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Surgery for Obesity and Related Diseases 10 (2014) 1188–1195

SURGERY FOR OBESITY AND RELATED DISEASES

Original article

# Pre-surgical cortical activation to food pictures is associated with weight loss following bariatric surgery

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Received February 6, 2014; accepted June 2, 2014

**Abstract**

**Background:** Recent research suggests that preintervention functional magnetic resonance imaging (fMRI) data may predict weight loss outcomes among patients who participate in a behavioral weight loss plan. No study has examined whether presurgical brain activation can predict outcomes following bariatric surgery.

**Method:** The aim of the present study was to determine if brain activations during a presurgical fMRI food-motivation paradigm are associated with weight loss 3 and 6 months following laparoscopic adjustable gastric banding (LAGB). Nineteen participants viewed food and nonfood pictures from a well-established food motivation paradigm during an fMRI scanning session before LAGB surgery. Weight was assessed presurgery and 3 and 6 months postsurgery; data for all participants was available at each time point. fMRI data were analyzed using the BrainVoyager QX statistical package. Whole brain voxelwise correlations of presurgery (food–nonfood) brain activation and weight, corrected for multiple comparisons, were performed to analyze the relationship between presurgical brain activation and subsequent weight loss. The settings were a medical university brain imaging center and 2 surgical weight loss centers in a major metropolitan area.

**Results:** Increased activity in frontal regions associated with cognitive control (medial, middle, superior frontal gyrus) and posterior cingulate cortex was associated with weight loss following LAGB.

**Conclusion:** We found that neural activity in previously established regions associated with cognitive and behavioral self-regulation predicts weight loss following bariatric surgery. These preliminary findings highlight the role of neural circuitry in the success and maintenance of weight loss and suggest a possible future use of fMRI in screening LAGB surgery candidates. (Surg Obes Relat Dis 2014;10:1188–1195.)


*Keywords:* Functional MRI; Bariatric surgery; Neural mechanisms; Weight loss; Neuroimaging; Baseline predictor

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Two thirds of adults in the United States are overweight or obese [1]. Excess weight is associated with problems related to physical, emotional, social, and economic

http://dx.doi.org/10.1016/j.soard.2014.06.005

well-being [2]. Despite serious consequences, most obese individuals fail to lose and maintain weight loss using behavioral means alone [3].

A growing number of individuals have turned to surgery in an attempt to lose excess weight [4]. Laparoscopic adjustable gastric banding (LAGB) is an effective method to induce/sustain weight loss and reduce health-related conditions for many who have not succeeded using diet and exercise [5–8]. LAGB was championed in the late 1990s to mid-2000s as the surgery of choice for weight loss [9]. More recent research reveals that enduring outcomes of LAGB may be mixed [10]. Suter and colleagues found that 7 years after LAGB surgery, one third of individuals experienced late complications, and 40% had failed to lose at least 25% of their excess weight (the minimum criterion for success) [9]. These mixed results highlight a need for better understanding of the biological mechanisms associated with variable outcomes and a need for improved identification of patients most likely to succeed with LAGB or other weight loss procedures.

Researchers have recently begun to implement functional magnetic resonance imaging (fMRI) techniques to better understand the neural mechanisms of food motivation and obesity; they have found that even passive viewing of food images reveals differences in brain activation that are associated with weight, food motivation, and cognitive control [11–16]. This research also suggests that weight loss from bariatric surgery may be associated with specific functional brain changes [11,14,17]. Ochner and colleagues [14] found that patients who underwent Roux-en-Y gastric bypass surgery displayed decreased activation in the striatal area, which they interpreted as patients' decreased food motivation following weight loss. In another study [11], at 12 weeks post-LAGB surgery, patients exhibited less brain activation to food pictures in areas associated with food motivation and increased brain activation in a known inhibition and cognitive control region.

Visual fMRI food motivation paradigms offer a potentially powerful way to predict outcomes following LAGB. Studies have shown that individuals who are obese exhibit greater activation to food in brain areas associated with reward [13]. Furthermore, a recent study by Murdaugh and colleagues [18] found that obese patients who exhibit increased activation to images of high-calorie foods in regions associated with reward are less successful following a behavioral weight loss intervention. Considering the results and methods of these prior studies, we sought to determine if baseline brain activation to a food motivation fMRI paradigm could be used to predict postsurgical LAGB outcomes. Because bariatric patients who show relatively greater activation in regions of cognitive control and less activation in regions implicated in reward may have underlying neural circuitry more similar to that of healthy weight individuals, we theorized that they may also have a greater ability to abstain from tempting food and therefore follow the strict dietary regimen required by the LAGB procedure. Consequently, we hypothesized that at baseline, more activation in known areas of cognitive and behavioral control and less activation in areas related to food motivation would be associated with more weight loss postsurgery.

## Method

### *Procedure*

Nineteen participants were scanned before LAGB surgery (i.e., baseline) using an established food motivation fMRI paradigm [19] as part of a larger study examining neural changes associated with LAGB surgery (LAP-BAND, Allergan Inc., Irvine, CA) [11]. Participants underwent 2 scanning sessions that occurred on the same day: (1) after fasting for 4 hours (premeal), and (2) immediately after eating a meal (postmeal) that was standardized for energy [Kcal = 500] and micronutrient content (e.g., a weighed lean meat [turkey or ham] sandwich wrap, carrot sticks, a piece of fruit, and skim milk). Order of sessions (premeal, postmeal) was counterbalanced across patients so that approximately half the group started with the premeal session and half started with the postmeal session.

Weight and height were recorded on the day of surgery, and 3 and 6 months postsurgery. These data were obtained from medical records at the respective recruitment sites for each individual and were used to calculate percent change in body mass index (BMI).

### *Participants*

Participants were identified at 2 surgical sites in the Kansas City metropolitan area. Obese participants (BMI 35–45; age 25–60) with approval for LAGB weight loss surgery (LAP-BAND®) were recruited. Individuals with BMI $\geq$46 kg/m$^2$ were not included due to MRI scanner size constraints. Individuals were ineligible if they had internal metal objects, pregnancy within the past year, reported use of appetite suppressants or stimulants, current eating disorder, current major depression, history of central nervous system disease, cancer, or recent cardiac event. However, given the prevalence of subclinical depressive symptoms among patients seeking bariatric surgery, we included participants taking psychotropic medications not directly targeting the mesolimbic dopamine system (selective serotonin reuptake inhibitors). Additionally, because the majority of patients seeking LAGB have a history of diabetes, patients who had well-controlled diabetes (most recent hemoglobin A1 C $<$7) and were not taking insulin were included. This study was approved by the University of Missouri–Kansas City and University of Kansas Medical Center Institutional Review Boards.

### *fMRI cognitive activation paradigm*

The experimental paradigm was based closely on LaBar et al. [19] and is described in detail elsewhere [13].