Research

Aesthetic Surgery Journal
2016, Vol 36(6) 718–729

DOI: 10.1093/asj/sjv268
www.aestheticsurgeryjournal.com
OXFORD UNIVERSITY PRESS

Safety of Aesthetic Surgery in the Overweight Patient: Analysis of 127,961 Patients

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Abstract

Background: Nearly 70% of US adults are overweight or obese (body mass index, BMI $\geq$ 25 kg/m^2), and more such patients are seeking aesthetic surgery. Previous studies have evaluated surgical risk in obese (BMI $\geq$ 30) or morbidly obese (BMI $\geq$ 40) patients, with mixed results.

Objectives: This study evaluates BMI 25 to 29.9 and BMI $\geq$ 30 as independent risk factors of major complications following aesthetic surgery in a large, prospective, multi-center database.

Methods: A prospective cohort of patients undergoing aesthetic surgery between 2008 and 2013 was identified from the CosmetAssure database (Birmingham, AL). BMI was evaluated as a risk factor for major complications, defined as complications requiring an emergency room visit, hospital admission, or reoperation within 30 days of the procedure. Multivariate analysis controlled for variables including age, gender, smoking, diabetes, combined procedures, and type of surgical facility.

Results: Of the 127,961 patients, 36.2% had BMI $\geq$ 25. Overweight patients were more likely to be male (12.5%), diabetic (3.3%), nonsmokers (92.8%), or have multiple procedures (41%). Complication rate steadily increased with BMI: 1.4% (BMI < 18.5); 1.6% (18.5-24.9); 2.3% (25-29.9); 3.1% (30-39.9); 4.2% ($\geq$40). Infection (0.8%), venous thromboembolism (VTE, 0.4%), and pulmonary dysfunction (0.2%) were twice as common among overweight patients. Incidence of hematoma was similar in the two groups (0.9%). Complications following abdominoplasty (3.5%), liposuction (0.9%), lower body lift (8.8%), or combined breast and body procedures (4.2%) were significantly higher in overweight patients. On multivariate analysis, being overweight (BMI 25-29.9) or obese (BMI $\geq$ 30) were independent predictors of any complication (Relative Risk, RR 1.17 and 1.51), especially infection (RR 1.63 and 2.73), and VTE (RR 1.67 and 2.56).

Conclusions: Overweight (BMI 25-29.9) and obesity (BMI $\geq$ 30) are both independent risk factors for post-operative infection and VTE in aesthetic surgery.

Level of Evidence: 2

Accepted for publication December 17, 2015; online publish-ahead-of-print February 9, 2016.

Obesity has become an epidemic in the United States. An estimated 69% of US adults are overweight (body mass index, BMI $\geq$ 25 kg/m^2), and 35.1% are obese (BMI $\geq$ 30).[1] BMI $\geq$ 25 is most prevalent among adults age 35 to 50 years (73%), the group which receives 38.8% of all cosmetic surgical procedures.[2] Obesity is associated with cardiovascular disease,[3-5] diabetes mellitus,[6] hypertension,[7] obstructive sleep apnea,[8] and increased infections.[9] Therefore, concern exists for increased perioperative morbidity and mortality when these patients undergo any type of surgery, and certainly elective aesthetic surgery.

There is a paucity of studies systematically examining risk factors and complications of aesthetic surgical procedures.

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Presented at: the 94th Annual Meeting of the American Association of Plastic Surgeons in Scottsdale, AZ in April 2015.

Nearly 1.9 million surgical aesthetic procedures were performed in 2013 at a cost of 7 billion dollars. Aesthetic surgery saw a 6.5% increase from 2012 to 2013.[10] Major complications are rare but can cause prolonged morbidity and significant financial burden as often aesthetic surgical complications are not covered by the patient's health insurance in the United States.

Previous studies have evaluated surgical risk in obese (BMI ≥ 30) or morbidly obese (BMI ≥ 40) patients. An analysis of National Surgical Quality Improvement Program (NSQIP) data found that obese patients undergoing non-bariatric general surgery had paradoxically lower mortality rates and only higher rates of morbidity with BMI ≥ 35.[11] A single institution study across all surgical specialties found obesity to be a risk factor for myocardial infarction, wound infection, and urinary tract infections while morbid obesity was a risk factor for mortality.[12] Obesity has been associated with increased costs in common outpatient plastic surgery operations,[13] surgical site complications in reduction mammaplasty,[14] and increased morbidity after abdominoplasty and facelifts.[15-17] However, there is a lack of data on risks associated with being overweight (BMI ≥ 25) on complications from aesthetic surgical procedures.

The primary objective of this study is to evaluate BMI 25 to 29.9 and BMI ≥ 30 as independent risk factors for major complications following aesthetic surgery using a large, prospective, multicenter database (CosmetAssure, Birmingham, AL). We also aim to define the prevalence of BMI ≥ 25 in patients undergoing aesthetic surgery procedures; compare incidence and type of complications in patients with BMI ≥ 25 to those with BMI < 25; and to identify specific procedures in which BMI ≥ 25 significantly increases risk of complications.

METHODS

The study population comprised of a cohort of patients who were prospectively enrolled into the CosmetAssure insurance program and underwent cosmetic surgical procedure(s) between May 2008 and May 2013. The database was accessed in February 2014, after approval by the Vanderbilt University Institutional Review Board (IRB #140082).

Database

CosmetAssure is an insurance program that covers the costs of unexpected major complications from 24 covered cosmetic surgical procedures, which may not be reimbursed by the patient's primary health insurer. CosmetAssure was introduced in 2003 and has been collecting data on patient risk factors since 2008. This insurance program covers all 50 states in the United States. It is available to American Board of Plastic Surgery (ABPS)-certified plastic surgeons and is endorsed by the American Society of Plastic Surgeons (ASPS) and the American Society for Aesthetic Plastic Surgery (ASAPS). The program is also available to ASPS Candidates for Membership who have passed the ABPS Written Examination. Every patient undergoing any covered procedure at participating practices is required to enroll in the program. Patients are entered in the database prior to undergoing the operation or occurrence of complication, thus making it a prospective cohort. Surgeon-reported major complications, filed as claims, are recorded in the database. Personnel employed by CosmetAssure enter data provided by the surgeon at the time of patient enrollment, as well as any claims filed by the surgeon. CosmetAssure, being a private insurance company, has a vested interest in maintaining an accurate database for actuarial and audit purposes.

Major complication is defined as that occurring within 30 days of the operation that requires hospital admission, emergency room visit, or a reoperation. This excludes complications that can be managed in clinic, such as minor wound infections and seromas, as they are not applicable for an insurance claim. The covered major complications include hematoma, infection, pulmonary dysfunction, cardiac complication, suspected or confirmed venous thromboembolism (VTE), myocardial infarction, and fluid overload. Other major complications (nerve injury, urinary retention, etc.) have been reported to CosmetAssure but may not qualify for compensation. The database lists all procedures performed on the patient, making it possible to study specific individual procedures as well as procedure combinations (ie, patients undergoing multiple procedures under the same anesthetic.). The database also records demographic and comorbidity data including age, gender, BMI, smoking, diabetes mellitus (DM), and type of surgical facility (accredited surgical centers, ASC; hospitals; and office-based surgical suites, OBSS).

Exposure

In this study cohort, primary exposure was defined as a patient being overweight (BMI ≥ 25) at the time of surgery. Obesity (BMI ≥ 30) and morbid obesity (BMI ≥ 40) were assessed as a secondary exposure to evaluate complication risk across strata of increasing BMI. The BMI thresholds were determined in accordance with the World Health Organization (WHO) definition (Figure 1).

Outcome

The primary outcome was occurrence of any major complication(s) (as defined above) within 30 days of the procedure. The secondary outcome studied was the type of complication (Figure 1).

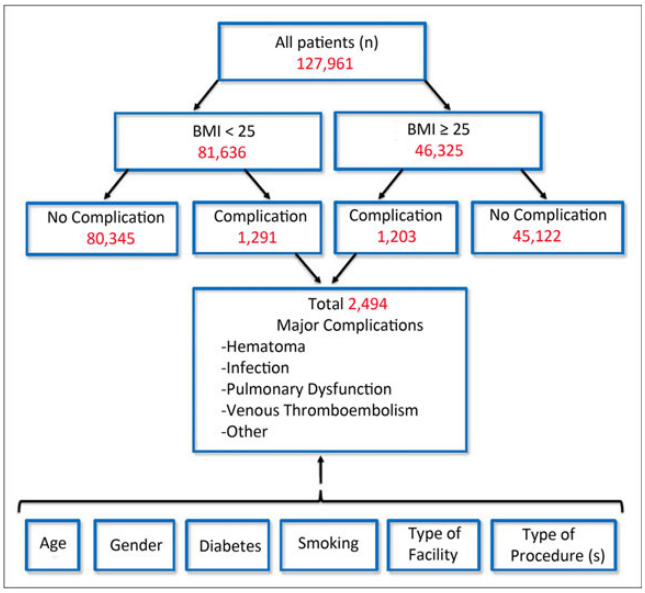

Figure 1. Study design.

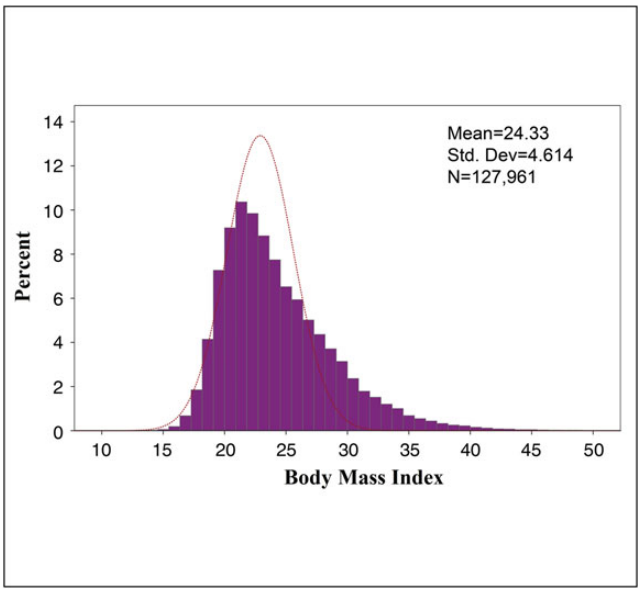

Figure 2. BMI distribution.

Demographic Variables and Surgical Procedures

Distribution of factors including age, gender, smoking, DM, and combined procedures were compared between the exposed (BMI ≥ 25) and non-exposed (BMI < 25) populations. The dataset included 24 unique cosmetic surgical procedures, and patients underwent anywhere from 1 to 7 procedures resulting in more than 700 procedure combinations. Thus, for the purpose of this study, we categorized all cosmetic procedures into 3 groups based on body region. These groups were face (blepharoplasty, browlift, cheek implant, chin augmentation, facelift, facial resurfacing, hair replacement, otoplasty, rhinoplasty), breast (augmentation, reduction, revisional breast implant procedures, mastopexy, male breast surgery), and body (abdominoplasty, brachioplasty, buttock lift, calf implant, labioplasty, liposuction, lower body lift, thigh lift, upper body lift). Patients who underwent more than one cosmetic procedure under the same anesthetic were considered to have combined procedures. In addition, we looked at outcomes in each of the 24 surgical procedures performed as a solitary procedure to offset the potential effect-modification from combining procedures.

Statistical Analysis

Two separate, limited, datasets were obtained from CosmetAssure, one with the enrollment data and other with claims information. The enrollment dataset contained entries for each unique procedure. Thus, a patient undergoing combined procedures had separate entries for each procedure. A unique identifier was created using variables; date of birth, date of surgery, and BMI. Using this unique identifier, the enrollment dataset was restructured such that a patient undergoing combined procedures was counted once with each of the procedures listed as a separate variable. Another unique identifier was created with variables shared between the enrollment and claims datasets; date of birth, date of surgery and gender. This identifier was then used to match the claims dataset to the restructured enrollment dataset. Of the 2506 patients in the claims dataset, 20 did not match to the enrollment data using the identifier. These cases were manually matched to enrollee's with closest demographic characteristics. Kolmogorov-Smirnov statistic was used to check normal distribution of continuous variables; age, and BMI. The only missing data were absent BMI information for 1046 (0.8%) patients. Due to lack of exposure data, these patients were excluded from the analysis. Patient characteristics, risk factors and complication rates between patients undergoing different procedure combinations were compared by two-tailed t test, Fisher exact test or by Pearson chi-square tests. Standard logistic regression analysis was performed to evaluate BMI 25 to 29.9 and BMI ≥ 30 as an independent risk factor for postoperative complications. For this purpose, BMI categories were coded into 2 dummy variables one each for BMI 25 to 29.9 and BMI ≥ 30 with BMI < 25 being the reference category. Outcomes were reported as 30-day incidence rates after the surgery. Unless otherwise noted, probability of type I error of less than 5% ($P < .05$) was used to determine statistical significance. All analyses were performed using IBM SPSS Statistics 23.0 software (IBM Corporation, Armonk, NY).

Table 1. Clinical and Demographic Characteristics of Normal and Overweight Patients

Characteristic	Patient groups (%)			*P* value
	Total *(n = 127,961)*	BMI < 25 *(n = 81,636)*	BMI ≥ 25 *(n = 46,325)*	
Age (mean ± SD)	40.9 ± 13.9	39.2 ± 13.7	43.9 ± 13.8	<.01
Gender (Male)	8280 (6.5%)	2478 (3.0%)	5802 (12.5%)	<.01
Smoking	10,524 (8.2%)	7187 (8.8%)	3337 (7.2%)	<.01
Diabetes	2346 (1.8%)	822 (1.0%)	1524 (3.3%)	<.01
Type of facility				<.01
Office based Surgery suite	20,387 (15.9%)	12,929 (15.8%)	7458 (16.1%)	
Ambulatory surgery center	73,402 (57.4%)	49,020 (60.1%)	24,382 (52.6%)	
Hospital	34,172 (26.7%)	19,687 (24.1%)	14,485 (31.3%)	<.01
Combined procedures	41,523 (32.4%)	22,552 (27.6%)	18,971 (41.0%)	<.01
Any body procedures	48,083 (37.6%)	20,682 (25.3%)	27,401 (59.1%)	<.01
Complication rate	2494 (1.95%)	1291 (1.58%)	1203 (2.60%)	<.01

BMI, body mass index; SD, standard deviation.

Table 2. BMI Categories

Body mass index (BMI kg/m^2)	Number of patients	Percent
<18.5	5175	4.0
18.5-24.9	76,511	59.8
25.0-29.9	32,167	25.1
30.0-39.9	13,251	10.4
≥40.0	907	0.7

RESULTS

Clinical and Demographic Characteristics

Between May 2008 and May 2013, a total of 183,914 cosmetic surgery procedures were performed on 129,007 patients enrolled into the CosmetAssure program. Of these, 127,961 (99.2%) patients who had BMI information available formed our study sample. Overall, the mean age was 40.9 ± 13.9 years (range, 5-93 years), BMI 24.3 ± 4.6 kg/m^2 (Range, 17.0-56.3 kg/m^2), and the majority of patients were women (93.5%) (Table 1). Of these, 46,325 (36.2%) were overweight with BMI ≥ 25, with 13,251 (11.1%) having a BMI ≥ 30. The BMI distribution of the study sample is depicted in Figure 2 and Table 2. The overweight cohort of patients (BMI ≥ 25) had a mean age of 43.9 ± 13.8 years (range, 16-82 years) and mean BMI of 29.1 ± 3.9 kg/m^2 (range, 25.0-56.3 kg/m^2). This group consisted of more men (12.5% vs 3.0%, $P < .01$), diabetic (3.3% vs 1.0%, $P < .01$) and older (age ≥ 40 years) patients (60.4% vs 45.5%, $P < .01$) compared to the normal-weight patients. There were fewer smokers in the overweight group (7.2% vs 8.8%, $P < .01$) (Table 1).

Surgical Characteristics

The percentage of BMI ≥ 25 patients had a modest, but statistically significant, increase from 35.7% in 2008 to 38.2% in 2013. Table 3 demonstrates the frequency distribution of various aesthetic surgical procedures, performed as solitary or combined procedures, among overweight patients. Overweight patients underwent more body procedures (59.1% vs 25.3%, $P < .01$) but fewer breast procedures (39.4% vs 67.0%, $P < .01$) compared to BMI < 25 patients. The number of face procedures was similar (19.0% vs 19.6%, $P < .01$) between the two groups. The most common single procedures among overweight patients were liposuction (23.5%) and abdominoplasty (19.3%), in contrast to non-overweight patients who most frequently underwent breast augmentation (61.7%) (Figure 3). Overweight patients were also more likely to undergo combined procedures (41.0% vs 27.6%, $P < .01$).

Analysis of Complications

Among all patients, 2494 (1.95%) had a major complication (Figure 1). Within these, 114 developed multiple complications. Overweight patients had a 2.60% incidence of major complications, significantly higher than 1.58% observed in normal-weight patients (Table 1). On univariate analysis, infection (0.80% vs 0.28%, $P < .01$), pulmonary complication (0.19% vs 0.09%, $P < .01$), fluid overload (0.09% vs 0.04%, $P < .01$), hypotension (0.08% vs 0.03%, $P < .01$), and suspected VTE (0.26% vs 0.12%, $P < .01$) or confirmed VTE (0.17% vs

Table 3. Frequency of Different Cosmetic Procedures in Normal and Overweight Patients

Procedure	Patient groups, n (%)			*P* value
	Total *(n = 127,961)*	BMI < 25 *(n = 81,636)*	BMI ≥ 25 *(n = 46,325)*	
Face	24,853 (19.4%)	16,041 (19.6%)	8,812 (19.0%)	<.01
Face lift	11,240 (8.8%)	6908 (8.5%)	4332 (9.4%)	<.01
Blepharoplasty	11,948 (9.3%)	7012 (8.6%)	4936 (10.7%)	<.01
Brow lift	3867 (3.0%)	2491 (3.1%)	1376 (3.0%)	.424
Rhinoplasty	4,941 (3.9%)	3,854 (4.7%)	1,087 (2.3%)	<.01
Cheek augmentation	159 (0.12%)	116 (0.14%)	43 (0.09%)	.018
Chin augmentation	798 (0.6%)	523 (0.6%)	275 (0.6%)	.319
Otoplasty	808 (0.6%)	671 (0.8%)	137 (0.3%)	<.01
Hair restoration	5 (0.003%)	0 (0.0%)	5 (0.01%)	<.01
Breast	72,990 (57.0%)	54,715 (67.0%)	18,275 (39.4%)	<.01
Breast augmentation	59,377 (46.4%)	48,891 (60.0%)	10,486 (22.6%)	<.01
Mastopexy	19,135 (15.0%)	11,810 (14.5%)	7325 (15.8%)	<.01
Reduction Mammaplasty	4939 (3.9%)	1783 (2.2%)	3156 (6.8%)	<.01
Correction gynecomastia	2081 (1.6%)	554 (0.7%)	1527 (3.3%)	<.01
Body	48,083 (37.6%)	20,682 (25.3%)	27401 (59.1%)	<.01
Liposuction	30,750 (24.0%)	13,259 (16.2%)	17,491 (37.8%)	<.01
Abdominoplasty	25,261 (19.7%)	10,575 (13.0%)	14,686 (31.7%)	<.01
Brachioplasty	2275 (1.8%)	559 (0.7%)	1716 (3.7%)	<.01
Thigh lift	1476 (1.2%)	486 (0.6%)	990 (2.1%)	<.01
Lower body lift	1283 (1.0%)	363 (0.4%)	920 (2.0%)	<.01
Buttock lift	1564 (1.2%)	495 (0.6%)	1069 (2.3%)	<.01
Upper body lift	56 (0.04%)	9 (0.01%)	47 (0.1%)	<.01
Labiaplasty	84 (0.1%)	70 (0.1%)	14 (0.03%)	<.01

Sum of percentages of different body regions exceeds 100 because nearly one third of patients underwent more than one procedure. For the same reason, sum of percentages within a given body region may exceed the total percent for that body region.

0.04%, $P < .01$) were significantly higher among overweight patients. Hematoma rate was similar between groups (0.95% vs 0.90%, $P = .43$). (Table 4).

Complication rates further increased with Class I-II (BMI 30.0-39.9) and Class III (BMI ≥ 40) obesity (Figure 4).

Association Between BMI and Complications in Different Aesthetic Procedures

When stratified by the body region being operated (breast, body, face, or any combination of regions), overweight patients had significantly higher complications in body (3.1% vs 2.0%, $P < .01$), breast (1.7% vs 1.4%, $P = .014$), and breast/body combination cases (4.2% vs 3.1%, $P = .001$) (Table 5). Similarly, in other regions overweight patients suffered more complications though the difference was not statistically significant.

Association between BMI and complications following commonly performed procedures is shown in Table 6. Overweight patients suffered higher complication rates in abdominoplasty (3.5% vs 2.6%, $P = .011$), liposuction (0.9% vs 0.5%, $P = .044$), combination abdominoplasty-liposuction (4.3% vs 3.0%, $P = .01$), and lower body lifts (8.8% vs 3.2%, $P = .04$). No specific breast procedure was identified where

BMI significantly increased risk. Overweight patients who underwent breast augmentation-mastopexy-abdominoplasty-liposuction combination had more complications (6.0% vs 3.0%, $P = .022$).

Association Between BMI and Diabetes

As previously noted, diabetes is more prevalent in overweight patients (3.3% vs 1.0%, $P < .01$). We performed stratified analysis across 3 BMI categories – normal weight (BMI < 25), overweight (BMI 25-29.9), and obese (BMI ≥ 30). We found that the significant association between diabetes and complications was limited only to obese patients (5.2% vs 3.1%, $P < .01$) (Figure 5). This finding was replicated when we specifically looked at infections (2.5% vs 1.1%, $P < .01$) and pulmonary complications (2.5% vs 1.1%, $P = .02$). Since diabetes and obesity often co-exist, they may have a synergistic effect on complications.

BMI as an Independent Risk Factor for Major Complications

In addition to the stratified analysis to identify potential confounders, we performed multivariate logistic regression analysis to evaluate BMI as an independent risk factor after controlling for the effect of age, smoking, diabetes, gender, type of procedures, and surgical facility. We found BMI 25 to 29.9 to be an independent risk factor of any complication (relative risk 1.17, 95% confidence interval 1.06-1.28, $P < .01$) (Table 7), infection (relative risk 1.63, 95% confidence interval 1.34-1.99, $P < .01$) (Table 8), and VTE (relative risk 1.67, 95% confidence

Table 4. Distribution of Complications Between Normal and Overweight Patients

Complication	Patient groups, n (%)			*P* value
	Total (*n* = 127,961)	BMI < 25 (*n* = 81,636)	BMI ≥ 25 (*n* = 46,325)	
Hematoma	1176 (0.9%)	737 (0.9%)	439 (0.9%)	.43
Infection	598 (0.5%)	228 (0.3%)	370 (0.8%)	<.01
Pulmonary	163 (0.13%)	74 (0.09%)	89 (0.19%)	<.01
Confirmed VTE	116 (0.09%)	36 (0.04%)	80 (0.17%)	<.01
Suspected VTE	218 (0.2%)	98 (0.12%)	120 (0.26%)	<.01
Fluid Overload	76 (0.06%)	35 (0.04%)	41 (0.09%)	<.01
Hypotension	57 (0.04%)	21 (0.03%)	36 (0.08%)	<.01
Cardiac	36 (0.03%)	21 (0.03%)	15 (0.03%)	.50

VTE, venous thromboembolism.

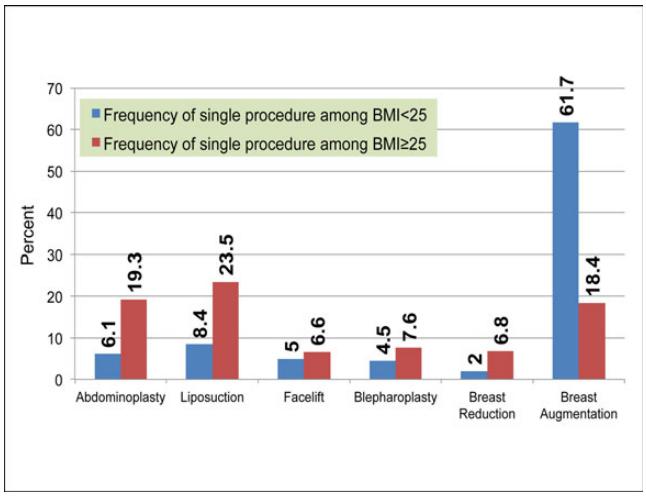

Figure 3. Frequency of solitary procedures among normal and overweight patients.

Table 5. Univariate Analysis of Association between BMI and Complications Following Procedures on Different Body Regions

Procedure	Frequency	Complications, n (%)			*P* value
		Total	BMI < 25	BMI ≥ 25	
Body	31,869	860 (2.7%)	250 (2.0%)	610 (3.1%)	<.01
Breast	57,813	850 (1.5%)	654 (1.4%)	196 (1.7%)	.014
Breast-body	13,324	482 (3.6%)	211 (3.1%)	271 (4.2%)	<.01
Face	20,548	225 (1.1%)	136 (1.0%)	89 (1.2%)	.181
Face-body	2452	43 (1.8%)	17 (1.3%)	26 (2.2%)	.090
Face-breast	1415	24 (1.7%)	19 (1.7%)	5 (1.9%)	.795
Face-breast-Body	438	10 (2.3%)	4 (1.4%)	6 (3.8%)	.177

Table 6. Univariate Analysis of Association between BMI and Complications Following Selected, Frequently Performed, Cosmetic Procedures

Procedure	Frequency	Complications, n (%)			*P* value
		Total	BMI < 25	BMI ≥ 25	
Breast augmentation	41,506	581 (1.4%)	499 (1.4%)	82 (1.6%)	.138
Liposuction	11,403	81 (0.7%)	26 (0.5%)	55 (0.9%)	.044
Abdominoplasty	8915	280 (3.1%)	93 (2.6%)	187 (3.5%)	.011
Breast augmentation - Mastopexy	8014	151 (1.9%)	107 (1.8%)	44 (2.2%)	.300
Abdominoplasty - Liposuction	6873	264 (3.8%)	71 (3.0%)	193 (4.3%)	.01
Blepharoplasty	4739	19 (0.4%)	13 (0.5%)	6 (0.3%)	.357
Facelift	4780	71 (1.5%)	42 (1.4%)	29 (1.6%)	.622
Mastopexy	3365	39 (1.1%)	25 (1.2%)	14 (1.1%)	.895
Facelift – Blepharoplasty	2562	60 (2.3%)	28 (1.9%)	32 (3.0%)	.062
Breast Augmentation - Abdominoplasty	1708	60 (3.5%)	48 (3.7%)	12 (2.8%)	.448
Brachioplasty	7587	10 (1.3%)	2 (1.2%)	8 (1.4%)	.867
Lower Body Lift	419	30 (7.2%)	4 (3.2%)	26 (8.8%)	.04
Thigh Lift	413	19 (4.6%)	5 (3.9%)	14 (5.1%)	.617

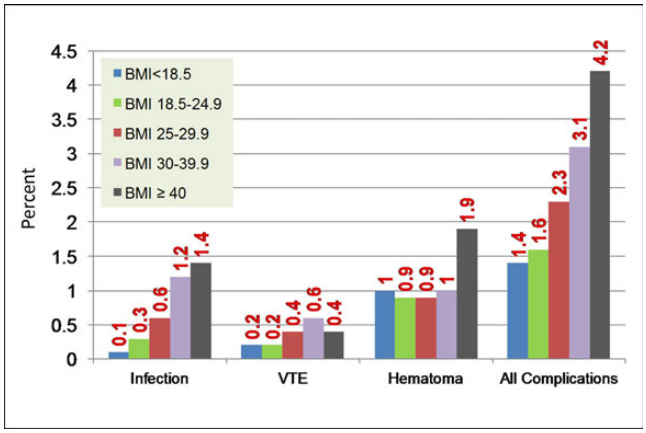

Figure 4. Complications stratified by BMI category.

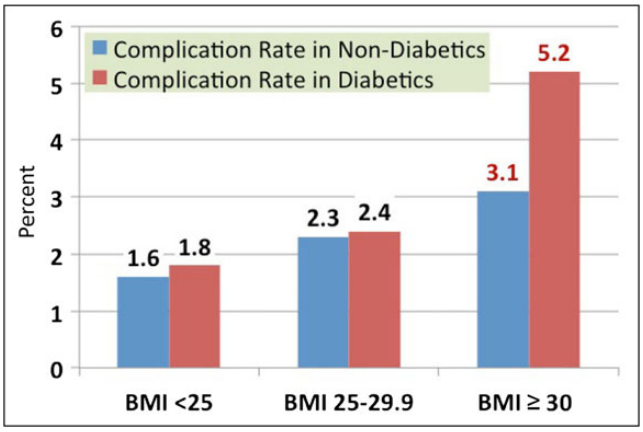

Figure 5. Univariate analysis of association between diabetes and all major complications, stratified by BMI categories.

interval 1.07-2.61, $P < .01$) (Table 9). There was a trend of higher pulmonary complications in patients with BMI 25- to 29.9, but it did not reach statistical significance (relative risk 1.40, 95% confidence interval 0.98-2.01, $P = .07$) (Table 10).

We found that BMI ≥ 30 was associated with even higher risk of these complications. BMI ≥ 30 increased risk of any complication (relative risk 1.51, 95% confidence interval 1.34-1.69, $P < .01$) (Table 7), infection (relative risk 2.73, 95% confidence interval 2.20-3.38, $P < .01$) (Table 8), and VTE (relative risk 2.56, 95% confidence interval 1.60-4.14, $P < .01$) (Table 9).

DISCUSSION

The prevalence of overweight patients undergoing aesthetic surgery is lower than the national prevalence. In our cohort, 36.2% were overweight or obese (BMI ≥ 25)

Table 7. Multivariate Logistic Regression Analysis of Any Complication ($n = 2494$)

	Relative risk	95% CI		*P*-value
Combined procedure	1.67	1.54	1.82	<.01
Body procedures	1.64	1.50	1.79	<.01
Smoking	1.18	1.02	1.36	.02
Diabetes	1.31	1.03	1.66	.03
BMI 25-29.9[a]	1.17	1.06	1.28	<.01
BMI ≥ 30[a]	1.51	1.34	1.69	<.01
Age	1.01	1.004	1.01	<.01
Type of facility (ASC-hospital)	1.56	1.36	1.77	<.01
Gender (female)	0.95	0.81	1.11	.49

ASC, Ambulatory Surgery Center; BMI, Body Mass Index; CI, Confidence Interval. [a]Reference category BMI < 25 kg/m^2.

Table 8. Multivariate Logistic Regression Analysis of Infection ($n = 598$)

	Relative risk	95% CI		*P*-value
Combined procedure	1.83	1.54	2.17	<.01
Body procedures	2.73	2.25	3.31	<.01
Smoking	1.59	1.22	2.07	<.01
Diabetes	1.73	1.17	2.57	<.01
BMI 25-29.9[a]	1.63	1.34	1.99	<.01
BMI ≥ 30[a]	2.73	2.20	3.38	<.01
Age	1.01	1.003	1.02	<.04
Type of facility (ASC-hospital)	1.41	1.09	1.81	.01
Gender (female)	1.87	1.25	2.81	<.01

ASC, Ambulatory Surgery Center; BMI, Body Mass Index; CI, Confidence Interval. [a]Reference category BMI < 25 kg/m^2.

Table 9. Multivariate Logistic Regression Analysis of Confirmed Venous Thromboembolism ($n = 116$)

	Relative risk	95% CI		*P*-value
Combined procedure	2.32	1.55	3.49	<.01
Body procedures	13.40	6.39	28.09	<.01
Smoking	0.56	0.21	1.53	.26
Diabetes	0.28	0.04	2.00	.20
BMI 25-29.9[a]	1.67	1.07	2.61	<.01
BMI ≥ 30[a]	2.56	1.60	4.14	<.01
Age	1.02	1.006	1.037	<.01
Type of facility (ASC-hospital)	1.27	0.73	2.22	.40
Gender (female)	2.16	0.79	5.88	.13

ASC, Ambulatory Surgery Center; BMI, Body Mass Index; CI, Confidence Interval. [a]Reference category BMI < 25 kg/m^2.

Table 10. Multivariate Logistic Regression Analysis of Pulmonary Complications ($n = 163$)

	Relative risk	95% CI		*P*-value
Combined procedure	1.62	1.17	2.24	<.01
Body procedures	2.21	1.55	3.14	<.01
Smoking	0.98	0.53	1.82	.96
Diabetes	1.91	0.93	3.92	.08
BMI 25-29.9[a]	1.40	0.98	2.01	.07
BMI ≥ 30[a]	1.52	0.97	2.34	.07
Age	1.02	1.01	1.03	<.01
Type of facility (ASC-hospital)	1.27	0.80	2.01	.31
Gender (female)	1.49	0.72	3.05	.28

ASC, Ambulatory Surgery Center; BMI, Body Mass Index; CI, Confidence Interval. [a]Reference category BMI < 25 kg/m^2.

compared to a national prevalence of 69%. Additionally, only 11.1% were obese (BMI ≥ 30), compared to a national prevalence of 35.1%. This observed difference may due to patients who are overweight or obese being less likely to seek out aesthetic surgery or surgeons being careful about offering elective surgery to those who are overweight or obese. Despite the disparity, this group represents a large minority of those undergoing aesthetic surgery. Our prospective analysis highlights outcomes of overweight patients undergoing aesthetic surgery, and specifically reveals that BMI is an independent risk factor for major complications, specifically infection and VTE.

A novel finding in our study was that both BMI 25 to 29.9 and greater than 30 were independent risk factors for complications. This establishes an increased risk for obese patients and overweight patients, who together make up the majority of the US population. Increased risk in the obese population confirmed our suspicion that obese patients were more prone to complications. However, the fact that BMI 25 to 29.9 is an independent risk factor is an

interesting finding. It establishes that any excess adipose tissue elevates risk.

Mechanisms by which obesity affects surgical morbidity and mortality are not entirely clear. Studies have shown improvement in associated comorbidities such as diabetes,[18] hypertension,[19] coronary artery disease,[20] and obstructive sleep apnea[21] with weight loss. One potential theory is that a pro-inflammatory state is promoted by extra adipose tissue, which contributes to the pathogenesis of the aforementioned comorbidities.[22] This pro-inflammatory state may foster an environment that makes patients susceptible to injury in times of stress such as surgery or trauma. A large series of trauma patients revealed obesity to be an independent risk factor for multi-organ failure.[23] With these findings, it is warranted to consider obesity a systemic disease.

While systemic effects of obesity are not well understood, local wound complications in obesity have been well documented. Reviews of abdominoplasty and breast reduction have found higher rates of wound dehiscence and seroma in obese patients.[24-26] The postulated mechanisms for wound complications in the obese are secondary to the delicate nature, avascularity, increased oxidative stress, and poor nutrient availability inherent to adipose tissue.[27] This class of wound complications is likely underreported in our database secondary to the fact they were predominantly managed in a clinic setting.

However, our analysis did reveal increased infection rates in overweight patients and even higher infection rates in obese and morbidly obese patients. This finding is not surprising given poor wound healing leads to high infection rates. The association of obesity and wound infection has been demonstrated across surgical fields[11] as well as in elective breast surgery[28,29] and abdominoplasty.[26] Unfortunately, our database did not include information on prophylactic antibiotic use. However, the American Association of Plastic Surgeons recently released a consensus statement recommending prophylactic antibiotics for clean breast surgery and contaminated cases of the hand and head/neck but not abdominoplasty.[30] Given higher rates of infection in obesity, the use of prophylactic antibiotics may be warranted in higher risk patients and needs further investigation.

Obesity and VTE have a known relationship that has been demonstrated in many studies.[31,32] No universal guidelines for deep vein thrombosis prevention exist, but most advocate risk stratifying patients to determine risk and prevention strategy.[33] The most commonly used tool is the Caprini risk assessment model, which has been validated for use in plastic and reconstructive surgery patients.[34] Unfortunately, our database did not provide us with types of prophylaxis used in patients. However, a 2007 survey of plastic surgeons revealed low rates of VTE prophylaxis usage.[35] Interestingly, our data showed near double risk of VTE in overweight patients compared to normal weight patients. Thus, BMI $\geq$ 25 may be used as a threshold when considering pharmacological VTE prophylaxis. The best approach to deep VTE is risk reduction with appropriate prophylaxis and early ambulation, especially in the obese population.

Our univariate analysis found a higher prevalence of respiratory complications in overweight patients. Respiratory complications are likely multifactorial and may be the result of interplay between comorbidities such as obesity and obstructive sleep apnea (OSA). There is an established relationship between obesity and OSA, and it is common for OSA to be undiagnosed. Patients with OSA are at risk for acute respiratory failure and postoperative oxygen desaturation.[36] The use of general anesthesia may also increase risk of respiratory complications. Postoperative respiratory complications have been observed in patients with obstructive sleep apnea undergoing general anesthesia.[37] However, choice of anesthetic was not associated with early complications after hand surgery in the NSQIP database.[38] Unfortunately, information on anesthetic technique was not available for our analysis. Respiratory complications in the cosmetic surgery population are rare but can be devastating. Proper preoperative evaluation of obesity and associated comorbidities is imperative to help reduce this risk.

Rates of fluid overload and hypotension were higher in overweight patients compared to normal weight patients. The prevalence in both groups was low, but the higher incidence in overweight patients could be explained by higher rates of abdominoplasty and liposuction in this patient group. Fluid management in abdominoplasty and liposuction can be more challenging than other aesthetic procedures due to larger volume losses. Missteps in anesthesia can easily lead to fluid overload or hypovolemia which can manifest as hypotension. Fluid overload has even been associated with VTE and pulmonary complications,[39] which were observed to have higher rates in overweight patients in our study. Though the prevalence of fluid overload and hypotension is low in aesthetic surgery, peri- and intraoperative fluid management is an important aspect of surgical care that needs meticulous management by surgeons and anesthesiologists.

Obesity and its associated comorbidities lead to increased surgical morbidity and mortality. Our analysis found both BMI 25 to 29.9 and greater than 30 to be independent risk factors for any complication as well as infection and VTE. Though obesity-related illnesses such as diabetes and coronary artery disease play a role in adverse outcomes, being overweight or obese alone increases risk. Our data revealed that diabetics with higher BMI suffered more complications including infection and respiratory complications. Specifically, obesity has been notorious as a risk factor for wound complications and deep venous thrombosis across all surgical fields, and it is apparent that it holds true in aesthetic surgery as well.

We observed that overweight patients had more complications for body, breast, and combination body and breast cases. Our database also revealed that high BMI is a risk factor in abdominoplasty, liposuction, and lower body lifts.

Multiple reviews have previously found obesity to be a risk factor for wound complications in abdominoplasty.[24-26,40] However, obesity was not a risk factor for complications in combination breast and abdominoplasty in one large series.[41] Our study included examining more than 700 procedure combinations, but it is difficult to report the effect on every permutation. For simplicity, we have grouped the procedures by body region to give an overall picture. We found that procedures on breast or face have lower complications than procedures on the rest of the body. We have also reported complications in specific, frequently performed, procedures or combinations (Table 6). Surgeons should be aware of increased complications in the overweight patients for these procedures, and appropriate risk reduction strategies should be implemented.

The best risk reduction strategy may be weight loss, but this has not been evaluated as a strategy in plastic surgery. Bariatric surgery for weight loss in certain patients is becoming more widely accepted when diet and exercise are not enough, but there is no evidence to support this strategy. Encouraging healthy living and implementing our best known risk reduction strategies such as VTE or antibiotic prophylaxis when appropriate are the best tools we have currently.

To the best of our knowledge this study represents the largest investigation looking at the effect of BMI on complications of aesthetic surgery procedures. The CosmetAssure insurance database is a powerful tool for assessment of clinical outcomes of cosmetic surgery. It provides prospectively collected data, which is necessary for determining true incidence of complications and risk factors. It is a multicenter database encompassing hospitals, ASCs and OBSS, making the results generalizable to a wide variety of practice models. It is robust in establishing baseline complication rates following various procedure combinations. Since CosmetAssure offers significant incentive to a surgeon for reporting a complication, in the form of payment of the claim, this database offers major advantage over other registries by potentially minimizing the under-reporting of complications. In addition, the dataset is validated by similar patient profiles as that reported by ASAPS.[2] The relative frequency of procedures is different as the ASAPS estimate reports are based on data not only from plastic surgeons, but also from otolaryngologists and dermatologists. CosmetAssure offers coverage across all 50 states in the United States. Even if CosmetAssure is more commonly used in certain regions of the country, this is unlikely to affect the effect size of risk factors, thus maintaining the internal validity of the study. The study of geographical variation in demographics of facelift patients is beyond the scope of the current study. The database goes a step further by establishing the minimum surgeon qualifications (plastic surgeons who are certified or are candidates for certification by the ABPS), thus avoiding variability in complications attributable to the credentials of the healthcare provider.

While the CosmetAssure database has many advantages, some of its limitations merit discussion. The database fails to include minor, but clinically significant, complications (minor infection, wound breakdown, seroma etc.) since these are managed in the clinic and do not require hospitalization, emergency room visit or reoperation and therefore, do not generate a reimbursable claim. These complications are significantly more common than major complications, and important in cosmetic outcomes and patient perceived results. The database does not register complications occurring after 30 days of the operation. This results in unknown final outcomes after the management of these complications. The database does not differentiate between different techniques of a particular procedure which may predispose patients to certain complications. No information is available on measures such as ASA class, VTE prophylaxis, preoperative antibiotics, intraoperative temperature and blood pressure management, and duration of surgery, and thus their impact cannot be analyzed.

The database also lacks comprehensive information about patients' other comorbidities. Obesity is associated with multiple comorbid conditions such as coronary heart disease, hypertension, dyslipidemia, and fatty liver disease, which may contribute to surgical risk. However, assessment of available health conditions (diabetes, obesity, and smoking) suggest that the patient population seeking cosmetic surgery is significantly healthier compared to the general population of the United States, with low burden of comorbid conditions. Even though management of these major complications incur significant costs, it is possible that the plastic surgeon may write it off or be compensated by patient's primary health insurance provider. Either of these scenarios, though very unlikely, may lead to under-reporting of major complications to CosmetAssure. Finally, CosmetAssure is used by only a fraction of eligible plastic surgeons in the United States.

A statistical limitation of using a cohort study design for examining risk factors in aesthetic surgery is that major complications are rare. Even with such a large cohort, infrequent complications such as cardiac events (0.03%) cannot be comprehensively studied. Moreover, the BMI data were not available for 1046 (0.8%) patients. It is possible that this additional data could have allowed us to better evaluate any association between BMI and pulmonary complications.

Despite this study's limitations, our review provides an insight into the complication rates overweight and obese patients face in cosmetic surgery. One of our stated objectives was to define the prevalence of overweight patients undergoing aesthetic surgery, which we found to be 36.2%. As expected, overall complication rates are higher in overweight and obese patients, especially with regards to infections and deep venous thrombosis rates. Another stated objective was to identify specific procedures in which BMI $\geq$ 25 significantly

increases risk of complications, which was found to be abdominoplasty, liposuction, and lower body lifts. Obesity is a modifiable risk factor, and further studies are needed to investigate if an advantage of preoperative weight loss exists. Both providers and patients should be aware of the increased risk in patients with higher BMI as well as strategies to reduce that risk.

CONCLUSION

The prevalence of overweight and obese patients in aesthetic surgery patients is lower than the general population but represents a significant minority in aesthetic surgery. Overweight patients are more likely to undergo combined procedures than normal weight patients. Abdominoplasty, liposuction, and lower body lifts are procedures with higher complication rates in overweight patients. BMI 25 to 29.9 and BMI $\geq$ 30 are independent risk factors of major complications, particularly infection and deep venous thrombosis, after aesthetic surgical procedures.

Disclosures

Dr Grotting is a founder and shareholder of CosmetAssure (Birmingham, AL). He also receives book royalties from Quality Medical Publishing (St. Louis, MO) and Elsevier (New York, NY), and is a shareholder in Keller Medical, Inc. (Stuart, FL) and Ideal Implant, Inc. (Dallas, TX). The other authors have nothing to disclose.

Funding

The authors received no financial support for the research, authorship, and publication of this article.

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