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COMPLEX MEDICAL-PSYCHIATRIC ISSUES (MB RIBA, SECTION EDITOR)

Neuropsychological Factors and Bariatric Surgery: A Review

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Abstract Obesity has become a global epidemic with associated physical, psychological, and cognitive deficits that tax the healthcare system and result in a significant economic burden. These costs have necessitated treatment measures to reduce the incidence of obesity as well as comorbidities associated with obesity. We review the current literature in order to describe the pre-surgical psychological and cognitive characteristics of individuals undergoing bariatric surgery and the possible changes in these functions following surgery. We discuss the importance of a pre-surgical evaluation that adequately evaluates cognitive and emotional functioning and what this evaluation should entail. Finally, we discuss recent trends in the types of bariatric surgeries being performed and how these changes may influence subsequent physical, cognitive, and emotional health.

Keywords Bariatric surgery · Psychology · Cognition

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Introduction

Obesity: A Global Epidemic

Obesity rates in the USA continue to rise, and the physical and economic costs of obesity and obesity-related conditions are becoming astronomical. In the years 2010–30, the continuing rise in obesity is projected to add a combined 6–8.5 million incident cases of diabetes, 5.6–7.3 million incident cardiovascular diseases, and more than half a million new cancers in the USA and the UK [1]. These increases in obesity-related diseases are projected to add to health-care costs by $48–$66 billion a year in the USA, and effective policies to promote healthier weight would therefore have dramatic economic benefits [1]. Along with physical and economic implications, obesity has been shown to be an independent risk factor for cognitive dysfunction [2•, 3], with deficits in memory and executive functioning commonly reported [2•, 3–5], as well as a significantly increased risk of disorders such as Alzheimer's disease [6]. In fact, there is growing evidence of the structural and functional abnormalities on neuroimaging in obese patients [7–9]. Raji and colleagues [8] examined gray matter and white matter volume differences in elderly subjects using tensor based morphometry (TBM). They found that BMI, fasting plasma insulin, and type 2 diabetes were strongly linked with atrophy in the frontal, temporal, and subcortical brain regions, with patients with a BMI >30 showing more atrophy in the frontal lobes, anterior cingulate, hippocampus, and thalamus compared to people with normal BMI. The authors concluded that higher BMI was associated with lower brain volumes. Furthermore, obesity has significant associations with a variety of psychiatric illnesses, with higher rates of stress, anxiety, depression, personality disorders, eating behavior disorder (EBD), and substance use disorders [10, 11, 12•, 13–15]. In fact, people with a BMI >40 are five times more likely to have an episode of depression in the past year

than those with average weight [15]. Preiss, Brennan, and Clark [16] found that the relationship between obesity (BMI>30) and depression is influenced by the severity of obesity, education, body image, physical health, interpersonal effectiveness, binge eating, and experience of stigma. Given that obesity has significant influence on physical, economic, cognitive, and emotional health, it is now clear that attention must be paid to reducing the incidence of obesity worldwide.

Obese Individuals Seeking Bariatric Surgery

One of the fastest growing methods of weight loss for morbidly obese individuals today is bariatric surgery. Individuals seeking bariatric surgery are described as similar in education, income status, and IQ compared with the general population [5]. However, significant medical comorbidities are often the primary reason that individuals seek surgery. Common comorbidities include knee and back pain, fatigue, and difficulties with everyday functioning. Other comorbidities relate to medical conditions with known cognitive complications (e.g., diabetes, hypertension, and obstructive sleep apnea), to the point that obese patients seeking bariatric surgery often exhibit impaired cognitive performance prior to surgery [5], particularly in learning, memory, attention, and executive functioning [17–19]. In addition, despite a recent study suggesting that bariatric surgery candidates endorse minimal levels of depression and psychopathology [5], other studies have indicated that people who seek bariatric surgery have a higher prevalence of psychiatric and personality disorders compared to non-treatment seeking obese individuals [20, 21], with the highest rates of psychopathology in those of a female gender, low SES, and higher BMI [21]. In fact, 66 % of bariatric surgery candidates have a lifetime prevalence of at least one DSM Axis 1 disorder, with 38 % having a current DSM Axis 1 disorder [22] (most commonly depression and anxiety [22, 23]). Among bariatric surgery candidates with binge eating disorder, 40 % have been shown to also have a current mood or anxiety disorder [24]. At the time of surgery, it has been reported that 16 % of patients are seeing a psychotherapist [25] and 23-47 % of bariatric surgery candidates are taking psychotropic medications [25, 26]. Other areas of concern in this population include higher rates of eating disorders (ranging from 10-25 % [27, 28]), ADHD [29], and impulse control disorders (current prevalence 19 %, lifetime prevalence, 27 % [30]).

Baseline Physical, Psychological, and Cognitive Predictors of Successful Surgery

Literature regarding the effect of pre-surgical demographic factors and post-surgical weight loss is inconsistent. Physical characteristics that may lead to more positive outcomes suggest that a lower BMI prior to surgery may lead to improved physical, psychological, and social quality of life after surgery [31]. In addition, some research suggests that having surgery at a younger age, at least in women, may result in increased excess weight loss [32]. Although there is no consistently proven relationship between pre-surgical psychological factors and weight loss after surgery [18], there do appear to be some characteristics that may relate to better outcomes. For example, positive social support appears strongly related to post-surgical outcome [33, 34], as do realistic expectations about how surgery can help [35]. Conversely, there is some evidence that individuals who have depression [36] or actively abuse substances [37] prior to surgery may have reduced weight loss success. Finally, identifiable deficits in memory, attention, and executive functioning in patients seeking bariatric surgery appear linked to decreased weight loss 12 months after surgery [17].

Pre-surgical Evaluation

Although the predictive utility of pre-surgical psychological assessments remains controversial, the identification of individuals that need additional pre- or post-surgical assistance is important. Therefore, Mechanick, Youdim, and Jones [38] recently outlined clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric patient. In their outline, they highlight the importance of psychological assessment and monitoring. In general, preoperative neuropsychological assessment is encouraged to include a detailed clinical interview as well as objective mood measure and brief cognitive evaluation. Snyder and colleagues [39] outline the core parts of a pre-surgical clinical interview. They suggest that topics should include an individual's reasons for seeking surgery, weight and diet history, current eating behaviors, understanding of the surgery and lifestyle changes, post-surgical expectations, social supports, and remote and current psychiatric symptoms. Several authors suggest that the psychological assessment should serve primarily an education and planning function, as opposed to a gate-keeping function [24, 40]. Wadden and Sawyer [26] suggest that outright denial of surgery based on psychiatric reasons actually is quite rare (~3 %), though referrals for psychotherapy to provide support and assistance to the patient through the bariatric surgery process are very common (~33 %). It is important that clinicians not rely solely on an interview to fully evaluate psychological functioning and a patient's readiness for surgery, given that patients may feel pressure to present themselves in a positive light in order to be deemed a good candidate for surgery. Therefore, objective measurement of mood and personality is critical. A commonly administered personality measure in bariatric surgery evaluations is the Minnesota Multiphasic Personality Inventory-2-RF [41] (MMPI-2-RF), which has been shown to be reliable, valid, and useful in this population [42]. The MMPI-2-RF

provides bariatric patient normative data and only requires a 5th grade reading level. Again, given patients' strong desire to present themselves positively, it has been suggested that a more conservative cutoff for clinical concern in this population (T=55 or T=60) be considered. Patient's responses to items regarding past and present suicidal ideation may be particularly helpful, as patients may be resistant to talk about these feelings directly in a clinical interview. Similarly, although it is quite common for obese patients to endorse a significant number of somatic symptoms on the MMPI-2-RF, it is important to follow up on such findings to determine whether the results simply reflect an increase in physical symptoms as a result of medical comorbidities or indicate that the patient may be prone to manifest physical symptoms in response to stress. The latter may lead to increased postoperative issues with coping with pain or discomfort.

Along with a thorough interview and objective personality measure, it has been recommended that pre-surgical evaluations also include a brief cognitive screen in order to assure that the patient is able to read and comprehend relevant medical instructions, remember them appropriately, and possess the cognitive skills necessary to understand and adhere to pre- and post-surgical requirements. Bariatric surgery candidates have been shown to generally have average IQs that do not differ significantly from the general population [5]. However, Garcia and colleagues [43] suggest that bariatric surgery candidates have little insight into their current level of cognitive functioning and self-report is not, therefore, reliable. A brief cognitive evaluation can be helpful in providing accurate and specific recommendations to the treatment team.

Within our bariatric program at the University of Michigan, the pre-surgical test battery includes a clinical interview, Shipley-2 Institute of Living Scale [44] as an estimate of intellect, Wide Range Achievement Test - 4 [45] reading subtest to assist in decisions about using reading-based self-report measures, Mini-Cog 3 word recall [46] for basic memory, Questionnaire on Eating and Weight Patterns-Revised (QEWP-R) [47] to assist in determining if binge eating is present, an Alcohol Use Questionnaire, a clinical history form, and the Minnesota Multiphasic Personality Inventory-2RF (MMPI-2-RF) [41]. In line with present research, we obtain a reading level and an estimate of general intellectual ability, which help guide recommendations to the treatment team about whether patients need information presented to them in writing or verbally, or require that a caregiver attend pre- and post-surgical appointments with them to assist in auditory comprehension. Similarly, obtaining a global estimate of analytic skills and memory sheds light on the patient's ability to solve problems and remember important medical information. If these measures are impaired, a recommendation may be made that a family member or close friend who will assist the patient immediately after surgery accompanies the patient to pre- and post-surgical appointments, that the patient be given information in writing, or that the providers use special care in their explanations when using complex medical terminology, as well as careful attention to ensuring the patient has expressed their requests or concerns adequately.

The Surgery Itself: Trends and Implications

Over the last 5 years, bariatric surgeries have advanced, and there appears to be a significant shift in the types of surgeries that are being performed. Initially, surgeries entailed primarily adjustable gastric banding, which is a purely restrictive procedure, and Roux-en-Y gastric bypass, which is a combination of restrictive and malabsorbtive procedures. In 2009, data from the clinical registry of the Michigan Bariatric Surgery Collaborative [48•], a Blue Cross Blue Shield of Michigan-funded quality initiative collaborative that captures data on nearly all patients having bariatric surgery in Michigan, documented 4,537 gastric bypass surgeries (60 %) and 2,131 gastric band procedures (28 %). At that time, the sleeve gastrectomy had recently been approved for coverage by BCBSM, and only 857 (11 %) sleeve gastrectomy procedures were done in 2009. In the past5 years, the proportion of gastric banding procedures has declined sharply (only 246 in 2013; 5 %), and the proportion of sleeve gastrectomies has markedly increased (3,564 in 2013; 68 %). Sleeve gastrectomies have partially replaced gastric bypass surgeries; as well, the proportion of gastric bypass surgeries has also declined (1,450 in 2013; 28 %). During this time frame, the mean BMI of patients obtaining bariatric surgery has remained relatively stable (48.0 in 2009 and 47.8 in 2013). Similarly, the mean age of patients undergoing surgery has remained stable (45.8 in 2009 and 46.9 in 2013), as has the proportion of females to males (23.2 % male in 2009 and 22.1 % male in 2013). The change in the types of surgeries performed results in different postoperative physical recovery patterns and potentially patients' subsequent cognitive and psychiatric functioning and overall quality of life. Specifically, gastric bypass surgery has been shown to produce significantly more physical complications, including increased risk of malabsorption and nutritional deficiencies [48•]. As patients sometimes have difficulty absorbing nutrients, they similarly have difficulty absorbing medications. Therefore, those that require medication to maintain psychiatric stability are at risk of psychiatric breakthrough symptoms following gastric bypass surgery [49, 50]. The risk of medication malabsorption is significantly reduced following sleeve gastrectomy, and it is common to recommend sleeve gastrectomy in patients who rely on psychiatric medication to maintain emotional stability. Future research into the cognitive and psychological functioning of patients undergoing gastric bypass versus sleeve gastrectomy procedures and whether cognitive and psychiatric complications are reduced with the increasing prevalence of the sleeve gastrectomy is warranted.

Bariatric Surgery and Resulting Psychiatric Issues

Mueller and colleagues [51•] recently conducted a thorough literature review of psychiatric issues that can follow bariatric surgery. They cite several studies reporting a decrease in psychiatric symptoms post-surgery, as well as a reduced prevalence of binge eating disorder. More specifically, increased self-esteem and self-concept, along with improved body image and sense of control and reduction in depression, were reported in combination with reduced medical comorbidities [35, 52–54]. Quality of life has also been shown to significantly improve after successful surgery [55, 56] when compared to obese patients who did not undergo surgery [56]. Chang [57] found improvements in the physical, psychological, and social domains of quality-of-life questionnaires after bariatric surgery (with corresponding improvement in weight and medical comorbidities). A slight dip in well-being in these domains was noted at 3-6 months following surgery, most likely related to medical issues, but all patients gradually improved between 6-12 months after surgery. However, in some patients improvements appear to erode over time. Improvements in mood have been reported before patients actually lose weight (and in those that do not lose weight as well), suggesting that significant weight loss alone may not be necessary for improved mood after surgery [58].

With specific regard to depression and anxiety, the Swedish Obese Subjects Study (SOS) found that of 4,047 obese patients, there was significantly less depression and anxiety after surgery compared to non-treatment controls employing diet and exercise [59]. Despite maintenance of improved depression for 5-10 years after surgery [60], there is evidence that interpersonal and family roles and relationships may be disrupted, and several studies suggest that suicide rates are higher than normal after bariatric surgery, with rates ranging from 4.1/10,000 [61] to 6.6/10,000 [62]. Consistent with suicide rates in the general population, the ratio of males completing suicide to females among bariatric surgery patients is approximately 3:1. Questions have been raised about whether the increased suicide rate relates to the surgery or reduction in obesity itself. Adams and colleagues [63] found that of 7,925 bariatric patients 7 years post-surgery, there were three times as many suicides when compared to matched controls on age, BMI, and gender. Other potentially detrimental effects of surgery include increased difficulties with impulse control [64] and elevated alcohol use disorders [65], especially if there was difficulty with alcohol use before surgery [37]. Rates of alcohol abuse are particularly apparent in some patients in the second year after bariatric surgery [66]. Such increases in impulse control disorders and substance use disorders have elicited claims that there is a transfer of addiction after surgery that may contribute to eventually regaining weight that was successfully lost after surgery.

Bariatric Surgery and Resulting Cognitive Issues

Additional research into patient's cognitive functioning prior to and following bariatric surgery is needed, as there are several reasons for surgery to potentially impair cognition (e.g., general anesthesia and nutritional deficiencies). In contrast, there also are several reasons that surgery may lead to an improvement in cognitive status (e.g., reduced incidence of diabetes, hypertension, and obstructive sleep apnea). Imaging and rodent research show that there may be functional changes that occur with gastric restriction that influence cognition. For example, Goldman and colleagues [67] found that simulating food cravings elicited significant activity in the dorsal-medial prefrontal cortex, whereas simulating food resistance elicited significant activity in the dorsolateral prefrontal cortex. These results suggest that neural circuits involved in executive control following bariatric surgery may be a unique component of successful outcome. In rodent models, de Freitas Sonada and colleagues [68] found that rats with reduced gastric capacity presented a significant increase in the expression of the parvalbumin interneurons in the hippocampal CA1 and CA3 subfields, providing the first experimental evidence that restrictive bariatric surgery may alter hippocampal cytoarchitecture, potentially influencing memory.

Several studies, primarily arising from the same laboratory, have found that there are lasting improvements in cognition following bariatric surgery, particularly in attention, executive functioning, and memory, for several years after surgery [69]. Gunstad and colleagues [17] found that of 109 bariatric surgery patients, significant improvement was seen in memory at 12 weeks post-surgery, whereas obese patients not seeking treatment actually declined, suggesting that obesity-related cognitive dysfunction may be at least partially reversible. Cognitive functioning at 12 weeks following surgery also has been suggested to be associated with lower BMI and higher percent weight loss at 24 months post-surgery [18]. In the first study to prospectively examine the independent contribution of cognitive function to weight loss after bariatric surgery, Spitznagel and colleagues [19] recently reported that clinical impairment in task performance in 84 patients after surgery was most prominent in tasks associated with verbal recall and recognition (14.3-15.5 % of the sample) and executive functioning-based perseverative errors (15.5 %) and that baseline test results of attention/executive and memory functioning predicted the BMI and percent excess weight loss at 12 months after surgery. Together, these recent studies suggest that baseline cognition predicts greater percent excess weight loss and lower BMI 12 months after surgery and that cognitive functioning at 12 weeks post-surgery predicts excess weight loss and lower BMI at 24 months post-surgery. Although information is not definitive and more research is clearly necessary, cognitive functioning does appear to be important to measure both prior to and following surgery, in particular

because such information appears to relate to adherence to postoperative guidelines [70]. Future research can be enhanced by incorporating more longitudinal data of increased sample size and again comparing the cognitive performance of patients undergoing gastric bypass versus sleeve gastrectomy.

Conclusion

As bariatric surgeries advance and newer techniques continue to reduce the potential medical complications, while at the same time improving the comorbidities associated with obesity, the percentage of obese people who utilize bariatric surgery to lose weight will likely increase. The literature to date cites several subjective accounts and studies with smaller numbers of patients, and thus the field can clearly continue to benefit from structured research. Current literature citing improvements in physical, cognitive, and emotional functioning is encouraging, but further studies are warranted given some negative findings and concern about increases in impulse control and substance abuse disorders after surgery, potentially supporting the hypothesis of a transfer of addiction. In addition, although several studies highlight the importance of pre-surgical psychiatric evaluation, the importance of postoperative monitoring of cognitive and psychological functioning appears worthy of equal efforts.

Compliance with Ethics Guidelines

Conflict of Interest Kristen Votruba, David Marshall, Jonathan Finks, and Bruno Giordani declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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