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## Possible Risk Factors for Increased Suicide Following Bariatric Surgery

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### Abstract

There is a growing research literature suggesting that there may be elevated risk of suicide following bariatric surgery. Most of the data reported thus far has been cross-sectional and observational, and very little is known about the possible specific causal variables involved. The purpose of this report is to review this literature and to review possible risk factors for increased suicidal risk following bariatric surgery, in order to delineate future research directions. First a variety of medical, biological, and genetic factors, including the persistence of recurrence of medical comorbidities after bariatric surgery, the disinhibition and impulsivity secondary to changes in the absorption of alcohol, hypoglycemia, as well as pharmacokinetic changes that may affect the absorption of various medications including antidepressant medications are reviewed. Also reviewed are possible mediating factors involving changes in various peptidergic systems such as GLP-1 and Ghrelin. A number of psychosocial issues that might be involved are discussed, including lack of improvement in quality of life after surgery, continued or recurrent physical mobility restrictions, persistence or recurrence of sexual dysfunction and relationship problems, low self-esteem, and a history of child maltreatment. Inadequate weight loss or weight regain are also discussed. Possible theoretical models involved and directions for research are suggested.

### Introduction

In recent general population samples it has been shown that elevated body mass index (BMI) is associated with an increased risk of depression. However, although several large scale studies suggest a reduced risk of suicide associated with elevated BMI in men and women (1–3), the data have been somewhat inconsistent, and a recent review concluded that overall the literature favors a positive association between BMI and suicide risk (4). Despite

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this controversy, a growing literature suggests that the risk of suicide may be increased after bariatric surgery compared to obese controls who have not had such a surgery. The purpose of this paper is to review this evidence, and then, in detail, to discuss possible reasons that this increased risk might occur. The other purpose of this article is to suggest directions for future research. For our purposes here, we are focusing on completed suicide, not suicidal behavior or thoughts.

## Is the Risk of Suicide Increased after Bariatric Surgery?

An early report by Pories et al. included a series of 608 severely obese patients who had undergone Roux-en-Y gastric bypass surgery (RYGBP) for obesity over the prior 14 years (5). The overall peri-operative mortality rate was 1.5%. Only 17 of the 608 patients (<3%) were lost to follow-up. In this sample there were 3 suicides, and 3 deaths from cirrhosis due to a recurrence of alcohol abuse. Powers et al. studied a cohort that at a baseline included 131 patients who had undergone extensive pre-surgical evaluations (6). At a mean duration to follow-up of 5.7 years, the outcome of 86 patients (66% of the original group) was ascertained. In this sample, one patient had committed suicide, and this individual had a history of multiple previous suicide attempts.

Our group reported a 13–15 year follow-up on an initial cohort of 100 patients who had undergone RYGBP (7). Seventy-eight were interviewed and 8 had died; thus outcome data were available on 86%. Two of the deaths were considered related to psychiatric factors, including 1 suicide and 1 death from gastrointestinal bleeding associated with severe cirrhosis and alcoholism. In 2006, Goldfeder and colleagues from the New York City Office of the Medical Examiner and Department of Forensic Medicine at NYU retrospectively reviewed all deaths investigated by their office between 1997 and 2005 in which individuals had undergone bariatric surgery (8). The sample included 107 deaths, including 1 death by suicide.

These reports suggest that suicide is a potential outcome following bariatric surgery, but provide little information regarding the prevalence of the problem. Three more recent studies have provided additional information. Adams et al. reported a retrospective cohort study which examined the long-term mortality among 9,949 patients who had undergone RYGBP in the state of Utah, and 9,628 severely obese controls who had applied for driver's licenses in the state (9). From this overall sample they were able to match 7,925 surgical patients and 7,925 controls on the variables of age, sex and body mass index. At a mean follow-up of 7.1 years, adjusted long-term mortality was reduced 40% in the surgery group, including a 56% reduction in death rates from coronary artery disease, a 92% reduction from diabetes mellitus, and a 60% reduction from cancer. However, death rates from accidents and suicides were 50% higher in the surgery group, although this difference did not reach statistical significance. Overall there were 15 suicide deaths compared to 5 such deaths in the control group. Omalu and colleagues published data on all bariatric operations performed on Pennsylvania residents between 1995 and 2004 using matching mortality data from the Division of Vital Records from the Pennsylvania State Department of Health (10). They found an excess of deaths from both suicide and coronary heart disease. Most recently Tindle et al. (11) again examined bariatric records on Pennsylvania residents between 1995

and 2004, using matching data from the Division of Vital Records in the Pennsylvania State Department of Health, and found an overall suicide rate of 6.6 per 10,000 (13.7 per 10,000 among men and 5.2 per 10,000 among women). Thirty percent of the suicides occurred within the first two years following surgery and almost 70% occurred within 3 years. Comparable sex matched suicide rates in the United States among those aged 35–64 were 2.4 per 10,000 for men and 0.7 per 10,000 for women. These authors concluded that there was a substantial excess of suicides among patients who had undergone bariatric surgery.

In summary, although the data are limited, including earlier anecdotal reports and more recent epidemiological data, and although this outcome is uncommon, we conclude that the available data suggest an increased risk of suicide after bariatric surgery.

## Medical, Biological and Genetic Factors

### Persistence or Recurrence of Medical Comorbidities after Bariatric Surgery

As is widely recognized, many medical comorbidities such as hypertension, obstructive sleep apnea (OSA) and type II diabetes may resolve after bariatric surgery. However, some of these medical comorbidities may persist. For example, Lettieri and colleagues in attempting to clarify the impact of bariatric surgery on OSA found that surgical weight loss did reduce the apnea-hypoxia index, but that most patients had residual symptoms of OSA 1 year after surgery (12). In a study of those with type II diabetes, Chikuguwo et al. obtained 5 to 16 year follow-up data on a series of 177 patients who had undergone RYGBP (13). While 157 (89%) had a complete remission of type II diabetes, 20 patients (11.3%) did not remit, despite a mean percent excess weight loss of  $58.2 \pm 12.3\%$ , and of the 157 patients with initial remission, 68 (43%) subsequently developed recurrence of type II diabetes. In this study weight regain was a statistically significant but weak predictor of recurrence of type II diabetes. DiGiorgi et al. followed-up a series of 42 patients who had undergone RYGBP who also had type II diabetes at baseline a minimum of 3 years (14). Type II diabetes had resolved (64%) or improved (36%) in all patients, but in 24% it later recurred or worsened. In this study patients who experienced a recurrence or worsening regained a greater percentage of their lost weight compared to those who did not experience a recurrence (37.7% versus 15.4%). The re-emergence of such medical problems may contribute to a sense of failure and disappointment, which theoretically may increase suicide risk. Also suicide rates are known to be elevated in those with diabetes (15).

### Disinhibition/Impulsivity Secondary to ETOH Kinetic Changes

Limited but consistent research suggests that following certain forms of bariatric surgery, the pharmacokinetic parameters of alcohol are altered (16,17), and alcohol sensitivity may be heightened (18,19). Ertelt and colleagues reported that in a survey of 70 post-bariatric surgery patients, 54.3% experienced changes in their response to alcohol, with 34.3% indicating that they became intoxicated more quickly (18). Similarly, 84% of post-bariatric surgery patients in a survey by Buffington and colleagues reported feeling more sensitive to the effects of alcohol compared to before surgery (19). These reports are supported by the findings of alcohol-administration studies. Klockhoff and colleagues performed a cross-sectional blood alcohol concentration (BAC) comparison between 12 RYGBP patients and

12 body mass index and age-matched controls (16). Following a single 0.30 g/kg dose of 95% v/v alcohol, the time to maximum BAC (Tmax) was shorter (10 vs. 30 minutes), the maximum BAC (Cmax) was higher (0.74 versus 0.58 g/l), and the BAC remained higher in the RYGBP group at 10 and 20 minutes post-dose relative to the control group. Hagedorn and colleagues found similar results in a cross-sectional comparison of 19 post RYGBP patients with 17 nonsurgical controls. Consumption of five ounces of red wine produced a higher peak breath alcohol level in the RYGBP group versus controls (0.08% versus 0.05%), as well as a longer time to reach a breath alcohol level of zero (108 vs. 72 minutes) (17). Similar results have been reported by Woodard et al. after RYGBP (20) and by Maluenda et al. after sleeve gastrectomy (21).

There may be several anatomical and physiological changes produced by surgery which could account for alterations in alcohol absorption and/or metabolism. These include significant weight loss, which results in relatively higher dosages of alcohol after surgery on a mg/kg basis and accelerated emptying of liquids from the gastric pouch following surgery (22) substantially reduced stomach volume, which theoretically results in decreased availability of gastric alcohol dehydrogenase, which is responsible for oxidation of approximately 6–8% of an oral alcohol dosage (23). This idea is supported by research from Caballeria and colleagues (24), who demonstrated that following gastrectomy the areas under the curve (AUC) following oral and intravenous alcohol administration were similar, whereas the AUC was significantly higher following intravenous dosing than after oral dosing in non-gastrectomized patients. One mechanism suggested for this finding is a decrease in gastric oxidation (first-pass effect) of alcohol following gastrectomy, due to a reduction in gastric alcohol dehydrogenase activity in the remnant stomach or a reduction in alcohol contact time with this gastric enzyme (24). Further, given that alcohol use disorder and alcohol consumption very commonly play a role in suicide attempts (25,26), this area seems to have promise as a possible explanatory variable as to why post-bariatric surgery patients might be more likely to attempt or commit suicide.

### **Hypoglycemia**

Brief reports and case series have recently appeared in the literature indicating that postprandial hyperinsulinemic hypoglycemia (PHIH) with neuroglycopenia is a potential complication of RYGBP (27). This syndrome is characterized by symptoms such as lightheadedness, sweating, confusion, loss of consciousness or seizure, which occur following consumption of a meal containing a large amount of carbohydrate (28). Motor vehicle accidents have also been reported (29). Although the majority of patients with this condition are managed pharmacologically or through dietary intervention, up to 10% of patients require pancreatectomy to relieve symptoms (30). This suggests the possibility that confusion from PHIH should be considered a possible contributor to suicide risk.

### **Changes in Pharmacokinetics**

At this point in time, very little direct research regarding drug absorption in patients post bariatric surgery has been conducted (31), despite the fact that these patients often present on multiple drug therapies for comorbid conditions associated with obesity (32). While some

of the drugs therapies will be reduced or discontinued following surgery, this is not uniformly true.

Malabsorption is a potential concern post-bariatric surgery, with multiple factors playing a role. Oral agents are maximally absorbed in the small intestine primarily in the proximal portion (e.g. duodenum and jejunum). The loss of the large absorptive surface area of the duodenum by the RYGBP creates the potential for clinically significant alterations in the absorption/bioavailability of ingested medications. Malabsorption of nutrients such as iron, folate, vitamin B1, and B12 has been demonstrated (31). In addition, changes in drug dissolution and solubility associated with alterations in intestinal pH, may be operative (33). The complexity of the malabsorption issues increases considering the metabolic enzyme located in the duodenum such as cytochrome P450 3A4. Atorvastatin has been demonstrated to have a greater absorption post- surgery compared with pre-surgery due to the bypassing of a major portion of the total 3A4 enzyme (34). This may apply to other drugs that rely heavily on the 3A4 enzyme for their metabolism.

Our group recently showed that the area under the plasma level time curve (AUC) for the antidepressant sertraline was associated with bariatric surgery (35). In this study the AUC and the maximum plasma concentration for sertraline were reduced by approximately 40% in a bariatric surgery group versus controls. Therefore, in the case of antidepressants, patients who undergo RYGBP may be at risk for depressive symptom recurrence unless dosage alterations are made.

### **Suicide and Genetics**

A great effort has been underway to identify predictor genetic profiles associated with suicide. However, it is likely that the genetic contributions to suicide will involve small effects of many gene variants associated with various components of suicidal behavior which may then interact with environmental factors (36).

Focus has centered on the serotonin system as it has been demonstrated to influence anxiety, mood, aggression and impulsivity. Reduced levels of the serotonin metabolite, 5-hydroxyindoleacetic acid (5-HIAA), have been found in the cerebrospinal fluid (CSF) in violent suicidal acts compared to levels in controls (37).

### **Peptidergic Systems**

It is well established that gastrointestinal peptides change markedly following RYGBP. Indeed, these hormonal changes may be responsible for the reduction in appetite and improvement in satiation which facilitate weight loss following RYGBP (38). A growing body of literature now recognizes that several of these peripherally released peptides are also active in the central nervous system (CNS), and may promote changes in centrally-mediated processes including mood, anxiety and cognition. Data addressing the interactions between peripherally released peptides and neurobiological processes and psychopathology remain limited, although these relationships have been examined with several peptides. Data regarding ghrelin, PYY3-36, and GLP-1 post-RYGB have been most prominent.

## Peripherally Released Peptides

**Ghrelin**—Numerous studies have investigated plasma ghrelin levels at varying times following RYGBP. Results of these studies have been inconsistent and have ranged from finding ghrelin levels to be increased, decreased, or unchanged following surgery. Whether a given individual will experience a significant increase or decrease in ghrelin levels following RYGB is unclear. Studies evaluating depression following ghrelin administration (39) and examining the plasma ghrelin levels among depressed patients (e.g. 40) have generally found little correlation between ghrelin and mood. However, this literature is small and not conclusive.

**GLP-1**—Data have consistently shown a rapid and robust increase in GLP-1 following RYGBP, which is often cited as the reason for the early resolution of diabetes following surgery. Data have shown that obesity is associated with reduced cognitive function, and significant improvement in memory has been observed as early as 12 weeks following RYGBP (41). While this post-RYGBP finding has not yet been associated with GLP-1, there is evidence of a role for GLP-1 in cognition. Further, there is evidence that GLP-1 has neurotrophic properties and may reduce Alzheimer's dementia (AD) associated beta-amyloid peptide levels in the brain. In one study, beta-amyloid protein load increased in mice following streptozotocin induction of Type II Diabetes Mellitus, and administration of a GLP-1 analog (i.e. *Ex-4*) reduced this increase (42). Exogenously administered *Ex-4* has also been shown to improve cognitive performance in rats, including spatial learning and working memory. The same researchers also found improvements in mood and hopelessness as assessed via a forced swim test following administration of *Ex-4* to mice (43).

One small study in humans which explored GLP-1 plasma levels found no difference between an AD cohort and matched controls (44). Currently, GLP-1 analogs are in clinical trials for the treatment of AD. Native GLP-1 is rapidly catabolized peripherally; hence, it is not clear to what extent the increase in GLP-1 produced by RYGB leads to alterations in CNS functions. Still, it is interesting to speculate about whether GLP-1 increases and resultant resolution of Type II Diabetes following RYGB contribute to the increases in cognition and improvement in mood typically observed following surgery. It is also of interest to determine whether these increases in GLP-1 that occur following surgery may impact on suicidality.

**PYY3-36**—PYY stimulates the release of NPY (38). Several research groups have explored the relationship between the centrally released peptide, NPY, and depression and suicidal behavior. Given the relationship between PYY and NPY, some groups have also explored the relationship between plasma PYY concentrations and depression. For example, levels of PYY in the cerebral spinal fluid (CSF) were measured in another study of depressed, antidepressant-free, inpatients and control subjects (45). CSF PYY content did not correlate with overall scores on depression rating scales and was similar between depressed patients and healthy controls.

### Centrally Released Peptides

Centrally released peptides have also been explored in patients experiencing depression and/or displaying suicidal behavior in other studies. Included among this list are endogenous opioids, cocaine and amphetamine regulated transcript (CART), brain derived neurotrophic factor (BDNF), monoamine metabolites, urocortin, orexin, corticotrophin releasing hormone (CRH), arginine vasopressin, neuromedin B, substance P, and neuropeptide Y (NPY).

The majority of the literature concerning this topic has concentrated on NPY. It is not clear whether RYGBP alters CSF NPY levels or receptor density either directly or indirectly through effects on peripheral peptides which may influence NPY. One study showed that 10 days following RYGB in rats, there was a 43% reduction in NPY expression in the arcuate nucleus and further reductions in the magnocellular and parvocellular parts of the paraventricular nucleus (46).

Several rat and human studies have linked low NPY levels or receptor expression aberrations with suicidal behavior and depression. One study found that patients who had recently attempted suicide had lower NPY levels than healthy controls, and those had repeatedly attempted suicide had the lowest NPY levels among those examined (47). The relationship found between NPY and psychopathology, cognition, and suicide has not been consistent between reports. This literature has been reviewed elsewhere by Morales-Medina and colleagues (48).

### Psychosocial, Weight and Eating Factors

The empirical literature suggests that overall, psychosocial functioning in various domains improves post-surgically for the majority of patients (49,50). Many studies suggest that the degree of post-surgery psychosocial functioning is associated with the degree of excess weight that is lost following surgery, with individuals who have experienced greater weight loss exhibiting larger improvements (51,52). However, patients vary widely in the degree to which they successfully lose weight and then maintain weight loss (53,54). Post-surgery psychosocial functioning may both influence weight outcomes (e.g., depressive symptoms resulting in poor adherence to nutritional instructions) and be influenced by weight outcomes (e.g., inadequate weight loss or weight regain resulting in mobility problems). Therefore, in light of the association between overall psychosocial functioning and suicide (e.g., 55), specific domains within this broad construct may be important to consider as potential risk factors for suicide.

### Health-Related Quality of Life

Health-related quality of life (HRQOL) encompasses several domains, including physical, occupational, social, and psychological functioning associated with health status (56). In general, HRQOL tends to improve following bariatric surgery, and is positively associated with weight loss (57,58). Furthermore, ratings of emotional well-being often improve substantially and reach levels comparable to age-matched norms within the first six months following surgery, although these levels seem to decrease moderately by 24 months, particularly for patients who start to regain weight (59,60). Maladaptive eating behaviors after surgery (e.g., binge eating and grazing) have been linked to weight regain and reduced

HRQOL (59,60). Patients may also continue to exhibit health distress and bodily pain post-surgery, particularly at long-term follow-up. In summary, evidence suggests that a subset of patients continue to experience impairments or eventually experience worsening of impairments in various domains of HRQOL. This level of impairment may contribute to a sense of disappointment and failure, which conceivably might impact on suicide risk.

### **Physical Activity and Mobility**

By six months after bariatric surgery, patients often show improvements in levels of physical activity (61,62). Specifically, physical activity level, functional walking distance, and self-reported physical function often improve following surgery (61,62). Some studies report that patients show exercise levels that are consistent with health recommendations for disease prevention and long-term weight maintenance (62,63), yet other studies have shown that patients still report lower levels of physical activity in comparison with normative groups, and may even become less active following surgery (63). Furthermore, long-term activity levels often decline in conjunction with weight regain (64). Physical limitations (e.g., discomfort, pain) and psychological barriers (e.g., fear of injury, lack of confidence, embarrassment) may inhibit patients from engaging in physical activity and are likely to persist if not addressed (61,62). Given the negative health outcomes associated with limited physical activity and poor mobility (64,65), further research is needed to understand the consequences of such difficulties among bariatric surgery patients, and the possible impact on suicide risk.

### **Sexual Functioning and Relationship Problems**

Post-surgery improvements in sexual functioning are commonly found among bariatric patients, including greater sexual satisfaction, desire, libido, frequency of sexual activity, and reductions in erectile dysfunction (66,67). For both men and women, sexual dysfunction following surgery has been found to decrease to levels that are comparable with age-based norms (67–69). However, other findings indicate that negative body attitudes (e.g., poor body image due to excess/hanging skin), fertility problems associated with erectile dysfunction, and weight regain between one and two years after surgery are linked with reduced sexual functioning (67,68). Also, marital problems prior to surgery often continue post-surgery. In addition, given that patients often become more active and self-confident following surgery, such personality and behavioral changes may create problems for romantic partners given the change in dynamics within an established relationship. These new forms of tension in the relationship may be further compounded by partners' own appearance concerns, which may lead to jealousy, insecurity, and added relationship difficulties. Patients who are single may also experience similar concerns, particularly in the form of anxiety related to dating and attracting new romantic partners. In sum, further research on functioning in these domains and their possible association with increased depression and/or suicide risk is needed.

### **Low Self-Esteem**

Findings from a variety of studies examining self-esteem in bariatric surgery patients pre- and post-surgery provide support for improvements in self-esteem among the majority of patients following surgery, particularly within the first six to twelve months (59,60). For



example, in a study of patients assessed pre- and post-surgery, Dymek and colleagues (59) found that patients experienced significant increases in overall self-esteem during the first six months after surgery. However, studies of patients who are two years or more post-surgery have revealed mixed results, suggesting that this may begin to diminish over time (68,69). For instance, in a study of 149 patients assessed pre-surgery and at 1 and 2 years post-surgery, Burgmer and colleagues (70) found that self-esteem improved within the first year, but no further improvements were observed during the second year. Furthermore, findings from several studies indicate that improvements in self-esteem may be associated with amount of post-surgery weight loss thus suggesting that a substantial minority of patients who exhibit poor weight-based outcomes might continue to experience problems with self-esteem. Again, the role of this factor in suicide risk, and their association with other risk factors, need to be examined.

### **Depression Symptoms**

Mood disorders, including lifetime and current diagnoses, as well as clinically relevant symptoms of depression are commonly observed among bariatric surgery patients (53,70). Overall, the existing empirical literature provides support for significant symptom reductions among the majority of patients (70). Evidence suggests that these reduced levels of depression symptoms may remain consistent over time, with some studies reporting that symptoms remain significantly below pre-surgery levels several years post-surgery (71). However, the prevalence of depression has been shown to still be elevated compared to rates described in the general population (72). Other findings indicate that the improvements in symptoms of depression may begin to decline over time, and in some cases may even return to pre-surgery levels (73). Furthermore, a substantial proportion of patients may continue to exhibit mild to moderate symptoms, or even experience a worsening of symptoms post-surgery (74). Finally, consistent with other psychosocial factors, changes in symptoms of depression after surgery have been found to be associated with degree of weight loss (e.g., 75–77). In light of the well-documented link between depression and suicide (e.g., 78), the continuing presence or reemergence of depressive symptoms following surgery may be a particularly salient risk factor for suicide.

### **Child Maltreatment and Risk for Suicide Post-Bariatric Surgery**

Childhood maltreatment has often been associated with higher BMI scores and obesity during adulthood (79). Despite this connection, bariatric surgery patients who have been maltreated experience medical improvements and weight loss similar to those without histories of maltreatment (80,81). However, maltreated individuals often note greater levels of depression as well as mood and anxiety disorders both prior to and following surgery (79–82). Additionally, survivors of childhood sexual abuse may be at an elevated risk for psychiatric hospitalizations following surgery, especially those who are suffering from mood or substance use disorders (79). Indeed, researchers have speculated that childhood maltreatment may be a nonspecific risk factor for obesity given that it appears to be linked with Axis I psychiatric disorders and indirectly associated with elevations in body weight (83,84). Furthermore, childhood maltreatment has also been identified as a risk factor for suicidal behavior during adulthood (85).

## Weight and Eating Outcomes

Not much is known about the number of weight loss failures after bariatric surgery. Many authors report reasonable mean excess weight loss (EWL) at follow-up but do not differentiate among patients with good and very good EWL and patients with poor results. In addition, different definitions of weight loss failure have been used. Today, weight loss failure is usually defined as less than 50% EWL. Using this definition, the overall rate of failure with laparoscopically adjustable band (LAGB) is significant with up to 50% failure rate after 5–10 years as opposed to less than 10% after RYGBP (86,87). In addition, after LAGB the need for re-operation is not uncommon with case series reporting reoperation rates as high as 30%, including band removal because of weight loss failure (88). Insufficient weight loss and early weight regain have also been reported after laparoscopic sleeve gastrectomy (88).

It is widely known that binge eating and binge eating disorder (BED) are common among obese patients seeking bariatric surgery. The average rate of BED in this sample is approximately 25%. After bariatric surgery the prevalence of binge eating usually decreases significantly together with a reduction in body dissatisfaction and weight and shape concerns. However, several studies have demonstrated that a subgroup of patients after weight loss surgery will develop or redevelop subjective binge or “loss of control” eating and even self-induced vomiting for weight and shape reasons (89). A pre-surgery eating disorder seems to be a clear predictor of such outcomes; however, not all those with pre-surgery binge eating develop subjective binge or “loss of control” eating and self-induced vomiting after surgery. Post-surgery “loss of control” eating has consistently been shown to be associated with less weight loss and increased subjective distress (90).

What constitutes “typical” or “normal” eating behavior after bariatric surgery is difficult to define and no nomenclature has been developed to classify and capture these behaviors. Patients will have marked changes in their eating behavior and will require the frequent intake of small amounts of food with extensive chewing before swallowing. Many ill-defined behaviors have been reported as being frequent after surgery such as “grazing”, “nibbling”, and “snacking”. Medical sequelae such as “plugging”, “dumping”, constipation, gastroesophageal reflux, or dysphagia may mimic eating disordered behaviors or symptoms. Once weight loss slows down or stops, some patients will engage in restrictive or compensatory behaviors in an effort to prevent weight regain. A number of case reports have even discussed the development of bulimia nervosa and anorexia nervosa following bariatric surgery (e.g., 90).

There is no evidence so far that the amount of weight loss and weight regain or the emergence of pathological eating behavior contributes to an increased suicide risk; however, the increased subjective distress associated with disturbed post-operative eating behavior might play a role in certain patients.

## Theoretical Models and Directives for Research

We will briefly discuss 4 possible models, out of many possibilities, that represent directions that might prove fruitful in pursuing research in this area.

## Hopelessness

Beck (91) posited that suicidal ideation develops when people view ending their lives as the only solution to what they perceive as hopeless problems. Hopelessness has emerged as a robust predictor of a variety of suicidal behavior, including deaths by suicide. It is possible that obese individuals seek bariatric surgery as a solution to the physical and psychosocial problems associated with their weight. People who experience continued, new, or re-emergent problems associated with weight regain following bariatric surgery may feel that their last hope for a better life was dashed and enter a state of hopelessness. This is a hypothesis which can be tested by utilizing Beck's Hopelessness Scale (92) as a predictor of suicidal behavior (including suicidal desire, attempts, and deaths) in bariatric surgery samples. One existing study reported a cross-sectional association between hopelessness and suicidal ideation in severely obese individuals who were seeking bariatric surgery (93). However, this has not been examined in individuals following bariatric surgery.

Research will need to investigate the association with psychopathology, and perhaps subsequent risk of suicide, experienced by patients who have unrealistic expectations of body appearance post-bariatric surgery and are consequently disappointed in the aesthetic outcomes of their surgery. Patients who continue to experience physical and sexual limitations in functioning following bariatric surgery may also be unhappy with the outcome.

## Negative Bodily Self

Orbach (94) proposed that parental maltreatment in childhood (e.g., physical neglect or abuse) leads to the internalization of negative feelings toward the body, which can then facilitate a lethal attack on one's body if suicide is desired. Orbach's (94) model is supported by data showing that suicidal individuals tend to harbor more negative feelings about their bodies than nonsuicidal individuals. As reviewed earlier in this paper, survivors of childhood sexual abuse are at particularly elevated risk for psychiatric hospitalizations and mood disorders following bariatric surgery. In addition, suicidal ideation is elevated in bariatric surgery-seeking individuals with a history of physical and/or sexual abuse. Though it is speculative at this point, it is possible that these individuals may experience an intensification of negative bodily attitudes following bariatric surgery due to associated unpleasant bodily experiences (e.g., excess/hanging skin, pain; 95). This combination of mood disturbance and potential increase in negativity toward the body may be one pathway to suicide in this population. This pathway could be investigated by measuring changes in bodily attitudes among people who have had bariatric surgery using the Body Investment Scale, which assesses theoretically relevant constructs such as levels of body protection, body care, and body image feelings and attitudes (96).

## Escape from Self

Baumeister (97) hypothesized that suicide attempts occur when people experience a failure or severe disappointment that results from either unrealistically high standards or severely unfortunate circumstances and then blame themselves for it. This self-blame supposedly leads to intense, painful negative emotions about the self, which causes a psychologically numb state where suicide is viewed as the only way to escape the aversive self-awareness. If

people's standards are not met following bariatric surgery (e.g., being thin, substantial improvements in social or physical functioning) or if they fail to meet personal expectation following weight regain, they may end up on this trajectory. It is possible that people who know that their post-surgical outcomes are significantly worse than others are at increased risk for this type of self-hatred.

### Interpersonal Theory

The interpersonal theory of suicide proposes that individuals die by suicide when they view themselves as a burden on others (i.e. perceived burdensomeness), feel disconnected from others (i.e. thwarted belongingness), and have overcome the fear and pain involved in death such that they can lethally injure themselves (i.e. acquired capability for suicide, 98). There are no tests of this theory in a bariatric surgery population. People who have undergone bariatric surgery may be at elevated risk on the perceived burdensomeness and thwarted belongingness factors. Research reviewed earlier in this paper suggests that changes following surgery can cause tension or disruption in existing family, friend, and marital relationships for some individuals despite the majority reporting overall improvements in their interpersonal relationships. It is also possible that a subset with continued medical complications, limited functioning, and decreased mobility have more difficulty contributing and are consequently at greater risk for feeling that they are a burden. Indeed, physical illness has been identified as a risk factor for suicide. Finally, according to this theory individuals acquire the capability for suicide when they habituate to fear and pain through repeated painful and provocative experiences (including physical abuse and pain, both of which occur at elevated rates in obese populations. Additionally bariatric patients may have experienced increased rate of medical problems which were painful, thus increasing the acquired capability for suicide, adding to this theory. This theory can be directly tested by administering developed measures for each of the three factors within bariatric surgery populations (99).

### Research Directions

In an effort to identify potential mechanisms for post-bariatric surgery suicides, we have reviewed risk factors and theoretical models relevant to this population. Three major research directions are recommended for testing the hypotheses generated from this review.

The first approach involves retrospective examination of data utilizing psychological autopsies (100). This method involves identifying suicide decedents through coroners' reports and requesting meetings with the decedents' loved ones. The decedents' family members then participate in extensive interviews designed to reveal factors that led to the suicide. The major advantage of this approach includes the capability to target data collection with suicide decedents' families, which could lead to the identification of common factors across these types of deaths. A disadvantage of this approach is that family members vary in their ability to provide insight into the decedent's subjective experiences prior to death.

A second approach consists of cross-sectional studies in bariatric surgery populations designed to uncover the impact of factors reviewed above on a range of suicidal behaviors

(e.g., suicidal ideation, suicide attempts). A strength of this approach is that it allows for direct assessment of individuals' psychological functioning while they are alive rather than relying on family members or friends for information after their death. Major limitations of this type of design include difficulty determining the temporal sequence of variables and the inability to include death by suicide as a dependent variable.

The strongest methodological approach would involve a prospective longitudinal examination of factors that predict suicide. In this design, large samples of people who have undergone bariatric surgery would be followed over time and outcomes (including deaths by suicide) would be tracked. This type of study would be the most illuminating with regards to factors that predict deaths by suicide in this population. The challenges include the substantial resources needed to follow a large sample needed to identify causes of death by suicide such that there are enough deaths by suicide (relatively speaking, a rare outcome) to provide adequate statistical power for model testing. Studies employing these and other types of research methods may ultimately identify risk factors and therapeutic targets with the potential to save lives in this population.

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