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Incidence and Risk Factors for Major Surgical Site Infections in Aesthetic Surgery: Analysis of 129,007 Patients

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Abstract

Background: Surgical site infections (SSIs) represent one of the most common postoperative complications in patients undergoing aesthetic surgery.
Objectives: This study reports the incidence and risk factors of major SSIs following aesthetic surgery.
Methods: A prospective cohort of patients who underwent aesthetic surgery between 2008 and 2013 was identified from the CosmetAssure database. Primary outcome was occurrence of a major SSI requiring emergency room visit, hospital admission, or reoperation within 30 days of the index operation. Univariate and multivariate analysis evaluated potential risk factors for SSIs including age, gender, body mass index (BMI), smoking, diabetes, type of surgical facility, procedure by body region, and combined procedures.
Results: A total of 129,007 patients were identified, of which 599 (0.46%) had a major SSI. Mean age (43.8 ± 12.4 years vs 40.9 ± 13.9 years, $P < .01$) and BMI (27.3 ± 5.5 kg/m^2 vs 24.3 ± 4.6 kg/m^2, $P < .01$) were higher in patients with SSIs. Patients with a SSI were more likely to be smokers (10.5% vs 8.2%, $P = .04$) and diabetic (4.5% vs 1.8%, $P < .01$). Females suffered more SSI than males (0.5% vs 0.3%, $P = .02$). Trunk/extremity procedures had a higher incidence of SSI compared to breast or face procedures (0.9% vs 0.2%, $P < .01$). On multivariate analysis, independent predictors of SSI included age (Relative Risk [RR] 1.01), female gender (RR 1.86), BMI (RR 1.07), smoking (RR 1.61), diabetes (RR 1.58), hospital or ambulatory surgery center procedures (RR 1.39), trunk/extremity procedures (RR 2.42), and combined procedures (RR 1.88).
Conclusions: SSIs following cosmetic surgical procedures are associated with numerous independent predictors, which should be taken into consideration when counseling patients undergoing aesthetic surgery.

Level of Evidence: 2

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Aesthetic plastic surgery has seen an enormous growth in the United States, and demand continues to increase annually. According to the American Society for Aesthetic Plastic Surgery, 1.9 million cosmetic surgical procedures were performed in 2015, an increase of 94% since 1997.[1] Although the overall incidence of major complications after aesthetic procedures is low, it can result in a potentially devastating cosmetic outcome and pose significant financial burden on

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the patient and the surgeon. Surgical site infections (SSIs) remain one of the most commonly occurring postoperative complications.[2] Often, they are dealt with in the office setting, however, more severe cases may require emergency room visits, hospital admissions, or even reoperations.

The Centers for Disease Control and Prevention (CDC) defines a SSI as an infection related to an operative procedure that occurs at or near the surgical incision within 30 days of the procedure.[3] According to the US National Research Council, "clean" extra-abdominal operations have an overall infection incidence between 2% and 5%.[4] This is in contrast to intraabdominal operations, which carry a risk of developing a SSI up to 20%.[4] In the field of plastic and reconstructive surgery, and especially in regards to aesthetic surgical procedures, there is paucity of literature relating to postoperative SSIs. It has been noted that the incidence varies according to the specific operation performed and the presence of specific risk factors.[2] Without larger sample sizes and multi-institutional or multi-surgeon studies, it is difficult to come to generalizable conclusions from the available studies. In addition, to the best of our knowledge, minimal data exist with regards to which risk factors are most significant for the development of postoperative SSIs. Further research is required to better understand the risk factors that affect SSIs after cosmetic surgical procedures in an attempt to not only improve postoperative outcomes but also decrease healthcare expenditures.

This study queried the CosmetAssure (Aesthetic Surgeons' Financial Group, Birmingham, AL) insurance database to determine the incidence of SSIs amongst some of the most commonly performed cosmetic procedures and amongst different procedure combinations. Additional goals were to delineate significant risk factors for postoperative SSIs after aesthetic surgery. We hypothesized that modifiable risk factors play an important role in the development of postoperative SSIs in patients undergoing cosmetic procedures.

METHODS

Study Population

This prospective cohort study was approved by the Institutional Review Board at Vanderbilt University (reference number 140082). The study population comprised of a cohort of patients who enrolled into the CosmetAssure insurance program and underwent cosmetic surgical procedure (s) between May 2008 and May 2013. The CosmetAssure database was accessed in February 2014 following approval by the Institutional Review Board.

Database

CosmetAssure is an insurance program that covers the cost of unexpected major complications from 24 covered cosmetic surgical procedures, which may not be reimbursed by the patient's primary insurer. CosmetAssure was introduced in 2003 and has been prospectively collecting risk factor data for research purposes 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). 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' demographics and risk factor information are entered into the database prior to undergoing the procedure, thus making it a prospective cohort. Surgeon-reported major complications, filed as a claim, 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 emergency room visit, hospital admission, or reoperation. This excludes complications that can be managed in the clinic, including minor wound infections and superficial wound dehiscence, as they are not applicable for insurance claim. Major SSIs are one of the covered complications. 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, body mass index (BMI), smoking, self-reported diabetes mellitus (including both type 1 and type 2), and type of surgical facility (office-based surgical suites, accredited surgical centers, and hospitals).

Exposure

In this study cohort, exposure was defined as the type of cosmetic surgical procedure(s) performed. Each procedure was studied when performed alone or in combination with other cosmetic procedures.

Risk Factors

The potential risk factors evaluated included age, gender, BMI, smoking, diabetes mellitus, type of surgical facility, procedure by body region, and combined procedures.

Outcome

Primary outcome was the occurrence of any SSI(s) requiring emergency room visit, hospital admission, or reoperation within 30 days of the index operation.

Demographic Variables and Surgical Procedures

Distribution of factors including age, gender, BMI, smoking, diabetes mellitus, type of surgical facility, procedure by body region, and combined procedures were compared between patients with and without a diagnosed SSI. 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 (ie, blepharoplasty, browlift, cheek implant, chin augmentation, facelift, facial resurfacing, hair replacement, otoplasty, rhinoplasty), breast (ie, augmentation, mastopexy, male breast surgery, reduction, revision breast implant procedures), and body (ie, abdominoplasty, brachioplasty, buttock lift, calf implant, labioplasty, liposuction, lower body lift, thigh lift, upper body lift). Patients who underwent more than 1 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, de-identified 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 sex. 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 the enrollment data using the identifier. These cases were matched manually to enrollees with the closest demographic characteristics. The 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. These patients were included in the analysis without replacing these missing data points. Patient characteristics, risk factors, and SSI rates between patients undergoing different procedure combinations were compared by two-tailed t test, Fisher exact test, or Pearson chi-square test. Univariate analysis for risk factors of SSI was performed after stratifying data by type of procedure combinations. For the purpose of univariate analysis, age, and BMI were recorded as ordinal variables with clinically appropriate categories. Standard logistic regression analysis was performed to identify the independent risk factors for postoperative SSIs. For purpose of logistic regression analysis, age and BMI were entered as continuous variables. Unless otherwise noted, the probability of a type I error of <5 percent ($P < .05$) was used to determine statistical significance. All analyses were performed using IBM SPSS Statistics 23.0 software (IBM Corporation, Armonk, NY).

RESULTS

Between May 2008 and May 2013, a total of 183,914 cosmetic surgery procedures were performed on 129,007 patients who enrolled in the CosmetAssure insurance program. Overall, the mean age was 40.9 ± 13.9 years (range, 5-93 years) and BMI 24.3 ± 4.4 kg/m^2 (range, 17.0-56.3 kg/m^2). There were 8357 men (6.5%) and 120,650 women (93.5%) in the dataset. Active smoking was reported by 10,621 (8.2%) patients. Self-reported diabetes was recorded in 2368 (1.8%) of patients. Patient demographics and other characteristics comparing the two patient populations (ie, patients with and without a postoperative SSI) are shown in Table 1.

A total of 2506 patients developed major complications (1.9% overall rate), of which 599 (0.46%) patients were reported to have a postoperative SSI. This was the second most common major complication after hematoma (0.9%). Patients with a postoperative SSI were older (mean age, 43.8 ± 12.4 years vs 40.9 ± 13.9 years, $P < .01$) and more likely to be female (0.5% vs 0.3%, $P = .02$) (Figure 1A). The BMI was higher for patients with a postoperative wound infection when compared to patients without a wound infection (27.3 ± 5.5 kg/m^2 vs 24.3 ± 4.6 kg/m^2, $P < .01$). Patients with a SSI were also more likely to be smokers (10.5% vs 8.2%, $P = .04$) and have pre-existing diabetes mellitus (4.5% vs 1.8%, $P < .01$). Cosmetic procedures were most commonly performed in accredited surgical centers (57.4%), followed by hospitals (26.7%), and finally in office-based surgical suites (15.9%). Incidence of postoperative SSIs was significantly lower after procedures performed in office-based surgical suites as opposed to accredited surgical centers and hospitals (0.3% vs 0.5% vs 0.6%, respectively, $P < .01$) (Figure 1B). In addition, the incidence of postoperative SSI was significantly higher in patients undergoing multiple procedures when compared to single procedures (0.8% vs 0.3%, $P < .01$), and body procedures when compared to breast or face procedures (0.9% vs 0.2%, $P < .01$). The incidence of SSIs amongst different procedure combinations per body region was also analyzed, and shown in Table 2. The trend towards a higher incidence of SSIs for patients who underwent a combined procedure, specifically with the inclusion of a body procedure was again evident.

Table 1. Clinical and Demographic Characteristics

Variable	Surgical Site Infection Present N = 599 (0.46%)	Surgical Site Infection Absent N = 128,408 (99.54%)	*P* value
Age, mean ± SD	43.8 ± 12.4	40.9 ± 13.9	<.01
Female gender, N (%)	574 (95.8%)	120,076 (93.5%)	.02
Body mass index, mean ± SD	27.3 ± 5.5	24.3 ± 4.6	<.01
Body mass index per category, N (%)			<.01
<18.5	4 (0.7%)	5121 (4.0%)	
18.5-24.9	224 (37.5%)	76,287 (59.9%)	
25-29.9	204 (34.1%)	31,963 (25.1%)	
30-39.9	153 (25.6%)	13,098 (10.3%)	
≥40	13 (2.2%)	894 (0.7%)	
Smoking, N (%)	63 (10.5%)	10,558 (8.2%)	.04
Diabetes mellitus, N (%)	27 (4.5%)	2341 (1.8%)	<.01
Type of facility, N (%)			<.01
Accredited surgical center	337 (56.3%)	73,657 (57.4%)	
Hospital	193 (32.2%)	34,284 (26.7%)	
Office-based surgical suite	69 (11.5%)	20,467 (15.9%)	
Multiple procedures, N (%)	344 (57.4%)	41,542 (32.4%)	<.01
Single procedure per body region, N (%)			<.01
Face	18 (7.1%)	14,588 (16.8%)	
Breast	104 (40.8%)	49,753 (57.3%)	
Body	133 (52.2%)	22,424 (25.8%)	

(%): frequencies.

When stratified by gender, differences were noted in the incidence of infection following different procedures and combinations (Table 2).

The incidences of postoperative SSIs amongst some of the most commonly performed cosmetic procedures are shown in Table 3. The highest rates of major SSIs were observed in trunk and extremity procedures, as well as some of the facial procedures less commonly performed (eg, cheek implants and chin augmentations).

Risk Factors

On multivariate logistic regression, independent risk factors ($P < .05$) for postoperative SSIs after cosmetic procedures include: age (Relative Risk (RR) 1.01), female gender (RR 1.86), BMI (RR 1.07), smoking (RR 1.61), diabetes mellitus (RR 1.58), the procedure being performed in a hospital or accredited surgical center rather than office-based surgical suites (RR 1.39), body procedures rather than the breast and face procedures (RR 2.42), and combined procedures (RR 1.88). These results are summarized in Table 4.

DISCUSSION

This multi-institutional cohort study of 129,007 patients who were prospectively enrolled in the CosmetAssure insurance program and who underwent cosmetic surgical procedures throughout the United States revealed a low overall incidence of major postoperative SSIs (0.46%). As mentioned previously, the incidence of SSIs in the literature for some of the common aesthetic surgical procedures vary, such as breast augmentation ranging from 0.001% to 7%, breast reduction 0.11% to 22%, abdominoplasty 0.16% to 32.6%, and body lifts 3% to 25%.[5-28] In our analysis, the incidence of SSIs for these procedures were noted to be at the lower end of these ranges at 0.2%, 0.5%, 1.0%, and 1.9%, respectively. There are several possible explanations for this finding. Most importantly, it has to be emphasized that this study captured only major SSIs requiring emergency room visit, hospital admission, or reoperation, rather than those dealt with in the office setting. In addition, the standardization of the plastic surgery practitioners in the CosmetAssure database most likely also contributes to this finding, with proper patient selection and safe practice measures implemented by board certified plastic surgeons. On the other hand, our analysis showed a very low incidence of wound infections after liposuction and facelift at 0.1%, which is comparable with the existing literature with an incidence of < 0.3% for both procedures.[28-32] It should also be recognized that some of the procedures examined in our study, such as cheek implants and chin augmentations, are not as prevalent and there is paucity of literature with regards to wound related complications.

Identifying factors that increase the risk of SSIs has the potential to minimize this untoward complication with its undesirable consequences and optimize aesthetic outcomes. The CosmetAssure database provides a sufficient number of cases to allow an analysis of the risk factors associated with wound infections following a wide spectrum of aesthetic surgical procedures. This has a substantial advantage over single center studies and even review articles on this topic, which would require a prohibitively large number of participants to detect these differences. This study, to the best of our knowledge represents the largest in current literature demonstrating a multitude of factors, both patient and procedure related, that impact SSIs.

Risk Factors

Age as a risk factor for any type of surgical procedure has been controversial, often complicated by physiologic

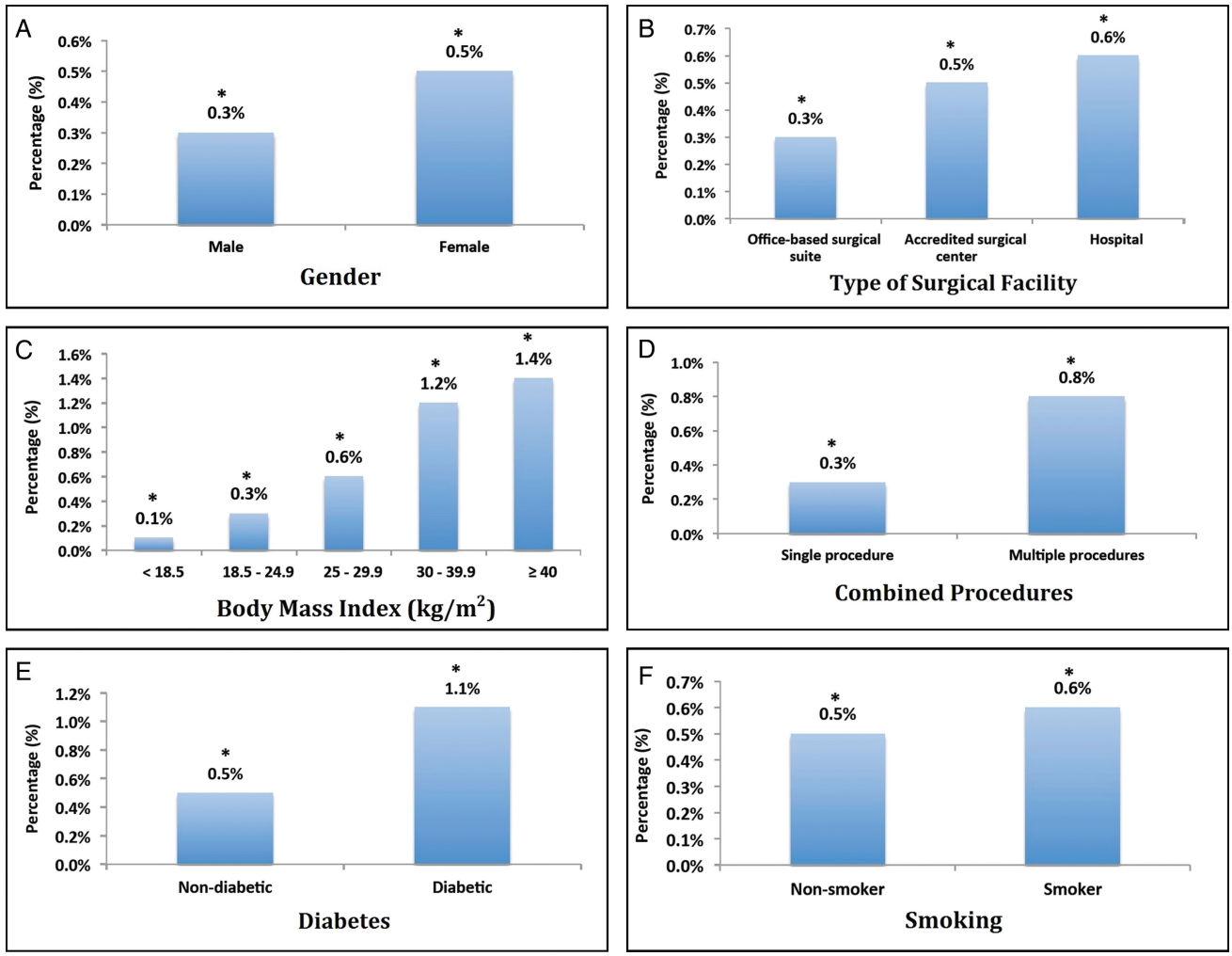

Figure 1. Risk factors (A, gender; B, type of surgical facility; C, body mass index; D, smoking; E, diabetes; and F, combined procedures) for major surgical site infections on univariate analysis (*$P < .05$).

Table 2. Incidence of Surgical Site Infections amongst Different Procedure Combinations per Body Region(s), Stratified by Gender

Body Region(s)	Surgical Site Infection	Surgical Site Infection (male)	Surgical Site Infection (female)
Face	34 (0.2%)	5 (0.2%)	29 (0.2%)
Breast	143 (0.2%)	1 (0.1%)	142 (0.3%)
Body	266 (0.8%)	14 (0.5%)	252 (0.9%)
Face + breast	5 (0.4%)	0	5 (0.4%)
Face + body	15 (0.6%)	2 (0.7%)	15 (0.6%)
Breast + body	132 (1.0%)	2 (0.3%)	130 (1.0%)
Face + breast + body	4 (0.9%)	1 (5.9%)	3 (0.7%)

aging-related changes and underlying disease states.[33] The effect of these physiologic changes on the mechanisms of wound healing is of particular importance in plastic surgery. Previous literature about patient age as an independent risk factor on wound-related complications is scarce. One of the few available studies revealed no association between aging and increased incidence of wound dehiscence.[34] In contrast, this study has shown that advancing age is associated with a slight increase in risk of postoperative SSIs following cosmetic procedures. This correlates with prior literature advocating that increasing age is associated with a decline in both the innate and the adaptive immune systems, resulting in a higher incidence of SSIs and inability to respond adequately to postsurgical stress.[35-38] This is further supported by the concept of homeostenosis that has recently gained more attention. Homeostenosis represents a process of progressive constriction of homeostatic reserve on organ systems that occurs with aging. As patients age, the human body maintains homeostasis by utilizing the residual physiological reserve, which leaves less reserve to sufficiently react to stressful stimuli. Cosmetic surgical procedures can thus disrupt the

Table 3. Incidence of Surgical Site Infections amongst Some of the Most Commonly Performed Cosmetic Procedures

Procedure	Number of Procedures Performed	Surgical Site Infection Present N (%)
Face:		
Cheek implants	33	1 (3.0%)
Chin augmentation	157	2 (1.3%)
Rhinoplasty	3,608	6 (0.2%)
Facelift	4809	6 (0.1%)
Breast:		
Breast reduction	3,094	14 (0.5%)
Breast mastopexy	3,397	11 (0.3%)
Breast augmentation	41,836	78 (0.2%)
Body:		
Thigh lift	405	11 (2.7%)
Lower body lift	426	8 (1.9%)
Buttock lift	407	7 (1.7%)
Abdominoplasty	8,975	88 (1.0%)
Brachioplasty	762	8 (1.0%)
Liposuction	11,490	11 (0.1%)

Table 4. Risk Factors for Surgical Site Infections for all Cosmetic Procedures

Risk Factor	Relative Risk	95% Confidence Interval	*P* value
Age	1.01	1.003-1.015	<.01
Female gender	1.86	1.24-2.80	<.01
Body mass index	1.07	1.06-1.08	<.01
Smoking	1.61	1.24-2.10	<.01
Diabetes mellitus	1.58	1.06-2.35	.02
Hospital-based procedures[a]	1.39	1.08-1.78	.01
Body procedures[b]	2.42	1.99-2.93	<.01
Multiple procedures	1.88	1.58-2.23	<.01

[a]Compared to office-based procedures. [b]Compared to non-body (ie, face and breast) procedures.

physiological balance of the body, which may negatively impact postoperative recovery.

Gender-dependent differences in the clinical outcomes of surgical patients have been studied extensively. Statistically significant associations have been found in some surgical populations, such as trauma and cardiovascular surgery, because male subjects tend to represent the majority of patients in those cohorts. On the contrary, aesthetic surgery patients are overwhelmingly females. In 2015, according to the statistics by the American Society for Aesthetic Plastic Surgery, 90.5% of all cosmetic procedures were performed on females.[1] As expected, the majority of subjects in our study were also female (93.5%). It is not surprising that the majority of studies analyzing cosmetic surgery outcomes are not successful in identifying statistically significant difference in outcomes based on gender given the usually small sample size and low number of male patients. In our analysis, female gender was found to be a risk factor for postoperative major SSIs in patients undergoing cosmetic procedures, with a relative risk of 1.86. This differs from current literature, where male gender has been reported as a risk factor for postoperative complications in cosmetic surgery, but not specifically for wound infections. For example, in patients undergoing rhytidectomy, men have been shown to have a higher incidence of postoperative hematomas after surgery.[39-43] Also, a prior CosmetAssure study reviewing 25,478 abdominoplasties demonstrated male gender to be a significant preoperative risk factor for major complications, with a relative risk of 1.8 on multivariate regression.[44]

According to the CDC, an adult who has a BMI of 25 to 29.9 kg/m^2 is considered overweight; equal or >30 kg/m^2, obese; and 40 kg/m^2 or higher, morbidly obese. The number of obese patients in the United States has increased steadily over the past decade, which was also reflected in our analysis with a small increase in the percentage of patients with a BMI of 25 kg/m^2 or greater undergoing aesthetic surgery between 2008 and 2013 (35.7% vs 38.2%). Obesity has been a well-established risk factor for SSIs in a variety of surgical fields including cosmetic surgery.[2] Specifically, prior series examining breast reduction and abdominoplasty procedures have shown obesity to be an important risk factor for the development of postoperative SSIs.[9,11-14,23,45-50] In the present study, BMI was also found to be associated with an increased risk of major SSIs following cosmetic surgical procedures. There was a clear trend of a statistically significant increase in SSI rates in overweight (0.6%), obese (1.2%), and morbidly obese patients (1.4%) compared with a 0.3% SSI rate in patients with a BMI of 18.5 to 24.9 kg/m^2 (Figure 1C). This finding may be partly attributed to the relative hypoperfusion and ischemia that occurs within the excess subcutaneous adipose tissue, which can make the wound more susceptible to postoperative SSIs. This suboptimal tissue perfusion may also hinder appropriate delivery of perioperative antibiotics, leading to an even higher risk of infection. In fact, this phenomenon was evident in patients undergoing elective colorectal surgery, where the incidence of SSI was higher in patients with a BMI equal or >30 kg/m^2, regardless of the

prophylactic antibiotics.[51] In addition to the effect of obesity on the local environment, several systemic factors have also been proposed to negatively impact wound healing and increase wound complications. For instance, obesity can be associated with conditions that impair the immune response such as stress, anxiety, and depression.[52]

This study found smoking to be an independent predictor for postoperative SSIs following cosmetic surgical procedures, with a 61% increase in risk compared to non-smokers. This finding is not surprising since there has been a growing amount of literature in the last few decades indicating that smoking has an enormous impact on all phases of wound healing and the microenvironment of the tissue. Theories revolve around the relationship of nicotine in decreasing cutaneous blood flow through vasoconstriction and the hypoxic effects of smoking, but no conclusive pathophysiology has been defined.[53] This has been established through the higher rates of postoperative wound infections observed across multiple surgical specialties including plastic surgery.[54-56] One series examining patients undergoing cosmetic abdominoplasty demonstrated a 12-fold increase in infection complications in smokers.[55] The improvement of inflammatory cell function and host defense by smoking cessation provides a potential mechanism for the clinical observations of reduced infectious complications, such as SSI, after at least 4 weeks of abstinence from smoking in randomized controlled trials.[54,57] However, in a systematic review analyzing the pathophysiological impact of smoking and smoking cessation on wound infection in surgery, it was concluded that smoking cessation only reverses some of the pathologic processes induced by smoking because many of these mechanisms appear to be prolonged or even irreversible.[54] It is thus important for plastic surgeons to carefully inform their patients undergoing cosmetic procedures about the consequences of smoking on wound healing, and the potential postoperative complications, which can lead not only to physical but equally emotional and financial strains. Interestingly, a study examining the accuracy of information on smoking habits provided by patients seeking elective plastic surgery revealed underreporting of cigarette consumption.[58] More specifically, 26% of self-reported non-smokers tested positive for cotinine (metabolite of nicotine) in the urine, and 50% of smokers under-reported the amount they smoke. The CosmetAssure database does not differentiate between current and former smokers, and does not register whether smoking status is based on patient self-report or laboratory tests such as urine cotinine screening. It is thus very possible that the risk of major SSIs is underestimated in our analysis. On the other hand, our study provides risk estimates based on "real world" scenarios where urine cotinine is not routinely obtained.

Diabetes mellitus has inconsistently been reported as a risk factor for postoperative SSIs in cosmetic surgery. In a prospective multicenter study, Drapeau et al examined 2806 consecutive patients undergoing plastic and reconstructive procedures and demonstrated diabetes to be independently associated with SSIs.[59] Other smaller series examining breast augmentation and breast reduction found no significant association between diabetes and postoperative wound infections.[6,9] To the best of our knowledge, this study represents one of the very few in the literature to establish an association between diabetes mellitus and postoperative SSIs in the aesthetic population, with an increased risk of 58%. It is unclear if this finding is related to elevated perioperative blood glucose levels in diabetic patients, but it does emphasize the need for optimization of perioperative blood glucose levels in patients with diabetes undergoing cosmetic procedures. Additional clinical trials with carefully controlled protocols for the measurement of serum glucose levels, and accurate preoperative assessment of patients' diabetes status, may be necessary to determine the ideal perioperative serum glucose targets for this patient population.

The type of facility where a cosmetic procedure is performed was found to be significantly associated with SSIs in this study. Procedures performed in accredited surgical centers or hospitals were associated with a higher risk of wound infections compared to office-based surgical suites. These results may be a representation of appropriate patient selection by plastic surgeons, where patients that are considered to be at "higher risk" for complications undergo surgery in a facility with available higher level of care such as an accredited surgical center or hospital setting. Equally plausible is the possibility that increased hospital complications could be related to operating room and anesthesia staff who are not as experienced with aesthetic plastic surgical procedures or hospital acquired infections. It can also be interpreted as selection bias since CosmetAssure database does not provide data on American Society of Anesthesiologists classification and comorbidities such as cardiac disease, which might have affected surgeon's choice on the type of the facility. Over the last few decades, aesthetic surgical care in the United States has shifted to an outpatient non-hospital setting, with the majority of procedures performed as such.[60] This dramatic increase has prompted research into the safety of these facilities. Available studies showed a complication rate of $<1\%$, suggesting that these facilities are safe for appropriately selected patients by qualified providers.[61-63] Our data reinforce these findings and lend clarification to these results with a wound infection rate of 0.3% in office-based surgical suites, 0.5% in accredited surgical centers, and 0.6% in hospitals (Figure 1B).

Body region was a significant risk factor for the development of major SSIs in this study. There is a paucity of previous literature looking specifically at the effect of different body regions on postoperative wound infections after aesthetic surgery. This study found that patients who underwent

trunk and extremity procedures were at significantly higher risk for postoperative SSIs when compared to breast and face procedures. Trunk and extremity procedures were the strongest predictors of wound infections in our analysis with a relative risk of 2.42. Plastic surgeons should not only counsel their patients about the increased risk of SSIs related to these procedures, but also carefully evaluate and optimize some of the risk factors, such as smoking cessation and weight loss, in an attempt to decrease the risk of wound infections.

In this analysis, the majority of patients (68%) underwent a combined procedure. A higher incidence of postoperative SSIs was found in patients undergoing multiple procedures (0.8%) when compared to single procedures (0.3%), which was statistically significant ($P < .01$) (Figure 1F). This implies that patients who undergo multiple cosmetic operations simultaneously are more likely to develop a SSI. Even though the increase in complication rate in combined procedures is less than the sum of the complication rates of each procedure done separately, it still requires careful consideration. The most commonly combined procedures were body and breast (10.4%), followed by body and face (1.9%), followed by breast and face (1.1%). The least common combination was body, breast, and face (0.3%). There was a trend towards a higher SSI rate with each additional region added to the operation (Table 2). This might be related to the increased operative time with each additional procedure, regardless of the body region. This is supported by a recent study investigating the association of operative duration and SSIs in "clean" and "clean/contaminated" plastic surgery procedures from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, which showed increased SSI rates with longer operative times.[64] Equally, Andenaes et al performed a prospective study examining wound infections after cosmetic and reconstructive procedures, and showed that the SSI rate nearly tripled when duration of surgery was more than 120 minutes compared with < 60 minutes.[65] The duration of operation is not available in the CosmetAssure database, and thus we were unable to examine this association. It has to be noted that there have been several studies looking at the effect of combined procedures on complication rates including wound infections following aesthetic surgery that have shown no increased risk of complications with combined procedures.[29,66,67]

Limitations

There are several limitations associated with the use of the CosmetAssure database, which have to be taken into consideration when interpreting the results of this study. First, the database does not include minor but clinically significant complications related to SSIs such as wound breakdown. Postoperative SSIs with associated wound healing complications that can be managed in the outpatient setting are significantly more common for this patient population and very important in cosmetic outcomes as well as patient-perceived results. The database lacks outcome specific details since it does not provide microbiological findings, and does not separate the SSIs into different categories such as superficial, deep, or wound dehiscence. This could have potentially allowed us to better understand the severity of this outcome. In addition, during the period analyzed (2008-2013), the CosmetAssure database does not register long-term outcomes, ie, complications occurring after 30 days postoperatively. This results in unknown final outcomes after the management of the initially diagnosed wound infections.

Our analysis is limited to the variables that are available in the database. This does not allow us to evaluate and account for all potential confounders. For instance, the impact of measures that were previously advocated to play a role in the development of SSIs such as preoperative decolonization protocols with intranasal mupirocin, perioperative antibiotic use, intraoperative body temperature regulation, and operative times cannot be analyzed. Also, some important patient-specific characteristics that may affect the choice of facility where the procedure will be performed and resultant outcomes, such as American Society of Anesthesiologists classification, were not available and thus not examined. Although the database lacks comprehensive information about patients' other comorbidities, assessment of available health conditions (eg, diabetes mellitus, obesity, and smoking) suggest that the patient population seeking cosmetic surgery is significantly healthier compared with the general population of the United States, with a low burden of comorbid conditions. It has to be noted that the prevalence of diabetes in the database may be under-estimated since it is based on self-reported patient data. There is little doubt that surgeon-specific factors can confound our results and are difficult to control with the current CosmetAssure dataset. For example, information related to the surgical technique is not available. A word of caution seems appropriate here regarding the generalizability of our results. Although the CosmetAssure database is limited to participating centers, it includes a variety of practices across the United States encompassing hospitals, accredited surgical centers, and office-based surgical suites, making it a representable sample generalizable to different practice models. On the other hand, CosmetAssure is used by only a fraction of eligible plastic surgeons in the United States.

CONCLUSIONS

In conclusion, this multi-institutional multi-surgeon study analyzed a large cohort of patients undergoing cosmetic surgical procedures. This resulted in significant findings,

and has added relevant information to educate providers and patients about the incidence and risk factors of SSIs. We demonstrated that the overall incidence of major SSIs after aesthetic surgery is very low but not irrelevant given the fact that these procedures should carry a minimal risk of major complications since they are performed with an ultimate goal of cosmesis in healthy individuals. It has to be stressed that minor SSIs may be common following these procedures and, although not examined in our study, should not be undervalued. We have also shown that the incidence of major postoperative SSIs is significantly higher in patients undergoing multiple procedures, as well as trunk or extremity procedures when compared to breast or face procedures. In addition, this large prospectively collected cohort examined predictive factors for major postoperative SSIs after cosmetic procedures, in order to identify modifiable actions that could improve this important outcome, and thus optimize the overall care of patients undergoing aesthetic surgery. Significant patient-related risk factors for postoperative SSIs included age, female gender, obesity, smoking, pre-existing diabetes mellitus, trunk and extremity procedures as opposed to breast and face procedures, and combined procedures. Careful preoperative evaluation and addressing some of the modifiable risk factors is thus critical, and may decrease SSIs even further in this patient population.

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.

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REFERENCES

1. Cosmetic Surgery National Data Bank Statistics. *Aesthet Surg J*. 2016;36(suppl 1):1-29.
2. Gravante G, Caruso R, Araco A, Cervelli V. Infections after plastic procedures: Incidences, etiologies, risk factors, and antibiotic prophylaxis. *Aesthetic Plast Surg*. 2008;32:243-251.
3. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC Definitions of Nosocomial Surgical Site Infections, 1992: A Modification of CDC Definitions of Surgical Wound Infections. *Infect Control Hosp Epidemiol*. 1992;13(10):606-608.
4. Bratzler DW, Houck PM, Surgical Infection Prevention Guidelines Writers Workgroup, et al. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. *Clin Infect Dis*. 2004;38(12):1706-1715.
5. LeRoy J, Given KS. Wound infection in breast augmentation: The role of prophylactic perioperative antibiotics. *Aesthetic Plast Surg*. 1991;15:303-305.
6. Brand KG. Infection of mammary prostheses: A survey and the question of prevention. *Ann Plast Surg*. 1993;30(4):289-295.
7. Pittet B, Montandon D, Pittet D. Infection in breast implants. *Lancet Infect Dis*. 2005;5(2):94-106.
8. Araco A, Gravante G, Araco F, Delogu D, Cervelli V, Walgenbanch K. Infections of breast implants in aesthetic breast augmentations: A single-center review of 3,002 patients. *Aesthetic Plast Surg*. 2007;31(4):325-329.
9. Kompatscher P, von Planta A, Spicher I, et al. Comparison of the incidence and predicted risk of early surgical site infections after breast reduction. *Aesthetic Plast Surg*. 2003;27(4):308-314.
10. Davis GM, Ringler SL, Short K, Sherrick D, Bengtson BP. Reduction mammaplasty: long-term efficacy, morbidity, and patient satisfaction. *Plast Reconstr Surg*. 1995;96(5):1106-1110.
11. Serletti JM, Davenport MS, Herrera HR, Caldwell E. Efficacy of prophylactic antibiotics in reduction mammoplasty. *Ann Plast Surg*. 1994;33:476-480.
12. O'Grady KF, Thoma A, Dal Cin A. A comparison of complication rates in large and small inferior pedicle reduction mammaplasty. *Plast Reconstr Surg*. 2005;115:736-742.
13. Culver DH, Horan TC, Gaynes RP, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. National Nosocomial Infections Surveillance System. *Am J Med*. 1991;91(3B):152S-157S.
14. Beer GM, Spicher I, Cierpka KA, Meyer VE. Benefits and pitfalls of vertical scar breast reduction. *Br J Plast Surg*. 2004;57(1):12-19.
15. Platt R, Zucker JR, Zaleznik DF, et al. Prophylaxis against wound infection following herniorrhaphy or breast surgery. *J Infect Dis*. 1992;166(3):556-560.
16. Dabbah A, Lehman JA Jr., Parker MG, Tantri D, Wagner DS. Reduction mammaplasty: an outcome analysis. *Ann Plast Surg*. 1995;35(4):337-341.
17. Menke H, Eisenmann-Klein M, Olbrisch RR, Exner K. Continuous quality management of breast hypertrophy by the German Association of Plastic Surgeons: a preliminary report. *Ann Plast Surg*. 2001;46(6):594-600.
18. Asplund O, Davies DM. Vertical scar breast reduction with medial flap or glandular transposition of the nipple-areola. *Br J Plast Surg*. 1996;49(8):507-514.
19. Lejour M. Vertical mammaplasty: early complications after 250 personal consecutive cases. *Plast Reconstr Surg*. 1999;104(3):764-770.
20. Lassus C. A 30-year experience with vertical mammaplasty. *Plast Reconstr Surg*. 1996;97:373-380.
21. DC H. Short scar periareolar inferior pedicle reduction (SPAIR) mammaplasty. *Plast Reconstr Surg*. 1999;103(3):890-902.
22. Chaouat M, Levan P, Lalanne B, Buisson T, Nicolau P, Mimoun M. Cosmetic Abdominal Dermolipectomies :

Early Postoperative Complications and Long-Term Unfavorable Results. *Plast Reconstr Surg*. 2000;106: 1614-1618.
23. Manassa EH, Hertl CH, Olbrisch R-R. Wound healing problems in smokers and nonsmokers after 132 abdominoplasties. *Plast Reconstr Surg*. 2003;111(6):2082-2087; discussion 2088-2089.
24. Dillerud E. Abdominoplasty combined with suction lipoplasty: a study of complications, revisions, and risk factors in 487 cases. *Ann Plast Surg*. 1990;25(5):333-343.
25. Hurwitz DJ. Single-Staged Total Body Lift After Massive Weight Loss. *Ann Plast Surg*. 2004;52(5):435-441.
26. Nemerofsky RB, Oliak DA, Capella JF. Body lift: an account of 200 consecutive cases in the massive weight loss patient. *Plast Reconstr Surg*. 2006;117(2):414-430.
27. Gusenoff JA, Coon D, Nayar H, Kling RE, Rubin J. Medial thigh lift in the massive weight loss population: outcomes and complications. *Plast Reconstr Surg*. 2015;135(1):98-106.
28. Nazarian Mobin SS, Keyes GR, Singer R, Yates J, Thompson D. Infections in outpatient surgery. *Clin Plast Surg*. 2013;40(3):439-446.
29. Cárdenas-Camarena L. Lipoaspiration and its complications: a safe operation. *Plast Reconstr Surg*. 2003;112 (5):1435-1441; discussion 1442-1443.
30. Jones BM, Grover R. Endoscopic brow lift: a personal review of 538 patients and comparison of fixation techniques. *Plast Reconstr Surg*. 2004;113(4):1242-1250.
31. Ullmann Y, Levy Y. Superextended facelift: our experience with 3,580 patients. *Ann Plast Surg*. 2004;52 (1):8-14.
32. Matarasso A, Elkwood A, Rankin M, Elkowitz M. National plastic surgery survey: face lift techniques and complications. *Plast Reconstr Surg*. 2000;106(5):1185-1195; discussion 1196.
33. Lubin MF. Is age a risk factor for surgery? *Med Clin North Am*. 1993;77(2):327-333.
34. Karamanos E, Osgood G, Siddiqui A, Rubinfeld I. Wound healing in plastic surgery: does age matter? An American College of Surgeons National Surgical Quality Improvement Program study. *Plast Reconstr Surg*. 2015;135(3):876-881.
35. Graham JE, Christian LM, Kiecolt-Glaser JK. Stress, age, and immune function: toward a lifespan approach. *J Behav Med*. 2006;29(4):389-400.
36. Kiecolt-Glaser JK, Page GG, Marucha PT, MacCallum RC, Glaser R. Psychological influences on surgical recovery. Perspectives from psychoneuroimmunology. *Am Psychol*. 1998;53(11):1209-1218.
37. Roubenoff R, Harris TB, Abad LW, Wilson PW, Dallal GE, Dinarello CA. Monocyte cytokine production in an elderly population: effect of age and inflammation. *J Gerontol A Biol Sci Med Sci*. 1998;53(1):M20-M26.
38. Lord JM, Butcher S, Killampali V, Lascelles D, Salmon M. Neutrophil ageing and immunesenescence. *Mech Ageing Dev*. 2001;122(14):1521-1535.
39. Baker DC, Aston SJ, Guy CL, Rees TD. The male rhytidectomy. *Plast Reconstr Surg*. 1977;60(4):514-522.
40. Baker DC, Stefani WA, Chiu ES. Reducing the incidence of hematoma requiring surgical evacuation following male rhytidectomy: a 30-year review of 985 cases. *Plast Reconstr Surg*. 2005;116:1973-1985; discussion 1986-1987.
41. Grover R, Jones BM, Waterhouse N. The prevention of haematoma following rhytidectomy: a review of 1078 consecutive facelifts. *Br J Plast Surg*. 2001;54 (6):481-486.
42. Lawson W, Naidu RK. The male facelift. An analysis of 115 cases. *Arch Otolaryngol -- Head Neck Surg*. 1993;119 (5):531-535.
43. Gupta V, Winocour J, Shi H, Shack RB, Grotting JC, Higdon KK. Preoperative Risk Factors and Complication Rates in Facelift: Analysis of 11,300 Patients. *Aesthet Surg J*. 2016;36(1):1-13.
44. Winocour J, Gupta V, Ramirez JR, Shack RB, Grotting JC, Higdon KK. Abdominoplasty: Risk Factors, Complication Rates, and Safety of Combined Procedures. *Plast Reconstr Surg*. 2015;136(5):597e-606e.
45. Van Uchelen JH, Werker PMN, Kon M. Complications of abdominoplasty in 86 patients. *Plast Reconstr Surg*. 2001;107(7):1869-1873.
46. Mast BA. Safety and efficacy of outpatient full abdominoplasty. *Ann Plast Surg*. 2005;54(3):256-259.
47. El-Khatib H, Bener A. Abdominal dermolipectomy in an abdomen with pre-existing scars: a different concept. *Plast Reconstr Surg*. 2004;114(4):992-997.
48. Hensel JM, Lehman JAJ, Tantri MP, Parker MG, Wagner DSTopham NS. An outcomes analysis and satisfaction survey of 199 consecutive abdominoplasties. *Ann Plast Surg*. 2001;46(4):357-363.
49. Vastine VL, Morgan RF, Williams GS, et al. Wound complications of abdominoplasty in obese patients. *Ann Plast Surg*. 1999;42(1):34-39.
50. Lahiri A, Duff CG, Brown TL, Griffiths RW. Anthropometric measurements and their value in predicting complications following reduction mammaplasty and abdominoplasty. *Ann Plast Surg*. 2006;56(3):248-250.
51. Itani KMF, Jensen EH, Finn TS, Tomassini JE, Abramson MA. Effect of body mass index and ertapenem versus cefotetan prophylaxis on surgical site infection in elective colorectal surgery. *Surg Infect (Larchmt)*. 2008;9(2):131-137.
52. Wilson JA, Clark JJ. Obesity: impediment to postsurgical wound healing. *Adv Skin Wound Care*. 2004;17 (8):426-435.
53. Leow YH, Maibach H. Cigarette smoking, cutaneous vasculature, and tissue oxygen. *Clin Dermatol*. 1998;16 (5):579-584.
54. Sørensen LT. Wound healing and infection in surgery. The clinical impact of smoking and smoking cessation: a systematic review and meta-analysis. *Arch Surg*. 2012;147(4):373-383.
55. Araco A, Gravante G, Sorge R, Araco F, Delogu D, Cervelli V. Wound infections in aesthetic abdominoplasties: the role of smoking. *Plast Reconstr Surg*. 2008;121 (5):305e-310e.
56. Toia F, D'Arpa S, Massenti MF, Amodio E, Pirrello R, Moschella F. Perioperative antibiotic prophylaxis in plastic surgery: a prospective study of 1,100 adult patients. *J Plast Reconstr Aesthet Surg*. 2012;65(5):601-609.

57. Sorensen LT, Karlsmark T, Gottrup F. Abstinence from smoking reduces incisional wound infection: a randomized controlled trial. *Ann Surg*. 2003;238(1):1-5.
58. Payne CE, Southern SJ. Urinary point-of-care test for smoking in the pre-operative assessment of patients undergoing elective plastic surgery. *J Plast Reconstr Aesthet Surg*. 2006;59(11):1156-1161.
59. Drapeau CM, D'Aniello C, Brafa A, et al. Surgical site infections in plastic surgery: an italian multicenter study. *J Surg Res*. 2007;143(2):393-397.
60. Horton JB, Janis JE, Rohrich RJ. MOC-PS(SM) CME article: patient safety in the office-based setting. *Plast Reconstr Surg*. 2008;122(3):1-21.
61. Byrd HS, Barton FE, Orenstein HH, et al. Safety and efficacy in an accredited outpatient plastic surgery facility: a review of 5316 consecutive cases. *Plast Reconstr Surg*. 2003;112(2):636-641; discussion 642-646.
62. Keyes GR, Singer R, Iverson RE, et al. Analysis of outpatient surgery center safety using an internet-based quality improvement and peer review program. *Plast Reconstr Surg*. 2004;113(6):1760-1770.
63. Morello DC, Colon GA, Fredricks S, Iverson RE, Singer R. Patient safety in accredited office surgical facilities. *Plast Reconstr Surg*. 1997;99(6):1496-1500.
64. Khavanin N, De Oliveria GS, Vieira BL, McCarthy R, Kim J. The Association of Surgical Duration with Surgical Site Infection in Clean and Clean/Contaminated Plastic Surgery Procedures. *Plast Reconstr Surg*. 2015;136(4 (suppl)):74-75.
65. Andenaes K, Amland PF, Lingaas E, Abyholm F, Samdal F, Giercksky KE. A prospective, randomized surveillance study of postoperative wound infections after plastic surgery: a study of incidence and surveillance methods. *Plast Reconstr Surg*. 1995;96(4):948-956.
66. Stevens WG, Repta R, Pacella SJ, et al. Safe and consistent outcomes of successfully combining breast surgery and abdominoplasty: an update. *Aesthet Surg J*. 2009;29 (2):129-134.
67. Hester TR Jr, Baird W, Bostwick J III, Nahai F, Cukic J. Abdominoplasty combined with other major surgical procedures: safe or sorry? *Plast Reconstr Surg*. 1989;83 (6):997-1004.