Clinical Study

Surgical Site Infections in Breast Surgery:
The Use of Preoperative Antibiotics for Elective, Nonreconstructive Procedures

Christopher B. Crawford,1 James A. Clay,2 Anna S. Seydel,2 and Jessica A. Wernberg2

1Department of Surgery, University of Nebraska Medical Center, Omaha, NE, USA
2Department of General Surgery, Marshfield Clinic, Marshfield, WI, USA

Correspondence should be addressed to Jessica A. Wernberg; wernberg.jessica@marshfieldclinic.org

Received 29 April 2016; Revised 11 August 2016; Accepted 15 September 2016

Academic Editor: Debra A. Tonetti

Copyright © 2016 Christopher B. Crawford et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. Antibiotic prophylaxis for surgical site infections (SSIs) for breast surgery is widespread, but the benefit in clean surgical cases is not well defined. Methods. A retrospective analysis of 855 patients undergoing elective, nonreconstructive breast operations was performed, with 401 patients receiving no antibiotics and 454 patients receiving a single dose of preoperative antibiotic. Results. Administration of a preoperative antibiotic did not decrease the SSI rate. In this community-based study, antibiotic use practices varied considerably by surgeon. In univariate analyses, SSI rates appeared to increase with prophylactic antibiotic use (12% SSI with antibiotics versus 4% without, \( p < 0.0001 \)), likely because the use of underdosed antibiotics was associated with higher rates of SSI (13.2% SSI with cefazolin 1 gram, \( p < 0.0001 \), and 15.4% SSI with clindamycin 300 mg or less, \( p = 0.0269 \)). Methicillin-resistant Staphylococcus aureus was the most common isolate from SSI cultures, 31.8% (7 of 22). In multivariable analyses, increased risk of SSI was associated with BMI > 25 kg/m² (OR: 1.08, 95% CI: 1.04–1.11, \( p < 0.0001 \)). Conclusion. The administration of a single dose of preoperative antibiotic did not decrease the rate of SSI in this large series of patients undergoing clean breast operations. BMI > 25 kg/m² and the use of an inadequate dose of antibiotics for prophylaxis may increase risk of SSI.

1. Introduction

Surgical site infection (SSI) is a commonly reported source of postsurgical morbidity. In breast surgery, three separate reviews of the National Surgical Quality Improvement Program (NSQIP) database demonstrated SSI rates of 1.4%–3.2% [1–3]. Despite the relatively low SSI rates in registry data, other studies have reported SSI rates of up to 36% for procedures such as modified radical mastectomy [4]. Additional randomized controlled trials (RCTs) reported SSI rates ranging from 3.2% to 18.9% [5–11]. The historically cited rate for clean surgical cases is 1.5% [12]. When an SSI occurs, it can impact patient recovery and result in added cost and hospital readmission. To alleviate these concerns, perioperative antibiotics have been used in an attempt to decrease the rate of SSI in breast surgery for both benign and malignant indications.

A large RCT published by Hall et al. in 2006 evaluated the use of antibiotics in nonreconstructive breast surgery for both benign and malignant pathologies. It failed to show a difference in SSI rates with the use of a preoperative antibiotic not available in the USA, flucloxacillin [5]. In contrast, a 2014 Cochrane Collaboration review demonstrated a beneficial effect of preoperative antibiotics in breast cancer surgery [13]. The question of whether preoperative antibiotic use decreases SSI using antibiotics available in the USA in a comprehensive breast surgery practice remains unanswered. Thus, we sought to investigate the impact of a timely single dose of preoperative antibiotic on SSI rates in an elective, nonreconstructive breast surgery population encompassing both cancer and cosmetic operations.

2. Methods

A retrospective records analysis was performed for patients who underwent elective, nonreconstructive breast surgery between 2008 and 2012 at the National Accreditation Program for Breast Centers (NAPBC) accredited institutions:
the Marshfield Clinic Ambulatory Surgery Center or Min-
istry Saint Joseph's Hospital, a tertiary referral hospital in
Marshfield, Wisconsin. Marshfield Clinic Institutional
Review Board approval was obtained. Current Procedural
Terminology (CPT) codes were used to identify patients
who had elective breast surgery not involving simultaneous
placement of an implant or tissue expander. The procedures
were performed by surgical oncologists or plastic surgeons.
Operative indications included benign and malignant dis-
ease. Patients undergoing a concurrent sentinel lymph node
biopsy or lymphadenectomy were included. Selection of
antibiotic was at the discretion of the surgeon.

Procedures were classified as small and large surface area
because procedures involving larger surface areas alone have
been shown to increase the risk of SSI [2]. Small surface area
procedures included partial mastectomy, breast biopsy, and
sentinel lymph node biopsy. The CPT codes for small surface
area procedures included 19101, 19110, 19120, 19125, 19126, and
19301. Large surface area procedures included mastectomy,
axillary lymph node dissection, reduction mammoplasty, and
mastopyexy. The CPT codes for large surface area procedures
included 19300, 19302, 19303, 19305, 19307, 19316, and 19318.
Preoperative placement of a localizing wire was documented.
Reduction mammoplasty and mastopyexy were captured as a
separate variable.

Exclusion criteria included placement of a breast implant
or tissue expander, evidence of preoperative infection,
improper timing of antibiotic administration (administration
after incision or more than 1 hour earlier or timing not clearly
recorded), treatment with an antibiotic within 30 days for an
unrelated infectious process, a concurrent major operation at
a secondary site, or absence of surgical follow-up within 30
days.

Data was gathered by clinical chart review. Initial abstrac-
tion was done by the primary author and verified by the
second. The operative reports were reviewed to ensure that
the procedures were properly coded. Patients who underwent
bilateral procedures were considered as a single subject. If
one side of a bilateral procedure was a large surface area
procedure, the patient was included in the large surface area
analysis. Timing of antibiotic administration, dose, and time
of incision were gathered from perioperative nursing, phar-
cacy, and anesthesia records. All Marshfield Clinic and Saint
Joseph's Hospital documentation within at least 30 days of the
procedure was reviewed. The diagnosis of an SSI was doc-
umented by the surgeon of record based on postoperative clin-
eal examination and/or the presence of positive bacterial cul-
tures from wound drainage within 30 days of the procedure.

3. Statistical Analysis

Assuming a 5% absolute difference in SSI rates between
patients who received a single preoperative dose of antibiotic
and those who did not, a minimum of 400 cases and 400
controls were necessary to attain 80% statistical power. This
was based on an expected difference of SSI rates from 8% for
the patients who did not receive any antibiotics to 3% for
those who received a single dose of preoperative antibiotic
[6, 7, 9–11, 14–16]. In the bivariable analysis, a Z-/t-test was
used for normally distributed data, Wilcoxon Rank-Sum test
for skewed data, and Fisher's Exact or Chi-square test for
categorical data. Controls were chosen as the referent group
in order to derive the odds ratio, 95% confidence interval,
and corresponding p value for antibiotic use in association
with the SSI outcome. Similarly, analyses were performed for
the following clinical variables: wire localization, body mass
index (BMI), diabetes mellitus, sex, prior operation within
30 days, surgeon, small or large surface area, BMI > 25 or
≤ 25 kg/m², and age > 50 or ≤ 50 years, as well as whether
the procedure was a reduction mammoplasty or mastopyexy.
Age and BMI were assessed as both binary and continuous
variables. A cross-tab analysis comparing antibiotic use and
resulting SSI rate was conducted to determine whether certain
subgroups of patients benefited from preoperative
antibiotic use. These groups were stratified by age > 50 or ≤ 50
years, sex, BMI > 25 or ≤ 25 kg/m², large surface area, small
surface area, diabetes, wire localization, previous ipsilateral
breast operation within 30 days, and whether or not the oper-
ation was a reduction mammoplasty or mastopyexy. Antibiotic
dosages were also analyzed for significant associations with
SSI between patients with similar BMI.

In the multivariable analysis, stepwise logistic regression
modeling was applied to determine the set of statistically
significant clinical risk factors in association with the SSI
outcome. A p value of <0.05 is considered statistically
significant. All data analyses were carried out using the com-
mercially available statistical software package, SAS, version
9.3, English (Cary, NC).

4. Results

Records of 1,461 patients were reviewed. Of these patients,
606 were excluded: 120 received implants or expanders
within 30 days, 6 had a documented breast infection prior
to operation, 145 had improper timing of antibiotics, 249
were given postoperative antibiotics prophylactically or for
unrelated conditions, and 18 had no follow-up within 30
days, leaving 855 qualifying patients. The study contained
454 patients who received a single dose of preoperative
prophylactic antibiotic within 60 minutes of incision and 401
patients who did not receive antibiotics.

Patient demographics and rate of antibiotic administra-
tion are displayed in Table 1. Antibiotics were used differently
among subgroups. Patients with large surface area procedures
were more likely to receive an antibiotic. Patients with a local-
izing wire were less likely to receive an antibiotic. Providers
used antibiotics with different frequencies and dosages. Using
age and BMI as continuous variables, younger patients and
obese patients were more likely to receive antibiotics.

Table 2 displays the main outcomes by clinical charac-
teristics of the patient population. The overall surgical site
infection rate was 8.3% (71 of 855 patients). The SSI rate for
patients who received a dose of preoperative antibiotic was
12.1% versus 4% for those who did not (p value < 0.0001).
There was an increase in SSI rates for patients with a previous
ipsilateral breast operation within 30 days, a large surface area
procedure, or a BMI > 25 kg/m². Elevated BMI was associated
with an increased SSI rate. Reduction mammoplasty and
mastopexy were independently associated with a higher SSI rate. Localizing wire placement was associated with a lower SSI rate.

Twenty-two of the 71 patients with a surgical site infection had cultures at the time of clinical diagnosis. The most common bacterium cultured was methicillin-resistant Staphylococcus aureus (MRSA), 31.8% (7 of 22). This was followed by coagulase-negative Staphylococcus, methicillin-susceptible Staphylococcus aureus (MSSA), and Escherichia coli: 22.7%, 13.6%, and 9.1%, respectively. Five patients had no growth from their cultures but were still felt to have an SSI clinically.

The antibiotic agent used in 87.7% of cases was cefazolin. The remaining patients received clindamycin (7.3%), vancomycin (3.7%), or ciprofloxacin (1.3%). Underdosing of antibiotics was common in those patients who did receive antibiotics. Of those who were treated with cefazolin, 325 (81%) received only 1 gram and none of the patients who weighed ≥120 kg received the currently recommended 3 grams [17]. In fact, patients who received 1 gram of cefazolin developed SSI at a significantly higher rate than those not receiving antibiotics (13.2% versus 4.0%, \( p < 0.0001 \), OR: 3.7, 95% CI: 2.03–6.65) (Figure 1). Similarly, the 26 patients who received 300 mg or less of clindamycin had significantly higher rates of infection compared to no antibiotic prophylaxis (15.4% versus 4.0%, \( p = 0.03 \), OR: 4.4, 95% CI: 1.3–14.2).

In contrast, patients who received antibiotic prophylaxis with 2 grams of cefazolin or more than 300 mg of clindamycin did not have a significantly different SSI rate from those that did not have prophylactic antibiotics.

To compare antibiotic use and SSI rate in subgroups, a cross-tab analysis was performed (Table 3). The subsets that attained significance in the cross-tab analysis were no prior operation within 30 days, female sex, small surface area...
Figure 1: Surgical site infection rate by antibiotic and dose. Rates of SSI in nonreconstructive breast surgery patients were compared by antibiotic and dose. Clindamycin doses* of 150 or 300 mg were combined as ≤300 mg and doses of 450 and 600 mg were combined as >300 mg. The 1-gram cefazolin dose was associated with significantly higher rates of SSI compared to no antibiotic prophylaxis, 13.2% versus 4.0%, \( p < 0.0001 \). A ≤300 mg dose of clindamycin was also associated with significantly higher rates of SSI compared to no antibiotics, 15.4% versus 4.0%, \( p = 0.027 \).

procedure, placement of a localizing wire, BMI > 25 kg/m², and a procedure other than reduction mammaplasty or mastopexy. In all of these groups, use of an antibiotic was associated with an increased SSI rate.

To better understand the effect of antibiotics on SSI, a multivariable stepwise logistic regression analysis was performed using the following variables: antibiotic use, diabetes, sex, prior operation, surgeon, small or large surface area, BMI > or ≤ 25 kg/m², age > 50 or ≤ 50 years, and patients with reduction mammaplasty or mastopexy (Table 4). In the multivariable analysis, antibiotics use did not affect the rate of SSI. The only variables that maintained significance were localizing wire placement and BMI. A localizing wire was associated with a decreased SSI rate (odds ratio [OR]: 0.17, 95% confidence interval [CI]: 0.08–0.36, \( p < 0.0001 \)) and BMI >25 kg/m² was associated with an increased SSI rate (OR: 1.08, 95% CI: 1.04–1.11, \( p < 0.0001 \)).

5. Discussion

Modern healthcare is accompanied by increased monitoring of individual and institutional outcomes. Pay-for-performance reimbursement models and CMS “never events” take into consideration postoperative complications. This affects all surgeons that operate on the breast for benign or malignant indications, not to mention the wellbeing of their patients. In some disciplines, SSI rates can be reduced with a single dose of preoperative antibiotic and a recent Cochrane review suggests that this may be the case in the context of breast cancer surgery [3]. However, in this retrospective observational study of elective, nonreconstructive breast operations, a single dose of preoperative antibiotic was not associated with a lower SSI rate. In fact, inadequately dosed antibiotic prophylaxis seemed to increase the rate of SSI. However, logistical regression analysis found BMI to be the key variable associated with increased SSI while wire localization decreased the rate of SSI.

Three separate NSQIP database reviews showed that the SSI rates in breast surgery range from 1.4% to 3.2% [1–3], suggesting that SSI rates may be decreasing compared to previous RCTs where reported SSI rates range from 3 to 19% [6–11]. This decrease could be due to the implementation of Surgical Care Improvement Project (SCIP) measures, improved skin preparation agents, or lower rates of SSI in breast-conserving surgery [2, 4, 18]. The NSQIP reviews may also be underreporting the SSI rates in breast surgery, as the overall complication rates are lower in the NSQIP data compared to single-institution studies [2]. This may be the case in this study, where the observed rate of SSI following breast surgery was 8.3% overall. Lower SSI rates in registry data reviews compared to single-institution studies have been reported in other surgical subspecialties, such as vascular surgery [19]. The largest review of the NSQIP database examined only female patients, and bilateral mastectomy was regarded as two procedures, thus increasing the number of cases without increasing the number of patients [3]. The impact this had on reported SSI rates is unclear, but it could potentially decrease the overall SSI rate. The NSQIP database also does not include information on the administration or timing of antibiotics; thus, the SSI rates based on these data cannot be directly compared to SSI rates in RCTs looking at antibiotic use. Our observation is that timely administration
use in relation to SSI rate.

Table 3: Cross-tab analysis of clinical characteristics and antibiotic use in relation to SSI rate.

| No prior operation within 30 days | No infection | Surgical site infection | p value<sup>1</sup> |
|----------------------------------|--------------|-------------------------|----------------------|
| No antibiotics                   | 366 (47%)    | 13 (18%)                | <0.0001              |
| Single dose of antibiotics       | 386 (49%)    | 51 (72%)                |                      |

Prior operation within 30 days

| No antibiotics | 19 (2%) | 3 (4%) |
| Single dose of antibiotics | 13 (2%) | 4 (6%) |

Male patients

| No antibiotics | 11 (1%) | 0 (0%) |
| Single dose of antibiotics | 9 (1%) | 0 (0%) |

Female patients

| No antibiotics | 374 (48%) | 16 (23%) |
| Single dose of antibiotics | 390 (50%) | 55 (77%) |

Small surface area

| No antibiotics | 317 (40%) | 7 (10%) |
| Single dose of antibiotics | 110 (14%) | 9 (13%) |

Large surface area

| No antibiotics | 68 (9%) | 9 (13%) |
| Single dose of antibiotics | 289 (37%) | 46 (65%) |

No wire localization

| No antibiotics | 130 (17%) | 13 (18%) |
| Single dose of antibiotics | 314 (40%) | 50 (70%) |

Wire localization placed

| No antibiotics | 255 (33%) | 3 (4%) |
| Single dose of antibiotics | 85 (11%) | 5 (7%) |

Nondiabetic patients

| No antibiotics | 338 (43%) | 14 (20%) |
| Single dose of antibiotics | 363 (46%) | 46 (65%) |

Diabetic patients

| No antibiotics | 47 (6%) | 2 (3%) |
| Single dose of antibiotics | 36 (5%) | 9 (13%) |

BMI ≤ 25

| No antibiotics | 108 (14%) | 3 (4%) |
| Single dose of antibiotics | 83 (11%) | 6 (9%) |

BMI > 25

| No antibiotics | 277 (35%) | 13 (18%) |
| Single dose of antibiotics | 316 (40%) | 49 (69%) |

Surgery age ≤ 50

| No antibiotics | 125 (16%) | 3 (4%) |
| Single dose of antibiotics | 208 (27%) | 30 (42%) |

Surgery age > 50

| No antibiotics | 260 (33%) | 13 (18%) |
| Single dose of antibiotics | 191 (24%) | 25 (35%) |

Any breast procedure not including mastopexy or reduction mammoplasty

| No antibiotics | 379 (48%) | 16 (23%) |
| Single dose of antibiotics | 177 (23%) | 19 (27%) |

Mastopexy or reduction mammoplasty

| No antibiotics | 6 (1%) | 0 (0%) |
| Single dose of antibiotics | 222 (28%) | 36 (51%) |

<sup>1</sup> p value was derived from Fisher's Exact test.

<sup>†</sup> Not applicable.

Table 4: Multivariable stepwise logistic regression modeling for risk factors<sup>1</sup> in association with infection.

| Regression coefficient (R) | Odds ratio (OR) | 95% confidence interval (CI) | p value |
|---------------------------|-----------------|-----------------------------|---------|
| Wire localization         |                 |                             |         |
| No<sup>2</sup>            | 1.00            |                            |         |
| Yes                      | −1.7695         | 0.17                        | 0.08–0.36 | <0.0001 |
| BMI (kg/m<sup>2</sup>)   | 0.0741          | 1.08                        | 1.04–1.11 | <0.0001 |

<sup>1</sup>The following risk factors were also included in the stepwise logistic regression modeling selection: antibiotic use, diabetes, gender, prior surgery, surgeon, large surface area, BMI > 25 kg/m<sup>2</sup> (yes/no), surgery age, surgery age > 50 years (yes/no), and mammoplasty.

<sup>2</sup>Referent group.

of preoperative antibiotics to a patient undergoing breast surgery does not play an important role in the reduction of surgical site infections.

In fact, the use of prophylactic antibiotics with dosages below current recommended dosing guidelines may increase the risk of SSI as seen in our study (Figure 1) [17]. This parallels the results of Olsen et al., who found that suboptimal prophylactic antibiotic dosing was a significant independent risk factor for SSI in major breast surgery [20]. The operations included in our study were done prior to recent antibiotic prophylaxis recommendations for higher doses, and our results suggest that antibiotics dosed based on current recommendations do not significantly alter the rate of SSI when compared to no antibiotic prophylaxis.

Staphylococci species were the most common bacteria isolated from the subset of patients with SSIs that were cultured. This compares similarly to a previous study which found 60% of cultures from SSIs complicating breast surgery isolated staphylococci species [21]. Also, in our study, drug resistant variants were common, with MRSA isolated in 31.8% of cultures. This corresponds to 9.8% of all the SSIs being MRSA infections; however, this likely underestimates the true number given that only 31% of the clinically diagnosed SSIs were cultured. This observation supports the use of cultures with susceptibility profiles in patients with SSI following breast surgery as suggested by Throckmorton et al. [21].

In other clean operations with higher than expected rates of MRSA infections, such as vascular surgery, identifying preoperative patient risk factors for MRSA and the use of prophylactic antibiotics able to cover MRSA had been advocated [22]. Further investigation into whether this would benefit breast surgery patients as well may be warranted.

Another finding in the study was that preoperative localizing wire placement was associated with a lower SSI rate than in procedures with no wire placement. However, preoperative instrumentation has been shown to increase the rate of SSI [23]. Our observation is likely because localizing wire placement was a surrogate marker for surface area, given that 98% (341/348) of the patients who received a localizing wire had small surface area procedures. However, with large surface area procedures such
prophylaxis in different subsets of breast surgery patients may not affect tumor size, which lends favor to the practice of obtaining cultures with antibiotic use or not. Additionally, Malignancy has been associated with immunosuppression, and poor perfusion of fatty tissue increase the risk of local wound infection. Additionally, obesity has substantial effects on the immune system with impaired chemotaxis, dysregulated immune response, and altered macrophage differentiation [25]. Additionally, antibiotic dosing can be challenging in obese patients. Physicians frequently inaccurately dose antimicrobials because obesity affects volume of distribution \( V_d \) of drugs, increasing \( V_d \) of lipophilic drugs and decreasing \( V_d \) of hydrophilic drugs [26].

Studies evaluating the use of antibiotics in reduction mammoplasty or mastopexy have conflicting results as to the role of antibiotics in preventing SSI [6, 16, 27]. In this study, patients undergoing large surface area procedure were more likely to receive an antibiotic (81%, \( p < 0.0001 \)), particularly if it was a reduction mammoplasty or mastopexy (98%, \( p < 0.0001 \)). There were increased SSI rates in both large surface area (13%, \( p < 0.0001 \)) and reduction mammoplasty and mastopexy procedures (14%, \( p = 0.0003 \), Table 2), but the use of an antibiotic did not decrease SSI in either group (Table 3).

Inherent limitations with our study include its retrospective design, variability in the patient population among surgeons, and variability in the rates of antibiotic administration among patient groups. These introduce the potential for selection bias.

The classification of large surface area and small surface area procedures is subjective. A woman with large breasts undergoing a lumpectomy may actually have an operation involving more surface area than a woman with small breasts undergoing a mastectomy. The results must be interpreted with this limitation in mind. Volume of resection or specimen weight would likely be a more accurate measure but may not be known preoperatively during the decision of prophylactic antibiotic use or not.

Additionally, in an attempt to make our study generalizable, we included both benign and malignant disease. Malignancy has been associated with immunosuppression and Angarita et al. found advanced tumors of the breast associated with increased SSI [18]. We did not see a difference in the rate of SSI following operations for cancer versus benign indications (data not shown). Because this study was designed to assess the impact of timely prophylactic antibiotics on a broad breast surgery patient population and not the effect of tumors on immunosuppression, detailed analysis of the cancer subset was not undertaken which is another limitation of the study. Future research targeting antibiotic prophylaxis in different subsets of breast surgery patients may be required to identify those patients that would benefit the most.

Again, in an attempt to have general applicability, both male and female patients were included. Obviously, far less data is available on male breast operations and there is the possibility of a gender difference in SSI. However, a small number of male patients included in our study were nearly equally divided between receiving antibiotics and not and none developed an SSI, so including them did not change the main findings of the study.

6. Conclusions

Given the increased surgical site infection rate in breast surgery compared to clean cases overall, our study aimed to determine whether the SSI rate was decreased by prophylactic antibiotic administration in a community-based clinical practice. While certain patient groups are more prone to developing SSI, such as those with elevated BMI, we found that a timely single dose of preoperative antibiotic did not lower the SSI rate overall or in at-risk groups. Inadequately dosed antibiotics may actually increase the risk of SSI. Our data suggests that when prescribed, antibiotics should at least follow current dosing recommendations. Of note, the most common organism identified in our SSIs was MRSA, which lends favor to the practice of obtaining cultures with susceptibilities in suspected postoperative wound infections following breast surgery. We also observed significant variability in antibiotic prescribing practices from surgeon to surgeon. Despite the perceived low cost and relative low morbidity, antibiotics without benefit should not be prescribed. This study, which included both benign and malignant conditions, challenges the routine practice of preoperative antibiotic use for elective, nonreconstructive breast surgery.

Disclosure

Portions of this study were presented on November 2, 2012, in Kohler, Wisconsin, at the Wisconsin Surgical Society meeting, a chapter of the American College of Surgeons.

Competing Interests

The authors have no competing interests regarding the publication of this paper.

Acknowledgments

Financial support for this research was provided by Marshfield Clinic Resident Research Funds. The authors would like to acknowledge the following individuals for contributions to this project: Michael Caldwell, M.D., Ph.D., for his valuable guidance in the design and analysis of this study; Po-Huang Chyou, Ph.D., for his assistance in statistical modeling and calculations; Rachel Stankowski, Ph.D., for her assistance in reviewing the manuscript; Carla Rottscheit, B.A., for her assistance in programming and electronic data abstraction; and Debra Kempf, B.S.N., for her assistance as the resident research facilitator.
References

[1] D. L. Eck, S. L. Koonce, R. F. Goldberg et al., “Breast surgery outcomes as quality measures according to the NSQIP database,” *Annals of Surgical Oncology*, vol. 19, no. 10, pp. 3212–3217, 2012.

[2] C. de Blacam, A. A. Ogunleye, A. O. Momoh et al., “High body mass index and smoking predict morbidity in breast cancer surgery: a multivariate analysis of 26,988 patients from the national surgical quality improvement program database,” *Annals of Surgery*, vol. 255, no. 3, pp. 551–555, 2012.

[3] G. B. Davis, M. Peric, L. S. Chan, A. K. Wong, and S. F. Sener, “Identifying risk factors for surgical site infections in mastectomy patients using the National Surgical Quality Improvement Program database,” *The American Journal of Surgery*, vol. 205, no. 2, pp. 194–199, 2013.

[4] D. Villar-Compte, B. Jacquemin, C. Robles-Vidal, and P. Volkow, “Surgical site infections in breast surgery: case-control study,” *World Journal of Surgery*, vol. 28, no. 3, pp. 242–246, 2004.

[5] J. C. Hall, P. C. Willsher, and J. L. Hall, “Randomized clinical trial of single-dose antibiotic prophylaxis for non-reconstructive breast surgery,” *British Journal of Surgery*, vol. 93, no. 11, pp. 1342–1346, 2006.

[6] P. F. Amland, K. Andenaes, F. Samdal et al., “A prospective, double-blind, placebo-controlled trial of a single dose of azithromycin on postoperative wound infections in plastic surgery,” *Plastic & Reconstructive Surgery*, vol. 96, no. 6, pp. 1378–1383, 1995.

[7] R. J. Bold, P. F. Mansfield, D. H. Berger et al., “Prospective, randomized, double-blind study of prophylactic antibiotics in axillary lymph node dissection,” *American Journal of Surgery*, vol. 176, no. 3, pp. 239–243, 1998.

[8] R. Gupta, D. Simnett, R. Carpenter, P. E. Preece, and G. T. Royle, “Antibiotic prophylaxis for post-operative wound infection in clean elective breast surgery,” *European Journal of Surgical Oncology*, vol. 26, no. 4, pp. 363–366, 2000.

[9] H. Paaajanen and H. Herrunen, “Does preoperative core needle biopsy increase surgical site infections in breast cancer surgery? randomized study of antibiotic prophylaxis,” *Surgical Infections*, vol. 10, no. 4, pp. 317–321, 2009.

[10] R. Platt, D. F. Zaleznik, C. C. Hopkins et al., “Perioperative antibiotic prophylaxis for herniorrhaphy and breast surgery,” *The New England Journal of Medicine*, vol. 322, no. 3, pp. 153–160, 1990.

[11] L. D. Wagman, B. Tegtmeyer, J. D. Beatty et al., “A prospective, randomized double-blind study of the use of antibiotics at the time of mastectomy,” *Surgery Gynecology and Obstetrics*, vol. 170, no. 1, pp. 12–16, 1990.

[12] P. J. E. Cruse and R. Foord, “The epidemiology of wound infection. A 10-year prospective study of 62,939 wounds,” *Surgical Clinics of North America*, vol. 60, no. 1, pp. 27–40, 1980.

[13] D. J. Jones, F. Bunn, and S. V. Bell-Syer, “Prophylactic antibiotics to prevent surgical site infection after breast cancer surgery,” *The Cochrane Database of Systematic Reviews*, vol. 3, Article ID CD005360, 2014.

[14] C. Rotstein, R. Ferguson, K. M. Cummings, M. R. Piedmonte, J. Lucey, and A. Banish, “Determinants of clean surgical wound infections for breast procedures at an oncology center,” *Infection Control and Hospital Epidemiology*, vol. 13, no. 4, pp. 207–214, 1992.

[15] K. A. Lipsky, J. P. Neifeld, R. M. Boyle et al., “Complications of mastectomy and their relationship to biopsy technique,” *Annals of Surgical Oncology*, vol. 3, no. 3, pp. 290–294, 1996.

[16] J. Veiga-Filho, D. F. Veiga, M. S. Neto, M. C. Amorim, N. F. Novo, and L. M. Ferreira, “The role of antibiotics in reduction mammaplasty,” *Annals of Plastic Surgery*, vol. 65, no. 2, pp. 144–146, 2010.

[17] D. W. Bratzler, E. P. Dellinger, K. M. Olsen et al., “Clinical practice guidelines for antimicrobial prophylaxis in surgery,” *American Journal of Health-System Pharmacy*, vol. 70, no. 3, pp. 251–283, 2013.

[18] F. A. Angarita, S. A. Acuna, L. Torregrosa, M. Tawil, J. Escallon, and T. A. Ruiz, “Perioperative variables associated with surgical site infection in breast cancer surgery,” *Journal of Hospital Infection*, vol. 79, no. 4, pp. 328–332, 2011.

[19] S. Kuy, A. Dua, S. Desai et al., “Surgical site infections after lower extremity revascularization procedures involving groin incisions,” *Annals of Vascular Surgery*, vol. 28, no. 1, pp. 53–58, 2014.

[20] M. A. Olsen, M. Lefta, J. R. Dietz et al., “Risk factors for surgical site infection following major breast surgery,” *Journal of the American College of Surgeons*, vol. 207, no. 3, pp. 326–335, 2008.

[21] A. D. Throckmorton, L. M. Baddour, T. L. Hoskin, J. C. Boughery, and A. C. Degnim, “Microbiology of surgical site infections complicating breast surgery,” *Surgical Infections*, vol. 11, no. 4, pp. 355–359, 2010.

[22] T. Inui and D. F. Bandyk, “Vascular surgical site infection: risk factors and preventive measures,” *Seminars in Vascular Surgery*, vol. 3, no. 4, pp. 201–207, 2015.

[23] A. Witt, D. Yavuz, C. Walcheseder, H. Strohmer, and E. Kubista, “Preoperative core needle biopsy as an independent risk factor for wound infection after breast surgery,” *Obstetrics and Gynecology*, vol. 101, no. 4, pp. 745–750, 2003.

[24] Y. S. Chun, M. A. Schwartz, X. Gu, S. R. Lipsitz, and M. J. Carty, “Body mass index as a predictor of postoperative complications in reduction mammaplasty,” *Plastic and Reconstructive Surgery*, vol. 129, no. 2, pp. 228e–233e, 2012.

[25] A. Marti, A. Marcos, and J. A. Martinez, “Obesity and immune function relationships,” *Obesity Reviews*, vol. 2, no. 2, pp. 131–140, 2001.

[26] R. Huttunen and J. Syrjänen, “Obesity and the risk and outcome of infection,” *International Journal of Obesity*, vol. 37, no. 3, pp. 333–340, 2013.

[27] A. H. Ahmadi, B. E. Cohen, and P. Shayani, “A prospective study of antibiotic efficacy in preventing infection in reduction mammaplasty,” *Plastic and Reconstructive Surgery*, vol. 116, no. 1, pp. 126–131, 2005.