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Surgical Site Infections in Aesthetic Surgery

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Abstract

Surgical site infections represent one of the most common postoperative complications in patients undergoing aesthetic surgery. As with other postoperative complications, the incidence of these infections may be influenced by many factors and varies depending on the specific operation performed. Understanding the risk factors for infection development is critical because careful patient selection and appropriate perioperative counseling will set the right expectations and can ultimately improve patient outcomes and satisfaction. Various perioperative prevention measures may also be employed to minimize the incidence of these infections. Once the infection occurs, prompt diagnosis will allow management of the infection and any associated complications in a timely manner to ensure patient safety, optimize the postoperative course, and avoid long-term sequelae.

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Learning Objectives

After studying this article, the participant should be able to:

1. Discuss the epidemiology of surgical site infections (SSIs) following aesthetic surgical procedures.
2. Recognize potential risk factors for the development of SSI following aesthetic surgery.
3. Recognize key perioperative prevention measures to decrease the incidence of SSI in aesthetic surgery.
4. Identify the principles for diagnosis and treatment of SSIs and their associated complications.

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Healthcare-associated infections have gained a great deal of attention in recent years and have been the target of numerous strategies to prevent their occurrence and optimize their management in many hospitals across the United States. They are a significant cause of morbidity, mortality, prolonged hospital stays, and hospital readmissions as well as significant burdens to the patient and healthcare system, and as such they have become a national priority by the US Department of Health and Human Services.[1-8] According to recent studies, SSIs are the most common healthcare-associated infection type, accounting for 20% to 31.0% of these infections among hospitalized patients, followed by pneumonia and urinary tract

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infections.[7,9] These figures include all surgical disciplines, and they equally extend to plastic surgery procedures, where SSIs remain one of the most commonly occurring postoperative complications.[10,11]

The Centers for Disease Control and Prevention (CDC) defines an SSI as an infection related to an operative procedure that occurs at or near the surgical incision within 30 days of the procedure.[12] This may occur at any depth, ranging from the skin to the deepest cavity that remains after resection of an organ, and as such the CDC has established criteria to further characterize SSIs following a procedure into superficial incisional, deep incisional, and organ/space (Table 1).[12] The CDC has also adopted the American College of Surgeons (ACS) wound classification schema defining surgical wounds at the time of an operation based on the microbial load. This includes clean, clean-contaminated, contaminated, and dirty or infected.[12]

Research on SSIs within the field of plastic surgery is limited by inconsistent definitions of an SSI,[13] resulting in a range of reported rates of 0% to 32.6%.[11] The importance of a standardized definition of an SSI and an appropriate grading scheme is demonstrated in a study from the ACS National Surgical Quality Improvement Program (ACS-NSQIP) dataset of more than 600,000 cases that showed increased SSI rates with worsening wound classification.[14] According to the US National Research Council, "clean" extra-abdominal operations have an overall SSI incidence between 2% and 5% in contrast to intra-abdominal operations, which can be up to 20%.[15] Although aesthetic surgery largely comprises clean and clean-contaminated cases, with over 13 million cosmetic procedures occurring in 2016 alone, SSIs remain one of the most common postoperative complications.[10,11,16] As with other postoperative complications, the incidence of SSIs following surgery may potentially be influenced by many factors, including but not limited to patient demographics, patient medical comorbidities, concomitant surgical procedures, procedure duration, operative techniques, and perioperative patient management. However, specifically in the field of plastic surgery, the incidence may be influenced most by the specific operation performed.[10]

Among aesthetic surgical procedures, abdominoplasty has often been associated with a higher overall complication rate, including SSIs.[17-19] The incidence of postoperative SSI following abdominoplasty in major studies has varied between 1.1% and 15.5%.[18-27] Literature regarding complication rates in abdominoplasty started in 1977 with Grazer and Goldwyn's survey of 958 surgeons, which found an overall complication rate of 14.6%, including a wound infection rate of 7.3% and wound dehiscence rate of 5.4%.[21] More recently, in a survey-based study, Matarasso et al analyzed 11,016 full abdominoplasties from 497 respondents of members of the American Society of Plastic Surgeons (ASPS) and demonstrated an infection rate of 1.1%.[24] Winocour et al investigated 25,478 abdominoplasties through the prospective CosmetAssure database and found an incidence of major SSIs of 1.1%.[26] A major SSI in the database was defined as an infection requiring an emergency room visit, readmission to the hospital, or reoperation within 30 days of surgery. This represented 27.2% of all the major complications related to abdominoplasty in the database. Several other smaller studies have demonstrated higher SSI rates from 7.3% to as high as 15.5%, and have hypothesized that these rates are affected by the addition of liposuction, smoking, and perioperative antibiotic use.[25,27,28]

Other body-contouring procedures, such as thighplasty and brachioplasty, are also associated with high overall complication rates. Such procedures are believed to be associated with higher incidences of postoperative SSIs due to the compounding effects of various risk factors such as high body mass index (BMI), metabolic diseases such as diabetes and hypertension, as well as long operative times. Unfortunately, a paucity of literature currently exists regarding these procedures. In a study from the CosmetAssure database of 2294 brachioplasties, Nguyen et al reported a major SSI rate of 1.7%.[29] These rates are lower than those previously published by Bossert et al, with an SSI rate of 6.4% among 80 patients who underwent excisional brachioplasty.[30] The authors attributed this difference to the fact that only major SSIs were included in the study (ie, requiring emergency room visit, hospital readmission, or reoperation within 30 days). A similar trend was found in another CosmetAssure study by the same group looking at 1493 patients who underwent thighplasty where the most common postoperative complication was SSIs in 2.7% of patients.[31] Again, due to only major SSIs being captured, they found a lower rate than previous studies. Gusenoff et al analyzed 106 patients who underwent either horizontal, short-scar, or full-length vertical thighplasty and identified an overall complication rate of 68%.[32] This included an SSI rate of 16%, the majority of which were in the full-length vertical and short-scar techniques. Bertheuil et al equally demonstrated a higher rate of SSIs in 53 medial thighlift patients, at 5.7%.[33] It is important to note that whereas many people believe that abdominoplasty is the body-contouring operation with the highest complication profile, including SSI, many studies have shown thighplasty and bodylifts to have the highest rates.[11,31-34]

According to the ASAPS annual statistics report, more than 600,000 cosmetic breast surgical procedures were performed in 2016.[16] Aesthetic breast cases include augmentation (both primary and secondary), implant explantation/removal, mastopexy, reduction, autologous fat grafting, and gynecomastia surgery. All these procedures have significantly increased during the past 2 decades.[16] Overall, complication rates following cosmetic breast procedures

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Table 1. SSI Criteria

Category	Criteria
Superficial incisional SSI	Date of event for infection occurs within 30 days after any NHSN operative procedure (day 1 is the procedure date) and involves only skin and subcutaneous tissue of the incision and patient has at least **one** of the following: 1. Purulent drainage from the superficial incision 2. Organism(s) identified from an aseptically obtained specimen from the superficial incision or subcutaneous tissue by a culture- or nonculture-based microbiologic testing method performed for purposes of clinical diagnosis or treatment 3. Superficial incision that is deliberately opened by a surgeon, attending physician[a], or other designee and culture- or nonculture-based testing is not performed AND patient has at least one of the following signs or symptoms: pain or tenderness, localized swelling, erythema, or heat 4. Diagnosis of the superficial incisional SSI by the surgeon or attending physician[a], or other designee
Deep incisional SSI	Date of event for infection occurs within 30 or 90 days after any NHSN operative procedure (day 1 is the procedure date) and involves deep soft tissues of the incision (eg, fascial and muscle layers) **and** patient has at least ***one*** of the following: 1. Purulent drainage from the deep incision 2. A deep incision that spontaneously dehisces or is deliberately opened or aspirated by a surgeon, attending physician[a], or other designee; and organism(s) is identified by a culture- or nonculture-based microbiologic testing method performed for purposes of clinical diagnosis; or treatment or culture- or nonculture-based microbiologic testing is not performed; and patient has at least one of the following signs or symptoms: fever (>38°C), localized pain, or tenderness. A negative culture- or nonculture-based test does not meet this criterion 3. An abscess or other evidence of infection involving the deep incision that is detected on gross anatomical or histopathologic exam, or imaging test
Organ/space SSI	Date of event for infection occurs within 30 or 90 days after any NHSN operative procedure (day 1 is the procedure date) and involves any part of the body deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure and patient has at least **one** of the following: 1. Purulent drainage from a drain placed into the organ/space (eg, closed suction drainage system, open drain, T-tube drain, CT guided drainage) 2. Organisms are identified from an aseptically obtained fluid or tissue in the organ/space by a culture- or nonculture-based microbiologic testing method performed for purposes of clinical diagnosis or treatment 3. An abscess or other evidence of infection involving the organ/space that is detected on gross anatomical or histopathologic exam, or imaging test evidence suggestive of infection and meets at least **one** criterion for a specific organ/space infection site as follows: osteomyelitis, breast abscess or mastitis, endocarditis, myocarditis or pericarditis, disc space, ear-mastoid, endometritis, gastrointestinal tract, intraabdominal (not specified), intracranial (brain abscess or dura), meningitis or ventriculitis, joint or bursa, mediastinitis, oral cavity (mouth, tongue, or gums), other infections of the male or female reproductive tract, periprosthetic joint infection, spinal abscess without meningitis, sinusitis, upper respiratory tract, other infections of the lower respiratory tract, urinary system infection, vaginal cuff, arterial or venous infection

Adapted from the Centers for Disease Control, SSI Event .[12] NHSN, National Healthcare Safety Network; SSI, surgical site infection. [a]The term attending physician for the purposes of application of the NHSN SSI criteria may be interpreted to mean the surgeon(s), infectious disease, other physician on the case, emergency physician or physician's designee (nurse practitioner or physician's assistant).

are low; however, they can result in significant morbidity and financial burden to the patient. The most common early complications following aesthetic breast surgery are hematoma and SSI.[35-38] Published rates of SSI have been shown to be lowest in breast augmentation, ranging from 0.001% to 7%, and highest in breast reduction, ranging from 0.11% to 22%.[36,38-53] Two of the largest studies analyzed the CosmetAssure database during different time intervals.[36,38] Hanemann et al reviewed 51,235 cosmetic breast surgery procedures between 2003 and 2009 and revealed a major SSI rate of 0.22%.[36] Similarly, Gupta et al found an overall major infection rate of 0.25% in more than 73,608 breast procedures.[38] This was broken down to an infection risk for breast augmentation of 0.19%, augmentation-mastopexy of 0.43%, mastopexy of 0.32%, and reduction of 0.55%. This study further demonstrated lower complication rates when cosmetic breast surgery was performed as a single region procedure. Specifically, adding a body procedure to the breast surgery increased the complication rates for both female and male patients.[38] Another significant study by Fisher et al analyzed the ACS-NSQIP database for complications following reduction mammoplasty.[54] This study included 3538 patients and found an overall postoperative complication rate of 5.1%, and specifically an SSI rate of 3.0% (superficial infection: 2.7%, deep infection: 0.2%, organ space infection: 0.1%). As advocated previously, the impact of surgical technique may play an important role on infection rates including meticulous hemostasis and dissection, avoiding the use of drains, careful handling of the implants, use of antibiotic/antimicrobial irrigations, and avoidance of external exposure to the air and patient skin.[55,56]

Facial rejuvenation and modification remains one of the most requested cosmetic procedures. Two commonly requested procedures are rhinoplasty and rhytidectomy, which have been consistently the sixth- and seventh-ranked cosmetic surgical procedures in the United States.[16] Infection rates from rhinoplasty vary greatly between 0% and 18%; however, most studies estimate the range to be 0.2% to 3.0%.[57-62] Many variations exist in facelift including surgical techniques as well as preoperative and postoperative care, which makes the interpretation of published SSI rates difficult. Another equally important contributing factor is the robust vascularity of the face that makes postoperative SSIs rare, with most studies publishing rates of less than 1%.[63] The authors of a large study of the CosmetAssure database involving 11,300 patients found a major SSI rate of 0.3%.[63] This is consistent with

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other large studies, including that by Pitanguy et al, who published an infection rate of 0.05% in their series of 8788 facelifts over 52 years, as well as Leroy et al with an SSI rate of 0.18% from 6166 procedures.[64,65]

Although the overall SSI rates after most aesthetic surgeries are low, it still constitutes one of the most common complications. Many factors play a role in the differences in rates, including patient demographics/characteristics, operative location, and surgical management/techniques. In the following section, we look more closely into various risk factors and preoperative considerations that should be taken into account by surgeons prior to conducting certain procedures to minimize the incidence of postoperative SSIs. Careful patient selection and appropriate counseling on specific modifiable risk factors can go a long way in minimizing the incidence of postoperative SSIs and ultimately improving patient outcomes and satisfaction.

RISK FACTORS/PREOPERATIVE CONSIDERATIONS

Age

Aesthetic surgery has evolved in recent decades to encompass a much wider audience with respect to gender, ethnicity, socioeconomic means, and, particularly, age. As aesthetic procedures become less invasive and more available to the general public, more elderly patients are seeking cosmetic surgery. In the last 2 decades, according to the 2016 ASAPS statistics report, the number of cosmetic procedures performed among those age 65 years and over has increased by a stunning 1263%, and by 58% in the last 5 years alone.[16] Age has gained more attention in recent years as a risk factor for postoperative complications in aesthetic surgery, because there is commonly a steady increase in the number of pathological comorbid conditions. Whether increasing age directly impacts the incidence of SSIs or contributes to other confounders, such as other medical comorbidities, is debatable. In a study by Kaye et al examining 144,485 surgical patients with an overall SSI rate of 1.2% (1684 patients), statistical analysis revealed a significant association between age and the risk of SSI ($P = 0.006$).[66] Interestingly, whereas the risk of SSI increased by 1.1% for each year between 17 and 65, it decreased by 1.2% for each year over 65. The authors, although unable to explain the protective findings of older age, discussed the possibility of selecting a relatively healthy group of older patients with a more robust genetic make-up, or this patient population did not manifest clinical signs of infection, such as fever, due to their older age. These findings are somewhat supported by Yesley et al who found no statistically significant difference between elderly and younger patient groups who underwent cosmetic procedures.[67] However, other literature advocated 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.[68-71] The authors of a recent study from the CosmetAssure database looking at 129,007 patients who underwent cosmetic surgical procedures also found increasing age was a significant risk factor for major SSIs.[11] Gusenoff et al evaluated 106 massive weight loss patients who underwent thighplasty and demonstrated age was associated with an increased postoperative infection rate (odds ratio [OR] = 1.47 per 5 years of age increase, $P = 0.01$).[32] With differences in the outcomes of various studies, a thorough preoperative evaluation is essential in selecting patients for cosmetic surgeries. Older patients should be appropriately evaluated in the preoperative setting to ensure they can tolerate the stress of surgery and anesthesia and they are physiologically capable to heal after surgery. As Lubin stated, although age alone should not be used as a criterion for performing surgery, operations on older populations must be conducted with caution to account for the physiological changes that accompany aging.[72]

Gender

Gender-dependent differences in the clinical outcomes of surgical patients have been studied extensively. In a large prospective cohort study of 129,007 patients who underwent cosmetic surgical procedures, Kaoutzanis et al found that females suffered significantly more SSIs compared with males (0.5% vs 0.3%, $P = 0.02$) with a relative risk (RR) of 1.86.[11] However, it was acknowledged that the overwhelming majority of aesthetic surgeries were performed in females. This is in contrast to the majority of studies that tend to find male gender to be a risk factor for postoperative complications. In a national German study involving more than 430,000 surgeries with greater than 8600 SSIs, women were found to have a significantly lower rate of SSI (SSI/100 procedures) than men for abdominal surgery (2.92-4.37, $P < 0.001$), but there was no such difference in orthopedic and vascular surgery procedures.[73] Studies have looked into plausible explanations for the influence of gender on healing and SSI incidence. One proposed theory involves Bateman's principle where females have improved immune function in order to prolong their reproductive function.[74] Another animal study has shown a correlation between gonadal hormones and wound healing, with androgens impairing it and estrogens protecting it.[75] Interestingly, male gender has been associated with a higher rate of complications in general. For example, in the CosmetAssure study by Winocour et al of 25,478 abdominoplasties, male gender was a significant risk factor for major complications (RR = 1.8, $P < 0.05$).[26] This was also shown in the same database in brachioplasty (RR = 3.44,

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$P < 0.01$) and facelift (RR = 2.1, $P < 0.01$).[29,63] It is important to note that in both of these studies, after controlling for other factors in the multivariate regression analysis, this was not a significant risk factor specifically for SSIs. However, many studies including these 2 previously mentioned have specifically linked male gender to other particular complications, most notable hematoma.[29,76] Although the focus of this article is postoperative SSIs, it is critical to inform male patients of their increased predisposition to complications, particularly hematomas.

Obesity

Obesity has been a well-established risk factor for SSIs in a variety of surgical fields including aesthetic surgery.[10,77] It is not surprising that increased BMIs influence the development of SSIs; many studies have demonstrated its negative effects on the inflammatory and wound-healing process.[78-81] In a meta-analysis of 16 studies looking at over 10,500 patients who underwent reduction mammoplasty, BMI greater than 30 kg/m^2 was associated with a significant increase in complications (OR = 0.73; 95% confidence interval [CI] = 0.61-0.89, $P = 0.001$), particularly infection (OR = 0.68; 95% CI = 0.52-0.89, $P = 0.004$).[82] In a prospective cohort study of 129,007 patients who underwent aesthetic surgical procedures, the mean BMI was significantly higher in patients with major SSIs (27.3 ± 5.5 vs 24.3 ± 4.6 kg/m^2, $P < 0.01$), and BMI was found to be a predictor for major SSIs (RR = 1.07, 95% CI = 1.06-1.08, $P < 0.01$).[11] Such a trend was also observed among body-contouring procedures including abdominoplasty, thighplasty, and brachioplasty.[26,29,31,83] In a study of more than 127,000 patients, Gupta et al found that the complication rate steadily increased with BMI; major wound infections were twice as common in overweight patients receiving aesthetic surgeries.[84] Additionally, being overweight (BMI 25-29.9 kg/m^2) and obese (BMI ≥ 30 kg/m^2) were independent predictors for major SSI (RR = 1.63 and RR = 2.73, respectively). Current national trends of obesity will continue to translate into surgeries being performed on patients with high BMIs. Given the increase in complications and SSIs with elevated BMIs, patients should be made aware of such risks and a multi-faceted approach should be employed to try to reduce their BMI, especially prior to elective procedures.

Smoking

The role of smoking in impacting wound healing has long been known, with several surgeons emphasizing cessation of smoking weeks prior to surgery. A recent meta-analysis and systematic review involving 140 cohort studies and 479,150 patients found a pooled adjusted OR of 1.79 (95% CI = 1.57-2.04) for SSIs for smokers compared with nonsmokers.[85] More importantly, interventions for smoking cessation in 4 randomized controlled trials included in the review reduced SSIs (OR = 0.43, 95% CI 0.21-0.85). However, 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. Smoking impacts wound healing through several ways including a decrease in tissue oxygenation, aerobic metabolism, reduction in cellular chemotaxis necessary for healing as well as impaired fibroblast migration and collagen deposition.[86] Preoperative evaluation and counseling of patients who are active smokers is crucial not only in reducing postoperative infectious complications, but also in establishing the appropriate expectations. Interestingly, a study examining the accuracy of information on smoking habits provided by patients seeking elective plastic surgery revealed underreporting of cigarette consumption.[87] More specifically, 26% of self-reported nonsmokers tested positive for cotinine (metabolite of nicotine) in the urine, and 50% of smokers underreported the amount they smoke.

Araco et al, in a prospective study examining 84 patients undergoing aesthetic abdominoplasty, reported postoperative infections were present in 15.5% of patients, 92% of which were smokers.[25] The RR of smoking on infections in that study was 12. In another study, Manassa et al retrospectively looked at 132 patients who underwent abdominoplasties and demonstrated a statistically significant difference between smokers and nonsmokers ($P < 0.01$) in wound healing and wound dehiscence.[20] Gravante et al studied 42 postbariatric patients who underwent mastopexy and breast reduction and showed an infection rate of 35.7% (15 patients) with two-thirds occurring in smokers.[88] They found the RR conferred by smoking to be 3.8, with a significant difference between the infected and noninfected groups in estimated cigarettes smoked and number of smoking pack-years ($P < 0.001$). Moreover, Bikchandani et al reviewed 764 breast reductions in 402 patients and found the probability of smokers developing wound infections was 3.3 times more compared with nonsmokers.[89] Yet another study that looked at 87 patients who underwent breast reductions found the incidence of SSI to be 27.9% (24 patients) with an OR of 2.04 for smokers.[90] In both this study and the one by Araco et al, smokers were advised to cease smoking at least 4 weeks prior to surgery. Even so, higher infection rates in smoking groups suggest the need for extensive counseling as well as smoking cessation, perhaps more than 4 weeks prior to aesthetic and elective surgeries. Although it is challenging to convince patients to stop smoking, knowledge of smoke-free intervals prior to scheduled surgeries can at least help surgeons guide postoperative care for such patient populations.

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Glycemic Control

Perioperative hyperglycemia may occur as a result of the normal physiologic response to the stress of surgery, but can also be observed in cases of uncontrolled or undiagnosed diabetes. This metabolic abnormality has been linked with postoperative infectious complications in several surgical specialties.[91-94] Diabetes has also been reported as a risk factor for postoperative SSIs in cosmetic surgery. In a large study of 129,007 patients who underwent cosmetic procedures where 2368 patients had diabetes, the authors found that the diabetic group had significantly more infectious complications (1.1% vs 0.5%, $P < 0.001$).[95] In that same study, multivariate analysis indicated diabetes to be an independent risk factor for infection (RR = 1.70, $P < 0.001$). In a study from the same database investigating risk factors for major SSIs, diabetes was an independent predictor of wound infections with an RR of 1.58 (95% CI = 1.06-2.35, $P = 0.02$).[11] Moreover, a prospective multicenter study by Drapeau et al examining 2806 consecutive patients who underwent plastic and reconstructive procedures, of which 3% (85 patients) developed an SSI, diabetes was a significant risk factor for SSIs both on univariate analysis (OR = 4.67, 95% CI 2.67-8.17, $P < 0.0001$) and multivariate analysis (adjusted OR = 2.54, 95% CI 1.10-5.87, $P < 0.028$).[96] These studies are contrasted by a few smaller series examining breast augmentation and breast reduction, which found no significant association between diabetes and postoperative wound infections.[40,43] Despite this, enough evidence exists to support the need for optimization of perioperative blood glucose levels in patients with diabetes undergoing cosmetic procedures to ensure adequate wound healing and recovery in the postoperative phase. Because the ideal perioperative serum glucose targets have not been determined for this patient population, additional clinical trials with carefully controlled protocols for the measurement of serum glucose levels and accurate preoperative assessment of patients' diabetes status will be beneficial.

Operative Time

Prolonged operative times have been associated with increased rates of SSIs in many fields.[97-100] In a study of 315 plastic surgery patients, the wound infection rate almost tripled for surgeries lasting more than 120 minutes compared with those that lasted less than 60 minutes.[101] Khavanin et al retrospectively reviewed 49,044 cases in the ACS-NSQIP database to evaluate the association between operative duration and the risk for SSI in plastic surgery.[102] It was noted that the relative likelihood of SSI increased on average by 9.6% for each hour of surgery (95% CI = 7.2%-11.9%) across all plastic surgery procedures. In addition, a random forest analysis identified operative duration as one of the most important variables in SSI prediction. Gusenoff et al, in a study of 101 patients who underwent brachioplasty, found longer operative times were associated with increased rates of surgical complications (OR = 3.8, $P = 0.003$).[103] This was attributed to several factors including intraoperative hypothermia, perioperative nutrition, surgeon fatigue, and average length of incisions. Interestingly, the authors suggested that larger operative teams may be helpful in facilitating reconstruction. Although not extensively studied in aesthetic surgery, a recent study by Haddock et al evaluated the role of a co-surgeon in microsurgical breast reconstruction and showed a significant reduction in operative times and postoperative complications.[104] Likewise, Weichman et al examined 157 patients who underwent microsurgical breast reconstruction and reported very similar results.[105] Taken together, these findings highlight the need for adequate surgical training and experience, which combined with highly skilled surgical teams, could lead to more efficient utilization of operative time and result in better patient outcomes.

Type of Facility

Aesthetic surgical care in the United States has shifted from the hospital setting to outpatient surgical centers over the last few decades, with the majority of cosmetic procedures being performed in outpatient facilities.[106-108] We previously investigated 129,007 patients who underwent cosmetic procedures and found the type of facility to be an independent predictor of SSIs, with hospital or ambulatory surgery centers having a higher risk of infections compared with office-based surgical suites.[11] This finding could be related to the appropriate patient selection by plastic surgeons, where higher risk patients underwent surgery in higher level of care facilities, such as an accredited surgical center or hospital setting. Gupta et al employed the same database to evaluate complication rates based on the type of facility and showed lower risk of developing a complication if the procedure was performed in an office-based surgical suite compared with an ambulatory surgery center (RR = 0.67, 95% CI = 0.59-0.77, $P < 0.01$) or hospital (RR = 0.59, 95% CI = 0.52-0.68, $P < 0.01$).[109] It was further noted, however, that patients who underwent procedures at office-based surgical suites were less likely to receive combined procedures.

Many studies have shown safety in performing surgeries, such as abdominoplasties, in the office setting with low complication rates. Spiegelman et al compared 37 inpatients and 32 outpatients who underwent abdominoplasty and found a wound infection rate of 10.8%

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(4 patients) for inpatient procedures and 3.1% (1 patient) for outpatient procedures.[110] Although such studies favor outpatient surgery, it is the responsibility of the plastic surgeon to properly evaluate patients to determine if they may require a higher level of care based on their health status (eg, demographics, health behaviors, comorbidities). Such patients should undergo surgery in facilities equipped to care for high-risk patients to ensure patient safety.

Combined Procedures

It is not uncommon for many patients seeking cosmetic surgery to request concurrent procedures under one anesthetic. Whereas some studies have demonstrated no increased risk of complications with combined procedures, others have. Stevens et al evaluated the safety of combining abdominoplasty and cosmetic breast surgery in 268 patients, and found a complication rate similar to those reported for individually staged procedures.[111] Likewise, other studies examined the effect of combining abdominoplasty or liposuction with other surgical procedures, and showed no increased risk of complications with combined procedures.[112,113] On the other hand, in an analysis of 31,010 liposuction procedures, combined procedures were an independent predictor of major complications.[114] In the same study, when examining specifically other aesthetic procedures performed alone or with liposuction, combined procedures carried a significantly higher risk of SSI with a RR of 2.41. Another study from the same database evaluating 129,007 patients who underwent cosmetic surgery revealed a higher incidence of postoperative SSIs in patients who underwent combined procedures compared with single procedures (0.8% vs 0.3%, $P < 0.01$).[11] The authors attributed this increase to the nature of combined procedures (involving multiple wound classification sites, such as a clean and clean-contaminated site) as well as longer operative times. Winocour et al also reported that combined procedures increased the risk of complications in abdominoplasty with a complication rate of 3.1% in abdominoplasties alone compared with 10.4% when combined with liposuction and another body-contouring procedure.[26] In fact, in the facelift population, where infection rates are typically very low, combined procedures have been shown to result in a RR of 3.5 in increasing the risk of infection.[63] For cosmetic rhinoplasties, although combined procedures were found to have a 10% higher risk of increasing complications, it did not reach statistical significance (95% CI = 0.25-4.87, $P = 0.90$).[62] Although the CosmetAssure studies listed above demonstrated an increased rate of several complications with combined procedures, they stated that the increase in complication rate in combined procedures was less than the sum of the complication rate of each procedure conducted separately. Nevertheless, careful consideration is still required, especially because this represents major complications following elective, nonmedically necessary surgery. Even though the safety profile of combined cosmetic procedures is still under scrutiny, patients should be made aware of the possibility of increased risk for wound infection associated with combined procedures. If a patient, especially with a high risk profile, seeks more than one procedure, it may be worth staging the operations to lower individual operative times and maintain sterile standards across the various operative fields (ie, clean vs clean-contaminated fields) at all times.

In summary, several factors play a role in influencing postoperative SSIs and it is not surprising that many of these have a synergistic effect. A thorough preoperative evaluation is necessary several weeks or months prior to cosmetic surgery to allow patients to correct any modifiable risk factors and improve their health to optimize their postoperative course and avoid long-term complications. Even with adequate preoperative care, surgeons should be cognizant of the high-risk patients and be vigilant in the postoperative phase to identify and manage possible complications and infections in a timely manner to ensure patient safety and maintain a successful surgical outcome.

PERIOPERATIVE PREVENTION MEASURES

Preoperative Hair Removal

Traditionally, preparation of patients for surgery included removal of hair from the planned incision site. Hair was felt not only to interfere with the exposure of the incision, but also to be associated with lack of cleanliness.[115] More recently, these beliefs have been questioned, which resulted in different practices throughout the world.[116,117] Tanner et al, in a Cochrane review including 14 trials, evaluated the effect of preoperative hair removal on SSIs.[118] Six trials (972 participants), 2 of which had 3 comparison arms, compared hair removal (shaving, clipping, or depilatory cream) with no hair removal and found no statistically significant difference in SSI rates; however, the comparison was underpowered. Three other trials (1343 participants) compared shaving with clipping and showed significantly more SSIs associated with shaving (RR = 2.09, 95% CI = 1.15-3.80). Seven trials (1213 participants) found no significant difference in SSI rates when hair removal by shaving was compared with depilatory cream (RR = 1.53, 95% CI = 0.73-3.21); however, this comparison was also underpowered. One trial compared 2 groups that shaved or clipped hair on the day of surgery compared with the day before surgery; the number of SSIs did not statistically significantly differ between groups, but this comparison was

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also underpowered. Of note, none of the included studies examined aesthetic surgery patients. When it is necessary to remove hair, the existing evidence suggests that clippers are associated with fewer SSIs than razors. There was no significant difference in SSI rates between depilatory creams and shaving or between shaving and clipping the day before surgery or on the day of surgery; however, studies were small and further research is required for definite conclusions.

Decolonization

Individuals colonized with Methicillin-Resistant Staphylococcus aureus (MRSA) have a 10- to 13- fold increased risk for subsequent development of MRSA infections.[119,120] Decolonization has been proposed as a way to prevent MRSA infections from recurring and to decrease the spread of this pathogen. Several regimens have been tested for their decolonization efficacy including chlorhexidine body washes, povidone-iodine body washes, mupirocin nasal ointment, and oral antibiotics.[121,122] Preoperative washing with 10% povidone-iodine solution in patients who underwent plastic surgery to the abdomen and thorax resulted in reduced staphylococcal skin colonization, but the effect on postoperative SSI was not studied.[123] A Cochrane review including 7 trials with a total of 10,157 participants showed no clear evidence of benefit for preoperative showering or bathing with chlorhexidine over other wash products to reduce SSI.[123] Another recent meta-analysis of 16 trials with a total of 17,932 patients suggested no appreciable benefit of preoperative whole-body chlorhexidine bathing for prevention of SSI.[124] Overall, 6.8% of patients developed SSIs in the chlorhexidine group compared with 7.2% of patients in the comparator groups (ie, soap, placebo, or no shower or bath). Of note, most of the included studies omitted details of chlorhexidine application. Better-designed trials with a specified duration and frequency of exposure to chlorhexidine are needed to determine whether preoperative whole-body chlorhexidine bathing reduces SSI.

As previously shown, a considerable number of *Staphylococcus aureus* infections originate from patients' own flora.[125-127] Because about 30% of the population carries nasal *S aureus*, a large portion of patients could potentially be at risk of postoperative infections.[128-130] Intranasal mupirocin has been studied among various surgical disciplines as a staphylococcal decolonization strategy. A systematic review by van Rijen et al showed that among 686 mupirocin-treated patients with *S aureus* nasal carriage, there were 25 infections (3.6%) compared with 46 (6.7%) in the controls (RR = 0.55, 95% CI = 0.34-0.89, P = 0.02).[131] The authors concluded that the prophylactic use of intranasal mupirocin significantly reduced the rate of postoperative *S aureus* infections among carriers, and, given the safety, low cost, and easy application of mupirocin combined with the limited risk of resistance associated with its short-term application, it should be considered perioperatively. Although mupirocin ointment was shown to be effective in short-term MRSA control, it did not prevent recolonization or subsequent infections.[132,133] Based on the available literature, the optimal decolonization regimen appears unclear at this time and should be reserved for patients who are colonized with MRSA or who previously had a MRSA infection.

Prophylactic Antibiotics

SSI is one of the core quality performance indicators for the Surgical Care Improvement Project (SCIP) of the Centers for Medicare and Medicaid Services.[134] To ensure compliance with SCIP measures, surgeons are expected to provide antibiotic prophylaxis by utilizing the appropriate antibiotic administered via the proper route within a specific time period prior to surgery and discontinued within the appropriate time postoperatively. These recommendations aim to not only prevent SSIs but also to decrease the adverse outcomes related to antibiotics, such as development of drug-resistant microorganisms.

The SCIP measures apply to specific operations, including coronary artery bypass graft, other cardiac surgery, vascular surgery, hip/knee arthroplasty, colon surgery, and hysterectomy.[134] Aesthetic surgical procedures are not required to follow these guidelines, because there is a lack of high-quality evidence addressing the benefits of systemic prophylactic antibiotics in SSI reduction for most cosmetic procedures. Despite this, as shown by several surveys, the prophylactic utilization of antibiotics by board-certified plastic surgeons has steadily increased over the last few decades.[135-137] In 2003, Lyle et al conducted a survey of members of the ASPS to elicit information on the frequency and timing of prophylactic antibiotic utilization for plastic surgery procedures.[135] These data were compared with the data from 2 previous surveys conducted in 1985 and 1975.[136,137] It was clear that prophylactic antibiotic utilization doubled or even tripled for several aesthetic procedures compared with the earlier data (Table 2).

In 2015, the American Association of Plastic Surgeons selected experts to evaluate the evidence for efficacy and safety of antibiotic prophylaxis in plastic surgery procedures and subsequently published consensus recommendations.[57] Meta-analysis of randomized-controlled trials has shown that routine antibiotic prophylaxis for patients undergoing clean cosmetic breast surgery results in a significant reduction in the risk of SSIs (2.5% vs 11.4%, OR = 0.16, 95% CI = 0.04-0.61, P = 0.01). The available studies did not address whether individuals

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Table 2. Trends of Prophylactic Antibiotic Use for Aesthetic Procedures Over the Last Few Decades

Procedure	1975; percentage of use	1985; percentage of use	2003; percentage of use
Breast			
Breast augmentation	43	59	94
Breast reduction	30	44	88
Body			
Abdominoplasty	31	43	88
Arm contouring	—	24	81
Buttock lift	—	41	87
Thigh lift	—	41	88
Suction-assisted lipectomy	—	33	79
Ultrasound-assisted lipectomy	—	—	81
Face			
Blepharoplasty	7	11	47
Brow lift	—	—	67
Chemical peel	—	17	49
Dermabrasion	—	—	60
Laser resurfacing	—	—	74
Malar/chin implant	—	64	93
Rhinoplasty	25	24	78
Rhinoplasty (septum)	—	31	80
Rhinoplasty (cartilage grafts)	—	50	88
Rhinoplasty (alloplastic implants)	50	74	93
Rhytidectomy	16	22	73

Adapted from Ariyan et al.[57]

receiving implants or tissue expanders benefit more from antibiotic prophylaxis. Further subgroup analyses of patients who underwent breast reduction vs breast augmentation with implants suggested that both groups received benefit from antibiotic prophylaxis. However, conclusions were not possible regarding the best antibiotic and optimal dose. For abdominoplasty, the authors did not provide an evidence-based statement because there were no randomized-controlled trials, and even the only available pseudo-randomized study addressing this population was underpowered. Finally, the authors performed a meta-analysis of several randomized and nonrandomized controlled trials for patients who underwent septoplasty/rhinoplasty surgery. Although the level of evidence was low, the authors concluded that antibiotic prophylaxis reduces the risk of SSI in this patient population and thus was recommended. Another recent review of the literature stated that although available literature does not support routine antibiotic prophylaxis, it is also not sufficient to make a legitimate argument against its use; further studies are necessary to draw definitive conclusions.[61]

The need for antibiotic prophylaxis for other aesthetic facial procedures has also been examined. An international multispecialty survey on rhytidectomy trends found that 11% of surgeons give no antibiotics, 21% give preoperative antibiotics only, and 68% give some combination of perioperative and postoperative antibiotics for up to 7 days.[138] These findings are consistent with another recent survey of members of the ASPS, which showed 84% of the respondents employing prophylactic antibiotics more than 50% of the time, and 75% utilizing them in every case.[139] Dauwe et al provided recommendations for the prevention of infection in face-lift surgery.[140] It was suggested that perioperative antibiotic administration guidelines for this patient population should follow SCIP guidelines for clean surgery. Specifically, a single dose of preoperative antibiotics should be administered within 1 hour of the surgical incision, and antibiotics should be discontinued within 24 hours of the end of surgery. Clearly, the majority of surgeons currently utilize prophylactic antibiotics for patients undergoing rhytidectomy; however, to the best of our knowledge, there are no high-quality studies comparing infection rates in patients who received antibiotics vs those who did not; thus, further research will be beneficial for this patient population.

Several studies have also shown a significant increase in antibiotic prophylaxis for patients undergoing blepharoplasty. For instance, a survey of members of the ASPS by Lyle et al showed a significant increase in antibiotic utilization from 1985 to 2000; in 1985 only 11% of the respondents utilized prophylactic antibiotics more than 50% of the time, but in 2000 that increased to 46.9% of the respondents.[135] Likewise, in 2010, Hauck and Nogan found an even higher number of respondents (64%) employing systemic antibiotics more than 50% of the time, with 51% always utilizing them and 21% never.[139] Interestingly, a recent multinational survey of members of international oculoplastic societies revealed common utilization of topical antibiotics (85.2%) after blepharoplasty but rare use of systemic antibiotics (13.5%).[141] Similarly, a retrospective review by Carter et al examined 1627 patients who underwent blepharoplasty and showed that all the patients received topical antibiotics, but only 11 received prophylactic oral antibiotics due to prosthetic joints or heart valves; the overall infection rate was extremely low (0.2%).[142] Based on the available evidence, it is difficult to justify routine utilization of prophylactic antibiotics for this patient population.

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Irrigation Solutions

Irrigation of a surgical site has been performed in many settings to decrease the likelihood of complications. For aesthetic surgery, a few studies have examined the effect of different irrigation solutions on postoperative SSIs, particularly for breast augmentation procedures. Pfeiffer et al compared cephalothin/saline/epinephrine irrigation solution to saline/epinephrine irrigation solution in 436 women who underwent breast augmentation and found significantly fewer infections in the first group (6.7% vs 12.8%, $P = 0.044$).[143] Giordano and colleagues examined 330 women who underwent breast augmentation and showed no difference in SSIs between no pocket irrigation and irrigation with a mixture of 10% povidone-iodine/cefuroxime/gentamicin solution (1.8% vs 1.2%, $P = 0.65$).[144] For several surgical specialties, such as gastrointestinal and cardiothoracic, povidone-iodine irrigation has been stated to be significantly more effective in preventing SSIs than saline, water, or no irrigation.[145] Araco et al reviewed 3002 patients who underwent breast augmentation wherein the implants were washed with a povidone-iodine solution and the breast pockets were irrigated with antibiotic solutions.[42] Their analysis suggested that the utilization of antibiotic irrigation might be associated with a decreased incidence of infections. Given the Food and Drug Administration restrictions on the utilization of povidone-iodine solutions for breast pocket irrigation, Adams et al evaluated the effect of non-povidone-iodine solutions and suggested a combination irrigant containing bacitracin, cefazolin, and gentamicin.[146] As an alternative, they recommended a 10% povidone-iodine/cefazolin/gentamicin solution to bathe the breast pocket for 5 minutes, followed by pocket irrigation with sterile saline before the implant placement. Although continuous irrigation of a breast pocket with a bacitracin/cefazolin/gentamicin solution for 24 hours after surgery has been studied and was shown to decrease SSIs following placement of tissue expanders after breast reconstruction, it has not been validated in aesthetic surgery.[147] A recent systematic review on antibiotic prophylaxis in prosthesis-based mammoplasty concluded that antibiotic irrigation might not be able to reduce infection rates.[148] Further studies are required to address these ideas.

The use of antibiotic irrigation for the implant pocket is even less studied in aesthetic facial surgery. Brandt and Moore in a review of facial skeletal augmentation with implants recommended the placement of the implant in an antibiotic bath of bacitracin saline solution along with the irrigation of the implant pocket with antibiotic solution to prevent postoperative SSIs.[149] Similarly, Niamtu published a technical note on cheek and midface augmentation with implants based on his experience, and suggested irrigation of the implant pocket with clindamycin/sterile water solution to achieve low infection rates.[150] Other techniques, such as preoperative antibiotic soak or impregnation, especially during rhinoplasty, have been proposed by several authors.[151-157] Despite all the available studies, very little objective evidence exists that these techniques are actually effective in reducing or preventing SSIs.

Body Temperature Regulation

Perioperative hypothermia occurs inadvertently in 50% to 90% of all surgical patients unless active rewarming measures are employed.[158,159] This is partially related to the impairment of the normal thermoregulatory vasoconstriction response or regional and general anesthetics.[160] Many investigators have examined the association between hypothermia and adverse events. Specifically for SSIs, both animal and human studies have shown the increased risk of wound infection with intraoperative hypothermia.[161-163] In a study of 416 patients who underwent short, “clean” surgeries, 5% of prewarmed patients developed SSIs compared with 14% of patients who were not prewarmed ($P = 0.001$).[164] Kurz et al randomized a group of 200 patients who underwent colorectal procedures to routine intraoperative thermal care (hypothermia group) and additional warming (normothermia group).[163] The incidence of SSI in the hypothermic group was about 3 times higher than in the normothermic group (19% vs 6%, $P = 0.009$). More recently, Van Vliet et al evaluated the effect of intraoperative core temperature on the incidence of SSIs in a prospective/retrospective study of patients who underwent abdominoplasty, panniculectomy, and autologous breast reconstruction.[165] The retrospective arm included 68 patients, and wound infections occurred more frequently in those patients who spent a greater amount of time below 36°C ($P = 0.04$). However, the prospective arm, which included 100 patients, failed to show a statistically significant correlation between core temperature and postoperative SSIs. Further studies are required to more clearly define the impact of perioperative hypothermia on postoperative SSIs in the aesthetic surgery population. Until these data is available, a variety of strategies to maintain normothermia should be employed, such as forced-air heating systems and fluid warming.[160]

POSTOPERATIVE DIAGNOSIS

The majority of SSIs manifest within the first month after surgery. There is usually a lag of at least 5 days and up to 2 weeks postoperatively when an SSI appears, but it is recommended that patients be followed-up for at least

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30 days postoperatively.[166] However, some infections, especially related to implants, can occur months or even years after the initial operation; thus, follow-up of these patients for at least 1 year is recommended.[40,41,167,168] In rare occasions, patients will present with symptoms and signs of SSI within the first 48 hours after surgery. SSIs that occur within this time frame are almost always due to Clostridium species or *Streptococcus pyogenes* and can progress very rapidly with devastating consequences if not addressed in a timely fashion. Postoperative toxic shock syndrome caused by *S aureus* wound infection can also be observed within the first 48 hours after surgery.[169-171] In these cases, the incision appearance can be deceptively benign on examination, and diagnosis is based on fulfillment of the following 6 criteria: fever, rash, desquamation, hypotension, multisystem organ involvement, and negative culture results and serologies.[166,172]

The recent shift of aesthetic surgical care from hospital facilities to outpatient surgical centers makes postoperative surveillance of infections more challenging because patients may have a difficult time diagnosing an infection. For this reason, preoperative education regarding the symptoms and signs of infection becomes critical, and every patient should have explicit instructions on how to seek medical attention if there is suspicion for infection. Initial patient evaluation with a thorough history and physical examination is essential. Local signs of swelling, pain, erythema, and purulent drainage are usually reliable in diagnosing an SSI. However, in morbidly obese patients or those with deep multilayer wounds, external signs of SSI may be delayed.[173] Physicians may order appropriate adjunct tests, such as laboratory or microbiology data and imaging studies, to assist with the diagnosis of infection. It is not unusual to observe some erythematous skin changes around or near the surgical incision during the first week after surgery without the other symptoms and signs of infection. Most of these changes resolve without any treatment, and may be related to tape sensitivity or other local tissue insult not involving bacteria. Several studies have previously demonstrated that antibiotics begun immediately postoperatively or continued for long periods after the procedure do not prevent or cure this inflammation or infection.[15,174-177] Therefore, for the majority of cases, the suspicion of possible SSI does not justify use of antibiotics without a definitive diagnosis and the institution of other therapeutic measures, such as opening the wound.[173] The CDC separates wound infections into 3 main categories as previously discussed; superficial incisional SSI, deep incisional SSI, and organ/space SSI.[12]

A recent systematic review of the plastic surgery literature concluded that the criteria used for identification of SSI in the literature have not been standardized, and the definition by receipt of specified treatment was the most frequently utilized way of classifying infections.[13] Adoption of a standardized definition of SSI would be ideal because this would not only allow optimal comparison of data across studies, but also enhance communication between plastic surgeons. The CDC definition is one of the most commonly utilized classifications of SSIs among various surgical specialties and has also been recommended for plastic surgery.[13]

Physicians should be familiar with the organisms responsible for infections. These organisms may differ depending on the body region and the type of surgical procedure. For example, the most frequently isolated bacteria following breast augmentations include *S aureus*, *Staphylococcus epidermidis*, streptococci A and B, *Klebsiella pneumoniae*, *Bacillus*, and *Propionibacterium*, whereas *Corynebacterium* species, *Propionibacterium* acnes, *Pseudomonas aeruginosa*, *Escherichia coli*, and Enterobacteriaceae are less common.[40,178-181] For liposuction, group A streptococci, *S pyogenes*, and synergistic infections (anaerobic and facultative anaerobic bacteria) are by far the most frequently isolated.[182,183] In addition, sporadic cases of mycobacteria have been described for several aesthetic procedures and should be suspected for late infections with an indolent course when common techniques fail to isolate a cause.[181,184-191]

TREATMENT

The majority of textbooks and literature for SSIs discuss extensively the epidemiology, prevention, and surveillance of these infections, but not their treatment.[173] Considering the extent of the problem, there is very little guidance as to the management of SSIs in aesthetic surgery.

In general, the first and most important step in the management of an SSI is incision and drainage. The incision should be opened, the infected material should be evacuated, the cavity should be thoroughly washed out, and appropriate dressing changes should be initiated to promote wound healing by secondary intention. Once the wound base is clean and granulation has begun, the frequency of dressing changes can decrease. Occasionally, for bigger wounds, negative pressure wound therapy can be considered to remove excess wound edema and promote wound contraction.[192] It was previously shown that incision and drainage of superficial abscesses rarely cause bacteremia;[193] therefore, prophylactic antibiotics are not necessary. Making the incision too small may fail to control the infection. It is essential to open the incision adequately not only to control the infection, but also to diagnose and treat associated problems such as necrosis of the subcutaneous tissue and fascia that require debridement. For necrotizing infections, serial aggressive surgical debridements may be required. The balance between effective debridement and unnecessary overexcision can be challenging, but it is particularly important in the aesthetic

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surgery population where cosmetic outcomes are central to the success of the operation.

The latest practice guidelines for the management of skin and soft tissue infections published by the Infectious Diseases Society of America state that adjunctive systemic antimicrobial therapy is not routinely indicated, but in conjunction with incision and drainage may be beneficial for SSIs associated with a significant systemic response such as erythema and induration extending >5 cm from the wound edge, temperature >38.5°C, heart rate >110 beats/minute, or white blood cell count >12,000/µL.[173] The antibiotic choice is usually empiric but can be supported by gram stain, culture of the wound contents, and the site of surgery. A first-generation cephalosporin or an antistaphylococcal penicillin is recommended for methicillin-susceptible *S aureus*, whereas vancomycin, linezolid, daptomycin, telavancin, or ceftaroline should be employed where risk factors for MRSA are high (nasal colonization, prior MRSA infection, recent hospitalization, recent antibiotics).[173] Infections following operations on the axilla have a significant recovery of gram-negative organisms, and those in the perineum have a higher incidence of gram-negative organisms and anaerobes; therefore, agents active against these organisms, such as cephalosporin or fluoroquinolone in combination with metronidazole, are recommended.[173]

Physicians should also be aware of several other problems that surround management of infections with antibiotics. For example, pharmacokinetic issues are becoming increasingly important in the management of severe infections. A few of the current antibiotics employed require dose monitoring and adjustments related to the clinical condition of the patient. In addition, antibiotic de-escalation should be encouraged in severe infection to achieve effective initial therapy but at the same time avoid unnecessary antibiotic use that would promote the development of resistance. Neutropenic and immunocompromised patients, although rare in the cosmetic arena, are at increased risk of harboring resistant and/or difficult-to-treat pathogens.[194] Given the high initial mortality rates for this patient population, relevant guidelines emphasize the need to consider gram-negative and polymicrobial infections, in addition to the most common gram-positive pathogens, when prescribing antibiotic therapy.[173] Although debridement of necrotizing infections should be performed immediately, drainage of soft tissue abscesses should be delayed until bone marrow recovers.

The utilization of implants is common in aesthetic plastic surgery; thus, a few important considerations related to SSI in the setting of such a foreign body merit discussion. Given the relatively low microbial burden required to cause an SSI in the context of a foreign body, infections tend to occur late (months and occasionally years after surgery) and are often associated with limited clinical manifestation.[192] Therefore, a high level of suspicion is required. Management remains challenging, and it is not clearly defined at this point. In the past, common practice was the immediate removal of infected prostheses; however, the more recent plastic surgery literature has explored options for device salvage.[195-201] Several ways of salvaging an infected device have been proposed including systemic antibiotics combined with conservative wound drainage,[196] antibiotic lavage,[201] capsulotomy and implant exchange,[202] capsule curettage and implant exchange,[197] antibiotic lavage followed by capsule curettage and implant exchange,[203] or capsulotomy/curettage/implant exchange followed by postoperative continuous antibiotic irrigation.[200,204] In 2004, Spear et al developed treatment guidelines for breast implant salvage in the setting of infection with and without implant exposure (Figure 1).[199] Patients with mild infections were started immediately on oral antibiotics, whereas patients with severe infections were started on parenteral antibiotics. Those patients who responded completely required no further treatment, but surgical intervention was recommended for persistent infections or threatened or actual exposure. In these cases, partial or total capsulectomy, debridement, pocket lavage, site change, implant exchange, and possible local tissue and/or flap coverage was chosen based on surgeon's experience and clinical judgment. The authors suggested that salvage attempts for implant infection and exposure depend on the degree of infection, response of the infection to initial antibiotic therapy, and availability of adequate soft-tissue coverage. Aggressive salvage measures also require a willingness to attempt salvage on the part of both the patient and the surgeon. Spear and Seruya, in a more recent review, further advocated that atypical pathogens on wound culture, such as gram-negative rods, MRSA, and *Candida parapsilosis*, are relative contraindications to breast implant salvage.[195] They also concluded that patients with a previous implant infection and/or exposure and a history of either radiotherapy or *S aureus* on wound culture should be monitored closely for signs of recurrence and managed cautiously in the setting of elective breast surgery.

ASSOCIATED COMPLICATIONS

Complications that arise as a result of an SSI and its subsequent treatment vary depending on the type of surgery and the severity of the SSI. A common approach in the management of these infections involves incision and drainage or even debridement of devitalized tissue, which usually leads to an open wound that requires frequent packing. Healing of such a wound may require several weeks or months, and can result in considerable scarring, aesthetic deformities or asymmetries, and chronic irritation or pain that may need revisionary surgery. Some of these patients may also require additional clinic or emergency room visits, hospital admissions, or reoperations,

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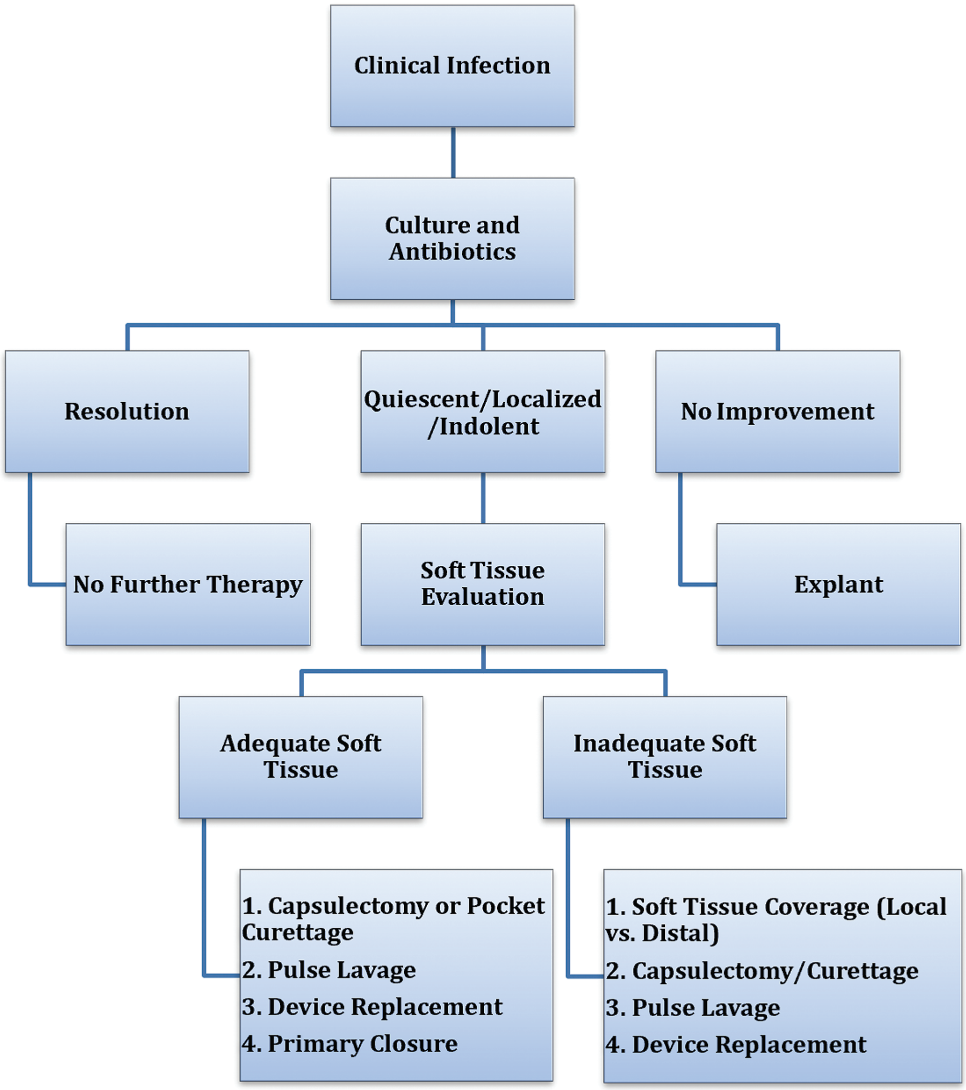

Figure 1. Possible pathways for the treatment of periprosthetic infections. Adapted from Spear et al.[199]

especially during the early postoperative period. Data collection from the American Association for Accreditation of Ambulatory Surgery Facilities between 2001 and 2012 including 3,922,202 plastic surgery cases revealed 3063 infections (0.078%), of which 225 (7.35%) required hospitalization and 1 succumbed (0.03%) due to an MRSA infection after liposuction.[23] Another 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 between 2008 and 2013 found 599 (0.46%) wound infections requiring emergency room visit, hospital admission, or reoperation.[11] These outcomes not only inflict significant financial burden on the patient and the physician but may also substantially impact the psychosocial well-being of the patient.

SSIs at specific regions of the body may be associated with more devastating sequelae. For example, although postoperative eyelid infections are rare due to the extensive vascularization of the periorbital region, they remain a feared complication by aesthetic surgeons. They can potentially progress rapidly to necrotizing fasciitis, leading to extensive tissue necrosis requiring debridement and thus significantly affecting the cosmetic outcome of the patient.[205-209] More importantly, they may lead to blindness, an extremely rare but dreadful complication after a purely cosmetic procedure.

More than 30 years ago, Burkhardt et al proposed that low-grade periprosthetic infection may be the underlying cause of capsular contracture after augmentation mammoplasty.[210] Since then, a growing body of literature, both basic science and clinical research, has supported the

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infective hypothesis of capsular contracture.[146,178,211-213] Contamination of breast implants at the time of surgical insertion with subsequent development of periprosthetic bacterial biofilm has been shown to be related with capsular contracture. More importantly, however, is that translational clinical research has recently demonstrated decreased incidence of capsular contracture and thus the need for reoperation by simply preventing bacterial access at the time of implant insertion.[144,146,214,215] Deva et al[216] described a 14-point plan, which, although does not represent a universally accepted gold standard, it does combine their experience and some proven strategies to fight biofilm infection at the time of breast implant placement. Some of their proposed strategies include the use of intravenous antibiotic prophylaxis at the time of anesthetic induction, avoidance of periareolar incisions, use of nipple shields to prevent spillage of bacteria into the pocket, careful atraumatic dissection and hemostasis, pocket irrigation with triple antibiotic solution or betadine, and use of an introduction sleeve for implant placement.

CONCLUSIONS

Aesthetic surgery, like any other surgical procedure, carries an inherent risk for SSIs with significant associated health, economic, and psychosocial burden. The incidence of SSIs following aesthetic surgery varies according to the specific operation performed and the presence of certain risk factors. Even though the incidence of SSIs after most of these procedures is very low, it cannot be underestimated given the fact that they are performed with an ultimate goal of cosmesis in fairly healthy individuals and hence should carry a minimal risk of complications. Some risk factors for postoperative SSIs include age, gender, obesity, smoking, pre-existing diabetes mellitus, trunk and extremity procedures as opposed to breast and face procedures, combined procedures, and operative times. Infections can be prevented or at least reduced if the modifiable factors are addressed. Even awareness of some of the nonmodifiable risk factors will facilitate preoperative assessment of patients seeking aesthetic surgery and set the appropriate expectations with regards to postoperative outcomes. Moreover, a variety of perioperative prevention measures has been proposed to further assist in reducing the incidence of SSIs including preoperative hair removal, targeted MRSA screening and decolonization, utilization of prophylactic antibiotics and irrigation solutions, as well as body temperature regulation in the perioperative period. Early diagnosis of these infections is critical, but can be a challenge because the majority of these procedures are conducted in an outpatient setting. Once the diagnosis is established, incision and drainage should be considered. Adjunctive systemic antimicrobial therapy is not routinely indicated, but may be beneficial for SSIs associated with a significant local and systemic response. Thorough preoperative patient education about the symptoms and signs of these infections is critical to increase the early detection rates and avoid some of the untoward sequelae related with these infections.

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