POSSIBLE WEIGHT REGAIN MANAGEMENTS AFTER BARIATRIC SURGERY

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Obesity is an uprising trend across the world resulting in huge costs for healthcare systems and declines in the quality of life in patients. Bariatric surgery is one of the most effective approaches to weight loss. Although bariatric surgery can be considered as a minimally invasive approach it has a series of complications such as weight regain 1 to 4 years after surgery. Nonetheless, most patients achieve sufficient weight loss, but the other subjects with supervised strategies would be able to manage food intake and change problematic lifestyles to continue the weight loss process. In this review article, we aim to gather valuable interventions performed and reported by researchers to manage weight regain in bariatric patients. Weight regain is a multi-factorial condition owing to hormonal imbalances, nutritional deficiencies, physical inactivity, mental health disorders, problematic dietary behaviors, medical issues such as thyroid, adrenal, kidney, or heart problems, taking new medications, diabetes relapse, and pregnancy, as well as anatomic and surgical factors. Therefore, its remission needs interdisciplinary approaches.

КЛЮЧЕВЫЕ СЛОВА: Bariatric surgery; obesity; weight regain; preventive medicine.

INTRODUCTION

Bariatric surgery is one of the final surgical methods which can achieve weight loss (WL), treat obesity-related comorbidities, and enhance the quality of life by improving cardiovascular disorders, metabolic status, and biochemical parameters [1], thereby decreasing the inflammatory markers and increasing hematological markers [2, 3]. Despite all the benefits of bariatric surgery, some individuals are not satisfied by their body sizes and weight, and some others experience weight regain (WR) in a long-term follow-up period. While WR has a series of undesirable medical and psychological consequences, which might occur following bariatric surgery to different extents at variable interval times, the causes for WR are multifactorial, including patient- and procedure-specific factors, and can vary from case to case.

We used three main databases in clinical research including Google Scholar, PubMed, and Web of Science to collect relevant data. Keywords for structural searches were divided into three vertices including 1) Bariatric surgery (RYGB, Laparoscopic sleeve surgery, robotic sleeve gastrectomy, weight loss surgery, obesity surgery, and bariatric surgery), 2) Management (weight regain management, preventive medicine, post-operative strategies, hormonal treatment, nutritional recommendation, dietary behavior, physical activity, pharmacotherapy), and 3) Weight loss (Insufficient weight loss, weight regain, weight gain, weight, higher BMI, overweight and obesity) from 2015 to 2022 research articles.

DEFINITIONS OF INSUFFICIENT WEIGHT LOSS AND WEIGHT REGAIN

Several studies described a range of definitions for WR following bariatric surgery. The lack of standard protocol for the management of WR, consensus statements, and guidelines leads to poor reporting and understanding of the significance of WR after bariatric surgery. The most common definition is a 25% increase in excessive weight compared to the nadir weight after bariatric surgery. Furthermore, there are some other definitions for WR such as gaining more than 15% or 10 kg from nadir weight [4], gaining more than 10% WR of pre-surgery weight [5], and more than 5 BMI kg/m2 points from nadir weight [6]. On the other hand, insufficient weight loss is defined as excess weight loss percentage (EWL%) of < 50% at 18 months after bariatric surgery. In addition, WR is defined as progressive regaining of weight that occurs after achievement of an initial successful weight loss (defined as EWL>50%) [7].

PREVALENCE OF WR AND INSUFFICIENT WEIGHT LOSS AFTER BARIATRIC PROCEDURES

Bariatric patients experience satisfactory weight loss even after 2 years of the procedure, but the tragedy begins when patients have no idea and why they go on weight. In a study for this purpose, WR rates ranged from 44–87% among 1406 Roux-en-Y Gastric Bypass (RYGB) subjects 5 years after the surgery (5). Another research reported that 5.7% of individuals who underwent sleeve gastrectomy (SG) experienced WR at 2 years [8], 39.5% at 5 years [9], and 76% over 2 to 6 years of follow-up periods [8]. There is a tremendous number of reports on WR after RYGB, including, 17.1% at 2 years [10], 22.5% at 3 years [5], 14.6%–26.8% at 5 years [5, 11], but this type of procedure seems to have a higher range of WR in patients compared to other types of bariatric surgery. Laparoscopic adjustable gastric banding (LAGB), on the other side, had a lesser range of WR in subjects, and just 1.4% of people who underwent LAGB reported WR in 3 to 7 years of the follow-up period [12]. Even in a long-term period, just 38% of subjects complained WR at 10 years after LAGB [13]. It can be concluded that around 40% of people who underwent bariatric

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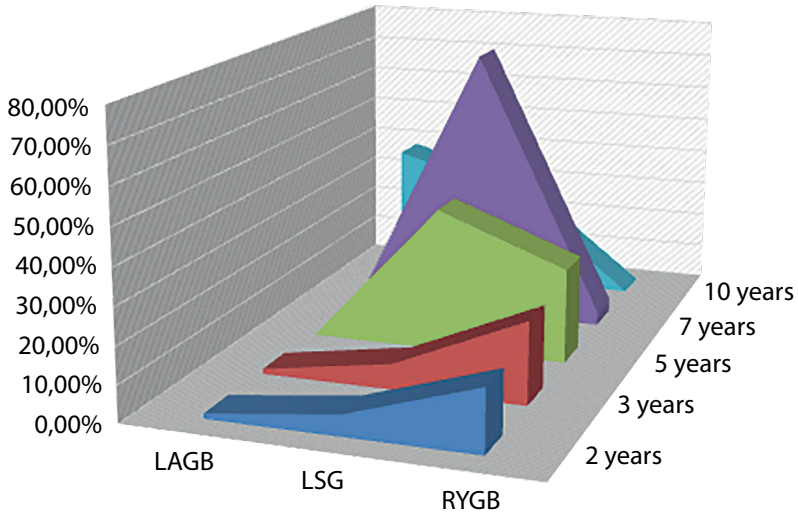

	LAGB	LSG	RYGB
2 years	1,40%	6%	17,10%
3 years	1,40%	7%	22,50%
5 years		39,50%	26,00%
7 years	1,40%	76,00%	3,90%
10 years	38%	27,80%	

Figure 1. The prevalence of weight regain in different types of bariatric surgery between 2 and 10 years after the surgery based on various recently published reports (5,8–13,85). LAGB: Laparoscopic gastric band; LSG: Laparoscopic sleeve gastrectomy; and RYGB: Roux en Y gastric bypass. around 40% of individuals experienced weight regain following 5 years of bariatric surgery.

surgery experienced WR following 5 years of surgery. Figure 1 presents the prevalence of WR of patients with various types of bariatric surgery including LAGB, LSG, and RYGB between 2 and 10 years following bariatric surgery.

THE PRINCIPAL REASONS OF WR AFTER BARIATRIC SURGERY

Considering that, the causes of WR following bariatric surgery are multifactorial, they can be divided into two types including physiological and anatomical factors. The first one is caused by hormonal parameters, the gut-brain axis, psychiatric conditions, eating disorders, and unstable lifestyles such as dietary non-compliance and physical inactivity. Those factors are directly involved in loss of control and increase in the food intake. Figure 2 presents more sub-themes involved in WR after bariatric surgery. Anatomical causes consist of an enlargement of the gastric pouch or gastrogastric fistula (GG fistula; an axis from the gastric pouch to the gastric remnant, which is a rare but important complication of RYGB), anatomic surgical failure, and gastrointestinal anatomy [14]. Considering these crucial etiologies

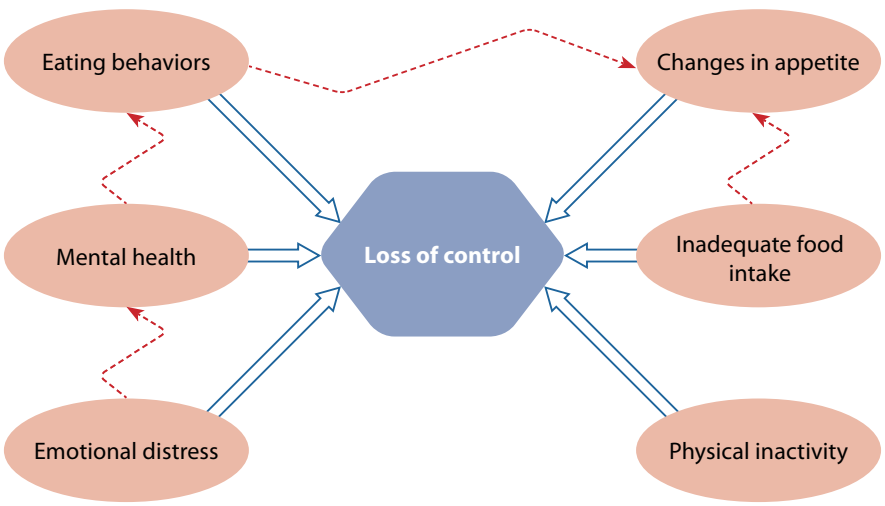

Figure 2. Schematic map of correlations between factors involved in loss of control in bariatric surgery patients in long-term follow-up period.

is a principal step to establishing a proper protocol for the management of WR following bariatric surgery. Figure 3 demonstrates a brief map of the multidisciplinary approaches involved in WR management.

Hormonal imbalance

Bariatric patients experience a series of improvements in hormonal and other health parameters following procedure which results in weight reduction and risen quality of life. For instance, Peptide YY, which is released by the L-cells of the gastrointestinal tract to suppress appetite after meals, is dropped down in individuals who experience WR [15]. Increased ghrelin is another hormonal imbalance that can be seen in this population after bariatric surgery [16, 17]. In addition, a reactive reduction in glucose levels of blood, which is dependent on altered GI hormones and insulin secretion, is a key point to skyrocket the transition of micronutrients into the jejunum leading to WR in bariatric patients [18]. The fasting insulin is another parameter that might be associated with WR after bariatric surgery [19]. It occurs when lower blood sugar levels caused by significant insulin secretion after food intake may restore appetite and lead to grazing or snacking which results in WR in subjects [20].

Leptin which is released by fat cells is responsible for the reduction in appetite. Although bariatric surgery has a positive impact on leptin regulation, patients with WR demonstrated

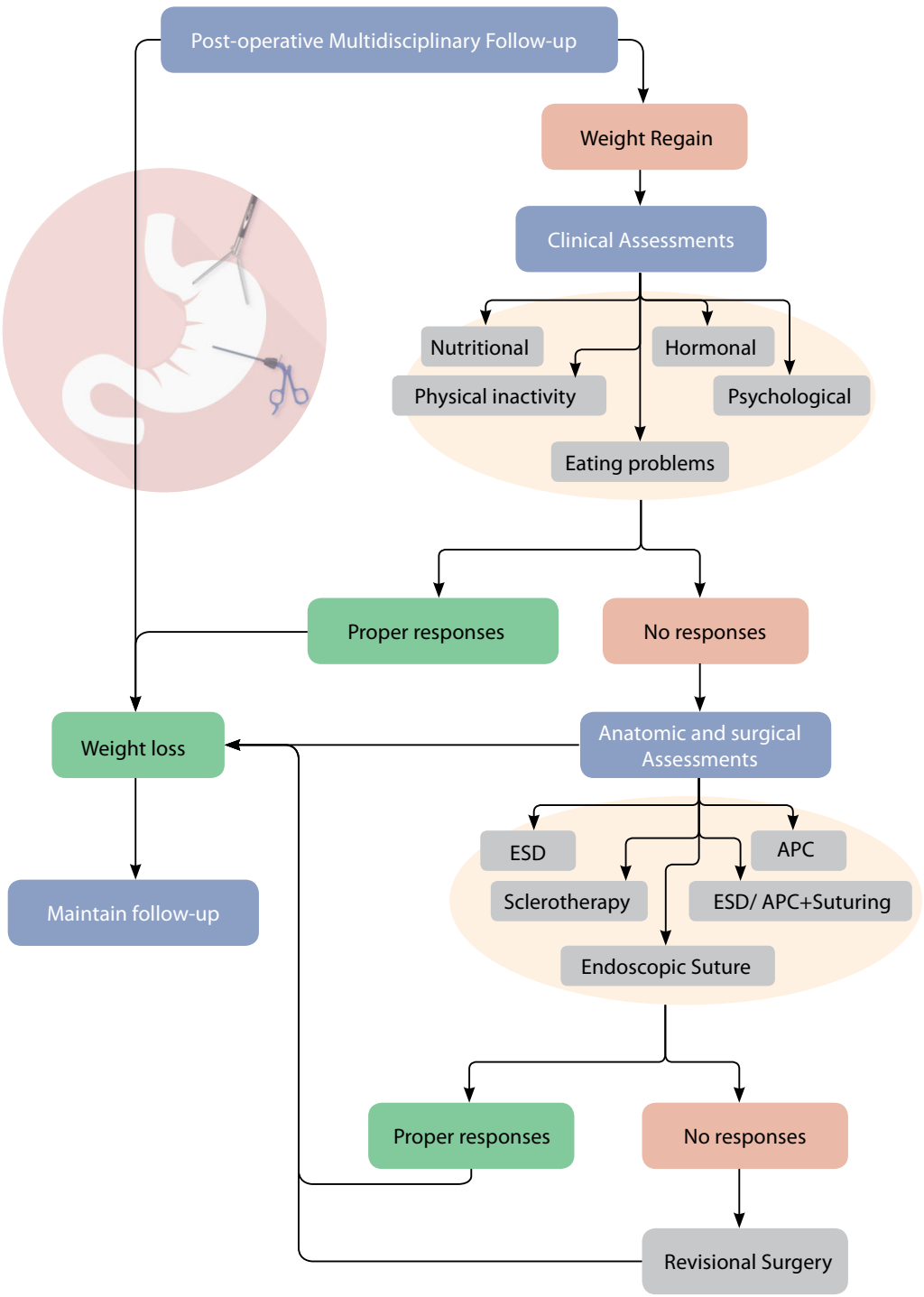

Figure 3. Algorithm of post-operative weight management with multiple approaches. APC: argon plasma coagulation; ESD: endoscopic submucosal dissection.

increased levels of leptin [17, 21, 22]. Eventually, decreased serotonin levels can be seen postoperatively in patients with WR [17]. While, hormonal analysis in bariatric subjects with weight loss illustrated opposite results in which dropped ghrelin, increased Peptide YY, glucagon-like peptide 1 (GLP-1), leptin, cholecystokinin, pancreatic polypeptide, and uroguanylin (It regulates electrolyte and water transport in intestinal and renal epithelia) and blood sugar levels were reported in previously published studies [1].

To suppress ghrelin secretion, which is known as the hunger hormone, obesity experts can encourage patients to avoid sweetened drinks including fruit drinks, sports (energy) drinks, sweetened waters, regular soda (not sugar-free ones), coffee and tea beverages with added sugars and high-fructose corn syrup, which can impair ghrelin response after food-intake to receive the strong signal to stop eating in the hypothalamus [23, 24].

When it comes to insulin, patients must have a low-carbohydrate diet [25], fill up on protein, omega-3 fats diet found in fatty fish and avoid or minimize the amounts of fructose and sucrose which promote insulin resistance and increase insulin levels [24, 26]. Furthermore, people suffering from insulin resistance demonstrate lower amounts of magnesium and in this case, magnesium supplements [27, 28] and green tea [29, 30] can improve insulin sensitivity.

Leptin and cholecystokinin play a major role in regulating appetite and preventing overeating. On the other hand, chronically enhanced insulin levels and inflammation in the hypothalamus are mainly responsible for leptin resistance. To improve insulin sensitivity and increase cholecystokinin, subjects with WR must limit inflammatory foods such as unsaturated fats, junk foods, refined carbohydrates, fried foods, sugar-sweetened beverages, processed meats, and sugary drinks and on the other side, healthy fat [31], anti-inflammatory foods such as berries, fatty fish, broccoli, avocados, green tea, mushrooms grapes, turmeric, extra virgin olive oil, dark chocolate and cocoa, tomatoes, cherries, peppers which are full of vitamin C and antioxidants can be efficient ingredients for the improvement of leptin levels [32]. In addition, moderate exercise, sufficient sleep at night, and taking the alpha-lipoic acid supplement and fish oil are other suggestions for the reduction in appetite and improving leptin sensitivity [33].

Lower serotonin levels can be seen in people with WR after bariatric surgery [17] which is required to be addressed by obesity medicine experts in long-time follow-up visits. Some dietary supplements namely pure tryptophan supplements [34], S-adenosyl-L-methionine (must not take with any other supplements or serotonin stimulating medications) [35], 5-Hydroxy-L-tryptophan content [36], St. John's wort (not recommended for long-term use) [37], and probiotics [38] can be prescribed to operate the serotonin production and release by declining cortisol and enhancing tryptophan levels [39]. There are also some other ideas for raising serotonin and reducing cortisol in patients with WR including a series of snacks such as salmon with brown rice, whole-wheat bread with turkey or cheese, plums or pineapple with a cracker, oatmeal with 30g of nuts, pretzel sticks with peanut butter and 200 ml of milk [40, 41], as well as aerobic exercises such as bicycling, brisk walking, and swimming, practicing meditation, spending 15 to 30 minutes in the sunshine each day [39, 42].

Peptide YY plays a major role in lowering food intake and the risk of obesity, and as has been mentioned previously, people with WR illustrated a reduction in this hormone in a long-term period after bariatric surgery [15]. In order for peptide YY to be risen and reduce neuropeptide Y in this population, experts suggest ingestion of fibers [43], protein-rich diets from animal or plant sources [44], soluble probiotics [45], and as well as low carbohydrate diets [46, 47].

Furthermore, subjects who had high-protein foods such as fish, whey protein, and yogurt, anti-inflammation diet, leafy green meals including spinach and kale and took probiotics under supervision of physician lost more weight than the control group and had higher GLP-1 levels compared to the rest of patients [48, 49].

Considering the environmental influences on estrogen levels in women, most researchers suggest nutrition and lifestyle strategies to manage estrogen levels and reduce insulin resistance. Eating plenty of fiber-rich diets, flax seeds, cruciferous vegetables such as arugula, bok choy, broccoli, brussels sprouts, and cabbage can be helpful to reach a normal balance of estrogen in women [50, 51].

NUTRITIONAL PROBLEMS

Although the anatomic and physiological improvements result in a smaller gastric capacity, diminished hunger, and increased satiety which reduce calorie intake following bariatric surgery, caloric intake slightly enhances over time which contributes to postoperative WR. Moreover, consumption of high-calorie meals and beverages contributes to the higher caloric intake resulting in WR. Strong connections between the prevalence of WR and consumption of large amounts of food lately, eating large quantities of high-fat dishes, and eating out have been reported by researchers [52]. In another survey, equally, 23% of RYGB patients illustrated dietary non-adherence and a continuation of pre-surgical eating patterns, leading to suboptimal weight loss and WR [53]. These studies presented the importance of caloric intake and diet quality as leading factors for WR following bariatric surgery, and also concluded the importance of food indiscretion, measuring and documenting the diet quality among bariatric patients [54] which alongside WR, patients may have some other challenging conditions in various organs owing to malnutrition in some specific ingredients such as protein malnutrition or iron deficiency (Figure 4), demonstrating the necessity of physical assessments in patients with WR after bariatric surgery. For instance, a survey on 100 patients revealed that poor dietary habits including consumption of excessive calories, snacks, sweets, oils, and fatty foods were statistically higher in patients with WR [55]. This highlights the importance of appropriate nutritional counseling and nutritional follow-up for long-term weight maintenance [55]. In line with this claim, studies showed that among RYGB patients 60% of WR subjects never maintained follow-up with appropriate nutritional consultants after the operation which might be associated with WR [56]. Based on studies, the optimal diet is high protein meals (1.0 to 1.5 g/kg per day), low glycemic index, low-fat contents, and high fiber foods including poultry, fish, lean, meats, eggs, low-fat dairy. Legumes, fruits, vegetables, and whole grains. At least 5 servings of fruits and vegetables per day are highly recommended. Bariatric patients must avoid sugars and refined carbohydrates to prevent hypoglycemia that results in dumping syndrome, one of the crucial risk factors of WR.

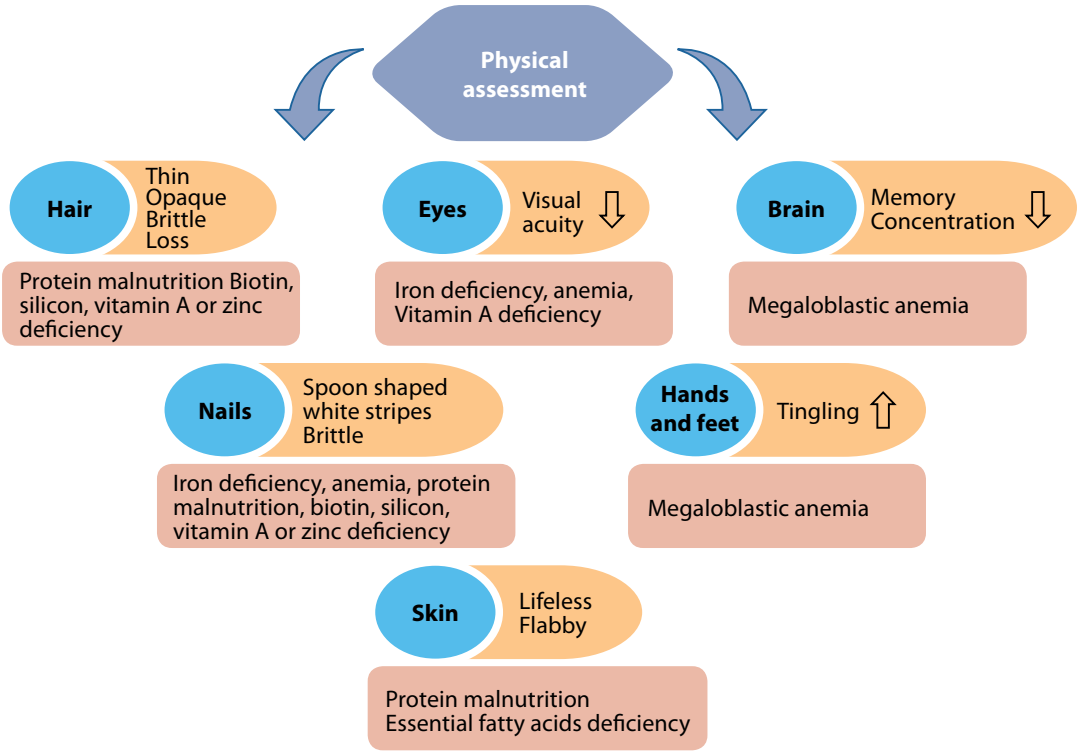

Figure 4. Organ complications after bariatric surgery caused by nutritional challenges in patients with weight regain.

PHYSICAL INACTIVITY

Physical activity is one of the most important factors that can prevent WR in patients after bariatric surgery. Only 10–24% of bariatric surgery patients met the guidelines regarding minimal physical activity for health promotion [57]. A meta-analysis of 14 studies and a literature review of 19 studies concluded that post-operative physical activity was significantly associated with greater weight loss among bariatric patients [58]. In another survey on 100 patients with obesity following RYGB, among those who had supervised exercise the rate of WR was less compared to those who had sedentary behaviors [55]. Nevertheless, there are several barriers to having daily exercise among those individuals such as feeling self-conscious lack of proximity to a gym/park, or health concerns, which should be identified and addressed by professional experts during follow-up visits [58]. Such findings highlight the importance of measuring and documenting physical activity levels after bariatric surgery [35].

Therefore, physical inactivity, which is defined as 'any waking habit performed while in a sitting or reclining posture that needs very low energy expenditure', represents a risk factor for WR. Lack of adequate exercise during the post-bariatric period is strongly correlated with an enhanced risk of obesity and its sequelae [58]. Some other researchers believe that bariatric candidates with higher BMIs are at high risk for sedentary behaviors [59]. In this report, they revealed that about 30% of those candidates' sedentary time was spent watching television, presenting that this is a crucial cause of physical inactivity and must be taken into account for patient counseling [59]. Enormous studies are suggesting that 80 min of (it includes 20 min for warm-up and cool-down) supervised strength training, aerobic and stretching exercise, and endurance activities for 3 weeks can be particularly effective at reducing visceral adipose tissue (VAT) [60], a fat accumulation area that is strongly linked to T2D and hepatic insulin resistance. On the other side, 120 min of supervised aerobic exercise for 6 to 10 months and starting 1 to 3 months after surgery can strongly prevent WR in a long-term period following bariatric surgery [61–63].

MENTAL HEALTH AND PSYCHOLOGICAL STATUS

Psychological status before surgery is associated with weight loss following bariatric surgery, which represents pre-operative psychological evaluation for the candidates. Psychological factors would play an intervening role in weight loss by undermining motivation, problematic dietary behavior, inadequate exercise, and other unhealthy behaviors crucial for successful weight loss [64]. Based on a study on 60 adults RYGB or LAGB subjects, around 73% had single or multiple psychiatric diagnoses, and 47.5% did not achieve their target weight, and 29.5% regained weight after 1 year [64]. In addition, individuals with more than 2 psychiatric conditions were 6 times more at risk of either stopping weight loss or regaining weight compared to those with no or single psychiatric diagnosis [64]. There are various reports, suggesting the correlation between postoperative depressive disorders and poorer weight loss [65, 66]; however, the directionality of the relationship and rationale mechanisms remain unclear [66]. The models predicting depressive symptoms, anxiety symptoms, and physical health-related quality of life were not significant in bariatric patients. Frequent psychological screenings for depression, anxiety, and other neurological disorders might be required in long-term follow-up visits. On the other side, psychotropic and anti-depressant medications are involved in WR, while several studies revealed that anti-depressant medications have negative [67] or no [68, 69] impacts on weight loss in bariatric surgery patients. Therefore, strong communication between obesity medicine experts and mental health physicians is a necessary step to manage weight loss to choose the least weight-promoting or weight-neutral agents.

UNHEALTHY DIETARY BEHAVIORS

Dietary behaviors which play a major role in WR must be evaluated after bariatric surgery in patients. Most of the people suffering from weight plateau complain about grazing, but they may have other dietary behaviors rather than bulimia nervosa or grazing. The most principal dietary problems can be divided into 13 groups including erratic eating, meal skipping or inappropriate portions, unhealthy ingredients selections, alcohol use, insufficient protein, and fiber intake, drinking fluids with meals, grazing, binge eating, night eating syndrome, post-surgical eating avoidance disorder, soft-food syndrome, and eating disorders such as bulimia nervosa and anorexia nervosa [70]. For instance, alcohol use disorder leads to binge eating and finally results in high-calorie intake in subjects after bariatric surgery. When patients are diagnosed with problematic eating behaviors, obesity medicine experts would determine the exact type of dietary behavior then all those mentioned interventions can be considered to solve the problem. There are some efficient intervention approaches following bariatric surgery for dietary behaviors involved in WR that can be found in Table 1 [70].

MEDICAL ISSUES AND PHARMACOTHERAPY

In some patients, WR occurred due to some medical issues such as thyroid, adrenal, kidney, or heart problems, taking new medications, diabetes relapse, and pregnancy which can be addressed by proper strategies to prevent WR or reduce its progression.

Table 2. Weight regain management in patients after bariatric surgery.

Involved factors	Clinical reasons/ Unhealthy Habits		Possible treatments	Sources
Hormonal changes	↓ Peptide YY		Protein/fiber-rich diets, soluble probiotics, and low carbohydrate diets	[43–47]
	↑ Neuropeptide Y			
	↑ Ghrelin		Avoid sweetened drinks	[23, 24]
	↑ Insulin		Fill up on protein, low-carbohydrate diet, avoid or minimize the amounts of fructose and sucrose	[24–26]
	↓ Blood sugar levels			
	Insulin resistance		Magnesium supplements, and green tea	[27–30]
	↓ Leptin		Limit inflammatory foods such as unsaturated fats, junk foods, refined carbohydrates, fried foods, sugar-sweetened beverages, processed meats, and sugary drinks	[32]
	↓ Cholecystokinin			
	↓ GLP-1		High-protein foods, anti-inflammation diet, leafy green meals, and probiotics	[48, 49]
	↓ Serotonin	↑ Cortisol	Tryptophan supplements, S-adenosyl-L-methionine, 5-Hydroxy-L-tryptophan content, St. John's wort, and probiotics, as well as aerobic exercises.	[34–37, 39, 42]
		↓ Tryptophan		
Nutritional challenges	Poor dietary habits	Excessive calories	Appropriate nutritional counseling and physical/hormonal assessment follow-ups. 5 servings of fruits and vegetables per day	[55, 56]
		Snacks		
		Sweets		
		Oils		
		Fatty foods		
Physical inactivity	Sedentary behaviors and lack of adequate exercise during the post-bariatric period		80 minutes supervised strength training, aerobic and stretching exercise, and endurance activities for 3 weeks	[60]
Mental health	Undermining motivation, problematic, inadequate exercise, and other unhealthy behaviors		Frequent psychological screenings, avoid anti-depressant medications	[67]
Dietary behavior	Unhealthy ingredients selections, alcohol use, insufficient protein, and fiber intake, grazing, binge eating, night eating syndrome, and post-surgical eating avoidance disorder,		Obesity medicine experts should determine the type of dietary behavior (Those intervention approaches were presented in table 1)	[70]
Anatomical factors	GG fistula formation, distention of the gastric pouch and dilation of the gastrojejunal stoma		Repair of a GG fistula, single anastomosis duodenoilieal and other endoscopic revisional surgeries	[76, 77]

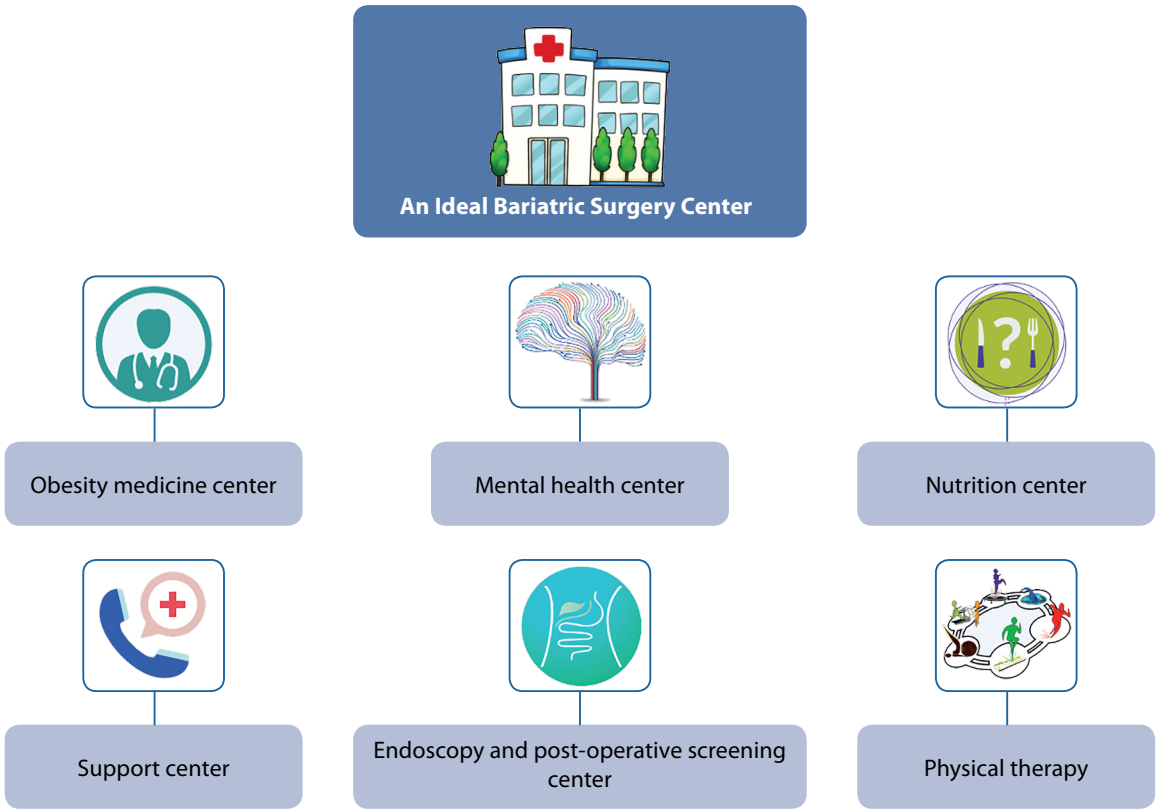

Figure 5. A brief look into an ideal bariatric surgery center with all required multidisciplinary assessments for management of weight regain after surgery.

Pharmacotherapy can significantly delay the progression of rapid WR as well as decline its occurrence. Nevertheless, pharmacotherapy approaches remain limited in scope for bariatric subjects due to a lack of formal guidelines and recommendations on anti-obesity medication use after bariatric surgery. Moreover, it needs obesity medicine specialists in bariatric surgery centers to support patients, which poses limitations on anti-obesity medication use. Figure 5 illustrates the features of an ideal bariatric surgery center with multidisciplinary wards for clinical and surgical assessments of patients with WR. On the other side, the lack of familiarity of bariatric surgeons with these medications and the rapid evolution of this medical field is another crucial obstacle in the way of pharmacotherapy approaches [71].

ANATOMIC AND SURGICAL FACTORS

When it comes to anatomical factors involved in WR, a GG fistula formation occurs between the gastric pouch and the excluded stomach and its incidence rate is 1% among RYGB patients, causing weight plateau and recurrence of T2D [72]. Other potential anatomical factors contributing to WR after RYGB are distention of the gastric pouch and dilation of the gastrojejunal stoma which may develop over time [73]. An upper GI should be considered for WR after vertical sleeve gastrectomy as well, mainly because the dilation of the sleeve has been strongly connected to WR in subjects after bariatric surgery [74].

Sclerotherapy is another surgical approach in patients with WR after RYGB which is injection of sodium morrhuate around the gastrojejunal anastomosis using an endoscopic needle to reduce its aperture and tissue compliance [75]. The repair of a GG fistula, when identified on upper GI or endoscopy, is one of the most widely accepted surgical interventions for WR prevention among surgeons [76]. In addition, an enlarged gastric pouch and dilated stoma are potential anatomical issues that might be considered endoscopically or laparoscopically after bariatric surgery, with good short-term weight loss outcomes but variable long-term results. The growing problem of WR after bariatric surgery has prompted the evaluation of different revisional surgeries that could be addressed even when there are no anatomic abnormalities identified in the primary procedure. Procedures such as endoscopic revisions that reduce gastric pouch size and diameter of the gastrojejunal anastomosis, the conversion of vertical sleeve gastrectomy to a gastric bypass, single anastomosis duodenoilieal (SADI) bypass, and distalization of the jejunojejunostomy for a gastric bypass, are employed to increase or add a malabsorptive component to the original procedure [76, 77]. When considering a revision for WR after vertical sleeve gastrectomy, patients who also have acid reflux disease are good candidates for gastric bypass; but the SADI procedure provides superior weight loss to the conversion to gastric bypass for those who would be converted for WR alone [78]. In this procedure, the duodenum is divided 3 cm distal to the pylorus; the small bowel is measured backward from the ileocecal valve to a length of 150 to 300 cm, where it is linked to the duodenum. Because the surgical complications and malnutrition rates of this approach are like conversion to gastric bypass, the SADI may become the procedure of choice to treat inadequate weight loss among patients following vertical sleeve gastrectomy.

Table 1. Problematic eating behaviors associated with weight regain and intervention approaches following bariatric surgery [70]

Eating Behavior	Problem	Intervention
Erratic eating	Inconsistent/unplanned eating schedule	Preplan approximate timing and appropriate spacing of meals throughout the day based on daily schedule
Meal skipping	Not eating for an extended time period leading to subsequent hunger and overeating	Plan meals ahead of time; create a shopping list to ensure selected food and appropriate amounts are available to prepare these meals
Unhealthy food and beverage selections	Frequent intake of high-calorie/processed meals and snacks including fast food/take-out, fried food, concentrated sweets, and refined carbohydrates; calorie-rich beverages such as soda and juices	Education on balanced meal preparation containing protein and fiber-rich sources to help optimize satiety; encourage cooking classes and/or online cooking resources
Nibbling/Grazing	Continuous/repetitive and unplanned eating of modest portions of food throughout the day; often associated with previous binge-eating behaviors; leads to excessive cumulative energy intake	Avoidance of skipping meals; appropriate meal portion sizes (1/2–1 cup). Identify triggers including stress, boredom, and emotional factors or engaging in other activities such as watching television
Night eating	Consuming more calories before sleep favors positive energy balance and weight gain	Schedule time for meals during the day; self-monitor using food journal
Inappropriate portions	Portion sizes beyond the feeling of fullness resulting in discomfort	Weigh and measure foods, use smaller plates and utensils, and limit volume to 1 cup of food per meal
Alcohol use	Excess nonnutritive calories; promotes increased hunger, food cravings, and compromises judgment regarding proper food selection	Avoid or limit alcohol consumption; consider referral to the treatment program if unable to control behavior
Insufficient protein and fiber intake	Protein and fiber promote optimal satiation; protein-rich foods optimize muscle integrity and energy metabolism	Education on quality sources of protein and fiber; assist with meal planning to achieve appropriate intake
Drinking fluids with meals	Potential enlargement of the gastric pouch and outlet with repeated behavior; leads to rapid emptying of the stomach	Delay fluid intake at least 30 minutes after consuming solid food

OTHER PREDICTOR FACTORS OF WEIGHT REGAIN IN BARIATRIC SURGERY PATIENTS

Detection of the preoperative predictors of WR post-bariatric surgery can facilitate identifying the candidates at risk for WR. The obesity specialists can then offer such patients appropriate resources and counseling. About age and gender, reports seem to be controversial. Some small studies have been done in this matter and claimed that older age is a potential preoperative predictor of WR [79]. While in another study, younger subjects were more likely to have WR after RYGB [10]. However, there are not enough shreds of evidence on SG patients but in our previous research, excessive BMI loss among older ages was significantly lower than younger groups [80]. Mental health, duration since surgery, preoperative BMI, and comorbidities such as T2D, hypertension, and low LDL are major factors involved in WR which mentioned their mechanisms and management approaches in previous sections. As far as psychological factor is concern, 27.1% of the variance of the WR is due to "locus of control, "present fatalist", and "positive past" [81]. In another study, analysis revealed that, initial age, waist circumference, type 2 diabetes, and total weight loss at primary months were associated with either 1-year or 3-year weight loss. Furthermore, total weight loss at 3 months was a predictor for 3-year WR after SG [82]. Some other lifestyle factors such as life satisfaction, conscientiousness, positive affect, and regular exercise were positively associated with weight loss 12 to 15 years after bariatric surgery [83]. Considering those possible strategies (Summary of possible interventions are presented in table 2) with clear vision in predictor factors of WR may help obesity medicine experts to be able to support patients efficiently, since Smith *et al.*, believe that the six months post-operative period may be a crucial window for implementing interventions to alight WR [84].

CONCLUSION

After bariatric surgery, the threat against WR will not completely be eliminated. The follow-up team should extensively have clinical assessments on patients to make sure that the predictor factors of WR are in control. For those patients who experience WR, the above-mentioned interventions should be considered.

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