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ORIGINAL ARTICLE

Substance Misuse Following Roux-en-Y Gastric Bypass Surgery

Summar Reslan[1], Karen K Saules[1], Mark K Greenwald[2] and Leslie M. Schuh[3]

[1]Department of Psychology, Eastern Michigan University, Ypsilanti, Michigan, USA; [2]Department of Psychiatry and Behavioral Neurosciences, Substance Abuse Research Division, Wayne State University School of Medicine, Detroit, Michigan, USA; [3]Bariatric Center of Excellence, St. Vincent Carmel Hospital, Carmel, Indiana, USA

Post-bariatric surgery patients are overrepresented in substance abuse treatment, particularly those who have had the Roux-en-Y gastric bypass (RYGB) procedure. The severity of the substance use disorder (SUD; i.e., warranting inpatient treatment) and related consequences necessitate a better understanding of the variables associated with post-RYGB SUDs. This investigation assessed factors associated with post-RYGB substance misuse. Post-RYGB patients ($N = 141$; at least 24 months postsurgery) completed an online survey assessing variables hypothesized to contribute to post-RYGB SUDs. Fourteen percent of participants met criteria for postoperative substance misuse. Those with a lower percent total weight loss (%TWL) were more likely to endorse substance misuse. Family history of substance misuse was strongly associated with postoperative substance misuse. Eating-related variables including presurgical food addiction and postsurgical nocturnal eating, subjective hunger, and environmental responsiveness to food cues were also associated with a probable postoperative SUD. These findings have clinical utility in that family history of substance misuse can be easily assessed, and at-risk patients can be advised accordingly. In addition, those who endorse post-RYGB substance misuse appear to have stronger cognitive and behavioral responses to food, providing some support for the theory of behavioral substitution (or "addiction transfer").

Keywords substance use disorders, alcohol, bariatric surgery, roux-en-Y, weight loss, food addiction

INTRODUCTION

Worldwide estimates classify 1.46 billion adults as overweight or obese (Finucane et al., 2011). Although escalating rates of overweight/obesity may be leveling off (Flegal, Carroll, Kit, & Ogden, 2012), an alarming trend is that prevalence of clinically severe, or morbid, obesity continues to rise (Sturm & Hattori, 2013). Morbidly obese individuals incur greater healthcare utilization costs relative to both their non-obese and overweight counterparts (Arterburn, Maciejewski, & Tsevat, 2005), warranting an effective treatment option. Bariatric surgery is the only intervention that has been shown to have significant long-term efficacy in treating obesity, producing not only meaningful and durable improvements in weight, but also improvements in many medical comorbidities, risk factors, and quality of life (e.g., Buchwald, 2005; Suter, Paroz, Calmes, & Giusti, 2006; Valezi, Junior, de Menezes, Brito, & de Souza, 2010). However, not all bariatric patients experience optimal outcomes, and about 30% of patients begin to regain weight by 18–24 months postsurgery (e.g., Adams et al., 2012).

In addition to potential weight regain, an emerging literature suggests that alcohol misuse may be a complication of bariatric surgery (e.g., Heinberg, Ashton, & Coughlin, 2012; King et al., 2012; Sogg, 2007). Roux-en-Y gastric bypass (RYGB) patients may be at risk for alcohol use disorders, particularly by the second postoperative year (King et al., 2012), and they may also encounter drug problems (Fogger & McGuinness, 2012; Saules et al., 2010). One study found that post-bariatric surgery patients are overrepresented in substance abuse detoxification/

Bariatric physicians (Drs. Brenda Cacucci, David Diaz, Christopher Evanson, John Huse, Margaret Inman, and Douglas Kaderabek) at the St. Vincent Bariatric Center of Excellence allowed access to patient records, and Katharine Hudson contacted potential subjects to inquire about their willingness to participate in this investigation. A poster based on the findings of this study was presented at The Obesity Society's 2012 Annual Scientific Meeting.

Address correspondence to Mrs Summar Reslan MS, Department of Psychology, Eastern Michigan University, 611 West Cross Street, Ypsilanti, MI 48197, USA; E-mail: shabhab1@emich.edu

rehabilitation programs for alcohol and other drug use disorders. Specifically, 2%–6% of admissions reported a history of bariatric surgery, and over 90% of these participants reported having had the RYGB procedure (Saules et al., 2010). It would not be surprising if these patients had relapsed to problems that were present before surgery, yet data suggest that about 60% of those who report drug and/or alcohol problems after bariatric surgery have no prior history of problematic substance use (Ivezaj, Saules, & Wiedemann, 2012; King et al., 2012; Wiedemann et al., 2010). Suzuki, Haimovici, and Chang (2012) reported that only 17% of their sample of bariatric surgery patients reported a current alcohol use disorder and had no prior history of problematic alcohol use, which is significantly lower than other published reports. Notably, their response rate was very low (51 out of 530), which calls into question the generalizability of these results. Only a minority of patients develop substance use disorders (SUDs) after surgery, but the severity of the SUD (i.e., warranting inpatient treatment) and associated consequences (i.e., poor quality of life; Pulcini, Saules, & Schuh, 2013) merit a better understanding of factors associated with post-bariatric SUDs, particularly among those who have had the RYGB procedure.

Evidence does suggest that post-RYGB patients reach higher peak blood alcohol levels than age- and BMI-matched controls, reach this level faster, and take longer to return to baseline (Hagedorn, Encarnacion, Brat, & Morton, 2007). Altered pharmacokinetics (faster absorption of ethanol and higher peak concentration) in post-RYGB patients could make alcohol a more potent reinforcer, thereby increasing their risk of developing alcohol problems. In addition, the portion of the stomach that secretes alcohol dehydrogenase, an enzyme that facilitates alcohol metabolism, is circumvented following RYGB (Lee, Chau, Yao, Wu, & Yin, 2006), and rapid emptying of the gastric pouch, particularly for liquids, accelerates absorption of alcohol into the jejunum (Horowitz, Collins, Harding, & Shearman, 1986). Data on metabolism of other drugs are lacking, but it is reasonable to expect they might be metabolized in a fashion that would enhance abuse liability. Recent data suggest this may extend to opioid pain medications and benzodiazepines (Wiedemann et al., 2010). Opioids may also be attractive to RYGB patients because of their effects on the gastrointestinal (GI) tract. Opioids decrease gastric motility and increase intestinal transit time (Chan, 2008), which could mitigate adverse effects associated with post-RYGB "dumping syndrome," a condition characterized by dizziness, nausea, cramps, bloating, diarrhea, fatigue, shakiness, chills, and hot flashes, particularly following consumption of sweet foods. Benzodiazepines may have abuse liability because they are rapidly absorbed in the GI tract; the exact nature of benzodiazepine absorption among RYGB patients is unknown. On the other hand, despite these physiological factors, not all RYGB patients develop post-surgical SUDs.

In recent years, parallels between overeating and addictive behavior have been drawn, with emphasis on shared clinical features and neurobiological mechanisms (Volkow, Wang, Fowler, & Telang, 2008). Activation of the mesolimbic dopamine (DA) system mediates the primary reinforcing characteristics of addictive substances (Salamone, Correa, Mingote, & Weber, 2003), and reduced availability of DA receptors has also been found among individuals with obesity (Wang, Volkow, Thanos, & Fowler, 2004). Both overconsumption of food and initial drug use involve activation of DA and endogenous opioids, which may mediate the rewarding effects of both types of stimuli (Pecina & Smith, 2010; Volkow et al., 2008). In brief, some neurobiological support exists for why an individual may shift from overeating to substance dependence when the former is no longer an option (as occurs following bariatric surgery). Although this phenomenon is commonly referred to as "addiction transfer," we will refer to this construct as behavioral substitution given that the empirical support for the notion of "addiction transfer" is limited and there is no clear consensus regarding the definition of the term "addiction."

The empirical support for the construct of "food addiction" is limited, but it is a popular topic for debate in the scientific community (e.g., Albayrak, Wölfle, & Hebebrand, 2012; Avena, Gearhardt, Gold, Wang, & Potenza, 2012; Benton, 2010; Ziauddeen, Farooqi, & Fletcher, 2012). When interviewed about the development of drug and alcohol problems, 83% of post-RYGB patients in a SUD detoxification/rehabilitation program identified "addiction transfer/substitution," which was defined as any mention of replacing one behavior or substance with another (Ivezaj et al., 2012). These qualitative reports are consistent with preclinical literature that suggests overconsumption of palatable foods can result in behaviors and brain changes that are like those seen in addiction (Avena et al., 2008). For instance, "sugar-addicted" rats, when forced to abstain from sugar but given access to normal chow, increase consumption of available alcohol (Avena et al., 2008) or cocaine (Carroll, Anderson, & Morgan, 2007). In consideration of this preclinical and clinical literature on associations between overeating and addiction, we hypothesized that endorsing symptoms of "food addiction" before surgery and specific eating-related variables after surgery would be associated with substance misuse after RYGB surgery. Several studies have investigated the preoperative factors related to post-operative substance use problems (e.g., King et al., 2012) but, to our knowledge, this is one of the first to examine the association between pre and postoperative eating-related variables and post-RYGB substance use, thereby adding to our understanding of the risk factors for this potential outcome following RYGB.

METHODS

Recruitment

Participants were recruited from those who had participated in our previous bariatric studies ($n = 37$), a bariatric support group at Henry Ford Hospital (Detroit, MI; $n = 15$), and from St. Vincent Bariatric Center of Excellence

(Carmel, IN; $n = 42$ online and $n = 47$ by mail). No participants were directly recruited from SUD treatment programs. Exclusion criteria included current pregnancy (to minimize pregnancy-related effects on self-reported eating behaviors) and less than 2 years since RYGB surgery (to capture the period when weight regain and SUD problems begin to occur).

Participants

A sample of 147 adults who were at least 24 months post-RYGB surgery was recruited. Only 141 participants provided responses to the Michigan Assessment – Screening Test for Alcohol and Drugs (MAST/AD); as such, analyses were limited to the sample of 141 respondents for whom valid MAST/AD scores were available. The sample was primarily female ($n = 112$; 79%) and Caucasian ($n = 130$; 93%), with a mean age of 53 years ($SD = 10.33$). The majority of respondents were married ($n = 92$; 65%), either employed full-time ($n = 66$; 48%) or retired ($n = 41$; 30%), and had an average of 14 years of education ($SD = 2.61$). Most reported that their current financial situation was "solidly middle class" ($n = 66$; 47%) or "enough to get by but no more" ($n = 43$; 31%). The mean number of years since RYGB was 6.17 ($SD = 2.69$; range: 2.00–14.00). The average current percent excess weight loss (%EWL) was 70.67% ($SD = 22.34$) and current percent total weight loss (%TWL) was 34.54% ($SD = 10.43$).

Procedures

Prior to data collection, approval was obtained from the Eastern Michigan University Human Subjects Review Committee, the St. Vincent Institutional Review Board, and the Henry Ford Health System Institutional Review Board. Candidates were sent a URL to an online survey deployed via Survey Monkey or a hard copy of the survey to mail back in a postage paid envelope wherein, after consenting to participate, survey completion took about 50 minutes. Participants completed this questionnaire once. This survey required retrospective self-report of specific presurgical characteristics and self-report of postsurgical variables. Those who provided their contact information were compensated with a $25 gift card.

Measures

Current and lifetime weight history and substance use were assessed.

Weight-related Variables

Preoperative and current body mass index (BMI) were computed from self-reported pre-RYGB and current height and weight. The following equations were used to compute current %EWL and %TWL: %EWL = (Presurgical excess weight – Current excess weight) / Presurgical excess weight) × 100; %TWL = (Weight change/Presurgical weight) × 100. The World Health Organization (WHO) has published a set of cut-off scores based on BMI, and a BMI above 25.00 kg/m^2 represents overweight status (WHO, 2013). Presurgical and current excess weights were computed by subtracting a participant's weight if their BMI was 25.00 kg/m^2 from their presurgical or current weight, respectively.

Substance Use

The MAST/AD (Westermeyer, Yargic, & Thuras, 2004) was used as the primary outcome measure because it can assess both alcohol and drug use problems. Directions and items were reworded to assess lifetime and current substance use problems. This measure was originally validated by comparing scores on the MAST/AD among individuals diagnosed with substance abuse or dependence and in comparison with other lifetime measures of substance abuse and dependence and with psychiatric scales reflecting current or recurrent symptoms. It is impossible to conclusively determine whether participants meet criteria for substance abuse and/or dependence based on MAST-AD scores. Based on the cut-off score established in the initial validation paper (Westermeyer et al., 2004), a score of five or more on the MAST/AD is regarded as indicative of a probable SUD, and we interpreted this as analogous to substance misuse. Thus, the terms "substance misuse" and "probable SUD" will be used interchangeably throughout this manuscript.

The WHO Alcohol, Smoking, and Substance Involvement Screening Test Version 3.1 (ASSIST v3.1; Humeniuk et al., 2008) made it possible to assess the frequency of use for different types of substances among those endorsing alcohol and drug use problems on the MAST/AD. Two items assessed family history of substance misuse, given that family history is a strong predictor of SUD development in the general population (Curran et al., 1999; Merikangas et al., 1998). The first question asked, "Do you have a family history of substance abuse?" and those who indicated a positive family history of substance abuse were directed to a checklist to indicate which family member category (i.e., mother, father, sibling, aunt, uncle, grandmother, and grandfather) suffered from substance-related problems.

Pre-Surgical Variables

Yale Food Addiction Scale (YFAS; Gearhardt, Corbin, & Brownell, 2009)

The YFAS is a 27-item self-report questionnaire designed to identify and characterize signs and symptoms of a "food addiction." This instrument is modeled after the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR) substance dependence criteria (American Psychiatric Association [APA], 2000). This measure was developed and validated using a sample of college students (Gearhardt et al., 2009) and was recently validated among obese individuals with binge eating disorder (Gearhardt et al., 2012) and post-bariatric surgery patients (Clark & Saules, 2013). Consistent with the methodology of Clark and Saules (2013), the directions for this measure were modified to assess symptoms of a presurgical food addiction among post-bariatric surgery patients. Thus, the statement "*BEFORE you had bariatric surgery*..." preceded all items. Given that diagnostic criteria for "food addiction" is modeled

after DSM-IV-TR substance dependence criteria, symptom count must be greater than or equal to three and clinically significant impairment must be endorsed. Total symptom count, not "food addiction" diagnostic criteria, was used in all subsequent analyses.

Post-surgical Variables

Night Eating Questionnaire (NEQ; Allison et al., 2008)

The NEQ is a 14-item instrument that assesses the multiple domains purported to comprise night eating syndrome (NES). Psychometric properties of the NEQ have been established (Allison et al., 2008). Among bariatric surgery candidates, scores on this instrument have been found to discriminate between NES and non-NES participants (Allison et al., 2008).

Power of Food Scale (PFS; Didie, 2003)

The PFS is a 21-item questionnaire that assesses appetite for, not the consumption of, palatable foods, or more specifically, responsivity to environmental food cues (Lowe et al., 2009).

Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985)

The TFEQ assesses cognitive and behavioral components of eating. The TFEQ is composed of three subscales. The 21-item restraint subscale assesses the degree to which one exerts control over food intake with the goal of influencing body weight, while the 16-item disinhibition scale taps the inability to control eating. The 14-item hunger scale measures subjective feelings of hunger and food craving (Stunkard & Messick, 1985). This instrument has also been used to assess restraint and disinhibition among post-bariatric surgery patients (Kalarchian et al., 2002).

Questionnaire on Eating and Weight Patterns – Revised (QEWP-R; Spitzer, Yanovski, & Marcus, 1994)

The QEWP-R is a 28-item screening instrument used to screen for binge-eating disorder (BED) and bulimia nervosa according to DSM-IV-TR criteria (APA, 2000). Traditionally, the QEWP-R has been used to assess objective binge episodes, which involve the consumption of an abnormally large amount of food. Given surgical constraints placed on the quantity of food that can be consumed following bariatric surgery, one item was added to the standard QEWP-R to facilitate the assessment of subjective binge episodes. Subjective binge episodes were defined as a sense of having binged, regardless of the amount of food consumed, and feeling a loss of control over eating.

Food Grazing

The Eating Disorder Examination (EDE; Fairburn & Cooper, 1993) provides definitions of aberrant eating behaviors in a semi-structured interview format, and this interview has been modified to enable detailed analysis of the eating behavior of post-bariatric surgery patients (EDE-BSV; de Zwaan et al., 2010). Five self-report items assessing picking or nibbling (that is, eating in an unplanned and repetitious way without loss of control) were drawn from the EDE-BSV to tap food grazing.

Emotional Eating Scale (EES; Arnow, Kenardy, & Agras, 1995)

The EES provides information about the relationship between negative emotions and problematic eating behaviors. Developed and validated in a sample of obese participants, this instrument is considered to be psychometrically sound (Arnow et al., 1995).

Statistical Analysis

Normality of the data distributions was checked by examining frequency distributions and descriptive statistics for all variables of interest. Because MAST/AD scores were found to be non-normally distributed, a binary version of this variable was created (i.e., no substance misuse versus substance misuse). A score of five or more was used as the minimum cut-off indicating substance misuse (Westermeyer et al., 2004).

Biserial and *phi* correlation coefficients were examined to assess the association of demographic and eating-related variables with post-RYGB probable SUD classification. Independent samples *t* tests were utilized to assess mean differences in age and age at the time of bariatric surgery, number of family member categories misusing substances, and weight loss between participants who endorsed post-RYGB substance misuse versus those who did not endorse substance misuse. Logistic regression was used to determine which variables were independently related to the odds of postoperative substance misuse.

RESULTS

Prevalence of Substance Misuse and Specific Substances of Abuse

Twenty of the 141 participants (14%) met criteria for postoperative substance misuse, with 70% of these individuals ($n = 14$) not endorsing a preoperative probable SUD (i.e., New Onset group) and 30% of these individuals ($n = 6$) meeting criteria for preoperative and postoperative substance misuse (i.e., Relapsed/Continued use group). Six percent of participants met criteria for preoperative substance misuse but not postoperative probable SUD ($n = 8$; Recovered group), and 80% did not met criteria for either a preoperative or postoperative probable SUD ($n = 113$; Figure 1). Those endorsing substance misuse were most often at moderate risk for pathological involvement with opioids, sedatives, tobacco and alcohol (Figure 2).

Demographic Differences Between Probable SUD and no Probable SUD Groups

Age at survey and age at the time of RYGB surgery were significantly associated with postoperative substance misuse (Table 1). The 20 participants who endorsed substance misuse were significantly younger ($M = 46.70$, $SD = 8.91$) than the 121 participants who did not endorse substance misuse ($M = 54.55$, $SD = 10.15$), $t\,(134) = 3.25$, $p = .001$. Those with probable SUDs also had RYGB at a

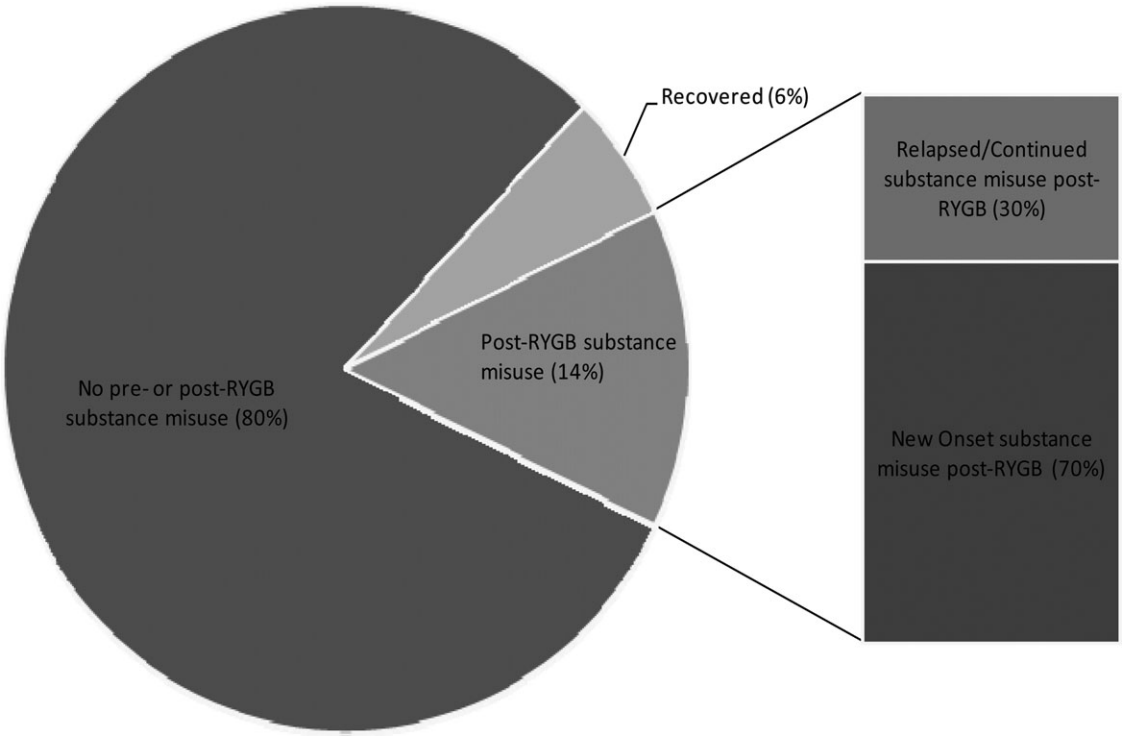

FIGURE 1. Percentage of participants within No pre- or post-RYGB substance misuse, Recovered, Relapsed/Continued substance misuse post-RYGB, and New Onset substance misuse post-RYGB groups. The combination of the Relapsed/Continued substance misuse and New Onset groups reflect the total percentage of participants who endorsed post-RYGB substance misuse.

younger age ($M = 40.05$, $SD = 8.34$) than those without probable SUDs ($M = 48.09$, $SD = 9.79$), $t\,(139) = 3.47$, $p = .001$.

Thirty-one percent of the entire sample endorsed a family history of substance misuse ($n = 43$). Relative to post-RYGB surgery patients who did not endorse substance misuse, those with postoperative probable SUDs were significantly more likely to have a family history of substance-related problems (Table 2), and these participants endorsed a significantly greater number of categories of family members with a history of substance misuse ($M = 1.05$; $SD = 1.28$) than those who did not endorse current substance misuse ($M = 0.50$, $SD = 0.93$), $t\,(139) = -2.29$, $p = .023$. Those with a family history of substance misuse had nearly a threefold greater odds for developing a postoperative probable SUD, $OR = 2.67$; 95% CI [1.02, 6.99], $p = .046$, and each additional family member category with substance-related problems compounded risk, $OR = 1.57$; 95% CI [1.05, 2.35], $p = .029$. Specifically, each additional family member category (i.e., mother,

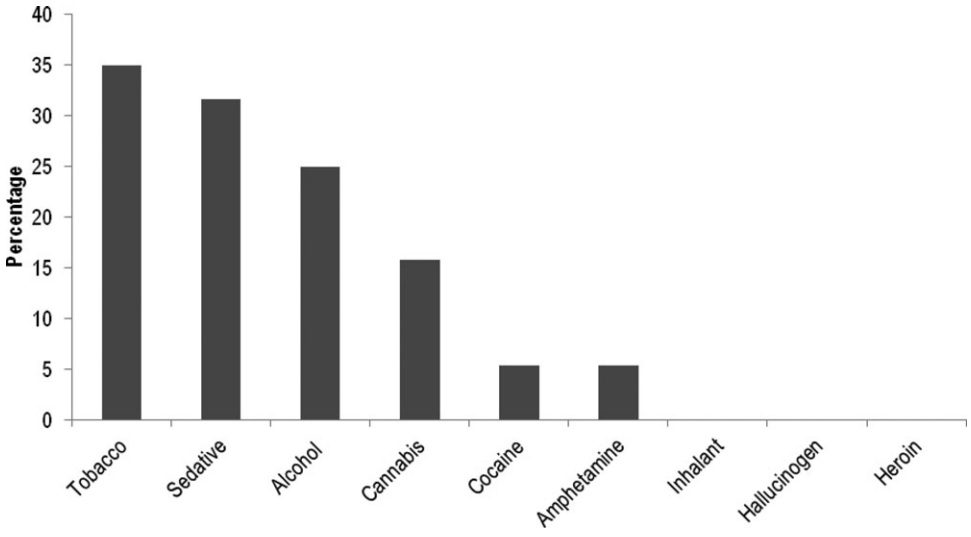

FIGURE 2. Percentage of participants endorsing post-RYGB substance misuse (classified by MAST/AD scores) at moderate risk for pathological involvement with specific substances (as indicated by the ASSIST).

TABLE 1. Correlation coefficients between primary outcome variable (post-RYGB substance misuse) with demographic variables ($N = 141$)

		1	2	3	4	5	6	7	8	9	10
1.	Post-RYGB substance misuse	—									
2.	%$TWL_{current}$	–.22**	—								
3.	Gender	–.06	.10	—							
4.	Age at survey	–.27***	.00	.01	—						
5.	Ethnicity	–.05	.05	.24**	–.18*	—					
6.	Marital status	.01	–.02	–.11	–.28**	.06	—				
7.	Education	.05	.03	.01	–.33***	.09	.21*	—			
8.	Income	–.02	–.05	.20*	–.06	.12	–.26**	.19*	—		
9.	# years since surgery	.08	–.06	.02	23**	–.12	–.08	–.19*	–.02	—	
10.	Age at time of surgery	–.28***	–.02	.01	.97***	–.14	–.26**	–.28**	–.06	–.03	—

Note. Dummy codes for categorical variables: 0 = No, 1 = Yes (Post-RYGB substance misuse); 1 = Female, 2 = Male (Gender); 1 = Caucasian, 2 = Not Caucasian (i.e., African American, Hispanic, American Indian, Alaskan Native, Asian, Pacific Islander, Middle Eastern) (Ethnicity); 1 = Married, 2 = Not Married (Marital Status); 1 = < $9,999, 2 = $10,000–$24,999, 3 = $25,000–$49,999, 4 = $50,000–$74,999, 5 = $75,000–$99,999, 6 = $100,000–$149,999, 7 = >$150,000 (Income).
*$p < .05$, **$p < .01$, ***$p < .001$.

father, sibling, aunt, uncle, grandmother, and grandfather) with substance-related problems increased the odds of post-RYGB substance misuse by 57%.

Association Between Post-RYGB Substance Misuse and Weight Loss

At the time of survey completion, participants meeting criteria for substance misuse ($n = 20$) reported a lower %TWL ($M = 28.90$, $SD = 14.01$) than those who did not endorse post-RYGB substance misuse ($n = 120$, $M = 35.48$; $SD = 9.46$), $t\,(138) = 2.67$, $p = .009$.

Eating-Related Factors Associated with Post-RYGB Substance Misuse

The post-RYGB substance misuse group had significantly higher scores on the NEQ, PFS, YFAS, and TFEQ hunger subscale (Tables 2 and 3). Objective and subjective postsurgical binge eating were not significantly associated with postsurgical substance misuse, but low numbers of participants endorsing these behaviors may have affected the chances of detecting a relationship between these behaviors and postsurgical probable SUD. Thirty-six percent ($n = 53$) of participants met diagnostic criteria for a presurgical food addiction.

As noted above, in univariate analyses, family history of substance misuse was significantly related to post-RYGB substance misuse, but this relationship was strongly attenuated in multivariate analyses that included eating-related variables (Table 4). A higher score on the NEQ was significantly associated with increased odds for substance misuse post-RYGB. Given that the remaining eating-related variables (i.e., PFS, YFAS, and hunger) were no longer significantly associated with postoperative substance misuse in analyses that included all combined predictors and logistic regression analyses completed utilizing SPSS do not provide multicollinearity statistics, intercorrelations between these eating-related variables and NEQ were explored. There were significant bivariate correlations between the NEQ and YFAS symptom total, $r = .29$, $p = .001$, PFS, $r = .53$, $p = .001$, and hunger, $r = .42$, $p = .001$.

DISCUSSION

Eating-related variables were associated with substance misuse; preoperative food addiction, as well as postoperative nocturnal eating, subjective feelings of hunger, and heightened responsiveness to environmental food cues were found to be especially important. Fourteen percent of this sample met criteria for post-RYGB substance misuse. The more remarkable finding is that 70% of those who met postsurgical probable SUD criteria reported developing this problem following their surgery. SUD onset is generally earlier in life, during teenage years and in young adulthood (Kessler et al., 2005). This makes the finding that more than two-thirds of patients with postsurgical substance misuse reported developing this problem in their late 40s and early 50s even more notable. The interaction of age-related physiological changes and the consumption of alcohol has been found to trigger or exacerbate serious problems among adults over the age of 40. Alcohol abuse has been linked to increased hypertension, cardiac arrhythmia, myocardial infarction, and hemorrhagic stroke, impaired immune system, decreased bone density, cirrhosis, and other liver diseases, GI bleeding, malnutrition, psychiatric disorders, cognitive impairment, and sleep disturbance (Substance Abuse and Mental Health Services Administration (SAMHSA), 1998).

This study was designed to advance our understanding of the relationship of preoperative and postoperative variables to substance misuse among the post-RYGB population. The demographics of the overall sample are representative of those who typically undergo bariatric surgery with respect to race, gender, and postsurgical weight loss (e.g., Nguyen et al., 2005; Poulose et al., 2005; Suzuki et al., 2012). Although participants were primarily middle-aged, the prevalence of substance misuse was

TABLE 2. Correlation coefficients between post-RYGB substance misuse, eating-related variables, and psychosocial variables

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Post-RYGB substance misuse	—											
2.	NEQ	−.32***	—										
3.	Restraint	.02	−.15	—									
4.	Disinhibition	.14	.47***	−.11	—								
5.	Hunger	.17*	.42***	−.08	.69***	—							
6.	EES	.08	.54***	−.23**	.57***	.40***	—						
7.	Grazing	−.10	.03	−.06	.19*	.12	.06	—					
8.	YFAS symptom total	.26*	.36**	−.06	.35**	.34**	.51***	−.13	—				
9.	PFS	.19*	.53***	−.14	.70***	.71***	.53***	.10	.51***	—			
10.	Objective binge eating (BED diagnosis)	−.05	.23**	−.05	.20*	.17*	.16	−.05	.17	.23*	—		
11.	Subjective binge eating	.04	−.24**	.27**	−.52***	−.43***	−.40***	−.18*	−.07	−.43***	−.24**	—	
12.	Family history substance misuse	.17*	.26**	.05	.09	.09	.22**	−.03	.24**	.12	−.08	−.02	—

Note. Dummy codes for categorical variables: 0 = No, 1 = Yes (Post-RYGB substance misuse, Family history substance misuse, Objective binge eating, Subjective binge eating).
*$p < .05$, **$p < .01$, ***$p < .001$.

TABLE 3. Eating-related variables that differed significantly between those who endorsed post-RYGB substance misuse and those who did not report post-RYGB substance misuse

	Substance misuse	No substance misuse
NEQ	20.70 (7.82)**	14.51 (6.09)**
PFS	59.15 (20.28)*	49.12 (18.97)*
YFAS symptom total	6.17 (.75)**	4.52 (1.91)**
Hunger	5.55 (3.32)*	3.94 (3.19)*

Note. Values presented are expressed as M (SD).
*$p < .05$, **$p < .01$.

significantly lower for those who were older and for those who had the RYGB surgery at an older age. Others have reported that older age at the time of bariatric surgery does not increase postsurgical complications (Ramirez, Roy, Hidalgo, Szomstein, & Rosenthal, 2012; Willkomm, Kennedy, Fisher, Barnes, & Kuhn, 2010), and findings from the present study suggest that, if anything, older age at the time of RYGB surgery could protect against substance misuse post-RYGB. Although post-RYGB SUDs may not adversely affect weight loss outcomes among those in a substance abuse treatment facility (Pulcini, Saules, Wiedemann, & Ivezaj, 2011) or among those with a history of SUD treatment (Clark et al., 2003), in this general population sample of RYGB patients, substance misuse was associated with worse long-term weight loss outcome. Results suggest that health care professionals should strongly advise post-RYGB patients to avoid substance use, not only for the obvious reasons associated with substance use, but because post-RYGB substance misuse may negatively impact postoperative weight loss or contribute to weight regain.

This post-RYGB elevation in substance misuse takes on additional significance in comparison to non-weight loss surgery populations. Data on the incidence of SUDs among middle-aged obese women are lacking, but a number of studies suggest that obesity is inversely or not at all associated with SUDs (e.g., Barry & Petry, 2009; Petry, Barry, Pietrzak, & Wagner, 2008). Rates of current SUDs among middle-aged women are substantially (nearly 10 times) lower than the 14% observed among this community sample of post-RYGB patients. For example, in a large-scale epidemiologic study, only 1.7% of women aged 45–64 met criteria for DSM-IV alcohol abuse and only 1.15% met dependence criteria (Grant et al., 2004). Based on these reports, we conclude that post-RYGB patients may develop problems with drugs and alcohol more than would be expected.

The finding that some patients with preoperative probable SUDs do not continue to use after surgery (i.e., our Recovered group), whereas some with no evidence of presurgical probable SUDs develop seemingly "New Onset" substance misuse, suggests two possibly different mechanisms, one protective against SUD for some and the second heightening risk for others. The emergence of these groups is consistent with prior studies (i.e., Ivezaj et al., 2012; Wiedemann et al., 2010) and takes on additional significance in light of reports of different alcohol intake patterns by alcohol preferring versus dietary induced obese rats after bypass surgery. Specifically, alcohol-preferring rats (akin to our Recovered group) attenuate their alcohol intake after gastric bypass (Davis et al., 2012), whereas diet-induced obese rats (akin to our New Onset group) *increase* alcohol intake after gastric bypass surgery (Thanos et al., 2012). The genes that regulate DA signaling in the nucleus accumbens of rodents are altered after RYGB, and these changes impact alcohol intake and general reward processes (Davis et al., 2013). Altered gene expression has been linked to RYGB surgery itself, but it is also possible that preoperative chronic overeating or obesity may contribute to alterations in DA associated with postoperative increases in alcohol ingestion. Further preclinical work may continue to advance our understanding of why those RYGB patients who endorse pre-existing substance misuse do not necessarily relapse post-RYGB, while some with no history of substance misuse seem to develop substance-related problems de novo.

TABLE 4. Factors elevating risk for post-RYGB substance misuse

	b	S.E	Exp(*B*)	95% CI
Model 1				
Family history substance misuse	1.50	.600	4.47*	[1.38; 14.47]
Model 2				
Family history substance misuse	1.19	.652	3.30	[0.92; 11.85]
NEQ	.141	.058	1.15*	[1.03; 1.30]
PFS	–.009	.026	0.99	[0.94; 1.04]
YFAS symptom total	–.030	.213	0.97	[0.64; 1.47]
Hunger	.063	.129	1.07	[0.83; 1.37]

Note. $N = 115$. CI = Confidence interval. The association between family history of substance misuse and post-RYGB surgery substance misuse in model 2 approached statistical significance ($p = .067$). Risk of a postoperative substance misuse conferred by family history of substance misuse in model 1 is larger than previously mentioned in the text because of the smaller sample size in this analysis. The sample size was smaller because participants who failed to complete eating-related measures ($n = 26$) were excluded using listwise deletion.
Abbreviations: RYGB, Roux-en-Y gastric bypass; NEQ, Night Eating Questionnaire; PFS, Power of Food Scale; YFAS, Yale Food Addiction Scale.
*$p < .05$.

Little is known about post-bariatric surgery patients who develop or relapse to SUDs, and there is a debate as to whether the eating pathology prevalent in bariatric surgery candidates, namely BED, is associated with postoperative SUDs. Presurgical BED was, unfortunately, not assessed in this study. The decision to focus on other eating-related variables was made because pre-surgical BED was unrelated to post-RYGB SUDs in two recent studies (i.e., Ivezaj, 2012; King et al., 2012). BED, however, is strongly associated with "food addiction" (Gearhardt et al., 2009), and presurgical food addiction (the only eating-related variable assessed for the preoperative period) was significantly associated with postoperative substance misuse. As the YFAS assesses food addiction in accordance with DSM-IV-TR substance dependence criteria, if behavioral substitution is operating, it may be through similar mechanisms captured by the seven standard symptoms of psychoactive substance dependence. Following bariatric surgery, patients are abruptly confronted with an inability to eat large quantities of food without feeling discomfort, which may create conditions that foster drug and/or alcohol dependence. Postoperative food responsiveness (e.g., nocturnal eating, heightened sensitivity to environmental food cues, and subjective feelings of hunger) was associated with having a presurgical food addiction, and our results suggest that preoperative food addiction may be a harbinger for postoperative substance misuse.

To date, nocturnal eating has received no attention in relationship to post-RYGB SUDs, but it seems notable that this relationship emerged in our study. Certain symptoms of NES parallel the symptoms of withdrawal from alcohol or drugs, although the association between NES and withdrawal from drugs/alcohol has yet to be empirically examined. Withdrawal is defined as a maladaptive behavioral, physiological, and/or cognitive change that occurs when blood concentration of a substance declines after prolonged heavy usage (APA, 2000), and NES has been described as a syndrome characterized by morning anorexia, evening hyperphagia, sleep difficulty, mood disturbance, and recurrent awakenings from sleep to eat (Colles & Dixon, 2006). Given that participants were approximately six years post-RYGB, NES may represent a protracted withdrawal response to food. Notably, there is literature to suggest that withdrawal from alcohol can persist for at least 12 months after the initiation of abstinence (Martinotti et al., 2008). Parallel symptoms with respect to "food withdrawal" may persist for longer among bariatric surgery patients because, following surgery, one cannot completely abstain from eating. To be successful, however, post-RYGB patients must reduce the amount of food they consume substantially, which may lead to symptoms of withdrawal, particularly for those who had developed tolerance, requiring larger quantities of food to experience the same effect. As is the case for other short-acting drugs of abuse (e.g., tobacco), reduced intake of food during evening hours may be particularly challenging. Thus, it is possible that NES may be an attempt to reduce withdrawal symptoms, or that those endorsing NES may use alcohol or drugs to reduce these withdrawal symptoms given that both overconsumption of food and initial drug use involve activation of mesolimbic DA and endogenous opioids (e.g., Pecina & Smith, 2010; Volkow et al., 2008). In this investigation, each one-point increment on the NEQ increased the odds of meeting probable SUD criteria by 15%, and there was a significant direct association between preoperative food addiction and postoperative nocturnal eating. If NES indeed reflects behavioral manifestation of withdrawal from food, the direct association between nocturnal eating and postsurgical substance misuse is understandable and provides additional support for behavioral substitution.

In addition to being associated with eating-related variables, post-RYGB substance misuse was strongly associated with family history of substance misuse. Family history of substance use can be easily assessed, and this may be important to inquire about during presurgical evaluations and in routine clinical practice. Given the stigma associated with having a SUD and the fact that it may potentially become an obstacle to weight loss surgery authorization, patients may be reluctant to admit to their own substance use difficulties. But, participants commonly admit to having individuals with substance-related problems in their families. For example, 29.3% of our total sample endorsed having at least one family member with a history of substance misuse. Therefore, screening for family history of substance misuse may provide a more valid indicator of a patient's postoperative risk of developing substance-related problems.

Limitations

This investigation (like the literature, in general) was limited by the absence of a standardized definition of pathological postoperative eating behavior. It is difficult to distinguish normal eating and pathological eating after surgery because most postoperative eating behavior will differ from the eating behavior of the general population. Thus, additional validation of measures that can be used to systematically assess pathological eating behavior among post-bariatric surgery patients is necessary. Generalizability was limited by restricting this investigation to only post-RYGB patients, and additional research is needed to extend the present findings to patients who undergo procedures other than RYGB. Specifically, Maluenda and colleagues (2010) have raised concerns about changes in alcohol absorption following laparoscopic sleeve gastrectomy. Lastly, given that this study was cross-sectional, directionality of relationships cannot be determined. For instance, we cannot determine if lower reported weight loss contributed to postoperative substance misuse or vice versa. The concern regarding directionality was also present when interpreting the association between eating-related variables and postoperative substance misuse.

CONCLUSION

To date, most studies that have attempted to forecast bariatric surgery patient outcomes have focused on

presurgical psychological and psychosocial factors that, for the most part, have not strongly related to postsurgical outcomes (Hsu et al., 1998). The American Society for Bariatric Surgery (2004, now ASMBS) published comprehensive recommendations for the presurgical assessment of bariatric surgery candidates, including behavioral, cognitive, emotional, developmental, psychosocial, and motivational domains. Nonetheless, our understanding of which factors are most strongly associated with post-bariatric surgery outcomes is quite poor, with only a limited number of variables (i.e., younger age at the time of surgery, male gender, Caucasian race, and lower preoperative BMI) showing any consistent relationship with outcomes. Given the vast amount of effort (and expense) that has gone into identifying presurgical predictors of treatment outcome, with disappointingly limited findings, we believe that the role of the mental health practitioner in bariatric care may not be best allocated to conducting comprehensive preoperative assessments of variables with no or minimal relationship to bariatric surgery outcomes. Instead, mental health practitioners may be best utilized by being enlisted to deliver peri- and postsurgical interventions designed to prevent SUDs. We conducted one of the first studies to better understand the postsurgical variables associated with post-RYGB substance-related outcomes. Findings from this investigation highlight the importance of eating-related variables to the presence of postsurgical substance misuse. Results support the need for postsurgical follow-up appointments to assess eating behaviors that may place patients at risk for SUD, as well as to assess for current substance misuse. Findings also support the concept of behavioral substitution, as strong cognitive and behavioral responses to food were associated with greater likelihood of a postsurgical substance misuse. In general, it will be important to advise post-RYGB patients against postoperative substance use, as this is associated with lower current postoperative weight loss and can result in its own set of postoperative challenges. Further education should also be provided about the specific risk for SUD following RYGB, how to recognize symptoms of SUD, and how to seek treatment if necessary. In addition, all RYGB candidates should be warned about the relationship of pathological postoperative eating behavior to both substance-related and weight loss outcomes following surgery.

Declaration of Interest

The authors declare no conflicts of interest related to the conduct or content of this work. The authors alone are responsible for the content and writing of the article.

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THE AUTHORS

Summar Reslan, MS, is a doctoral candidate in the Department of Psychology at Eastern Michigan University in Ypsilanti, Michigan, USA. Her research interests are bariatric surgery outcomes, eating- and weight-related disorders, addictive behaviors, and the interaction of addictive and eating behaviors. Her clinical interests include neuropsychology and rehabilitation psychology, and she teaches courses on quantitative methods in psychology.

Karen Saules, PhD, works at Eastern Michigan University (Ypsilanti, MI, USA), where she is Professor of Psychology and the Psychology Clinic Director. She teaches courses on clinical supervision, consultation, and teaching of psychology. Her research interests broadly encompass the intersection of eating and addictive behaviors, with a recent focus on bariatric surgery outcomes.

Mark Greenwald, PhD (Professor) is Director of the Substance Abuse Research Division, its Human Pharmacology Laboratory and treatment research clinic in the Dept. of Psychiatry and Behavioral Neurosciences at the Wayne State University School of Medicine in Detroit, Michigan. Dr. Greenwald conducts clinical research that focuses on pharmacological, environmental and individual difference determinants of drug seeking and relapse behavior; developing medication treatments for substance use disorders; and using brain-imaging techniques to understand in vivo neurochemistry of substance use disorders. The National Institute on Drug Abuse has continuously funded his research since 1996. Dr. Greenwald has served on many NIH and VA grant review panels, and regularly reviews manuscripts for substance abuse related journals. He is a former President of Division 28 of the American Psychological Association (Psychopharmacology and Substance Abuse).

Leslie M. Schuh, PhD, is Research Scientist at the St. Vincent Carmel Bariatric Center of Excellence in Carmel, Indiana, USA. Dr. Schuh conducts clinical research focusing on surgical and nonsurgical weight management in a multidisciplinary treatment program. Her research interests include medical and psychological outcomes after bariatric surgery including substance abuse, optimizing success of bariatric and nonsurgical weight management, enhancing physical activity in weight management patients, and weight management in children.

GLOSSARY

Behavioral substitution: Substituting one behavior for another. For example, following RYGB, an individual may shift from overeating to substance misuse when the former is no longer an option.

Percent Excess Weight Loss (%EWL): %EWL = (Presurgical excess weight – Current excess weight) / Presurgical excess weight) × 100.

Probable substance use disorder (SUD): A score of five or more on the Michigan Assessment - Screening Test for Alcohol and Drugs (MAST/AD) indicated a probable SUD.

Percent Total Weight Loss (%TWL): %TWL = (Weight change / Presurgical weight) × 100.

Roux-en-Y gastric bypass (RYGB): A type of weight loss surgery that involves dividing the stomach into two pouches, one smaller and one larger, with the latter closed off to prevent food from being transported to that section of the stomach. The intestinal tract is also diverted, so the newly formed smaller pouch is connected to the middle of the small intestine (jejunum). The RYGB surgery is thus a restrictive and malabsorptive procedure.

Substance abuse: A maladaptive pattern of substance use leading to clinically significant impairment or distress as manifested by one (or more) of the following occurring within a 12-month period: Recurrent substance use resulting in a failure to fulfill major role obligations, recurrent substance use in situations in which it is physically hazardous, recurrent substance-related legal problems, and continued substance use despite having persistent or recurrent social or interpersonal problems.

Substance dependence: A maladaptive pattern of substance use leading to clinically significant impairment or distress manifested by three (or more) of the following occurring in the same 12-month period: Tolerance, withdrawal, unsuccessful efforts to cut down or control substance use, taking the substance in larger amounts over a longer period than intended, spending a great deal of time in activities necessary to obtain the substance or recover from its effects, giving up important social, occupational, or recreational activities because of their substance use, and continuing to use substances despite experiencing physical or psychological consequences.

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