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REVIEW

Weight Recidivism Post-Bariatric Surgery: A Systematic Review

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Abstract Obesity is considered a worldwide health problem of epidemic proportions. Bariatric surgery remains the most effective treatment for patients with severe obesity, resulting in improved obesity-related co-morbidities and increased overall life expectancy. However, weight recidivism has been observed in a subset of patients post-bariatric surgery. Weight recidivism has significant medical, societal and economic ramifications. Unfortunately, there is a very limited understanding of how to predict which bariatric surgical patients are more likely to regain weight following surgery and how to appropriately treat patients who have regained weight. The objective of this paper is to systematically review the existing literature to assess the incidence and causative factors associated with weight regain following bariatric surgery. An electronic literature search was performed of the Medline, Embase and Cochrane library databases along with the PubMed US national library from January 1950 to December 2012 to identify relevant articles. Following an initial screen of 2,204 titles, 1,437 abstracts were reviewed and 1,421 met exclusion criteria. Sixteen studies were included in this analysis: seven case series, five surveys and four non-randomized controlled trials, with a total of 4,864 patients for analysis. Weight regain in these patients appeared to be multi-factorial and overlapping. Aetiologies were categorized as patient specific (psychiatric, physical inactivity, endocrinopathies/metabolic and dietary non-compliance) and operation specific. Weight regain following bariatric surgery varies according to duration of follow-up and the bariatric surgical procedure performed. The underlying causes leading to weight regain are multi-factorial and related to patient- and procedure-specific factors. Addressing post-surgical weight regain requires a systematic approach to patient assessment focusing on contributory dietary, psychologic, medical and surgical factors.

Keywords Post-bariatric surgery · Obesity · Weight recidivism

Introduction

Currently, more than 20 % of the world's population is overweight, and approximately 10 % are obese [1]. Severe obesity (BMI of over 35 kg/m^2) is associated with an increased incidence of chronic diseases including hypertension, type 2 diabetes mellitus, coronary artery disease, stroke and dyslipidaemia [1]. Furthermore, each five-point increase in BMI over 25 kg/m^2 is associated with a 30 % increase in all-cause mortality [2].

A number of meta-analyses have demonstrated the effectiveness of bariatric surgery in improving severe obesity and its associated co-morbidities [3–6]. As a result, it is not surprising that the number of bariatric surgeries performed has risen over 14-fold in the last 2 years [1].

Despite marked weight loss following bariatric surgery, long-term weight regain and failure of sustained weight loss is seen in a proportion of patients [7, 8]. Weight regain may occur with all three of the most commonly performed bariatric surgeries [Roux-en-Y gastric bypass (RYGB), adjustable gastric banding (AGB) and vertical sleeve gastrectomy (VSG)] [9]. Sugerman [8] reported that the magnitude of excess weight loss in gastric bypass patients diminishes over time with the percentage of excess body weight loss (EBWL) decreasing from 66 % at 1–2 years to 50 % at 10 years. It is estimated that approximately 10–20 % of patients regain a significant portion of their lost weight with long-term follow-up [7]. This weight

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recidivism has important health consequences including recurrence of obesity-related co-morbidities. Furthermore, weight regain imparts substantial economic repercussions with recurrent costs associated with managing on-going obesity and the costly associated conditions. Thus, it is critical that health practitioners understand weight recidivism post-bariatric surgery and develop a strategy to manage these patients and to guide future planning of diminishing health resources.

In an effort to develop a methodical approach to this issue, we performed a systematic review of the literature regarding potential causative and modifiable risk factors related to weight regain post-bariatric surgery.

Methods

An electronic literature search was performed of the Medline, Embase and Cochrane library databases along with the PubMed US national library from January 1950 to December 2012 to identify relevant articles. Google was also used to search for "grey" literature. Search terms including "bariatric surgery", "obesity surgery", "gastric band", "gastric bypass", "sleeve gastrectomy" and "gastroplasty" were combined with "weight gain" or "weight regain" or "weight failure" in each database. Inclusion of studies was limited to the English language manuscripts, adult populations (>18 years of age), and human subjects. Randomized controlled trials, meta-analyses, case reports, non-randomized control trials, reviews and retrospective and prospective case series were considered. Studies only reporting surgical/endoscopic techniques or studies without follow-up outcomes were excluded. The primary outcomes of interest were potential risk factors associated with weight regain or failure of significant weight loss following bariatric surgery. Patient-specific factors and bariatric surgical operation-specific factors were considered.

Results

Following an initial screen of 2,204 titles, 1,437 abstracts were identified (Fig. 1). Of the 16 studies included in our analysis, seven were retrospective case series [10–16], five were surveys [17–21] and four were non-randomized controlled trials (Table 1) [6, 22–24]. The number of patients ranged from 26 to 1,845, with follow-up from 12 months to 11.4 years post-surgery. Most studies discussed associated putative causes and risk factors. In the included studies, the most common procedures performed were RYGB, ABG and VBG; however, in some series, the surgical procedure was not specified.

There was a high degree of variability in assessing weight regain among the included studies. The heterogeneity of assessment methods utilized between the included studies made quantitative comparisons difficult. For example, some studies used kilograms regained, change in BMI, per cent EWL or percentage of total weight lost to quantify weight regain. In addition, one of the included studies did not quantify weight regain and only discussed the causal associations. Thus, no consensus could be reached as to what absolute number defines "weight regain" post-bariatric surgery. Nonetheless, qualitative descriptions were provided in study analysis in defining causative factors for weight regain. These factors are categorized below.

Nutritional Non-compliance

Five studies suggested non-compliance with dietary recommendations/loss of dietary control as an important aetiology for weight regain post-surgery [6, 13, 19–21]. Sjostrom et al. reported that in 641 subjects who underwent AGB, RYGB or VBG, 7.3 % of the initial weight was regained from the second to tenth year post-operatively [6]. Herein, weight gain was secondary to patients consuming an increased daily caloric intake over time [6]. Loss of dietary control with grazing behaviours (defined as consumption of smaller amounts of foods over extended periods of time) were factors identified in two studies [19, 21]. Colles et al. [19] reported that over 1 year follow-up of 129 AGB patients, uncontrolled eating with grazing was associated with decreased weight loss. Uncontrolled eaters lost 21.6 kg compared to 26.7 kg in controlled eaters, and "grazers" lost 17.3 % of their initial weight versus 22.9 % in patients with controlled eating habits. Kofman et al. found a significant relationship between loss of control when eating and weight regain. Approximately half of all respondents reported they deviated from their dietary plan, and frequency of grazing was positively correlated with weight recidivism post-RYGB [21]. Food indiscretion was a major contributing factor to weight regain in a survey of 100 morbidly obese patients who were followed up for 85 months in a study by Freire et al. [20]. These authors demonstrated that poor diet quality, characterized by an excessive intake of calories, snacks and sweets, as well as oils and fatty foods, was statistically higher in patients experiencing weight regain [20]. Finally, both Margo et al. and Freire et al. demonstrated the importance appropriate nutritional counselling on long-term weight maintenance wherein the lack of appropriate nutritional follow-up was significantly associated with weight regain post-surgery [13, 20].

Hormonal/Metabolic Imbalance

Three studies commented on potential hormonal or metabolic imbalances that could explain weight regain post-bariatric surgery [11, 14, 23]. The study of Engstrom et al. of 40 RYGB patients with a mean follow-up of 42.5 months reported that post-prandial suppression of plasma ghrelin level was correlated with weight loss and maintenance of weight loss [11].

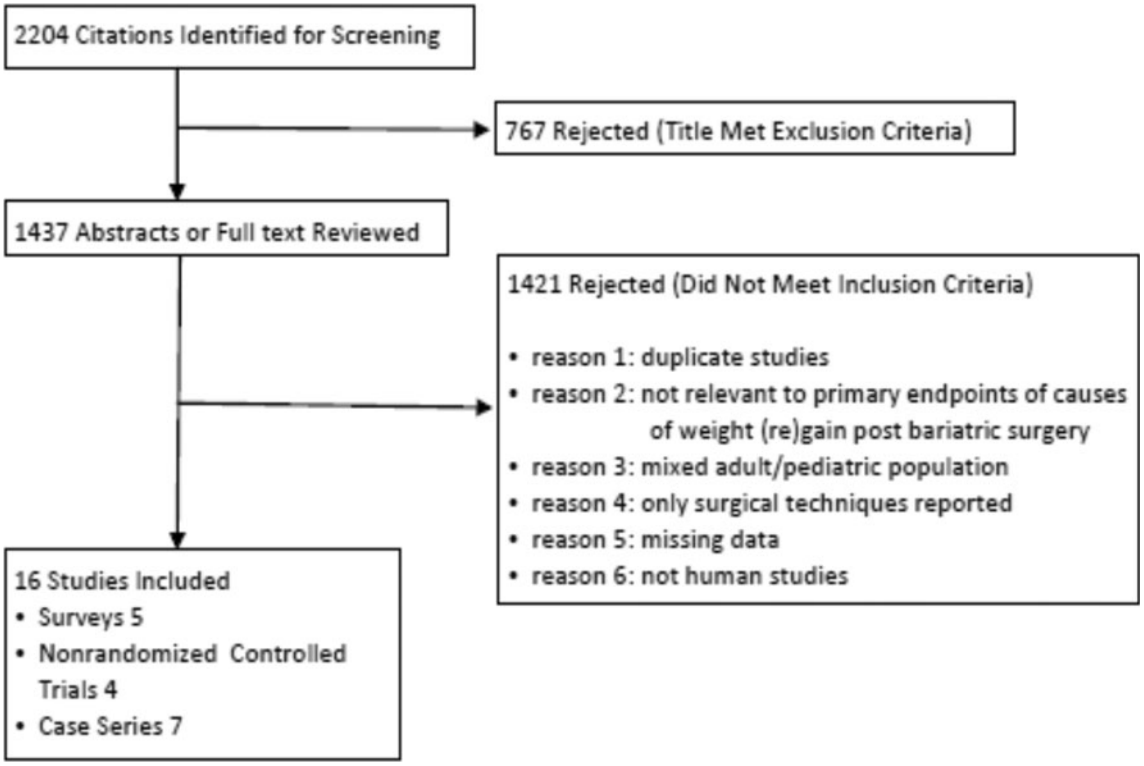

Fig. 1 Flow chart of literature searching

Ghrelin was also implicated as a factor influencing weight maintenance and ultimately failure of weight loss in a 5-year trial conducted by Bohdjalian et al. Herein, weight regain was observed in 19.2 % of patients post-LSG, and measurements of plasma ghrelin demonstrated that the levels were higher in weight regain patients compared to those who experienced appropriate weight loss or maintenance post-surgery [14]. A study by Roslin et al. [23] focused on assessing the incidence and extent of hypoglycaemia by conducting 4-h glucose tolerance testing (GTT) on 36 patients who were at least 6 months post-operative from a RYGB. In this study, 11 patients experienced weight regain of more than 10 % of their total weight, and on GTT, 10 of the 11 patients had an abnormal GTT with 6 of the 11 patients having blood glucose levels consistent with hypoglycaemia at 2 h [23].

Mental Health

Five studies implicated uncontrolled mental health disorders as an important cause of weight regain [17–19, 22, 24]. Kalarchian et al. followed 96 RYGB patients for 2–7 years post-surgery and reported that those classified as binge eaters increased their BMI by 5.3 kg/m^2 compared to a 2.4-kg/m^2 increase in non-binge eaters [17]. Depression, alcohol and drug use, food urges and fewer follow-up visits were reported to be predictors of weight gain in RYGB patients at a mean follow-up of 28.1 months by Odom et al. [18]. Colles et al. suggested that the presence of an eating disorder increased in prevalence over 1 year in patients following AGB from 26.3 % to 38.0 % and correlated with poorer weight loss [19]. Bond et al. suggested that impulsive behavioural traits were a risk factor for weight regain following bariatric surgery at 2-years follow-up [22]. Finally, a study of 60 adult veterans who were followed with a multidisciplinary evaluation for 24 months post-surgery found 18 participants experienced weight regain between the 12- and 24-month measurement points, and weight regain increased in a dose–response pattern in relation to increasing number of psychiatric diagnoses [24]. Further, patients with two or more psychiatric conditions were approximately six times more likely to either lose no further weight or regain weight [24].

Physical Inactivity

Inadequate physical activity was identified as a contributing factor for weight regain in the survey study of 100 obese patients post-RYGB by Freire et al. Patients who performed physical exercises had the lowest weight regain incidence compared to those who were relatively inactive [20].

Anatomic/Surgical Factors

Four studies commented on surgery-specific factors which may influence weight regain post-surgery [10, 12, 15, 16]. Catalano et al. retrospectively reviewed 28 patients following RYGB and reported weight regain to be associated with

Table 1 Summary of studies in systematic review

Author, year (ref. No.)	Type of study	Bariatric procedure(s) performed	Follow-up time	Patient No.	Findings	Aetiology of weight regain
Sjostrom et al. 2004 [6]	Prospective controlled trial	AGB, RYGB, VBG	2 and 10 years	2 years, 1,845; 10 years, 641	Regain of 7.3 % of initial weight on enrolment from post-operative year 2 to 10	Increased daily calorie intake over time
Catalano et al. 2007 [10]	Retrospective case series	RYGB	6–28 months; mean, 18	28	Mean weight regain 28 kg from lowest post-surgical weight	Dilated gastric stoma >1.2 cm
Engstrom et al. 2007 [11]	Case series	RYGB	RYGB mean, 42.5 months post-operative	40	Post-operatively RYGB pts have suppression of ghrelin levels post-prandially, similar to non-obese pts. Obese controls did not have suppression	Post-prandial suppression of ghrelin occurs with surgery and results in weight loss maintenance
Christou et al. 2006 [12]	Case series	RYGB	Mean, 11.4 years	228	Morbidly obese pt (BMI <50): change in BMI −13.9 vs. −12.2 (short vs. long limb). Super obese (BMI >50): change in BMI −17.8 vs. −18.1 (short vs. long limb)	Limb length does not impact long-term weight loss
Margo et al. 2008 [13]	Case series	RYGB	5 years	1 year, 782; 18 months, 594; 48 months, 470	Weight regain pts, per cent EBL was 78 % at 18 months after surgery; however, this rate decreased to 69 % within 60 months of follow-up	Among patients in whom surgery failed, 60 % never underwent nutritional follow-up and 80 % never underwent psychological follow-up
Bohdjalian et al. 2010 [14]	Case series	SG	5 years	26	Weight regain of >10 kg from nadir observed in 19.2 % (5/26 patients)	Plasma ghrelin levels were slightly higher in weight regain patients
Yimcharoen et al. 2011 [15]	Case series	RYGB	Mean, 6.9 years	205	Pts regained an average of 59.9 lbs from their lowest post-bypass weight resulting in a BMI increase from a nadir of 9.78±5.8	Dilation of stoma in 58.9 % (this group had the greatest weight regain also). Enlarged pouch in 28.8 %. Enlarged pouch and stoma in 12.3 %
Heneghan et al.2012 [16]	Case series	RYGB	Mean, 6.9 years	380 pts	205 pts represented the weight regain group. Mean BMI of group= 43.5; %EWL at study=35.5 % mean	Univariate analysis: Higher pre-RYGB BMI, longer interval since RYGB, increased pouch length and dilated stoma influenced weight regain. Multivariate analysis: higher pre-RYGB BMI, longer interval since RYGB and dilated stoma independently associated
Kalarchian et al. 2002 [17]	Survey	RYGB	2–7 years post-RYGB	96	BMI increase from lowest to current 2.4 (30.7→33.1) for NBE versus 5.3 (29.1→34.4) for BE	Binge eating results in greater weight regain and higher overall BMI
Odom et al. 2010 [18]	Survey	RYGB	Mean, 28.1 months	203	79 % pts had weight regain comparing to nadir, 15 % regained ≥15 % of total weight lost	Depression, alcohol and drug use, food urges, less follow-up visits and lack of self-monitoring predictors of weight regain
Colles et al. 2008 [19]	Survey	AGB	12 months	129	Grazing prevalence increased from 26.3 % to 38.0 %	Uncontrolled eating and grazing after surgery showed high

Table 1 (continued)

Author, year (ref. No.)	Type of study	Bariatric procedure(s) performed	Follow-up time	Patient No.	Findings	Aetiology of weight regain
						overlap and were associated with poorer %WL
Freire et al. 2012 [20]	Survey	RYGB	Group 1: up to 24 months (mean=12.4); group 2: 25–60 months (mean=40); group 3: > 60 months (mean=85)	273 (91 pts in each group)	56 % of patients regained weight (group 1=14.7 %, group 2=70 %, group 3=84.8 %). Mean weight regained, 10.8±7.9 kg	Poor diet quality (excessive intake of calories, snacks, sweets, fatty foods) statistically higher in wt regain patients. Pt who performed physical exercises had lowest weight regain incidence. Lack of nutritional counselling significantly associated with wt regain
Kofman et al. 2010 [21]	Survey	RYGB	4.2 years	497 pts	87 % (430) participants reported regain from 1 to 124 lbs (mean, 22.6 lbs)	Participants who regained > 10 % EWL reported higher frequencies of binge eating, grazing and loss of control
Bond et al. 2009 [22]	Prospective	RYGB, AGB and not specified	2 years	209	At 1 year, gained 1.8±7.5 kg; 2 years, 3.7±11.9 kg; similar to non-surgical control group	Increased dis-inhibition related to weight regain in both groups
Roslin et al. 2011 [23]	Prospective	RYGB	35 months	36	31 % (11/36) regained >10 % of total weight loss	91 % (10/11) had abnormal GTT with 54 % (6/11) having blood glucose levels consistent with hypoglycaemia at 2 h
Rutledge et al. 2011 [24]	Prospective	RYGB, AGB	24 months	60 (RYGB=52, AGB=8)	30 % (18/60) experienced weight regain between the 12- and 24-month measurement points	Weight regain increased in a dose–response pattern in relation to increasing number of psychiatric diagnoses; pts with 2 or more psychiatric diagnoses were six times more likely to either lose no additional weight or regain weight

AGB adjustable gastric banding, *RYGB* Roux-en-Y gastric bypass, *VBG* vertical banded gastroplasty, *SG* sleeve gastrectomy, *pt* patient, *BMI* body mass index, *BE* binge eaters, *NBE* non-binge eaters, *GTT* glucose tolerance test

dilatation of the gastric stoma [10]. In this group, successful reduction in anastomotic size (<12 mm) with a sclerotic agent resulted in a mean 26-kg weight loss at 18 months while non-responders lost a mean of 8.3 kg. Stomal dilation was also an important factor in Yimcharoen's study of 205 RYGB patients who were assessed for weight regain [15]. Stomal dilation was the most common anomaly in 58.9 % of patients (enlarged pouch in 28.8 %, enlarged pouch and stoma in 12.3 %), and this single anatomic aberration caused the greatest weight regain [15]. A statistical univariate analysis on factors influencing weight regain in 205 patients post-RYGB performed by Heneghan et al. identified both pouch length and stomal dilation as anatomic factors influencing weight recidivism. On multivariate assessment of variables, stomal dilation represented the only anatomic variant, in addition to greater pre-RYGB BMI and longer duration from RYGB as factors, all independently associated with weight regain post-RYGB [15]. Interestingly, while stomal dilation and pouch length seem to influence weight recidivism post-bariatric surgery, a retrospective review by Christou et al. of 228 RYGB patients found that the length of the roux limb, in fact, has no influence on weight regain [12].

Table 2 Aetiologies for weight regain post-bariatric surgery

(I) Patient-related
Dietary non-compliance
Poor diet quality
Inappropriate food choices
Lack of nutritional counselling
Mental health disorders
Binge eating
Grazing behaviours
Physical inactivity
Hormonal/metabolic
Ghrelin
Glucose homeostasis
(II) Surgery-related
Adjustable gastric band
Pouch distension
Band removal
Roux-en-Y bypass
Stoma dilation
Pouch dilation
Gastro-gastric fistulae
Sleeve gastrectomy
Sleeve dilation

Discussion

Despite the well-recognised issue of sub-optimal weight loss and/or weight regain post-surgery [12, 13], there is no clear consensus on a numerical definition of what constitutes weight recidivism (i.e. pounds gained, per cent weight regained). Nevertheless, this review identified five principle aetiologies representing nutritional indiscretion, mental health issues, endocrine/metabolic alterations, physical inactivity and anatomic surgical failure. In an effort to systematically approach a patient experiencing weight recidivism, causative factors are best grouped into two broad categories: patient-related (mental health and behaviour) and surgery-related (anatomical alterations and complications; Table 2). The discussion below expands on each of these factors and provides evidence regarding their impact on weight recidivism with comments on potential management.

Patient-Related

Hormonal/Metabolic Causes

Early findings suggest that weight reduction following bariatric surgery may be partially dependent on "normalization" of hormonal inputs. Furthermore, it may speculated that patients who fail to have weight loss post-bariatric surgery or experience weight regain may have persistent hormonal "imbalances" (high ghrelin, low peptide YY) which need to be addressed in order to achieve optimal weight loss. This notion was corroborated by the studies published by Engstrom and Bohdjalian, wherein post-prandial suppression of plasma ghrelin was correlated with weight loss and maintenance of weight loss [11], while post-operative elevation in plasma ghrelin levels was associated with a net overall weight regain post-surgery [14]. While elevated ghrelin has been found to correlate with a return of hunger in patients, currently, there are no therapies clinically available to manage recalcitrant ghrelin levels post-surgery. Investigational research is being conducted in the development of an anti-ghrelin vaccine by a group headed by Mariana Monteiro from the University of Portugal. Monteiro's group has developed a therapeutic vaccine using a non-infectious virus carrying ghrelin, which is designed to provoke an immune response—development of antibodies against ghrelin—that would suppress this hormone [25]. This work is still in its early investigational phase, but it offers hope for possible human use and particularly an option in patients who are experiencing weight recidivism secondary to recalcitrant ghrelin levels.

Post-operative metabolic disturbances have also demonstrated an effect on weight regain. The cyclical regulation of glucose has been shown to be a key chemical mediator for appetite. Herein, following a meal, there is a transient glucose surge that initiates insulin release which depending on the circulating glucose may trigger hypoglycaemia and generate a hunger response [23]. This reactive hypoglycaemia may be more pronounced after bariatric surgery wherein the rapid

transit of ingested carbohydrates caused by the changed intestinal anatomy may generate an early and significant insulin surge which results in a reactive hypoglycaemia shortly after a meal [23]. This cyclical glucose fluctuation may generate a hunger temptation a few hours after a meal, leading to frequent snacking or meals and thus potential weight regain. A study by Roslin et al. demonstrated that 91 % of patients (10 of 11) who experienced weight regain (>10 % of total weight loss regained) post-RYGB had abnormal glucose tolerance testing [23]. Further, 54 % of these patients (6 of 11) had blood glucose levels consistent with hypoglycaemia. Ergo, it is plausible that sharp drops in glucose levels post-surgery and the subsequent hunger response may cause maladaptive eating and ultimately weight recidivism [23]. Management of this condition is focused on redesigning a patient's dietary regimen. Herein, emphasis is placed on eating foods with a low-glycaemic index, and patients are encouraged not to go long periods without eating [23]. Furthermore, it is recommended that patients add bulk to their food, incorporating whey gelatinous proteins in their diet and a healthy afternoon snack [23]. These simple dietary changes aim to minimize glucose level fluctuations and subsequent hunger and weight regain.

Dietary Non-compliance

Dietary indiscretion with an associated failure of patients to adhere to appropriate nutritional and lifestyle recommendations is a common reason for weight regain post-bariatric surgery [6, 13, 19–21]. Surgery appears to reduce caloric intake in the immediate post-operative period [6, 26]. However, in a subset of patients, caloric intake gradually increases over time and unsurprisingly correlates with weight regain [6, 26]. The Swedish Obesity Study showed that self-reported daily caloric intake increased from 1,500 kcal/day at 6 months follow-up to 2,000 kcal/day at 4–10 years post-bariatric surgery [6]. Respectively, Magro et al. reported that of all patients who had weight gain post-RYGB, 60 % never maintained follow-up with appropriate nutritional consultants [13]. In a prospective study of patients following RYGB, self-reported adherence to the recommended post-operative diet at week 20 was found to be predictive of weight loss at post-operative week 92 [26]. Patients with higher dietary adherence scores lost 28 % more weight than non-adherent patients. This study also reported that over time, both daily caloric intake and the percentage of "empty" calories from sweets/desserts increased. The importance of a patient's diet is highlighted by findings that dietary alterations may cause a 50 % excess weight regain in as little as 3 months [27].

Hsu et al. postulate that bariatric surgery alters satiation ("the process which brings a period of eating to an end") but not satiety ("inhibition of hunger and eating brought on by food consumption itself") [28]. Self-reports by patients identify that when weight loss plateaued or became less rapid, patients would not maintain healthy eating habits [29]. The existing literature strongly suggests that nutritional and lifestyle compliance is crucial to weight management post-bariatric surgery. Poor diet quality, inappropriate food choices and lack of nutritional counselling served as key positive predictors for weight regain post-surgery [21]. Evidence confirms that the adoption and promotion of healthy lifestyle habits, particularly ensuring dietary compliance, are critical for the long-term maintenance of achieved weight loss [20, 21]. Comprehensive weight management programs must therefore provide improved patient education and promote adherence to post-bariatric surgery diets in order to ensure success. These programs must take action to support patients towards a long-term goal of healthy and appropriate dietary choices with active monitoring (journaling) and reinforcement (review of food records) strategies provided by a multidisciplinary health care team.

Mental Health Causes

Mental health and weight loss outcomes display a compelling linear relationship. For example, Kinzl et al. described a strong association between the presence of psychiatric disorders and weight loss following bariatric surgery. Specifically, the presence of a psychiatric diagnosis was associated with significantly lower weight loss over a 50-month period [30]. While there is no "typical" psychological profile of severely obese patients, evidence has shown that obese patients seem to differ from the general population in that they have greater difficulty with impulse control [31]. Accordingly, some authors have suggested a strong association between severe obesity and attention deficit hyperactivity disorder (ADHD) [32]. Levy et al. reported that over 30 % of severely obese patients with refractory weight loss had ADHD. Appropriate treatment of these patients led to improved compliance with dietary and lifestyle changes and ultimately weight loss [32]. Related to lack of impulse control, there appears to be a high prevalence of binge eaters seeking weight control management [31]. Our systematic review clearly identified that binge eaters experienced more weight regain compared to similar cohorts [17, 21]. Goldfein et al. reported in a non-bariatric surgical cohort that obese patients with a binge eating disorder ate more calories (on average 400 kcal) and for longer duration when presented with multiple food items compared to non-binge eating obese patients [33]. This lack of inhibition in some obese patients leads to greater susceptibility to impulsive eating and is shown to be a significant predictor of weight regain along with an increase in baseline food urges [18, 19, 22].

Bariatric surgery alone fails to address binge eating in the long term and may in fact be associated with an increase in maladaptive eating behaviour afterwards [19]. Saunders reported that 80 % of patients identified pre-operatively with an eating disorder, and who did not receive any treatment pre-

operatively, had recurrent feelings of binge eating at 6 months post-operation [29]. Margo et al. reported that in patients with limited weight loss post-RYGB, 80 % never underwent any psychological follow-up to address eating disorders [13]. In addition to binge eating, a new sub-clinical disorder described as "grazing" (consuming multiple small meals with feelings of loss of control with eating) has been reported [29]. The incidence of grazing has been shown to increase following bariatric surgery resulting in overall increased caloric intake over time [19]. The frequency of grazing has shown to be positively correlated with weight regain, and patients who reported grazing at least two times per week had greater weight regain and less EWL than patients who grazed on a less regular basis [21]. Cognitive behavioural therapy has been shown to be more successful in managing binge eating and grazing than medications or weight loss programs without a psychiatric component [34]. Completion rates of behavioural modification therapy increased to 91 % when performed post-operatively, compared to 14 % when done pre-operatively [35].

Many of these conditions can lead to maladaptive eating patterns, and if they remain unrecognized and untreated, they will continue to be a persistent impediment to successful weight loss. It is important to have all individuals experiencing weight regain post-surgery to have a formal psychological evaluation by a qualified mental health team member to assess for the presence of lack of impulse control disorders (binge eating or grazing) and/or a attention deficit hyperactivity trait.

Physical Inactivity

Engagement in moderate or high intensity physical activity results in greater weight loss in patients following bariatric surgery compared to surgery alone [36]. Pre-operative studies of bariatric surgery patients found 47 % were active enough to attain health benefits, while only 19.6 % reached activity levels consistent with long-term weight maintenance [37]. In a comparative study of matched patients, bariatric surgical patients had lower caloric expenditures through physical activity than those who achieved weight loss non-surgically, despite having the same daily caloric intake [22]. Patients who performed physical exercise on a regular basis (three or four times per week, 30 min minimum) show a propensity for lowest weight regain incidence [20].

A potential benefit of bariatric surgery is that it allows patients to become more active by reducing physical inability to perform activities [38]. Biochemical studies have shown that efficiency of skeletal muscle increases as a patient loses weight. Therefore, to continue to lose weight, patients need to increase the intensity of exercise performed [39]. However, based on self-reports from bariatric surgical patients, activity seems to decrease [6]. Thus, ensuring patients maintain a baseline physical activity regimen post-surgery remains a critical element for long-term weight loss and maintenance.

Surgery Specific

Weight regain following bariatric surgery may be related to late complications or procedure failures specific to the surgery performed.

Adjustable Gastric Band

Success with AGB is closely correlated with appropriate follow-up, as saline adjustment of the adjustable band is necessary to ensure appropriate restriction and weight loss. With appropriate follow-up, gastric distension with smaller quantities of food leads to an earlier satiation response and ultimately weight loss. Nonetheless, physiologically, the stomach is a distensible muscular organ, which expands to accommodate food boluses. Therefore, over time, the surgically created gastric pouch may enlarge in up to 50 % of patients at 4 years [40]. This risk is elevated in patients who lack appropriate follow-up and adequate band adjustment. In addition, the gastric band has been shown to slip proximally in 8 % of patients, releasing the intended compressive and restrictive effects [41]. Thus, it is important for patients who are experiencing weight recidivism after band placement to be assessed for potential pouch distension or slippage of the band as factors contributing to failure. Pouch distension can oftentimes be managed by complete band deflation, a low calorie diet, reinforcement of portion size and follow-up contrast study in 4–6 weeks [42]. This conservative management strategy is successful in over 70 % of patients. Band slippage can be managed similarly, but oftentimes, surgical intervention is required with band re-positioning or band replacement [42].

Premature explantation of the adjustable gastric band is another important aetiology for weight regain, as only 12 % of post-AGB patients with early band removal are able to maintain their current weight [43]. The explantation rate remains high in studies following patients long term. A study by Stroh et al. documented a 12.0 % rate for overall band removal. After 14 years, the reoperation rate was 30.5 % with a reoperation rate of 2.2 % for every year of follow-up [44]. One of the major reasons for removal was band intolerance secondary to increased reflux type symptoms. Removal of the gastric band due to reflux was found in 5 % of all patients with an AGB [40]. Therefore, it is important for the practitioner to address reflux symptoms in any patient with an AGB and offer appropriate treatment (band deflation or trial of proton pump inhibitors) in an attempt to avoid premature band explantation and the risk of weight recidivism.

Roux-en-Y Gastric Bypass

The RYGB produces weight loss through both restriction of intake and malabsorption. In assessing weight recidivism post-RYGB, anatomical abnormalities are postulated to play

a significant role in weight regain [15]. In particular, loss of restriction caused by enlargement of the gastric pouch and gastrojejunostomy (stoma) has been shown to be responsible for a loss of satiety and an associated increased intake with concurrent weight regain [15]. Stomal dilation is one of the most frequently identified abnormalities in patients experiencing weight regain [15]. A multivariate analysis on weight regain post-RYGB identified stomal dilation as independently associated with weight recidivism [16]. Functionally, dilation of the stoma results in a greater quantity of food being needed to distend the gastric remnant to cause satiation and has been reported to occur as early as 6 months post-operatively. Similar to stomal dilation, enlargement of the gastric pouch decreases the net restrictive effect of the gastric bypass by increasing the amount of food required to create the sensation of fullness. Yimcharoen et al. demonstrated that an enlarged gastric pouch was found in almost one third of patients examined for weight regain post-bariatric surgery [15]. If a dilated gastric remnant or enlarged gastrojejunal anastomosis is identified, a number of management options may be reasonable. Reduction of gastrojejunal size via sclerotic agents has been shown to result in weight loss after weight gain in RYGB patients [10]. Thompson et al. showed endoscopic suturing was feasible to reduce the gastrojejunal anastomosis to an average of 10 mm, leading to weight loss in 75 % of RYGB patients and resulting in loss of 23.4 % of EBWL [45]. Endoscopic interventions have generally been suggested to be safe and may be completed with minimal morbidity [10, 45]. Pouch and anastomosis size may also be reduced by placement of a ring, band or mesh wrap around the gastric remnant/anastomosis.

Another important anatomic change that has shown to reduce the effectiveness of the RYGB is the presence of a gastro-gastric fistula (GGF). A GGF is an abnormal communication between the gastric pouch and the excluded stomach. GGF is an uncommon, but potentially significant complication after divided laparoscopic Roux-en-Y gastric bypass, with an incidence ranging between 1.5 % and 6 % [46]. Gastro-gastric fistulas may reduce both the restrictive and malabsorptive components of RYGB by allowing food to travel through alternative routes and thus not passing through the surgically created gastric pouch, gastrojejunostomy and bypassed intestine. Ergo, most commonly, patients with a GGF present with weight regain in the long term [47]. Fistula formation has been suggested to be preventable with proper surgical technique. A large single-centre study reported that placement of an interposing loop of jejunum between the gastric pouch and remnant prevented fistula formation [47]. Comparatively, the fistulisation rate was 2.6 % when no intervening bowel was placed between the gastric pouch and remnant and 49 % in patients with incompletely transected stomachs [48]. Surgical technique and unrecognized leak/abscess remain major modifiable risk factors to fistula formation.

Vertical Sleeve Gastrectomy

While weight recidivism studies on the VSG are limited due to the fact that it has only been performed as a stand-alone procedure since 2008, some authors have suggested that over time, the gastric sleeve may dilate, and that size of the gastric sleeve is linearly correlated with post-operative BMI [49, 50]. It is hypothesized that an anatomical increase in the size of the sleeve will reduce the restrictive effect afforded by the procedure and thus allow patients to consume a larger volume of calories with a reduced satiety response. Atiologies for sleeve stretch or dilation remain unknown, and research in this area will be a pertinent topic for bariatric researchers in the future. As health practitioners assessing patients for weight recidivism, sleeve dilation should be considered in the differential diagnosis for weight regain, and appropriate investigations to rule out sleeve dilation (upper gastrointestinal endoscopy, radiographic upper gastrointestinal series) should be ordered. Refractory sleeve dilation causing weight regain requires surgical correction.

Surgical Revision of Failed Bariatric Surgery

Surgical revision is an option in the setting of weight regain following bariatric surgery. A failed gastric band with removal of the gastric band and conversion to a RYGB results in significant weight loss in those with inadequate weight loss or weight regain [51]. Surgical revision of an AGB to RYGB can be completed in a similar operative time and has the risk of complications similar to primary RYGB surgery [51]. Conversion to RYGB has been shown to be more effective than re-banding, with patients in the converted group having a greater reduction in BMI (−6.1 BMI points) compared to the re-banded group (+1.5 BMI points) [52]. Failed VSG can be managed by potentially "re-sleeving" wherein the gastric reservoir is decreased in size using surgical staplers. Alternatively, the VSG can be converted to a RYGB. A study by Langer et al. demonstrated this to be effective with a satisfactory return to optimal weight loss [53].

Revisional procedures to correct pouch and stomal dilation after RYGB have been performed for decades. Most procedures entail surgical re-creation of the pouch or stoma using either suture or stapling devices. Unfortunately, these procedures are fraught with extremely high complication and mortality rates [15].

An Algorithm for Management of Weight Regain ?following Bariatric Surgery

The aetiology for weight regain following bariatric surgery is complex and multifactorial (Fig. 2). The approach in managing weight recidivism requires a systematic dyad technique identifying both the patient-related and surgery-related factors

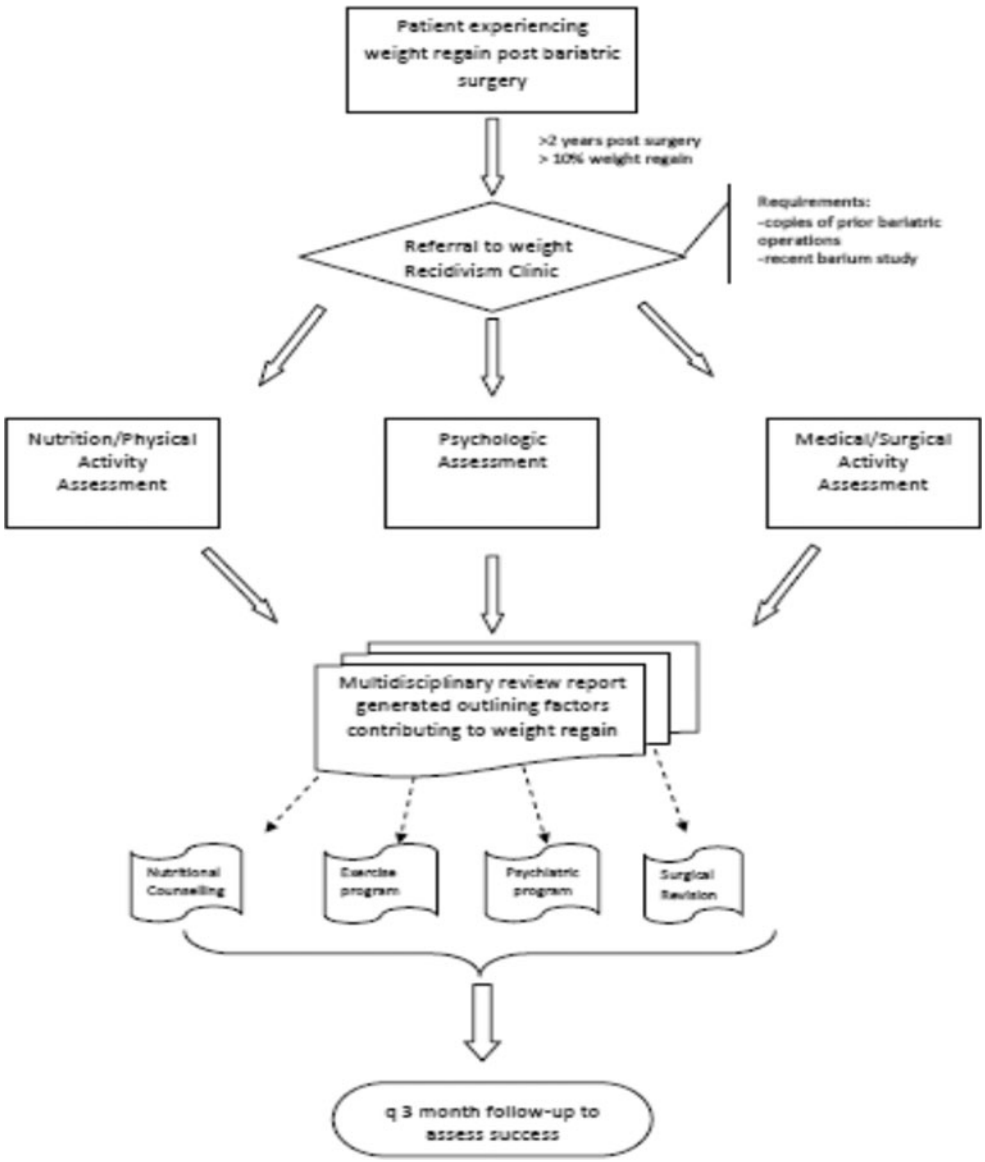

Fig. 2 Weight recidivism clinic algorithm

which may contribute to failure. Dietary patterns, psychological disorders and physical activity levels should all be reviewed in patients presenting with weight regain post-bariatric surgery. In patients with weight regain following bariatric surgery, diet (25.3 %), physical activity (21.0 %) and motivational issues (19.7 %) were identified to be the most common reasons [45]. Furthermore, patients seeking bariatric surgery often present with a wide range of mental health issues including mood, anxiety, addiction and personality disorders. Diagnosis and management of these disorders in patients may improve outcomes following surgical and non-surgical weight management. As the patient is undergoing psychological, dietary and activity counselling, it is important to address hormonal contributions to weight regain. Respectively, the health practitioner should aim to determine if any anatomic/post-surgical changes are propagating weight recidivism. Simple baseline anatomic studies should include either an esophagogastroduodenoscopy (EGD) or an upper gastrointestinal contrast study to evaluate the GI tract. Both of these investigations provide important information regarding gastric remnant size, size of the gastrojejunal anastomosis, presence of gastro-gastric fistulas and location/integrity of bands/rings.

Conclusion

Bariatric surgery in obese patients is effective in producing sustainable weight loss and improvement in obesity-related co-morbidities. However, suboptimal weight loss and weight regain can be seen in a subset of patients following bariatric surgery. Weight recidivism is an important public health issue with significant ramifications to both the patient (re-emergence of obesity-related co-morbidities) and the health care

system (economic costs of obesity, societal impacts of recalcitrant obesity). The underlying aetiologies contributing to weight regain are complex, multi-factorial and oftentimes overlapping. Thus, in an effort to manage weight regain, an organized and systematic approach is essential. A dedicated weight recidivism clinic that offers patients a methodical, organized and multidisciplinary plan may serve as a useful template for practitioners struggling with patients experiencing weight recidivism post-bariatric surgery.

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