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Comparison of weight loss and body composition changes with four surgical procedures

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Abstract

Background: A paucity of information is available on the comparative body composition changes after bariatric procedures. The present study reports on the body mass index (BMI) and body composition changes after 4 procedures by a single group.

Methods: At the initial consultation, the weight and body composition of the patients undergoing 4 different bariatric procedures were measured by bioimpedance (Tanita 310). Follow-up examinations were performed at 1 year and at subsequent visits after surgery. Analysis of variance was used to compare the postprocedure BMI and body composition. Analysis of covariance was used to adjust for baseline differences.

Results: A total of 101 gastric bypass (GB) patients were evaluated at 19.1 ± 10.6 months, 49 biliopancreatic diversion with the duodenal switch (BPD/DS) patients at 27.5 ± 16.3 months, 41 adjustable gastric band (AGB) patients at 21.4 ± 9.2 months, and 30 sleeve gastrectomy (SG) patients at 16.7 ± 5.6 months ($P < .0001$). No differences were found in patient age or gender among the 4 groups. The mean preoperative BMI was significantly different among the 4 groups ($P < .0001$): 61.4 kg/m^2, 53.2, 46.7, and 44.3 kg/m^2 for the SG, BPD/DS, GB, and AGB group, respectively. The postoperative BMI adjusted for baseline differences was 27.8 (difference 23.6 ± 8.3), 32.5 (difference 15.6 ± 5.0), 37.2 (difference 18.2 ± 8.2), and 39.5 kg/m^2 (difference 7.5 ± 4.3) for the BPD/DS, GB, SG, and AGB groups, respectively ($P < .0001$). The percentage of excess weight loss was 84%, 70%, 49%, and 38% for the BPD/DS, GB, SG, and AGB groups, respectively ($P < .0001$). The postoperative percentage of body fat adjusted for baseline differences was 25.7% (23.9% ± 7.0%) 32.7% (16.1% ± 10.5%) 37.7% (16.7% ± 5.6%), and 42% (6.0% ± 6.8%) for the BPD/DS, GB, SG, and AGB groups, respectively ($P < .0001$). The lean body mass changes were reciprocal.

Conclusion: Although the BPD/DS procedure reduced the BMI the most effectively and promoted fat loss, all the procedures produced weight loss. The AGB procedure resulted in less body fat loss within 21.5 months than SG within 16.7 months. Longer term observation is indicated. (Surg Obes Relat Dis 2009;xx:xxx.) © 2009 American Society for Metabolic and Bariatric Surgery. All rights reserved.

Keywords: Gastric bypass; Biliopancreatic diversion with duodenal switch; Sleeve gastrectomy; Adjustable gastric band; Body composition; Weight loss comparison

In a recent meta-analysis of the surgical treatment of obesity, the problems with comparing weight loss among the commonly used surgical procedures were discussed [1]. Most studies have presented data for a single type of procedure as case series. Maggard et al. [1] reported that one quarter of the studies had not stated whether consecutive patients were studied and fewer than one half of the published studies had recorded the proportion of original patients contributing to the outcome data. The outcome data from that analysis were reported in weight loss in kilograms for the more commonly performed procedures. Using only kilograms of weight change might well have presented a

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distorted picture of the efficacy of the procedures if patients of different weights had selected a particular procedure. However, even though these were the published data available for meta-analysis, the use of the body mass index (BMI) provides a more physiologically, meaningful weight change that allows for comparisons. Excess weight lost (EWL) is another calculation that has been encouraged for studies of bariatric procedures using BMI or the percentage greater than the "ideal" body weight as a basis for comparison. Such calculations have been used more consistently [2]. Buchwald et al. [2] performed a data review mostly of reports of single series from surgical centers with varying protocols and different levels of follow-up. Comparisons of different procedures completed both open and laparoscopically and performed on diverse populations by surgeons with differing levels of expertise are difficult to interpret, but their analysis has provided a helpful format for the evaluation of body weight change. The important synthesis of this information presents a range of the effectiveness of the commonly used surgical approaches to weight loss, with adjustable gastric banding (AGB) approaching 47.5% EWL, gastric bypass (GB) 61.6%, gastroplasty 68.2%, and biliopancreatic diversion (BPD) with or without the duodenal switch (DS) 70% [2].

Beginning in 2001, we prospectively collected data on the preoperative body weight and height, BMI, and body composition of all patients requesting a surgical procedure to assist with weight loss. Because the surgical procedures to augment weight loss implement different physiologic mechanisms, it was judged important to evaluate, not only the change in BMI, but also the change in body composition. Recently, we published data comparing the effects of GB and BPD/DS on these parameters [3]. Because our database had expanded to include the AGB and sleeve gastrectomy (SG), it was judged appropriate to compare the 4 commonly performed laparoscopic procedures completed by 4 experienced and skilled bariatric surgeons as primary intervention for weight loss. Other studies have not been able to rule out surgeon experience and expertise in comparisons that focused on different procedures, because the procedures were frequently completed by different groups of surgeons.

Methods

At their initial surgical consultation requesting weight loss surgery, all patients who qualified according to National Institutes of Health guidelines [4] were asked to review and sign an informed consent form describing the research protocol, which had institutional review board approval. The patients were weighed and measured, and underwent body composition analysis by the bioimpedance method using the Tanita 310 (Tanita Corporation of America, Arlington Heights, IL). This bioimpedance equipment has been validated for use in morbid obesity [5]. Only patients who had undergone an initial bariatric procedure that was completed laparoscopically were included in the present analysis. The 4 skilled laparoscopic bariatric surgeons had routinely performed the 4 procedures that were the subject of the present analysis.

In 2007, we published our techniques for the completion of GB and BPD/DS [3]. The first stage of BPD/DS is SG. Patients now may undergo SG as the sole procedure. Those patients who underwent SG without additional revision underwent evaluation at 12 months after surgery and thereafter.

The technique for AGB placement has been previously described [6]. Postoperative follow-up necessitates serial visits to the office or radiology suite, where adjustments are done by accessing the AGB's reservoir using a sterile technique and injecting saline to obtain the appropriate degree of restriction. Otherwise, the follow-up protocol paralleled that for the other types of weight loss surgery.

Postoperative follow-up

The postoperative follow-up visits for all procedures were scheduled at 4 weeks, 3, 6, and 12 months, and yearly thereafter. However, after the first postoperative visit at 4 weeks, patients who had undergone AGB placement generally scheduled the follow-up visits when their weight had reached a plateau and/or they no longer experienced restriction. All AGB adjustments were completed using radiographic visualization. At this analysis, we did not have a fixed, timed protocol for AGB adjustments.

All measurements of body weight and body composition included in the present analysis were at not <1 year and thereafter, when additional visits were completed. Because follow-up of bariatric patients has been acknowledged to be difficult and inconsistent, using an availability basis selection resulted in follow-up of all patients active in the protocol. The most recent measurement was used for the surgery comparisons. The percentage of EWL was calculated by assuming a normalized body weight with a BMI of 24 kg/m^2. The EWL was determined by dividing the postoperative BMI by the preoperative BMI and subtracting 24 kg/m^2.

Statistical analysis

All results are expressed as the mean and standard deviations, except as indicated. The analysis of covariance (ANCOVA) models were performed to compare the adjusted outcomes (e.g., postprocedure BMI and postprocedure percentage of body fat and lean body mass) and baseline clinical factors among the surgery groups (e.g., preoperative BMI, percentage of body fat, and percentage of lean body mass). ANCOVA is a multivariate linear regression model that allows for the postprocedure differences to be adjusted for differences in these measurements among the groups at baseline. For example, in the multivariate model,

Table 1
Patient characteristics

Procedure	Patients (n)	Gender		Age (y)	Postoperative measurement (mo)
		Male	Female		
GB	101	26 (25.7)	75 (74.3)	44.3 ± 9.9	19.1 ± 10.6
BPD/DS	49	20 (41.0)	29 (59.0)	43.9 ± 8.8	27.5 ± 16.3
AGB	41	13 (31.7)	28 (68.3)	39.8 ± 10.6	21.4 ± 9.2
SG	30	9 (30)	21 (70)	41.9 ± 14.4	16.7 ± 5.6
P value (ANOVA)		NS		NS	<.0001

GB = gastric bypass; BPD/DS = biliopancreatic diversion with the duodenal switch; AGB = adjustable gastric band; SG = sleeve gastrectomy; ANOVA = analysis of variance.

the postoperative mean percentage of body fat for each procedure was adjusted for the procedure group differences in the percentage of body fat at baseline. A separate ANCOVA model was performed for the adjusted postprocedure percentage of lean body mass and BMI. The adjusted postoperative mean values and standard errors for each surgery group are presented. The analysis of variance test was used to compare EWL, age, and months of follow-up after surgery among the groups. The chi-square test was used to compare the gender distribution among the groups. For specific pair-wise comparisons of interest, post hoc analysis were performed with Bonferroni adjustments for multiple comparisons. The Pearson correlation coefficient *(r)* was used to assess the correlation between the change in BMI and the change in the percentage of body fat for all patients combined and for patients stratified by gender and surgery group. All *P* values are two-sided, with statistical significance evaluated at the .05 alpha level. All analyses were performed using Statistical Analysis Systems, version 9.1 (SAS Institute, Cary, NC) and Statistical Package for Social Sciences, version 15.0 (SPSS, Chicago, IL).

Results

After surgery, 101, 49, 41, and 30 patients who had undergone GB, BPD/DS, AGB, and SG were evaluated at 19.1 ± 10.6, 27.5 ± 16.3, 21.4 ± 9.2, and 16.7 ± 5.6 months, respectively ($P < .0001$ by analysis of variance). No statistically significant differences were found among the 4 groups in age or gender (Table 1). The preoperative mean BMI was significantly different ($P < .0001$) at 61.4, 53.2, 46.7, and 44.3 kg/m^2 for the SG, BPD/DS, GB, and AGB group, respectively (Fig. 1). For comparison in Fig. 1, the postoperative BMI is shown unadjusted for the baseline differences ($P < .0001$). The postoperative mean BMI for each group, adjusted for the baseline BMI, was estimated and was 27.8 ± 0.6, 32.5 ± 0.4, 37.2 ± 0.9, and 39.5 ± 0.7 for BPD/DS, GB, SG, and AGB, respectively ($P < .0001$). Adjustment for baseline differences did not change the statistical significance. The mean change in BMI after the 4 procedures was evaluated. The mean change in BMI for those who had undergone BPD/DS, SG, GB, and AGB was almost 24, 18, 15.6, and 7.5 kg/m^2, on average, respectively.

Before surgery, the difference in the mean percentage of body fat among the 4 groups was statistically significant ($P < .004$; Fig. 2). For comparison, the postoperative percentage of body fat is shown unadjusted for the baseline differences ($P < .0001$). The postoperative mean percentage of body fat in each group, adjusted for the baseline value, was 25.7% for BPD/DS, 32.7% for GB, 37.7% for SG, and 42.0% for AGB ($P < .0001$), approximating the unadjusted

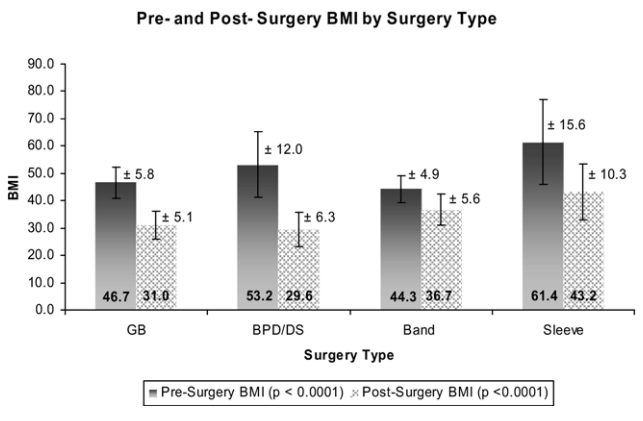

Fig. 1. Pre- and postoperative BMI by surgery type.

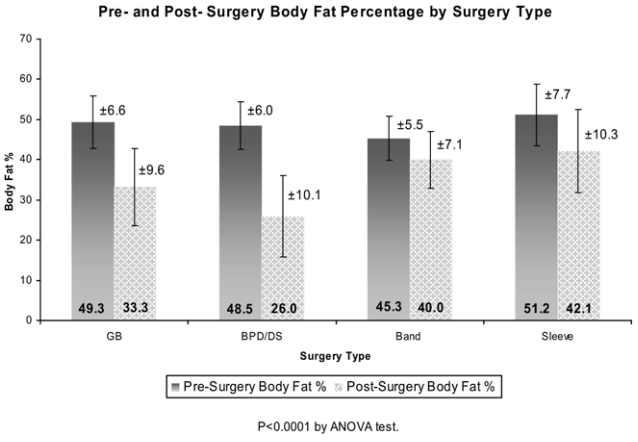

Fig. 2. Pre and postoperative percentage of body fat by surgery type.

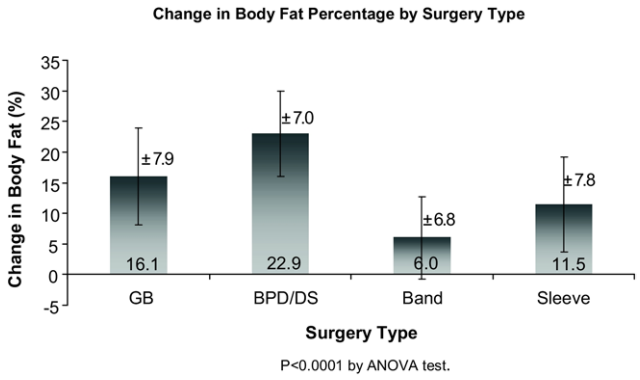

Fig. 3. Change in body fat by surgery type.

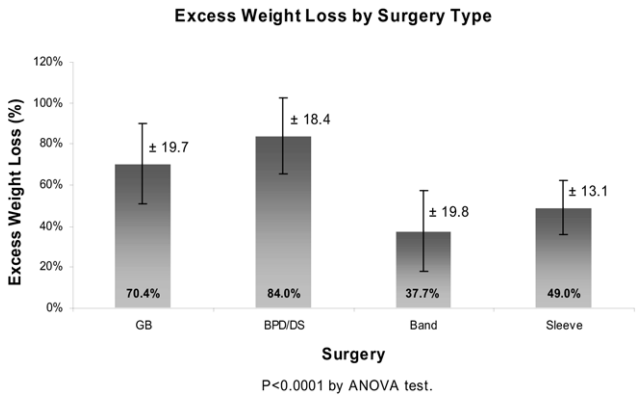

Fig. 5. EWL by surgery type.

values. As a group, the BPD/DS patients achieved a normalized percentage of body fat. Fig. 3 shows the change in the mean percentage of body fat after the 4 bariatric procedures (BPD/DS, 22.9% ± 7.0%; GB, 16.1% ± 7.9%; SG, 11.5% ± 7.8%; and AGB, 6.0% ± 6.8%).

The measured differences in lean body mass are shown in Fig. 4, unadjusted for the baseline differences to emphasize the relative stability of the lean body mass and a relative increase in the lean body mass as fat was metabolized. The lean body mass, adjusted for the baseline differences, remained significantly different ($P < .0001$, by ANCOVA test). The percentage of lean body mass was 74.5% ± 1.2% for BPD/DS, 67.3% ± .8% for GB, 62.3% ± 1.7% for SG, and 58.0% ± 1.3% for AGB.

When the patients were compared for BMI change and the change in the percentage of body fat, a strong correlation was found for all 221 patients studied ($r = .668$, $P < .0001$). The GB group had the greatest correlation coefficient ($r = .681$, $P < .0001$, followed by the AGB group ($r = .571$, $P = .001$), BPD/DS group ($r = .338$, $P = .03$), and SG group ($r = .429$, $P = .067$; not statistically significant). These observations highlight the differences in BMI change and fat loss in the severely obese.

Although no significant difference was found in the gender distribution among the 4 groups, differences in body fat in the general population related to gender have been identified. Because these bariatric procedures use different mechanisms to produce weight loss, we thought it relevant to examine the changes in BMI and the percentage of body fat related to the surgical procedures for possible differences in the weight loss process related to gender. For all procedures combined, a strong correlation was found for both genders for the change in BMI and the change in the percentage of body fat (men, $r = .718$; women, $r = .635$). For GB (men, $r = .702$; women, $r = .677$) and AGB (men, $r = .842$; women, $r = .575$), the correlations were stronger for the men, possibly in relation to the absolute differences in fat free mass. Although BPD/DS and SG assist with weight loss using different mechanisms, the reported correlations for these severely obese patients were weaker and not significant for either (BPD/DS, men, $r = .292$; women, $r = .309$; SG, men, $r = .397$; women, $r = .473$).

In agreement with other single-institution reports and meta-analyses of multicenter observations, the EWL for BPD/DS was 84.0% ± 18.4%, for GB was 70.4% ± 19.7%, for SG was 49.0% ± 13.1%, and for AGB was 37.7% ± 19.8% ($P < .0001$; Fig. 5).

Fig. 4. Pre- and postoperative percentage of lean body mass by surgery type.

Discussion

Because surgical procedures are continually evolving, the process of evaluating efficacy is an ongoing process. In 2004, when Buchwald et al. [2] published their meta-analysis, they combined laparoscopic and open procedures. Because the benefits of laparoscopic procedures have been defined and surgical competence has been developed to routinely use laparoscopic techniques, the focus of the present analysis was restricted to laparoscopic procedures performed as the first bariatric surgery. The EWL reported in our study approximated the findings of the earlier meta-analysis by Buchwald et al. [2].

Observations in published studies regarding the efficacy of the AGB have varied. Toouli et al. [7] reported EWL at the 50% level during an 8-year period, with AGB adjustments provided on an "as required" basis. The now classic review by Fielding and Ren [8] summarized multiple studies and generalized the EWL at approximately 50%. The recent meta-analysis by Cunneen [9] reported a similar EWL of 50%. Busetto et al. [10] and Wolnerhanssen et al. [11] reported a 40% EWL during a 5-year period, in line with other observations.

Wolnerhanssen et al. [11] also reported that 33.7% of their patients had their AGB removed and only 2.4% of that group declined additional surgical intervention. Weight loss failure with an AGB at 5 years (BMI >35 kg/m^2) was reported for 34.6% of a limited sample [12]. At >5 years, Silecchia et al. [13] reported that 24% of their 500 patients had undergone reoperation. The reoperation rate for AGB was reported at 20% by Jan et al. [14]. A major reoperation was required in 21.7% of 317 patients followed up for a mean of 74 months, and 43% had a 7-year success rate of 50% EWL [15].

Such observations point to the importance of longer term follow-up for AGB patients.

In a limited sample of 30 patients who had undergone AGB placement recalled for evaluation after 5 years, 95% had measured esophageal dilation of >5–9 cm and 47% reported reflux and dysphagia [16]. It seems that in the long term, concerns are increasing with regard to band placement related to the increased number of physical problems being reported.

The SG has recently been added as a possible single procedure to assist in weight loss [17]. From our site, the patient cases were limited because most patients subsequently undergo that second stage after the initial SG. A recent review by Nocca et al. [18] stressed the lack of available long-term follow-up after SG procedures. At 2 years postoperatively, 98 patients had demonstrated 61.5% EWL [18]. These were the patients who have done well and not requested an additional procedure; thus, it must be considered a subsample of those undergoing this procedure. Also, 22 patients (13.5%) had undergone SG after a previous failed bariatric intervention. With this challenging patient sample, such reports show promise for this less-complex procedure. Himpens et al. [19] randomized 80 patients to SG versus AGB. They found that weight loss and decreased feelings of hunger were better after SG than after AGB at 1 and 3 years. At 3 years, the percentage of EWL was 48% (range 0–124.8%) for the AGB and 66% (-3.1% to 152.4%) for the SG group [19]. It is not clear how the wide ranges of EWL were calculated or how a patient could lose 150% of their excessive weight, as reported. With this question in the foreground, the effect of possible dilation in the long term of the residual stomach has had little investigation. Langer et al. [20] reported that 1 of 23 patients who had undergone SG had measurable distension; however, an EWL of 56% resulted [20]. Larger patient samples with longer follow-up are required for a more definitive answer.

At present, the efficacy of the BPD/DS in producing the greatest EWL of the bariatric procedures has been well documented. However, GB remains the reference standard of the weight loss procedures [2,3,21], possibly because of the surgical difficulty of the switch procedure and concerns regarding the development of nutritional deficiencies with the gross lipid malabsorption that contributes to the effective weight loss with the BPD/DS.

Little information is available on the changes in body composition in the super obese after surgical weight loss [22]. The observations we have reported provide a previously unavailable comparison of the body composition changes produced by 4 procedures completed by a single surgical group. The effects of adipose tissue loss and the maintenance of fat free mass were different for the 4 different procedures. The 2 procedures generally reserved for the super obese, the SG and the BPD/DS, although hypothesized to promote weight loss by different mechanisms, both had lower correlations for BMI and the percentage of fat tissue change. It is possible that our findings reflected fluid changes in the extracellular and intracellular compartments, as well as modifications in the fat free mass that are different in those with a BMI >60 kg/m^2. However, the validation study had participants with a mean BMI of 50.2 ± 8.8 kg/m^2, with 24% having a BMI of 50–60 kg/m^2 and another 17% having a BMI >60 kg/m^2. The correlation of bioimpedance measurements and deuterium oxide dilution to measure body water had a Pearson r of 0.92 [5].

Our observations concerning the retention of fat free mass after bariatric surgery highlight an important area for additional investigation concerning the factors related to the retention of functional muscle mass. The present study included no observations on the differences in body fat accumulation and resolution in the various body fat depots with weight change. More in-depth body composition studies, which might be provided by the LABS consortium, will increase our comprehension of the mechanisms implemented by surgical weight loss procedures [23]. Future studies with larger sample sizes and longer follow-up should provide increased information to help patients and surgeons decide which procedure will be best for the individual patient.

Conclusion

After 4 surgical procedures, the patients, who had no differences in age or gender distribution, demonstrated significant differences in BMI change and percentage of fat loss with lean body mass retention. Adjusting for baseline differences in the surgical groups did not change the statistical significance. For all patients, a high correlation was found for BMI change and fat loss. Larger patients who underwent SG and BPD/DS had greater changes in BMI,

which did not have a high correlation with the percentage of fat loss. As a group, after surgery, the BPD/DS patients had achieved a normalized percentage of body fat. In contrast to the general population, no significant differences were seen in body fat related to gender in the severely obese. Our observations regarding EWL with these 4 procedures are in general agreement with other single-institution studies and meta-analyses of multicenter reports.

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Disclosures

The authors claim no commercial associations that might be a conflict of interest in relation to this article.

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