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Body Contouring

Changes in Glucose Control and Lipid Levels Following Trunk-Based Body Contouring Surgery in Postbariatric and Nonbariatric Patients

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Joshua T. Henderson, MD; Zachary A. Koenig, MD; and Kerri M. Woodberry, MD, MBA

Abstract

Background: Despite consistent interest over the past 2 decades regarding the metabolic effects of body contouring (BC), previous studies are limited by short follow-up periods, small sample sizes, gender-specific cohorts, and assessment of all anatomic regions together.

Objectives: This study evaluates the changes in glucose and lipid levels over long-term follow up after trunk-based BC and compares postbariatric with nonbariatric patients.

Methods: The retrospective cohort study included patients who underwent trunk-based BC from January 1, 2009 through July 31, 2020 at West Virginia University. A minimum 12-month follow up was required for inclusion. With BC surgery as the reference point, patients' glucose, hemoglobin A1c, and lipid levels were assessed prior to surgery and at long-term follow up. Change over time was compared between postbariatric and nonbariatric cohorts. Multivariable linear regression models were performed to assess the effect of potential confounding variables on the difference between cohorts.

Results: Seventy-seven BC patients had glucose levels evaluated during the study period, and 36 had lipid profiles obtained. Average follow up from date of BC was 41.2 months for the patients with glucose follow up and 40.9 months for those with lipid levels. From pre-BC to endpoint follow up, glucose levels mildly increased in all patients. Multivariable linear regression models accounting for age showed nonbariatric patients experience significantly improved total cholesterol levels compared to postbariatric patients ($P = 0.0320$). Weight loss maintained following BC was not associated with significant differences between cohorts.

Conclusions: Fasting glucose levels marginally increase in most BC patients through follow up. Nonbariatric patients generally experience more favorable changes in lipid profile following trunk-based BC than do postbariatric patients.

Level of Evidence: 3

3
Therapeutic

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From the Department of Surgery, Division of Plastic, Reconstructive, and Hand Surgery, West Virginia University, Morgantown, WV, USA.

Corresponding Author:
Dr Joshua T. Henderson, PO Box 9238 HSC-S, Morgantown, WV 26506, USA.
E-mail: joshhendersonmd@gmail.com; Instagram: @joshhendersonmd; Twitter: @JoshHendersonMD

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Over the past 2 decades, the US national mean body mass index (BMI) has steadily increased. In certain regions, obesity and the associated metabolic aberrancies are frequently encountered. Losing excess weight, whether with the help of bariatric surgery (BS) or through strict diet and exercise, is commendable but often results in redundant skin and an unsatisfactory aesthetic appearance. Abdominoplasty and panniculectomy can dramatically improve the appearance and mobility of these patients and have thus become some of the most common surgeries performed by plastic surgeons.

Massive weight loss (MWL) is also associated with dramatic improvements in comorbid conditions, such as diabetes and metabolic syndrome.[1] Quantifiable long-term improvements in diabetes and dyslipidemia have been documented following BS, despite some evidence showing gradually reduced glucose control postoperatively.[2] It is conceivable that body contouring (BC) procedures could bestow further benefit for MWL patients who continue to battle borderline-high glucose and lipid values.

In addition to removing excess skin, BC procedures target areas of fat that are resistant to diet, exercise, and surgical weight loss. It has been proposed that these lingering fat repositories have a role in lipid and glucose metabolism.[3] Early animal studies showed improved serum lipid levels associated with decreasing body fat stores.[4,5] Two studies evaluating postbariatric patients did not show substantial glucose or lipid changes 1.5 to 2 years after BC.[6,7] Other studies evaluating these effects following BC are limited by short follow-up periods, small sample sizes, gender-specific cohorts, and assessment of all anatomic regions together.[8–15] The systematic review evaluating metabolic outcomes after trunk-based BC includes studies with mostly follow up of 3 months or less, several of which evaluate patients who underwent exclusively liposuction rather than true dermatolipectomy.[16] The review also does not distinguish between patients who previously underwent BS.[16] Additional reviews of the metabolic outcomes of liposuction patients offer conflicting results, possibly related to the deficient sample sizes and limited follow up of most included studies.[17–19]

When evaluating outcomes following BC, it is helpful to separate postbariatric from nonbariatric patients. We recently published our BC patients' long-term weight control and discovered a gradual weight regain following BC surgery, particularly in the postbariatric patients.[20] Our postbariatric cohort regained significantly more weight than the nonbariatric patients.[20] This suggests the global metabolism of the postbariatric patients may be affected in different ways than that of the nonbariatric patients. While our anecdotal evidence supports this notion, no previous studies have evaluated outcomes following BC and compared patients based on previous BS. The present study aims to analyze long-term changes in glucose control and lipid profile following trunk-based BC and to further compare postbariatric and nonbariatric patients with a minimum 12-month follow up.

METHODS

With approval from the West Virginia University Institutional Review Board, we conducted a retrospective review of consecutive patients who underwent trunk-based BC at West Virginia University between January 1, 2009, and July 31, 2020. As patient data were de-identified, no consent was necessary for patients included in this retrospective study. Patients were separated into 2 cohorts based on whether they had previously undergone BS. Inclusion criteria required the patients to have had glucose levels and/or lipid profiles assessed preoperatively and at least 12 months following BC surgery. Results were trended through the first 6 years following BC surgery or until endpoint follow up (if 6 years of data were not available).

Demographics collected included age, sex, race, medical comorbidities, and baseline (pre-BC) weight and BMI. Tobacco users were required to abstain from tobacco in the 4 weeks preceding surgery. The timing and type of previous BS, if applicable, were also assessed. Additional BC procedures, whether performed concurrently with trunk-based BC surgery or at a different time, were identified.

With trunk-based BC surgery as the reference point, each patient's fasting glucose, hemoglobin (Hgb) A1c, and/or lipid profile immediately prior to BC (pre-BC) were obtained. As it is common for many patients to have multiple glucose levels on record, all fasting levels obtained in the month prior to BC were averaged to arrive at the pre-BC value. The lipid profile included total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), very low-density lipoprotein (VLDL), and triglyceride (TG) levels. These laboratory values were trended through endpoint follow up, the maximum of which was set at 6 years following BC surgery. The percent total weight loss (%TWL) from pre-BC to endpoint follow up was also calculated for each patient. To account for the potential effect of baseline variables on the change in laboratory values between cohorts, 6 multivariable linear regression models using weighted least squares were performed (accounting for %TWL, age at time of BC, weight of tissue resection, baseline "pre-BC" weight and "pre-BC" BMI, and follow-up time).

Data were collected in Microsoft Excel (Microsoft, Redmond, WA), which was also used to create tables and figures. Postbariatric and nonbariatric cohorts were compared with the unpaired Student's *t*-test or the Wilcoxon rank-sum test, based on normality of the distribution, which was assessed with the Shapiro–Wilk test. The chi-squared test was used for frequency comparisons. Comparative statistics were performed with STATA Statistical Software

(StataCorp LLC, College Station, TX), and multivariable statistical analyses were performed with R 4.2.1 (R Core Team, Vienna, Austria). Statistical significance was marked by a value of $P < 0.05$.

RESULTS

Seventy-seven BC patients had glucose levels assessed before and after trunk-based BC surgery, and of these, 36 also had lipid profiles obtained. For the 77 patients with glucose levels evaluated, the mean age at time of BC surgery was 49.8 ± 10.7 (range: 26-75 years), and the mean follow up from BC surgery was 41.2 ± 20.0 months (range: 12-72 months). Forty-five (58.4%) patients had previously undergone BS. Demographic data and baseline health information for these patients are shown in Table 1. Additional BC procedures involving anatomic regions other than the trunk, whether performed concurrently with the trunk procedure or at a different time, are highlighted in Table 2.

Table 1. Demographics and Baseline Health of Patients With Glucose Measurements

Characteristic	All patients	Postbariatric	Non-bariatric
Number of patients	77 (100.0%)	45 (58.4%)	32 (41.6%)
Gender			
Female	68 (88.3%)	41 (91.1%)	27 (84.4%)
Male	9 (11.7%)	4 (8.9%)	5 (15.6%)
Race			
White or Caucasian	74 (96.1%)	44 (97.8%)	30 (93.8%)
Black or African American	1 (1.3%)	0 (0.0%)	1 (3.1%)
Asian	2 (2.6%)	1 (2.2%)	1 (3.1%)
Diabetes			
Yes	16 (20.8%)	6 (13.3%)	10 (31.3%)
Resolved	12 (15.6%)	10 (22.2%)	2 (6.3%)
No	49 (63.6%)	29 (64.4%)	20 (62.5%)
Hyperlipidemia			
Yes	32 (41.6%)	16 (35.6%)	16 (50.0%)
Resolved	6 (7.8%)	6 (13.3%)	0 (0.0%)
No	39 (50.6%)	23 (51.1%)	16 (50.0%)
Tobacco use			
Current	4 (5.2%)	0 (0.0%)	4 (12.5%)
Former	28 (36.4%)	18 (40.0%)	10 (31.3%)
None	45 (58.4%)	27 (60.0%)	18 (56.3%)
Bariatric surgery			
RYGB	—	28 (62.2%)	—
Sleeve gastrectomy	—	10 (22.2%)	—
LAGB	—	3 (6.7%)	—
Not Specified	—	4 (8.9%)	—
BC Surgery			
Panniculectomy	41 (53.2%)	27 (60.0%)	14 (43.8%)
Abdominoplasty	36 (46.8%)	18 (40.0%)	18 (56.3%)
Age at time of BC (years)	49.8 ± 10.7	51.7 ± 9.1	47.1 ± 11.3
Follow-up from BC (months)	41.2 ± 20.0	38.4 ± 17.1	45.1 ± 23.2

A diagnosis of diabetes or hyperlipidemia ("yes" in this table) required a patient to be actively receiving treatment for one of these conditions. "Resolved" means a patient previously had one of these diagnoses but had since stopped all medications related to that disease. "Former" tobacco use means a patient had abstained from tobacco for at least 1 year prior to BC surgery. Although no patients were actively smoking at the time of BC surgery, "current" tobacco use refers to those patients who had used tobacco within the preceding twelve months. Patients were required to abstain from tobacco in the four weeks preceding surgery. Percentages in the postbariatric and non-bariatric columns are proportional to the total number of patients in each cohort. BC, body contouring; LAGB, laparoscopic adjustable gastric banding; RYGB, Roux-en-Y gastric bypass.

Table 2. BC Procedures Performed in Addition to Trunk-Based BC Procedure in Patients With Glucose Measurements

Procedure	All patients	Postbariatric	Non-bariatric	*P*-value
No. of patients	77	45	32	
Breast	18 (23.4%)	6 (13.3%)	12 (37.5%)	0.0135*
Concurrent	10 (13.0%)	2 (4.4%)	8 (25.0%)	
Different time	8 (10.4%)	4 (8.9%)	4 (12.5%)	
Upper extremity	5 (6.5%)	4 (8.9%)	1 (3.1%)	0.3117
Concurrent	3 (3.9%)	2 (4.4%)	1 (3.1%)	
Different time	2 (2.6%)	2 (4.4%)	0 (0.0%)	
Lower extremity	7 (9.1%)	5 (11.1%)	2 (6.3%)	0.4646
Concurrent	5 (6.5%)	3 (6.7%)	2 (6.3%)	
Different time	2 (2.6%)	2 (4.4%)	0 (0.0%)	

Breast procedures typically involved a mastopexy or reduction, upper extremity most commonly a brachioplasty, and lower extremity refers to a thighplasty. "Different time" includes procedures performed prior to or after the trunk-based BC procedure. Percentages in the postbariatric and non-bariatric columns are proportional to the total number of patients in each cohort. The *P*-values distinguish significance between postbariatric and non-bariatric patients who underwent BC of one of these areas, either at the same time or at a separate time from the trunk-based BC procedure. (*) denotes statistical significance. BC, body contouring.

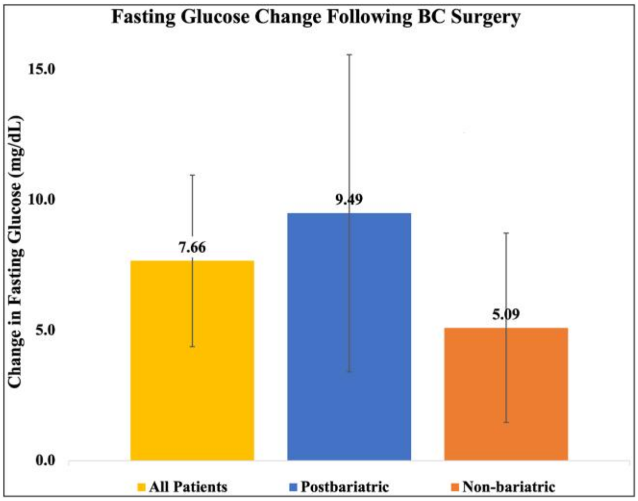

Figure 1. Fasting glucose level change following body contouring (BC) surgery.

Average fasting glucose change from pre-BC to endpoint follow up was 7.7 ± 28.9 mg/dL among all patients (9.5 ± 24.4 mg/dL in postbariatric patients and 5.1 ± 34.4 mg/dL in nonbarbaric patients, $P = 0.1351$, Figure 1). Fourteen patients had Hgb A1c levels obtained before and after BC surgery. Average Hgb A1c change from pre-BC to endpoint follow up was 0.54 ± 1.15% among all patients (0.56 ± 0.79% in postbariatric patients and 0.51 ± 1.49% in nonbarbaric patients, $P = 0.9476$, Figure 2). Additional information regarding changes in laboratory results related to glucose and Hgb A1c level changes are summarized in Table 3.

Demographic data and baseline health information for the 36 patients with lipid profiles assessed are shown in Table 4. Their mean age at time of BC surgery was 51.4 ± 11.6 years (range: 26-75 years), and mean follow up was 40.9 ± 17.2 months (range 15-72 months). Twenty-one patients (58%) had previously undergone BS. Additional BC procedures for these patients are highlighted in Table 5.

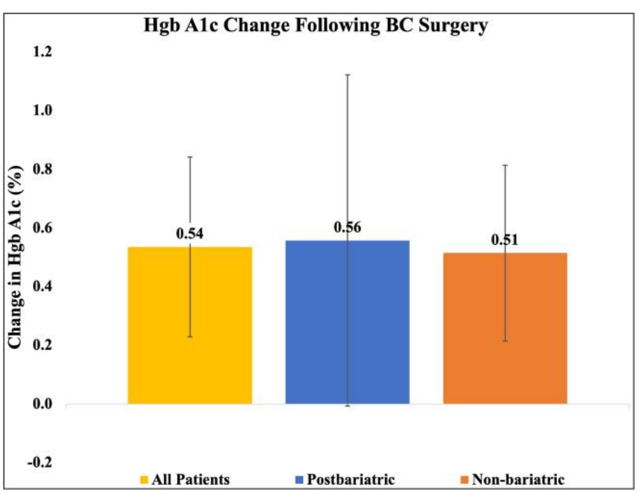

Figure 2. Hemoglobin A1c change following body contouring (BC) surgery.

Average TC change from pre-BC to endpoint follow up was −1.4 ± 46.8 mg/dL among all patients (5.6 ± 38.2 mg/dL in postbariatric patients and −11.3 ± 56.6 mg/dL in nonbarbaric patients, $P = 0.4702$, Figure 3). LDL levels decreased in both cohorts, and HDL levels increased. No statistically significant differences between the 2 cohorts were found for any of the lipid level changes (Table 6, Figure 3).

Multivariable linear regression models accounting for age showed nonbariatric patients having significantly improved TC levels ($P = 0.0320$) compared to postbariatric patients, as well as significantly lower increases in VLDL ($P = 0.0193$) and TG ($P = 0.0164$) levels (Table 7). No other variables (%TWL, weight of tissue resection, pre-BC weight, pre-BC BMI, or follow-up time) significantly affected the cohort comparisons regarding change in glucose or lipid levels.

Complications following surgery included wound dehiscence (8/77, 10.4%), wound infection (7/77, 9.1%), hematoma (6/77, 7.8%), and seroma formation (5/77, 6.5%). Of these total complications, those requiring surgical intervention included 5 hematomas (5/77, 6.5%), 2 wound infections (2/77, 2.6%), and 1 wound dehiscence (1/77, 1.3%). All seromas were managed with aspiration in the office and resolved before necessitating operative drainage.

DISCUSSION

Body contouring procedures serve a prominent role in the health and well-being of MWL patients after BS, as well as in overweight patients seeking a slimmer contour. Some studies have reported improved weight maintenance in postbariatric patients who undergo BC compared to BS alone. There is, thus, great value in exploring the associated metabolic changes that occur in the setting of BC, as changes in these parameters often align with changes in weight.

Effects on Glucose Control

Previous studies offer mixed results when evaluating the effects of BC on glucose metabolism. Outcomes reported for postbariatric patients who pursue trunk-based BC show no significant improvements in glucose or Hgb A1c levels at endpoint follow up.[6,7,9] Most studies in which these laboratory values are analyzed do not have sufficient follow up to draw reliable conclusions.[8]

In nonbariatric patients, Rizzo et al described significant improvements in insulin sensitivity evaluated by a euglycemic hyperinsulinemic clamp.[10] Insulin-tolerance testing,

Table 3. Glucose and Hgb A1c Levels Before and After BC Surgery

Variable	All patients	Postbariatric	Non-bariatric	*P*-value
No. of patients	77	45	32	
Age (years)	49.78 ± 10.74	51.69 ± 9.13	47.09 ± 11.28	0.0634
Pre-BC measurements				
Glucose (mg/dL)	95.58 ± 16.66	93.29 ± 16.50	98.81 ± 16.59	0.0719
Hgb A1c (%)[a]	5.91 ± 0.64	5.73 ± 0.50	6.13 ± 0.75	0.2469
Weight (kg)	99.10 ± 36.73	97.16 ± 25.99	101.83 ± 48.33	0.4853
BMI (kg/m2)	36.10 ± 11.50	35.60 ± 9.11	36.80 ± 14.35	0.7447
Tissue resection weight (kg)[b]	5.82 ± 6.74	4.64 ± 3.59	8.12 ± 10.23	0.9755
Pre-BC to endpoint follow-up				
Follow-up time (mo)	41.21 ± 19.97	38.42 ± 17.08	45.13 ± 23.18	0.1479
Change in glucose (mg/dL)	7.66 ± 28.81	9.49 ± 24.36	5.09 ± 34.37	0.1351
Change in Hgb A1c (%)[a]	0.54 ± 1.15	0.56 ± 0.79	0.51 ± 1.49	0.9476
%TWL	−0.02 ± 0.11	−0.05 ± 0.11	0.01 ± 0.10	0.0153*

"Pre-BC" refers to measurements obtained immediately prior to BC surgery. "Age" is the average age of the patients in each cohort at the time of trunk-based BC surgery. "Tissue resection weight" refers only to the pannus resection weight. In the case of concurrent BC procedures, resection weights of anatomic regions outside than the trunk (ie, breast) were not available. "%TWL" refers to the percent total weight loss from pre-BC to endpoint follow-up ([weight loss]/[baseline pre-BC weight]). The *P*-values distinguish significance between postbariatric and non-bariatric patients. (*) denotes statistical significance. ([a]) Only 14 patients had Hgb A1c levels measured before and after BC: 7 postbariatric and 7 non-bariatric. ([b]) 50 patients had tissue resection weights recorded: 33 postbariatric and 17 non-bariatric. BC, body contouring; TWL, total weight loss.

insulin levels and the homeostasis model assessment yielded contrasting results in three separate studies.[11,12,14] However, no study evaluating nonbariatric patients has reported significant improvement in fasting glucose from pre-BC, and all have follow-up timeframes of 3 months or less.[11–15]

A meta-analysis from Seretis et al evaluating glucose control after trunk-based BC and liposuction did not show meaningful improvement in insulin sensitivity or fasting glucose levels when endpoint values were compared to baseline pre-BC levels or when patients were compared to controls.[16] Included studies had limited follow up, and there was no distinction for previous history of BS. In addition, several important retrospective studies were omitted from the systematic review based on the review methodology, and many of the included studies evaluated patients who exclusively underwent liposuction rather than dermatolipectomy.

Our results after 3-4 years of follow up show fasting glucose and Hgb A1c levels marginally increased in most BC patients, regardless of whether they had previously undergone BS. Postbariatric patients experienced a slightly greater increase in fasting glucose and Hgb A1c than did nonbariatric patients. The difference in glucose change between cohorts did not meet statistical significance (Table 3), including when accounting for potential confounding variables (Table 7). Notably, average Hgb A1c prior to BC for patients in both cohorts fell within the prediabetic range. However, only 14 patients (7 in each cohort) had A1c levels obtained at baseline and at follow up. Although additional patients in the postbariatric cohort previously carried diagnoses of diabetes, several experienced resolution by the time of BC surgery and no longer required monitoring of Hgb A1c levels (Table 1).

Effects on Lipid Metabolism

The literature has shown conflicting lipid profile changes after BC as well. Most of the same studies reporting glucose levels in postbariatric patients who undergo trunk-based BC also described lipid changes at endpoint follow up. Cintra et al reported a significant improvement in HDL from pre-BC but a mild increase in TC.[6] Martin-del-Campo et al showed nonsignificant increases in all lipid levels of postbariatric patients 2 years following BC.[7] With only 3 months of follow up after BC, Leibou et al reported nonsignificant increases in LDL and TG in postbariatric patients.[9]

Evaluating nonbariatric patients, Robles-Cervantes et al reported significant increases in TC and LDL following abdominoplasty, however their endpoint follow up was only 30 days after surgery.[21] Martínez-Abundis et al, Swanson et al, and Vinci et al showed nonsignificant changes in lipid levels at 40 to 90 days following BC.[11,13,15] Rizzo et al and

Table 4. Demographics and Baseline Health of Patients With Lipid Levels

Characteristic	All patients	Postbariatric	Non-bariatric
No. of patients	36 (100.0%)	21 (58.3%)	15 (41.7%)
Gender			
Female	33 (91.7%)	20 (95.2%)	13 (86.7%)
Male	3 (8.3%)	1 (4.8%)	2 (13.3%)
Race			
White or Caucasian	34 (94.4%)	21 (100.0%)	13 (86.7%)
Black or African American	1 (2.8%)	0 (0.0%)	1 (6.7%)
Asian	1 (2.8%)	0 (0.0%)	1 (6.7%)
Diabetes			
Yes	7 (19.4%)	2 (9.5%)	5 (33.3%)
Resolved	5 (13.9%)	5 (23.8%)	0 (0.0%)
No	24 (66.7%)	14 (66.7%)	10 (66.7%)
Hyperlipidemia			
Yes	15 (41.7%)	8 (38.1%)	7 (46.7%)
Resolved	2 (5.6%)	2 (9.5%)	0 (0.0%)
No	19 (52.8%)	11 (52.4%)	8 (53.3%)
Tobacco Use			
Current	1 (2.8%)	0 (0.0%)	1 (6.7%)
Former	13 (36.1%)	9 (42.9%)	4 (26.7%)
None	22 (61.1%)	12 (57.1%)	10 (66.7%)
Bariatric Surgery			
RYGB	—	12 (57.1%)	—
Sleeve gastrectomy	—	4 (19.0%)	—
LAGB	—	2 (9.5%)	—
Not specified	—	3 (14.3%)	—
BC Surgery			
Panniculectomy	16 (44.4%)	9 (42.9%)	7 (46.7%)
Abdominoplasty	20 (55.6%)	12 (57.1%)	8 (53.3%)
Age at time of BC (years)	51.4 ± 11.6	54.5 ± 9.4	47.1 ± 11.2
Follow-up from BC (months)	40.9 ± 17.2	35.5 ± 15.3	48.4 ± 17.5

A diagnosis of diabetes or hyperlipidemia ("yes" in this table) required a patient to be actively receiving treatment for one of these conditions. "Resolved" means a patient previously had one of these diagnoses but had since stopped all medications related to that disease. "Former" tobacco use means a patient had abstained from tobacco for at least one year prior to BC surgery. Although no patients were actively smoking at the time of BC surgery, "current" tobacco use refers to those patients who had used tobacco within the preceding twelve months. Patients were required to abstain from tobacco in the four weeks preceding surgery. Percentages in the postbariatric and non-bariatric columns are proportional to the total number of patients in each cohort. BC, body contouring; LAGB, laparoscopic adjustable gastric banding; RYGB, Roux-en-Y gastric bypass.

Table 5. BC Procedures Performed in Addition to Trunk-Based BC Procedure in Patients With Lipid Measurements

Procedure	All patients	Postbariatric	Non-bariatric	*P*-value
No. of patients	36	21	15	
Breast	7 (19.4%)	2 (9.5%)	5 (33.3%)	0.0752
Concurrent	3 (8.3%)	1 (4.8%)	2 (13.3%)	
Different time	4 (11.1%)	1 (4.8%)	3 (20.0%)	
Upper extremity	2 (5.6%)	2 (9.5%)	0 (0.0%)	0.2187
Concurrent	1 (2.8%)	1 (4.8%)	0 (0.0%)	
Different time	1 (2.8%)	1 (4.8%)	0 (0.0%)	
Lower extremity	4 (11.1%)	3 (14.3%)	1 (6.7%)	0.4733
Concurrent	3 (8.3%)	2 (9.5%)	1 (6.7%)	
Different time	1 (2.8%)	1 (4.8%)	0 (0.0%)	

Breast procedures typically involved a mastopexy or reduction, upper extremity most commonly a brachioplasty, and lower extremity refers to a thighplasty. "Different time" includes procedures performed prior to or after the trunk-based BC procedure. Percentages in the postbariatric and non-bariatric columns are proportional to the total number of patients in each cohort. The *P*-values distinguish significance between postbariatric and non-bariatric patients who underwent BC of one of these areas, either at the same time or at a separate time from the trunk-based BC procedure. BC, body contouring.

Marfella et al, demonstrated statistically significant improvements in TG levels after abdominoplasty.[10,12] The previously referenced meta-analysis did not report significant changes for any lipid levels.[16] The variability in follow-up timeline, inclusion criteria, and laboratory assessment make it difficult to draw reliable conclusions from these collective results.

In our study population, nonbariatric patients generally experienced more favorable changes in lipid profile following trunk-based BC than did postbariatric patients. TC levels trended in opposite directions for the 2 cohorts over the nearly 41-month follow-up period: a slight increase for postbariatric patients and a decrease for nonbariatric patients. Both postbariatric and nonbariatric patients experienced a decrease in LDL and an increase in HDL, VLDL, and TG. Baseline characteristics for age at time of BC and follow-up duration were significantly different between cohorts (Table 6). While the general comparative statistics evaluating lipid level changes did not reveal significant differences between cohorts, multivariable linear regression analyses accounting for age at time of BC revealed significant cohort differences regarding changes in TC, VLDL, and TG levels (Table 7).

Anecdotal evidence points to a consistent exercise regimen and diet adherence for the improvement in TC in the nonbariatric patients. However, further studies need to be performed to further elucidate these potential causative factors. Interestingly, most patients in both cohorts did not have pre-existing hypercholesterolemia or hypertriglyceridemia (Table 6).

Table 6. Lipid Levels Before and After BC Surgery

Characteristic	All patients	Postbariatric	Non-bariatric	*P*-value
No. of patients	36	21	15	
Age (year)	51.39 ± 11.25	54.48 ± 9.29	47.07 ± 12.60	0.0498*
Pre-BC measurements				
TC	180.14 ± 47.61	173.76 ± 42.33	189.07 ± 54.40	0.3490
LDL	105.00 ± 37.70	98.57 ± 32.08	114.00 ± 43.97	0.2969
HDL	51.42 ± 14.38	52.48 ± 15.08	49.93 ± 13.71	0.6080
VLDL	21.91 ± 10.31	18.67 ± 6.18	26.07 ± 13.05	0.0418*
TG	115.17 ± 73.07	108.71 ± 77.92	124.20 ± 67.26	0.3950
Weight (kg)	92.14 ± 29.83	93.50 ± 28.14	90.23 ± 32.96	0.4902
BMI (kg/m2)	34.11 ± 10.38	34.28 ± 10.11	33.87 ± 11.10	0.6883
Tissue resection weight (kg)[a]	5.58 ± 7.09	5.17 ± 5.11	6.17 ± 9.60	0.4832
Pre-BC to endpoint follow-up				
Follow-up time (mo)	40.89 ± 17.23	35.52 ± 15.29	48.40 ± 17.46	0.0248*
TC change	−1.42 ± 46.77	5.62 ± 38.23	−11.27 ± 56.59	0.4702
LDL change	−10.92 ± 37.09	−5.52 ± 28.42	−18.47 ± 46.70	0.5209
HDL change	6.81 ± 12.25	6.48 ± 13.75	7.27 ± 10.23	0.5308
VLDL change	3.32 ± 9.37	5.79 ± 10.54	0.14 ± 6.70	0.0912
TG change	20.28 ± 51.43	33.81 ± 58.97	1.33 ± 31.39	0.0607
%TWL	−0.03 ± 0.12	−0.04 ± 0.14	0.00 ± 0.07	0.3352

"Pre-BC" refers to measurements obtained immediately prior to BC surgery. Age is the average age of the patients in each cohort at the time of trunk-based BC surgery. "Tissue resection weight" refers only to the pannus resection weight. In the case of concurrent BC procedures, resection weights of anatomic regions outside than the trunk (ie, breast) were not available. "%TWL" refers to the percent total weight loss from pre-BC to endpoint follow-up ([weight loss]/[baseline pre-BC weight]). All lipid levels are measured in mg/dL. The *P*-values distinguish significance between postbariatric and non-bariatric patients. (*) denotes statistical significance. (a) 22 patients had tissue resection weights recorded: 13 postbariatric and 9 non-bariatric. BC, body contouring; HDL, high-density lipoprotein; LDL, low-density lipoprotein; lipoprotein; TC, total cholesterol; TG, triglyceride; TWL, total weight loss; VLDL, very low-density.

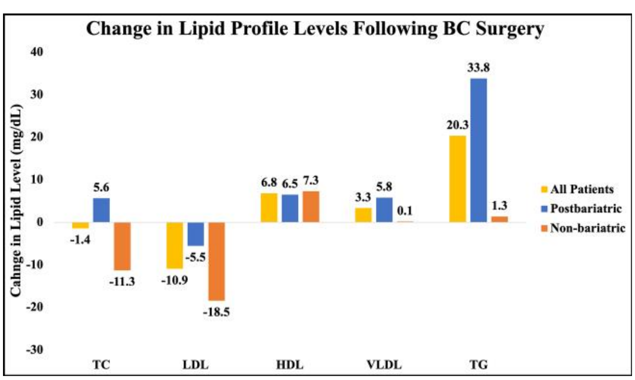

Figure 3. Lipid level changes following body contouring (BC) surgery. HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride; VLDL, very low-density lipoprotein.

Comparison with Liposuction

Numerous studies over the past 2 decades have evaluated the glucose and lipid trends following liposuction. Results differ depending on the diagnostic measurement (ie, homeostasis model assessment, fasting glucose, insulin-tolerance test, and hyperinsulinemic clamp).[22,23] Although a few of these studies report significant changes in certain lipid values, none report a significant decrease in LDL after large-volume liposuction. Several systematic reviews are comprised exclusively of liposuction studies without limitation to a specific anatomic region (ie, trunk), most of which have follow up of 3 months or less.[17–19,24] While these reviews address important questions, liposuction of multiple anatomic regions simultaneously may not reflect the same effects as dermatolipectomy. Thus, we

Table 7. Multivariable Linear Regression Analyses Accounting for Potential Confounding Variables Between Cohorts

Variable	Glucose	TC	LDL	HDL	VLDL	TG
%TWL	0.7419	0.2211	0.2488	0.9755	0.1436	0.0701
Age	0.4180	0.0320*	0.1641	0.9451	0.0193*	0.0164*
Tissue resection weight	0.7731	0.3112	0.3988	0.6723	0.1064	0.0725
Pre-BC weight	0.3653	0.2344	0.3547	0.6940	0.1171	0.0548
Pre-BC BMI	0.3537	0.2291	0.3454	0.8964	0.1285	0.0646
Follow-up time	0.4955	0.2789	0.5329	0.4982	0.1663	0.0944

P values for multivariable inear regression models assessing effect of %TWL, age at time of BC surgery, tissue resection weight, pre-BC weight, pre-BC BMI, and follow-up time on differences between cohorts in terms of change in outcomes. P values are listed for each variable analyzed. Those *P* values <0.05 indicate statistically significant differences in change in outcomes (ie, age and change in TC) between postbariatric and nonbariatric cohorts. Multivariable linear regression analyses were not performed for change in hemoglobin A1c since only 14 patients had these levels collected before and after BC surgery. "Tissue resection weight" refers only to the pannus resection weight. BC, body contouring; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride; TWL, total weight loss; VLDL, very low-density lipoprotein. *Statistical significance.

excluded liposuction-only patients in this study rather than comparing them with patients who undergo abdominoplasty or panniculectomy.

The Effects of Weight Control

Adipocytokines contribute to hunger and energy balance, highlighting the relationship between weight regain and metabolic levels.[6,8,15] Our report on weight control following BC showed that most patients (postbariatric and nonbariatric) tend to regain weight after achieving their low nadir following trunk-based BC.[20] Attaining proper weight control following BC may prevent long-term complications of metabolic syndrome and unfavorable changes in lipid profile.

When evaluating BC or BS outcomes, it is important to measure weight loss as %TWL.[25] The multivariable linear regression analyses (Table 7) in this study revealed no significant difference in change in glucose or lipid levels between cohorts when accounting for %TWL.

Limitations

Limitations of this study include the lack of a matched bariatric-only cohort, its retrospective nature, and potential confounding from additional BC procedures. The retrospective aspect minimally affected the quality of follow up, as the high prevalence of ongoing chronic disease in our patients required frequent visits within our health system and multiple opportunities to measure glucose and lipid levels in the years following BC surgery. The minimum 12-month follow-up period also ensured an acceptable follow-up length of all included patients. Although a small proportion (~10%) of patients had follow up between 12 and 18 months, the mean follow up was still greater than 3 years.

Comparing our patients to a matched cohort of patients who underwent BS without BC would make for an important comparative study. However, this is a separate investigation and requires different calculations from those performed for the current study, as it involves a different reference point (BS vs BC). There are many nonbariatric patients pursuing BC whose baseline values for glucose control and lipid metabolism are different than the postbariatric patients. Hence, we sought to evaluate the nonbariatric patients as well with a focus and reference time of BC surgery.

It is quite common for patients to undergo BC procedures of multiple anatomic areas. This inherently involves a greater weight of tissue resection than panniculectomy or abdominoplasty alone and could thus contribute to greater changes in glucose control or lipid metabolism. However, our experience is that most tissue resection weights from the upper extremity (brachioplasty), lower extremity (thighplasty), and breast (mastopexy or reduction) are negligible compared to the weight of the pannus. Still, there is potential for confounding since some patients with multiple BC procedures are included in the analysis.

Additional potential confounding variables exist in the baseline characteristics of our population. Both cohorts are comprised of predominantly perimenopausal females who commonly experience weight gain and difficulty maintaining consistent glucose levels and lipid profiles. The high baseline BMI and general health of our geographic region are also important to consider, as the lifestyle habits of our culture can further encumber optimal glucose control and lipid metabolism. The multivariable linear regression models account for these baseline variations and reveal significant differences between cohorts in terms of TC, VLDL, and TG when accounting for age. Still, prospective clinical trials controlling for these variables would better clarify the laboratory outcomes that can be anticipated following BC surgery.

CONCLUSIONS

Fasting glucose levels appear to marginally increase in most BC patients over long-term follow up, regardless of whether they have previously undergone BS. Nonbariatric patients generally experience more favorable changes in lipid profile following trunk-based BC than do postbariatric patients. These changes do not appear to be significantly affected by the weight loss maintained throughout follow up and may instead reflect a patient's adherence to diet and exercise. The follow up in this study is the longest of any similar study evaluating glucose control and metabolic syndrome following BC. Clarifying the expected trends in glucose control and lipid profile aids in preoperative counseling and management with these patients.

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