Prophylactic Antibiotics in Aesthetic Surgery

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Learning Objectives
Following this CME activity, the participant should be able to describe the definitions for surgical site infections (SSI) as defined by the National Healthcare Safety Network (NHSN); explain the difficulties inherent in quantifying the rate of postoperative SSI in aesthetic surgery patients; describe the current recommendations for antibiotic prophylaxis in surgery; list the risks of antibiotic over-utilization; and discuss the nonpharmacologic methods of preventing SSI.

Abstract
Improvements in infection prevention practices over the past several decades have enhanced outcomes following aesthetic surgery. However, surgical site infections (SSI) continue to result in increased morbidity, mortality, and cost of care. The true incidence rate of SSI in aesthetic surgery is unknown due to the lack of a national surveillance system, but studies of SSI across surgical specialties have suggested that many of these infections are preventable. Patient-related factors—including obesity, glycemic control, and tobacco use—may contribute to the development of SSI following aesthetic surgery. In terms of SSI prevention, proper handwashing and surgical skin preparation are integral. Furthermore, the administration of prophylactic antibiotics has been shown to reduce SSI following many types of surgical procedures. Unfortunately, there are few large, randomized studies examining the role of prophylactic antibiotics in aesthetic surgery. The authors review the medical literature, discuss the risks of antibiotic overutilization, and detail nonpharmacologic methods for reducing the risk of SSI.

Keywords
surgical site infections, prophylactic antibiotics, patient safety

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EDITOR’S NOTE

As we focus increasingly on objective evidence measures in our own practices, Aesthetic Surgery Journal will begin to highlight Evidence-Based Medicine (EBM) in relevant articles beginning in January 2011. The following article not only offers our readers an opportunity to collect Continuing Medical Education (CME) credits but is a thorough review of the literature currently available on prophylactic antibiotics in aesthetic surgery. Dr. Lane and his coauthors have ranked many of the articles they reviewed according to the level of evidence each article presented. These rankings can be found in the Reference section and correspond to the following classification system:

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<thead>
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<th>Level</th>
<th>Description</th>
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<td>Case control studies, or any of the above diagnostic studies in the absence of a universally accepted “gold” standard</td>
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<td>Expert opinion, case reports or clinical examples, or evidence based on physiology, bench research, or “first principles”</td>
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Our January 2011 issue will contain an even more thorough explanation and review of the EBM movement in plastic surgery.

In 2008, nearly 1.7 million cosmetic and 4.9 million reconstructive surgical procedures were performed in the United States.1 Due to the lack of a national reporting system, the true incidence of surgical site infections (SSI) following aesthetic surgery is unknown, and few prospective trials have been conducted to determine the rates of SSI following aesthetic and reconstructive surgery. Most reports on SSI rates and the effects of prophylactic antibiotics are based on surveys of patients or surgeons, retrospective case series, or anecdotal experience.2-5 However, estimates suggest that SSI may occur in 1% to 6% of clean surgical procedures and more than 12% of clean-contaminated procedures.6-7 It is estimated that 40% to 60% of these infections are preventable.8 If only 1% of the 6.6 million patients undergoing cosmetic or reconstructive surgical procedures developed an SSI, this would equate to infections in 66,000 patients per year.

Over the past few decades, changes in infection prevention practices have improved outcomes following surgery. These methods include a vast improvement in sterilization and barrier methods, surgical techniques, operating room ventilation, and antibiotic prophylaxis.9 In this article, the authors review the role of prophylactic antibiotics in aesthetic surgery and discuss nonpharmacological methods for preventing SSI.

HISTORY OF PROPHYLACTIC ANTIBIOTICS

The administration of antibiotics for surgical prophylaxis was not supported in early trials. Several large case series in the 1950s and 1960s showed no effect on wound sepsis in patients who received systemic antibiotics compared to those who did not receive antibiotics.10-15 Other studies actually showed an increase in wound sepsis among those who received prophylactic antibiotics.16-18 However, in all of these studies, antimicrobials were given after the surgical procedure. A groundbreaking study with animal models demonstrated that administration of antibiotics as little as three hours postoperatively produced histopathologic lesions similar to those seen in animals that did not receive antibiotics. Animals that received antibiotics before or shortly after inoculation of organisms had lesions that histopathologically resembled the inoculation of killed organisms.19 This study established the importance of antibiotic administration prior to the start of surgery in order to allow peak antibiotic concentration in the tissues at the time of inoculation with microorganisms. Among 1708 patients who received prophylactic antibiotics, patients who received antibiotics more than three hours before surgery or any time after surgical incision had higher rates of SSI. Patients who received prophylactic antibiotics two hours before surgical incision had the lowest rate of SSI.20 Subsequent studies focused on the optimal regimens and procedures for antimicrobial administration.

In 2002, the Centers for Medicare & Medicaid Services (CMS) joined with the Centers for Disease Control and Prevention (CDC) to implement the National Surgical Infection Prevention (SIP) project.21 The goal of the SIP project was to decrease the morbidity and mortality associated with postoperative SSI. A panel of experts in surgical infection prevention, hospital infection control, and epidemiology devised recommendations based on evidence available in the medical literature. The measures included (1) the proportion of patients who received parenteral antimicrobial prophylaxis within one hour of surgical incision, (2) the proportion of patients who received an appropriate antimicrobial in accordance with published guidelines, and (3) the proportion of patients whose antimicrobial prophylaxis was discontinued within...
Table 1. Centers for Disease Control and Prevention/National Healthcare Safety Network Definitions of Surgical Site Infections (SSI)

Superficial Incisional SSI
1. The infection occurs within 30 days after the procedure, AND
2. Involves only skin and subcutaneous tissue of the incision, AND
3. The patient has at least one of the following:
   - Purulent drainage from the superficial incision
   - Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision
   - At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat, and superficial incision is deliberately opened by surgeon and is culture positive or not cultured. A culture-negative finding does not meet this criterion.
   - Diagnosis of superficial incisional SSI by the surgeon or attending physician

Deep Incisional SSI
1. The infection occurs within 30 days after the procedure if no implant is left in place or within one year if implant is in place and the infection appears to be related to the operative procedure, AND
2. Involves deep soft tissues (e.g., fascial and muscle layers) of the incision, AND
3. The patient has at least one of the following:
   - Purulent drainage from the deep incision but not from the organ/space component of the surgical site
   - A deep incision spontaneously dehisces or is deliberately opened by a surgeon and is culture positive or not cultured when the patient has at least one of the following signs or symptoms: fever (>38°C) or localized pain or tenderness. A culture-negative finding does not meet this criterion.
   - An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination
   - Diagnosis of a deep incisional SSI by a surgeon or attending physician

Deep Organ/Space SSI
An organ/space SSI involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure. Specific sites are assigned to organ/space SSI to further identify the location of the infection.

24 hours of the end of surgery. The SIP project measures targeted surgeries frequently performed on Medicare patients, including coronary artery bypass grafting surgeries, other open chest cardiac surgeries, vascular surgeries, general abdominal colorectal surgery, abdominal and vaginal hysterectomy, and hip and knee arthroplasty.22

Following the results of their study, the CMS and the CDC joined several other national organizations to develop the Surgical Care Improvement Project (SCIP). The SCIP steering committee established a goal of reducing preventable surgical morbidity and mortality by 25% by 2010.23 SCIP targeted four areas in which to improve surgical outcomes. These included SSI, venous thromboembolism, adverse cardiac events, and respiratory complications.21 Although aesthetic surgery procedures were not targeted by SCIP, the project set the standard of care for many surgical specialties since these initiatives often filter down and are applied broadly to all surgical procedures. Financial incentives for reducing SSI were established by the CMS; these included reduction of mediastinitis following coronary artery bypass graft surgery among the hospital-acquired conditions, for which hospitals would not be reimbursed.23 Additional SSI, including those occurring after certain orthopedic procedures and bariatric surgery, have been proposed for future payment reductions.24

**THE CURRENT STATE OF SSI RESEARCH IN AESTHETIC SURGERY**

The CDC and National Healthcare Safety Network (NHSN) have established standard definitions for SSI (Table 1). Superficial SSI must occur within 30 days of the procedure...
and involve only the skin and subcutaneous tissue of the incision. Additionally, the patient must have signs, symptoms, or microbiological results consistent with infection. Deep incisional SSI must occur within 30 days postoperatively, or within one year if the procedure involved an implanted prosthetic device. Again, the patient must have signs, symptoms, or other data consistent with an infection. These are strict criteria for determining the presence of an SSI, but in cases that are unclear, determination of the presence of an SSI may be left up to the surgeon or attending physician's discretion.

Although these guidelines present concise criteria for establishing the presence of an SSI, aesthetic surgery practice presents unique challenges in determining the incidence of these infections. Greater than 70% of surgical procedures are performed on an outpatient basis. Additionally, in the outpatient setting, cosmetic procedures are performed by many different types of medical providers, including dermatologists, plastic surgeons, general surgeons, otolaryngologists, and ophthalmologists. These factors make postoperative surveillance difficult. Furthermore, studies on incidence rates often rely on case series and physician surveys. In procedures involving implants, the development of SSI may be many months after the surgery. Approximately two-thirds of infections following breast augmentation occur within one month of the surgery, but surveys indicate that 13.3% occur three months following surgery, and 8.3% only present after more than six months. In light of this prolonged latency period, patients may present with infection to other physicians, rather than their original surgeons.

Breast surgery has been studied more than other aesthetic surgical procedures. The NHSN collects data on SSI in multiple surgical procedures, including breast surgery. The SSI rate is reported based on NHSN risk index class, wherein patients are assigned into risk categories based on the following characteristics at the time of surgery: (1) wound category (contaminated or dirty/infected); (2) longer procedure duration, defined as one that exceeds the 75th percentile for the procedure; and (3) the medical characteristics of the patient as defined by an American Society of Anesthesiology (ASA) score of III, IV, or V. Patients in risk category 0 had a 0.95% SSI rate. Among all patients undergoing breast surgery in NHSN-participating hospitals, patients in risk class 1 and 2/3 had SSI rates of 2.95% and 6.36%, respectively. Although these data provide some insight into SSI rates following breast surgery, more detailed interpretation is difficult given the limited information available on the type of surgery.

Multiple studies have been performed examining rates of SSI following breast augmentation. In a prospective study of 51,235 consecutive cosmetic breast surgeries (including breast reduction, for the purposes of this article), the overall infection rate was 0.22%, with the highest rates seen among patients undergoing breast reduction (0.42%). In an international study including 10,941 patients undergoing breast augmentation, acute postoperative infections were seen in 1.7% and 0.8% for late infections. A retrospective Danish study identified infection in 1.1% of patients undergoing breast implant surgery.

Among 749 women undergoing breast implant surgery in the United States, 2.5% required surgery intervention due to infection. A study by Alderman et al utilized national databases to assess infection rates in patients undergoing breast augmentation. The Tracking Operations and Outcomes for Plastic Surgery (TOPS) database relies on voluntary self-reporting of data to track adverse events, whereas the CosmetAssure database includes data on selected elective cosmetic procedures performed by active members or candidates of the American Society of Plastic Surgeons (ASPS). The CosmetAssure database only includes information on complications requiring hospitalization, emergency room visits, or surgical intervention within 30 days of the procedure. Complications treated on an outpatient basis, including infections treated with oral antibiotics, are not included. The TOPS database does captures complications exclusively treated in the outpatient setting. Among 130,831 patients in the TOPS database, the infection rate for breast augmentation was 0.3%. The CosmetAssure database captured 14,227 patients, of whom 0.1% developed infections. These databases likely underidentify the incidence of infections due to selection bias. Studies examining infection rates following breast reduction surgery have shown higher rates than those seen in breast augmentation; infection rates ranging from 1.1% to 22% have been reported following breast reduction surgery.

Breast reconstruction carries a tenfold greater risk of developing infection compared to aesthetic surgery procedures. Some series demonstrate infection rates from 24% to 53% following reconstructive breast surgery.

Although abdominoplasty is a widely performed procedure, reported infection rates are highly variable. A retrospective study of 258 women undergoing abdominoplasty in France showed that 7% experienced infections. A German study demonstrated that 12.7% of smokers and 5% of nonsmokers had infectious complications following abdominoplasty. A Norwegian study of 487 patients undergoing abdominoplasty and liposuction showed infection rates of 0.2%. The TOPS database identified infection in 3.5% of patients undergoing abdominoplasty, whereas the CosmetAssure database reported infection rates of 0.7%.

There are few studies examining the incidence of infection following other types of aesthetic surgery. Infections following facelifts are uncommon, occurring in only up to 0.3% of procedures. There are case reports of infections following aesthetic surgery of highly vascularized areas, such as the brow and eyelids. Infection following septrhinoplasty is also rare, with less than 2% of cases developing this complication.

A national survey of physician practices regarding antibiotic prophylaxis in aesthetic surgery showed a wide range of practices. Antibiotics were administered in most procedures with the exception of blepharoplasty, where 56% of responding surgeons did not give antibiotics. In contrast, antibiotics were provided in 92% of breast augmentation procedures and 84% of abdominoplasties. Most surgeons also extended the course of antibiotics postoperatively.
Less than 25% of responding surgeons gave only perioperative intravenous antibiotics. Following abdominoplasty, 22% prescribed antibiotics for one to three days postoperatively, and 41% gave antibiotics for four to seven days postoperatively. For breast augmentation, 50% prescribed antibiotics for four to seven days postoperatively.\(^{51}\)

**RECOMMENDATIONS FOR APPROPRIATE PROPHYLACTIC ANTIBIOTIC ADMINISTRATION**

Although recommendations for antibiotic prophylaxis exist for cardiac, colorectal, neurosurgical, and orthopedic procedures, there are no national guidelines for antibiotic prophylaxis in aesthetic surgery. In fact, studies examining the impact of prophylactic antibiotics have produced contradictory results.

Several studies have investigated antibiotic prophylaxis in breast surgery. In a study of 1146 women undergoing nonreconstructive breast surgery, there was no statistical difference in infection rates among women who received prophylactic antibiotics compared to those who did not (3.2% vs 4.6%, \(P = .39\)).\(^{52}\) However, the majority of procedures performed in this study were local excisions, which are vastly different from aesthetic breast surgery and may carry an inherently lower infection risk. A small prospective study of breast augmentation found no difference in infection rates among those receiving prophylactic antibiotics but was limited by its small size and significance in infection rates among those receiving prophylactic antibiotics\(^{53}\) but was limited by its small size and significant differences in patient population. Studies by Platt et al\(^{54-56}\) demonstrated significant reductions in SSI among patients who received antibiotic prophylaxis when compared to those who did not. A case control study at a single center in the United States found that SSI rates were significantly reduced after administration of prophylactic antibiotics became routine (0.9% with prophylaxis vs 4.0% without prophylaxis, \(P = .02\)).\(^{57}\)

There are also conflicting data on the role of prophylactic antibiotics in abdominoplasty. A prospective study of 207 patients undergoing abdominoplasty showed a significant difference between those receiving antibiotic prophylaxis and those who did not.\(^{58}\) A retrospective, uncontrolled study of 300 patients who did not receive antibiotic prophylaxis showed an infection rate of 8%.\(^{59}\) The authors reason that this rate is similar to that seen in the study by Chaouat et al,\(^{62}\) where antibiotic prophylaxis was given; they therefore conclude that there is no benefit to treatment with antibiotics. However, methodological differences between the studies make it difficult to support this conclusion.

Until randomized controlled trials examining the efficacy of prophylactic antibiotics in aesthetic surgery are performed, we recommend giving prophylactic antibiotics in accordance with SIP project guidelines.\(^{22}\) The ideal antibiotic for surgical prophylaxis should (1) cause minimal toxicity or side effects, (2) be effective against the most likely organisms that will cause an SSI but have a narrow spectrum, (3) achieve adequate tissue concentrations at the surgical site for the duration of the procedure, and (4) be administered for the shortest effective period.

For most patients undergoing aesthetic procedures, the preferred antimicrobial agent is a first-generation cephalosporin such as cefazolin.\(^{22,26,60-62}\) If the patient weighs more than 160 pounds (approximately 80 kg), the dose of cefazolin may be increased to 2 g intravenously. An additional dose should be given if the surgical procedure lasts more than three to five hours or if the patient has lost a significant amount of blood (greater than or equal to 1500 mL).\(^{22,60}\) Patients with a beta-lactam allergy may receive clindamycin or vancomycin.\(^{60}\) Due to their longer half-lives, these medications can be redosed at longer intervals if necessary (clindamycin every four to six hours; vancomycin every six to 12 hours). Vancomycin may be given for surgical prophylaxis in facilities with a high incidence of methicillin-resistant *Staphylococcus aureus* (MRSA) or methicillin-resistant coagulase-negative staphylococci. Guidelines recommend against the routine administration of vancomycin for antibiotic prophylaxis.\(^{3,22,60}\)

Specific strategies to prevent MRSA SSI are controversial. Studies suggest that approximately 20% of the general population is persistently colonized with *S. aureus*. An additional 30% of the general population is intermittently colonized with *S. aureus*.\(^{63}\) but current guidelines from the CDC\(^{64}\) and the Society for Healthcare Epidemiology of America\(^{65}\) recommend against routine universal screening for MRSA. A large, prospective study that included more than 21,000 patients evaluated the benefit of active surveillance cultures to identify carriers of MRSA. Once identified, MRSA carriers underwent decolonization and received prophylactic antibiotics with activity against MRSA. Despite these interventions, MRSA infections did not change significantly.\(^{66}\)

Conversely, in a randomized, blinded, placebo-controlled multicenter trial, patients who underwent a mupirocin and chlorhexidine decolonization protocol had a lower risk of developing a deep surgical infection (risk ratio 0.21, 95% confidence interval [CI] 0.07-0.62).\(^{67}\) Additionally, a study of orthopedic patients undergoing joint arthroplasty showed a significant reduction in SSI among patients who underwent a five-day decolonization routine prior to surgery.\(^{68}\) These studies demonstrate that targeted screening and decolonization in those with prior MRSA colonization or infection may be beneficial, particularly if performed approximately one week prior to surgery to allow decolonization.

Multiple decolonization regimens have been studied, including topical nasal mupirocin, chlorhexidine body washes, povidone-iodine body washes, and oral antibiotics.\(^{69}\) None of these has shown benefit in long-term decolonization. At this time, the optimal decolonization regimen is unclear. Until more data are available to support routine active surveillance and decolonization among patients undergoing plastic and reconstructive surgery, these interventions should be reserved for patients who are colonized with MRSA or are known to have had an MRSA infection in the past.

In patients undergoing clean-contaminated head and neck surgical procedures, cefazolin will provide coverage against potential aerobic and anaerobic organisms.
However, cefazolin will not provide coverage against *Bacillus fragilis*. Metronidazole may be added to cefazolin, although the importance of covering this organism is not yet clear.60 Patients with a beta-lactam allergy who are undergoing a head and neck procedure that broaches the oral or pharyngeal mucosa may be treated with clindamycin. A randomized trial comparing clindamycin alone versus clindamycin plus gentamicin showed no significant difference in infection rates.70 Although not studied in head and neck surgical procedures, a fluoroquinolone may be a reasonable alternative for those with contraindications for other medications.

Antibiotic prophylaxis should be given prior to surgery to achieve tissue and serum concentrations that will produce bactericidal levels at the time surgical incision is made.9,60 A seminal study by Classen et al20 showed that receipt of antibiotics within two hours of surgery was associated with the lowest risk of SSI, as opposed to receipt of antibiotics at any other time. A study examining the timing of administration of antibiotics with short half-lives was studied in a prospective cohort of more than 3800 patients who received cefuroxime for surgical prophylaxis. Those who received antibiotics less than 30 minutes (odds ratio [OR] 1.95, 95% CI 1.4-2.8) or 60 to 120 minutes (OR 1.74, 95% CI 1.0-2.9) before the surgical procedure were at greater risk of SSI than those who received antibiotics 30 to 59 minutes prior to surgery.71 Most antibiotics should be administered within 60 minutes before incision. If fluoroquinolones or vancomycin is indicated, the infusion should begin 120 minutes before incision. If a proximal tourniquet is required for the surgery, the entire antibiotic dose should be administered before the tourniquet is inflated.9,22,60

Prolonged courses of antibiotics given for prophylaxis have not shown benefit as compared to a single dose of prophylactic antibiotics. A meta-analysis including 28 studies and more than 8000 patients showed that the rate of infection among patients receiving a single dose of antibiotics was comparable to those who received antibiotics after wound closure.72 The SIP project endorses cessation of antibiotics within 24 hours of the end of surgery.22

The placement of drains following many surgical procedures is common. Many surgeons have adopted the practice of continuing antibiotics for as long as the surgical drains are in place.73,74 However, there is a lack of evidence to support this practice in aesthetic surgery. Prior studies have shown that prolonging the course of prophylactic antibiotics for the duration of drain placement does not reduce the risk of SSI among patients undergoing cardiothoracic surgery.75 Based on this evidence, the SIP project guidelines recommend against continuing antibiotic prophylaxis for the duration of surgical drain placement for orthopedic and cardiothoracic procedures.22 It should be noted that antibiotic therapy is appropriate when the surgical drain is placed for therapeutic drainage of an infected space or abscess.

**Risks of Antibiotic Overutilization**

Despite the benefits of prophylactic antibiotics, there are significant consequences to overuse or inappropriate use. Some of these consequences (such as *Clostridium difficile* infections [CDI]) may occur at the individual level, whereas others (such as development of resistant organisms) occur at the societal level and may not directly harm the treated patient.76

There has been a dramatic increase in the number of patients who have developed CDI over the past decade.77 These infections have been associated with very high rates of morbidity and mortality.78 Exposure to several classes of antibiotics, including cephalosporins, fluoroquinolones, broad-spectrum penicillins, and carbapenems, has been shown to increase the risk of CDI.79 Among patients developing CDI in Quebec, fluoroquinolones were the most strongly associated with CDI (adjusted HR 3.44, 95% CI 2.65-4.47), whereas cefepime, macrolide, and beta-lactam/beta-lactamase inhibitor antibiotics conferred a less but still significantly increased risk (AHR 1.56-1.89).80

Widespread antibiotic administration has contributed to the development of resistant organisms. Due to their broad spectrum of activity, efficacy, and ease of dosing, fluoroquinolones were the most prescribed antimicrobial class between 1995 and 2002, based on a survey of ambulatory care and emergency department visits.81 However, multiple studies have shown that as many as 50% of fluoroquinolone prescriptions are not given in accordance with national or institutional guidelines and thus are inappropriate.82,83 There are increasing reports of treatment failure for pneumococcal pneumonia among patients who previously received fluoroquinolones.84-88 Correlating with the increasing rates of fluoroquinolone prescription, decreasing susceptibility of gram-negative organisms to fluoroquinolones has been reported. Among patients in intensive care units between 1994 and 2000, susceptibility of isolated gram-negative organisms to ciprofloxacin decreased from 86% to 76%.89 In a large teaching hospital, resistance rates to ciprofloxacin and amoxicillin-clavulanic acid correlated with rates of administration.90

Furthermore, exposure to broad-spectrum antibiotics such as piperacillin/tazobactam has been associated with a twofold increased risk of carriage of extended-spectrum beta-lactamase-producing bacteria. These organisms are emerging pathogens with limited treatment options and have been associated with adverse outcomes.75 A meta-analysis has also linked antibiotic exposure with MRSA carriage. Fluoroquinolone prescription was associated with a nearly threefold increased risk (relative risk [RR] 2.9, 95% CI 2.4-3.5) for MRSA carriage. Exposure to glycopeptides, including vancomycin, was associated with a greater than twofold increased risk of being placed on isolation (RR 2.2, 95% CI 1.7-2.9).92 Exposure to antibiotics for more than 48 hours after coronary artery bypass graft surgery did not show any impact on SSI but did show
increased rates of acquired antimicrobial resistance (OR 1.6, 95% CI 1.1-2.6).75

NONPHARMACOLOGICAL METHODS FOR PREVENTING SSI

Although the appropriate prescription of prophylactic antibiotics plays a key role in preventing SSI, other factors also contribute to a patient’s risk of developing an SSI. Some of these factors (including hair removal and antiseptic skin preparation) are modifiable, whereas others (including obesity and smoking) may not be easily modified.

Hyperglycemia

Prevention of SSI begins well before the surgical incision; therefore, patients with risk factors that increase the likelihood of infection should be identified during presurgical evaluation. Diabetes and perioperative hyperglycemia are two factors that have been associated with an increased risk for SSI, but many of the studies examining the impact of diabetes on SSI have focused on cardiac surgery. In a study of 8910 patients undergoing cardiac surgeries, the rate of deep sternal wound infections was over fourfold higher in diabetics as compared to nondiabetics (1.7% vs 0.4%).99 A meta-analysis of 9997 patients showed diabetics to be at a threefold increased risk of deep sternal wound infections compared to nondiabetics (RR 3.16, 95% CI 2.00-4.98).94 Multiple other studies have also shown an increased risk of SSI in diabetic patients undergoing cardiac surgery.95-100 Among patients undergoing cardiac surgery, the overall risk of deep sternal infection increased by more than threefold at serum blood glucose levels higher than 175 mg/dL. There was a twofold increase with serum blood glucose values from 175 to 225 mg/dL, a fourfold increased risk from 225 to 250 mg/dL, and a sixfold increased risk over 250 mg/dL.100 Perioperative glycosylated hemoglobin control has been shown to reduce the risk of sternal wound infections in diabetic patients by as much as 77%,93,101

Increased risk of SSI among diabetic patients is not limited to patients undergoing cardiac procedures. Among patients undergoing orthopedic spinal surgery, preoperative serum glucose higher than 125 mg/dL (or a postoperative level higher than 200 mg/dL) was associated with a higher than threefold increased risk of developing a wound infection (95% CI 1.4-7.5).102 Although these studies demonstrate the importance of optimal perioperative glucose control, good preoperative glycemic control has also been shown to decrease infectious complications across a wide array of surgical procedures. A study utilizing the Department of Veterans Affairs National Surgical Quality Improvement Program demonstrated that preoperative hemoglobin A1c greater than or equal to 7 was associated with a twofold increased risk of surgical site infections (OR 2.13, 95% CI 1.23-3.70).103

Despite the evidence from cardiac and noncardiac surgical procedures, there is little evidence about glycemic control in aesthetic procedures. One prospective study demonstrated an increased risk of infection among diabetic patients undergoing minor skin excisions, similar to those performed by plastic surgeons.104 When compared to nondiabetic patients undergoing cosmetic breast surgery, diabetics were at an increased risk of overall complications (3.8% vs 1.7%), but this did not achieve statistical significance (P = .055). Diabetic patients undergoing augmentation mastopexy had a significantly higher rate of complications than nondiabetics (6.5% vs 2.0%);31 but this study did not have the power to demonstrate differences in infection risks.

Hair Removal

Ideally, no hair removal should occur prior to any surgical procedure because most hair removal techniques at the operative site have been associated with increased rates of SSI.9 Use of a razor to remove hair at the surgical site has been shown to have a ninefold increase in the incidence of SSI compared to no hair removal or application of a depilatory cream (5.6% vs 0.6%).105 This increased risk associated with shaving may be due to microscopic trauma that diminishes the skin integrity. This has led to some aesthetic surgeons advising their patients to avoid shaving at least one to two weeks prior to their scheduled procedure.

When compared to shaving, clipping also shows a reduced risk of SSI. In a 1983 study, patients who were shaved were twice as likely to develop SSI than those who underwent clipping (5.8% vs 2.9%).106 A study of 1980 patients undergoing cardiac surgery showed significantly higher infection rates in the manually shaved (13 of 990) compared to electrically clipped patients (four of 990), with an odds ratio of 3.25 (95% CI 1.11-9.32).107

Perioperative Hypothermia

General and regional anesthetics impair the normal thermoregulatory vasoconstriction response, causing hypothermia.108 Perioperative hypothermia has been associated with many adverse events, including cardiac events and increased mortality.109,110 The association between perioperative hypothermia and SSI has been well studied. Investigators randomized a group of 200 patients undergoing colorectal procedures to hypothermia or normothermia. The wound infection rate in the hypothermic group was three times higher than in the normothermic group (19% vs 6%).111 Among patients undergoing cholecystectomy, hypothermia was found to be a significant risk factor for SSI, with a relative risk of 6.3. Among hypothermic patients, 11.5% developed SSI compared to 2% of normothermic patients.112 In a study of 416 patients undergoing short, “clean” surgeries, 5% of prewarmed patients developed infections, compared to 14% of patients who were not prewarmed (P = .001).113

There are multiple mechanisms that may explain the increased risk of infection associated with hypothermia.
 Decreased body temperature causes a compensatory vasodilation, leading to decreased tissue oxygenation. This reduces the oxygen available for the production of reactive oxygen intermediaries needed by neutrophils for oxidative killing. In addition, natural killer cell activity, cell-mediated antibody production, lymphocyte activation, cytokine production, and macrophage motility have been shown to be suppressed for up to two days following perioperative hypothermia. Although adequate studies do not exist examining the impact of hypothermia on plastic surgery outcomes, maintenance of normothermia likely is of benefit to this patient population.

### Tobacco

Cigarette smoking has been associated with SSI and delayed wound healing in several trials. A prospective study of 1009 patients undergoing cardiac surgery showed that current cigarette smoking conferred a nearly twofold increased risk of SSI (relative odds = 1.8, 95% CI 1.1-1.3). A prospective study of 489 patients undergoing ambulatory surgery (including plastic surgery) showed a sixfold higher rate of wound infection among smokers when compared to nonsmokers (3.6% vs 0.6%; OR 16.3, 95% CI 1.58-175). Among 425 patients undergoing breast cancer surgery, light (OR 2.95, 95% CI 1.07-8.16) and heavy (OR 3.46, 95% CI 1.52-7.85) cigarette smoking were associated with an increased risk of SSI following all types of surgery. Additionally, both light and heavy smoking were associated with an increased risk of skin flap necrosis, even after controlling for potential confounders, including diabetes mellitus, obesity, alcohol use, nonsteroidal anti-inflammatory drug (NSAID) use, duration of surgery, and surgical experience. In a prospective trial of 78 healthy individuals, the surgical wound infection rate in the smokers was 12% compared to 2% in patients who had never smoked (P < .05). Among smokers who abstained for four weeks, wound infection rates were significantly lower than in those who smoked continuously (3.4% vs 25%, respectively).

Higher wound infection rates have been observed among smokers undergoing aesthetic surgery. Among 84 patients who underwent aesthetic abdominoplasty, infection rates were significantly higher among smokers than nonsmokers (14.3% vs 1.2%, P < .001). Infection rates were also higher among smokers undergoing tissue expander/implant reconstruction as compared to nonsmokers (9.1% vs 2.9%, P = .006). In a retrospective study including all patients undergoing breast reduction, smokers had a threefold increased risk of wound infection compared to nonsmokers (OR 3.3, 95% CI 1.4-8.0). In addition to increased infection rates, smokers undergoing postmastectomy breast reconstruction have a higher rate of surgical complications, including flap necrosis, fat necrosis, and wound dehiscence. Given the higher rate of complications among smokers, it may be beneficial to encourage smoking cessation for a minimum of four weeks prior to elective procedures.

### Surgical Antisepsis

Although the previous factors play a role in the prevention of SSI, hand antisepsis and preoperative skin preparation are among the most important steps for preventing SSI. Unfortunately, a survey of facial plastic surgeons examining practices and knowledge of handwashing demonstrated a significant lack of knowledge and compliance with handwashing guidelines. Ideal agents for handwashing should have a broad spectrum of activity and little residual effect on the skin. Solutions containing chlorhexidine gluconate (CHG) or iodophor are most common with surgical teams in the United States. CHG-containing solutions have proven to be more effective than iodophor or medicated soap and water. If the hands are visibly soiled, washing with soap and water followed by drying and application of an alcohol-containing solution is recommended.

Skin preparation prior to surgery is also an integral part of preventing SSI. Although several antiseptic agents are approved by the Food and Drug Administration (FDA) for surgical skin preparation, their efficacy in preventing SSI has been evaluated in very few trials. Alcohol-based skin preps have been shown to be effective at reducing skin microbial counts, and they demonstrate activity against gram-positive and gram-negative organisms. However, alcohol-based skin preps are flammable. CHG is nonflammable and remains active longer than alcohol or iodophors, inhibiting microbial growth even after wound closure. Unfortunately, CHG does not work as quickly as alcohol and may not be as effective against gram-negative organisms, but the addition of alcohol to CHG overcomes some of the disadvantages of CHG alone. When compared to CHG alone, CHG with alcohol acts more rapidly, has activity against gram-negative organisms, and retains antiseptic activity for up to 48 hours. A recent randomized controlled trial involving 849 patients undergoing clean-contaminated surgical procedures showed that a chlorhexidine-alcohol skin prep was associated with a lower SSI rate compared to povidone-iodine skin prep (9.5% vs 16.1%; P = .004; RR 0.59, 95% CI 0.41-0.85). This protective effect was mostly seen in the rate of superficial incisional infections, as opposed to deep surgical site infections.

### Economics

In addition to significant morbidity and mortality associated with SSI, there are significant costs attributable to these infections. Overall, SSI are believed to cost between $1 billion and $10 billion annually. However, quantifying the costs associated with SSI following aesthetic surgery is difficult. Studies examining direct and indirect costs of SSI following aesthetic surgery do not exist. Additionally, many of the studies that account for the cost of SSI focus on inpatient procedures, whereas many of the cosmetic procedures performed today occur in the outpatient setting. Despite these limitations, it is clear that SSI incur a significant cost.
In the 1990s, patients who developed an SSI had a median excess direct cost of $3089 (95% CI $2148-$4136). The total excess of postoperative length of stay attributable to SSI was 6.5 days (95% CI five to eight days). Among patients who developed an SSI, 41% required readmission within 30 days. For these patients, the excess total direct cost attributable to SSI was $5038 (95% CI $4020-$6289). These patients also had a total excess length of stay attributable to SSI of 12 days (95% CI 10-14 days). A study utilizing data from 2005 showed that SSI extended hospital length of stay by 9.7 days and increased cost by $20,842 per admission. This study included skin, soft tissue, and breast surgeries as a variable. Patients undergoing these procedures had an increased length of stay attributable to SSI of 5.7 days (95% CI 3.6-10 days). The difference in cost attributable to SSI was $6731 (95% CI $3616-$10,246). Additionally, a study examining the costs of SSI following breast surgery showed an attributable cost of $4091 (95% CI $2839-$5533) after controlling for type of surgery, breast cancer stage, and other factors. This study may have underestimated the true costs of SSI, as it only included hospital-based costs and did not include physician costs, outpatient clinic costs, antibiotic costs, home health care, outpatient antibiotics, or outpatient surgical procedures. Despite these limitations, this study demonstrated the significant costs associated with SSI.

A 1998 study examining risk factors for SSI after breast surgery found that prophylactic administration of cefazolin reduced the rate of SSI from 4% to 0.9% (P = .02). The cost of rehospitalization for patients who developed SSI was approximately $8250, with outpatient visits costing $600 each. The authors note that the cost of cefazolin and administration was $11.50 per patient. If antibiotic prophylaxis prevented even a single SSI, it would result in a significant cost savings. Perencevich et al found that patients who developed an SSI were more likely to have spent a half-day in bed, missing planned regular activities, compared to those without SSI. Patients with SSI were more likely to require home health provider visits. Additionally, outpatient visits, phone calls to the patient by the physician, and calls from the patient to the provider were more frequent among those who had an SSI. These patients also reported significantly lower mental health and physical health scores on standardized testing as compared to baseline values. Although there are significant economic costs to SSI, it is important to also recognize the impact these events may have on patients’ mental health.

CONCLUSIONS

Aesthetic surgery, like any surgical procedure, carries an inherent risk for surgical site infections. Unfortunately, there are limited data to identify the frequency of these events following aesthetic surgery. Even if only 1% of the 6.6 million patients undergoing aesthetic or reconstructive surgical procedures each year developed an SSI, this still represents a significant health, economic, and emotional burden. Studies suggest that many of these SSI are preventable through multiple factors. Patient-related factors (including obesity, glycemic control, and tobacco use) may be difficult to modify but may improve outcomes. Appropriate handwashing and surgical skin preparation are also crucial in preventing SSI. The role of prophylactic antibiotics in preventing SSI has not been well studied in aesthetic surgery, but they have been shown to be effective in other clean and clean-contaminated surgical procedures. Until better studies are performed, we recommend the routine, judicious administration of prophylactic antibiotics to prevent SSI in aesthetic surgery, but only in the preoperative setting and up to only 24 hours after surgery. Care should be taken in prescribing broad-spectrum antibiotics due to the risk of development of resistant organisms such as MRSA. Additionally, although MRSA is a growing concern, the routine screening and prescription of vancomycin should be avoided. Targeted MRSA screening and decolonization may be of benefit to those with a history of MRSA infections or in patients who would have significant infection-related morbidity.

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REFERENCES


