Luo RB, Suzuki T, Hooker JC, Covarrubias Y, Schlein A, Liu S, et al. How bariatric surgery affects liver volume and fat density in NAFLD patients. Surg Endosc 2018;32:1675–82. https://doi.org/10.1007/s00464-017-5846-9 [PMID:29218660].
[114] Arterburn D, Gupta A. Comparing the outcomes of sleeve gastrectomy and Roux-en-Y gastric bypass for severe obesity. JAMA 2018;319:235–7. https://doi.org/10.1001/jama.2017.20449 [PMID:29340659].
[115] Osland E, Yunus RM, Khan S, Alodat T, Memon B, Memon MA. Postoperative early major and minor complications in laparoscopic vertical sleeve gastrectomy (LVSG) versus laparoscopic Roux-en-Y gastric bypass (LRYGB) procedures: a meta-analysis and systematic review. Obes Surg 2016;26:2273–84. https://doi.org/10.1007/s11695-016-2101-8 [PMID:26894908].
[116] Zhang Y, Ju W, Sun X, Cao Z, Xinsheng X, Daquan L, et al. Laparoscopic sleeve gastrectomy versus laparoscopic Roux-En-Y gastric bypass for morbid obesity and related comorbidities: a meta-analysis of 21 studies. Obes Surg 2015;25:19–26. https://doi.org/10.1007/s11695-014-1385-9.
[117] Young MT, Gebhart A, Phelan MJ, Nguyen NT. Use and outcomes of laparoscopic sleeve gastrectomy vs laparoscopic gastric bypass: analysis of the American College of Surgeons NSQIP. J Am Coll Surg 2015;220:880–5. https://doi.org/10.1016/j.jamcollsurg.2015.01.059 [PMID:25907869].
[118] Brethauer SA, Kothari S, Sudan R, Williams B, English WJ, Brengman M, et al. Systematic review on reoperative bariatric surgery: American Society for Metabolic and Bariatric Surgery Revision Task Force. Surg Obes Relat Dis 2014;10:952–72. https://doi.org/10.1016/j.soard.2014.02.014 [PMID:24776071].
[119] Mann JP, Jakes AD, Hayden JD, Barth JH. Systematic review of definitions of failure in revisional bariatric surgery. Obes Surg 2015;25:571–4. https://doi.org/10.1007/s11695-014-1541-2 [PMID:25515500].
[120] Nedelcu M, Khwaja HA, Rogula TG. Weight regain after bariatric surgery-how should it be defined. Surg Obes Relat Dis 2016;12:1129–30. https://doi.org/10.1016/j.soard.2016.04.028 [PMID:27350180].
[121] Mahawar KK, Nimeri A, Adamo M, Borg CM, Singhal R, Khan O, et al. Practices concerning revisional bariatric surgery: a survey of 460 surgeons. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3226-8 [PMID:29616464].
[122] Tran DD, Nwokeabia ID, Purnell S, Zafar SN, Ortega G, Hughes K, et al. Revision of Roux-En-Y gastric bypass for weight regain: a systematic review of techniques and outcomes. Obes Surg 2016;26:1627–34. https://doi.org/10.1007/s11695-016-2201-5 [PMID:27138603].
[123] Abu Dayyeh BK, Lautz DB, Thompson CC. Gastrojejunal stoma diameter predicts weight regain after Roux-en-Y gastric bypass. Clin Gastroenterol Hepatol 2011;9:228–33. https://doi.org/10.1016/j.cgh.2010.11.004 [PMID:21092760].
[124] Heneghan HM, Yimcharoen P, Brethauer SA, Kroh M, Chand B. Influence of pouch and stoma size on weight loss after gastric bypass. Surg Obes Relat Dis 2012;8:408–15. https://doi.org/10.1016/j.soard.2011.09.010.
[125] Brunaldi VO, Jirapinyo P, de Moura DTH, Okazaki O, Bernardo WM, Galvão Neto M, et al. Endoscopic treatment of weight regain following Roux-en-Y gastric bypass: a systematic review and meta-analysis. Obes Surg 2018;28:266–76. https://doi.org/10.1007/s11695-017-2986-x [PMID:29082456].
[126] Borbély Y, Winkler C, Kröll D, Nett P. Pouch reshaping for significant weight regain after Roux-en-Y gastric bypass. Obes Surg 2017;27:439–44. https://doi.org/10.1007/s11695-016-2329-3 [PMID:27510586].
[127] Elbahrawy A, Bougie A, Albader M, Aggarwal R, Demyttenaere S, Andalib A, et al. Laparoscopic wedge resection of gastrojejunostomy for weight recidivism after gastric bypass. Obes Surg 2017;27:2829–35. https://doi.org/10.1007/s11695-017-2706-6 [PMID:28470487].
[128] Cheung D, Switzer NJ, Gill RS, Shi X, Karmali S. Revisional bariatric surgery following failed primary laparoscopic sleeve gastrectomy: a systematic review. Obes Surg 2014;24:1757–63. https://doi.org/10.1007/s11695-014-1332-9 [PMID:24927693].
[129] Dijkhorst PJ, Boerboom AB, Janssen IMC, Swank DJ, Wiezer RMJ, Hazebroek EJ, et al. Failed sleeve gastrectomy: single anastomosis duodenoileal bypass or Roux-en-Y gastric bypass? A multicenter cohort study. Obes Surg 2018. https://doi.org/10.1007/s11695-018-3429-z.
[130] Weiner JP, Goodwin SM, Chang HY, Bolen SD, Richards TM, Johns RA, et al. Impact of bariatric surgery on health care costs of obese persons: a 6-year follow-up of surgical and comparison cohorts using health plan data. JAMA Surg 2013;148:555–62. https://doi.org/10.1001/jamasurg.2013.1504 [PMID:23426865].
[131] Alsumali A, Eguale T, Bairdain S, Samnaliev M. Cost-effectiveness analysis of bariatric surgery for morbid obesity. Obes Surg 2018. https://doi.org/10.1007/s11695-017-3100-0 [PMID:29335933].
[132] Kim DD, Arterburn DE, Sullivan SD, Basu A. Economic value of greater access to bariatric procedures for patients with severe obesity and diabetes. Med Care 2018;56:583–8. https://doi.org/10.1097/mlr.0000000000000924.
[133] Kim DD, Arterburn DE, Sullivan SD, Basu A. Association between the publication of clinical evidence and the use of bariatric surgery. Obes Surg 2018;28:1321–8. https://doi.org/10.1007/s11695-017-2990-1 [PMID:29086183].

[134] Henkel DS, Mora-Pinzon M, Remington PL, Jolles SA, Voils CI, Gould JC, et al. Trends in the prevalence of severe obesity and bariatric surgery access: a state-level analysis from 2011 to 2014. J Laparoendosc Adv Surg Tech A 2017;27:669–75. https://doi.org/10.1089/lap.2017.0157 [PMID:28557643].
[135] Macht R, Rosen A, Horn G, Carmine B, Hess D. An exploration of system-level factors and the geographic variation in bariatric surgery utilization. Obes Surg 2016;26:1635–8. https://doi.org/10.1007/s11695-016-2164-6 [PMID:27034061].
[136] Hennings DL, Baimas-George M, Al-Quarayshi Z, Moore R, Kandil E, DuCoin CG. The inequity of bariatric surgery: publicly insured patients undergo lower rates of bariatric surgery with worse outcomes. Obes Surg 2018;28:44–51. https://doi.org/10.1007/s11695-017-2784-5.
[137] Zhang L, Scott J, Shi L, Truong K, Hu Q, Ewing JA, et al. Changes in utilization and peri-operative outcomes of bariatric surgery in large U.S. hospital database, 2011–2014. PLoS One 2017;12:e0186306. https://doi.org/10.1371/journal.pone.0186306 [PMID:29053709].
[138] Birkmeyer NJ, Gu N. Race, socioeconomic status, and the use of bariatric surgery in Michigan. Obes Surg 2012;22:259–65. https://doi.org/10.1007/s11695-010-0210-3 [PMID:20559894].
[139] Stanford FC, Jones DB, Schneider BE, Blackburn GL, Apovian CM, Hess DT, et al. Patient race and the likelihood of undergoing bariatric surgery among patients seeking surgery. Surg Endosc 2015;29:2794–9. https://doi.org/10.1007/s00464-014-4014-8 [PMID:25492453].
[140] Imbus JR, Voils CI, Funk LM. Bariatric surgery barriers: a review using Andersen's model of health services use. Surg Obes Relat Dis 2018;14:404–12. https://doi.org/10.1016/j.soard.2017.11.012 [PMID:29249585].
[141] Funk LM, Jolles SA, Greenberg CC, Schwarze ML, Safdar N, McVay MA, et al. Primary care physician decision making regarding severe obesity treatment and bariatric surgery: a qualitative study. Surg Obes Relat Dis 2016;12:893–901. https://doi.org/10.1016/j.soard.2015.11.028 [PMID:26948943].
[142] Funk LM, Jolles S, Fischer LE, Voils CI. Patient and referring practitioner characteristics associated with the likelihood of undergoing bariatric surgery. JAMA Surg 2015;150:999. https://doi.org/10.1001/jamasurg.2015.1250.
[143] Simon R, Lahiri SW. Provider practice habits and barriers to care in obesity management in a large multicenter health system. Endocr Pract 2018;24:321–8. https://doi.org/10.4158/EP-2017-0221 [PMID:29561192].
[144] Pilitsi E, Farr OM, Polyzos SA, Perakakis N, Nolen-Doerr E, Papathanasiou AE, et al. Pharmacotherapy of obesity: available medications and drugs under investigation. Metabolism 2018. https://doi.org/10.1016/j.metabol.2018.10.010 [PMID:30391259].