ORIGINAL ARTICLE

Breast Tissue Expander–Related Infections: Perioperative Antimicrobial Regimens

George M. Viola, MD, MPH;[1] Issam I. Raad, MD;[1] Kenneth V. Rolston, MD[1]

OBJECTIVE. The rate of postmastectomy tissue expander (TE) infection remains excessively high, ranging between 2% and 24%. We hypothesized that current perioperative antimicrobial regimens utilized for breast TE reconstruction may be outdated as a result of recent changes in microflora and susceptibility patterns.

DESIGN AND METHODS. We reviewed the records of all patients who had a TE reconstructive procedure and developed a definite breast TE infection between 2003 and 2010 at MD Anderson Cancer Center. Antimicrobials were stratified into 3 groups: systemic perioperative, local irrigation, and oral immediate postoperative antimicrobials. These were considered discordant if they did not target the isolated organisms, while a breakthrough infection was defined as an infection that occurred despite concordant antimicrobial coverage.

RESULTS. Overall, 75 patients with a definite TE infection were identified. The most common organisms identified were methicillin-resistant *Staphylococcus epidermidis* (29%), methicillin-resistant *Staphylococcus aureus* (15%), and gram-negative rods (26%). The use of systemic perioperative antimicrobials was deemed discordant in 51% of the cases. Although 79% of the patients received broad-spectrum perioperative local antimicrobial irrigation, 63% developed a breakthrough infection. Even though 61% received oral postoperative prophylactic antimicrobials, 63% of the times they were deemed discordant.

CONCLUSIONS. Contrary to the proven effectiveness of a single dose of perioperative antibiotics, the common use of local antimicrobial irrigation and prolonged postoperative oral antibiotics appears to be an inadequate component of our preventive armamentarium. Also, because methicillin-resistant staphylococcal and pseudomonal infections occurred approximately 60% of the time, at institutions that have observed an increase of these organisms, it may be prudent that perioperative antimicrobials target these microorganisms.

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The incidence of postmastectomy breast reconstruction has been increasing on an annual basis.[1,2] In 2012, the American Society of Plastic Surgeons reported that more than 90,000 of patients in the United States underwent a postmastectomy breast reconstructive procedure. Approximately 80% of the time, a prosthetic breast implant was chosen over an autologous flap reconstruction.[3,4] Since their introduction in 1982, temporary breast tissue expanders (TE) have gained widespread popularity.[5,6] These implants serve as a temporary device that is placed below the pectoralis muscle within the mastectomy space. Once a sufficiently large soft tissue envelope has been created, the TE is replaced by a permanent saline or silicone implant (2-stage approach).

Patients undergoing TE reconstruction may develop infectious complications ranging from cellulitis to a deep-seated periprosthetic infection. These infections can develop during the perioperative period (as a result of introduction of microbes during the time of surgery) or beyond the immediate postoperative period (with the introduction of microbes through nonsterile percutaneous access of the TE expansion port).[7,8] Late infections due to bacteremia followed by secondary infection of the implant have also been reported, although this event is uncommon.[8] Infection of the TE that does not respond to antibiotic treatment usually requires removal of the temporary implant, which represents a devastating complication for both the patient and physician.

The use of perioperative antimicrobials is one of the most important measures for decreasing the rate of device-related infections.[9] The following prophylactic antimicrobial regimens are used either alone or more commonly in combination: (1) systemic perioperative antimicrobials, (2) immersion of the implant or surgical pocket with an antiseptic or antimicrobial irrigation before insertion of the device, and (3) immediate postoperative oral antimicrobials.[8]

Many antimicrobial regimens currently being used for perioperative prophylaxis were initially selected several decades ago on the basis of the microbiologic data available then. These data may be outdated as a result of recent changes in microflora and susceptibility patterns. The goal of this study was to determine the current microbiology of TE infections and the efficacy of currently used prophylactic antimicrobial regimens. Thereafter, we plan to provide data-driven updated

Affiliation: 1. Division of Medicine, Department of Infectious Diseases, University of Texas MD Anderson Cancer Center, Houston, Texas.
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prophylactic antimicrobials recommendations for our institution, a National Cancer Institute–designated comprehensive cancer center.

PATIENTS AND METHODS

We retrospectively reviewed the charts of all patients that underwent a breast TE reconstructive procedure between 2003 and 2010 at the University of Texas MD Anderson Cancer Center, Houston, Texas. We identified all those patients who had developed a postsurgical site infection as well as a subsequent TE infection. Patients were included in the analysis only if they fulfilled strict definition criteria for TE-related infection (see below), had the TE explanted, and yielded a positive intraoperative culture. We collected data on patient demographics, baseline comorbidities, breast cancer characteristics, cancer treatments, timing of TE placement, and operative approach. We documented the use, timing, and type of perioperative systemic antibiotics, intraoperative antimicrobial irrigation, and immediate postoperative oral antibiotics. The use of antimicrobials was confirmed for all patients via electronic chart review as well as inpatient and outpatient pharmacy records. Additionally, we gathered information on the time from TE placement to infection, subsequent reconstruction, as well as intraoperative culture results. To further evaluate the diverse prophylactic modalities, the study cohort was divided into 2 groups on the basis of time of TE placement to infection: 0 to 30 days and 30 to 90 days. This study was approved by the institutional review board.

DEFINITIONS

We utilized the Centers for Disease Control and Prevention definition of a deep surgical site infection involving an implant, which includes at least 1 of the following symptoms: purulent drainage, spontaneous dehiscence or surgically opened incision with positive cultures, evidence of abscess, or diagnosis by the surgeon of a deep infection occurring up to 1 year postoperatively.[10] Prophylactic antimicrobials were defined as discordant if an infection occurred within the first 30 or 90 days of placement of the TE and the antimicrobial did not target the causative organisms, while a breakthrough infection was defined as an infection that occurred despite concordant antimicrobial coverage.

STATISTICAL ANALYSIS

Descriptive statistics are presented as mean ± standard deviation or median with range for continuous variables according to normal distribution and as numbers with per-

TABLE 1. Baseline Demographics and Clinical Characteristics

Patient characteristics and breast cancer management	Infection occurred within 30 d (n = 24)	Total infections (n = 75)
Age, mean ± SD, years	51.5 ± 10.6	50.4 ± 11.8
Obese (BMI ≥30)	13 (54)	28 (37)
BMI, median (range)	31 (22–49)	28 (19–62)
Bra size, median (range)	37 (32–46)	36 (32–46)
Bra cup size		
A	1 (4)	4 (5)
B	8 (33)	19 (25)
C	6 (25)	28 (37)
D	5 (21)	14 (19)
DD	4 (17)	10 (13)
Breast cancer lymph node involvement		
N0	20 (83)	57 (76)
N1	3 (13)	11 (15)
N2	0	2 (3)
N3	1 (4)	5 (7)
Tobacco use	6 (25)	21 (28)
Diabetes	7 (29)	13 (17)
Renal insufficiency	2 (8)	3 (4)
Preoperative chemotherapy	7 (29)	25 (33)
Postoperative radiotherapy	0	14 (19)
Skin-sparing breast surgery	18 (75)	52 (69)
Bioprosthetic mesh	6 (25)	15 (20)
Alloderm	4 (17)	13 (17)
Surgimend	2 (8)	2 (3)
Postsurgical seroma and/or hematoma	8 (33)	30 (40)
Postsurgical skin flap necrosis	9 (38)	26 (35)
Time of reconstruction (immediate : delayed)	22 : 2	70 : 5

NOTE. Data are no. (%), unless otherwise indicated. BMI, body mass index; SD, standard deviation.

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TABLE 2. Microorganisms and Timing of Breast Tissue Expander Infections

Microorganisms (n = 75)[a]	Between days 0–30[b]	Between days 30–90[b]	Total
Gram-positive bacteria			
MRSE	9 (29)	10 (29)	26 (29)
MRSA	4 (13)	6 (18)	14 (15)
MSSA	1 (3)	5 (15)	11 (12)
Corynebacterium	2 (6)	1 (3)	3 (3)
Group B *Streptococcus*	0	0	2 (2)
MSSE	1 (3)	0	1 (1)
Propionibacterium	1 (3)	0	1 (1)
Enterococcus	0	0	1 (1)
Actinomyces	0	0	1 (1)
Peptostreptococcus	0	0	1 (1)
Gram-negative bacteria			
Pseudomonas	5 (16)	5 (15)	12 (13)
Klebsiella	1 (3)	2 (6)	5 (5)
Proteus	1 (3)	0	2 (2)
Serratia	1 (3)	0	1 (1)
Morganella	1 (3)	0	1 (1)
Bacteroids	1 (3)	0	1 (1)
Escherichia coli	0	1 (3)	1 (1)
Fusobacterium	0	1 (3)	1 (1)
Mycobacterium			
Mycobacterium abscessus	2 (6)	0	2 (2)
Mycobacterium mageritense	0	1 (3)	1 (1)
Fungal organisms			
Candida	1 (3)	1 (3)	2 (2)
Aspergillus	0	0	1 (1)
Total	31 (100)	34 (100)	91 (100)

NOTE. Data are no. (% within time frame). MRSA, methicillin-resistant *Staphylococcus aureus*; MRSE, methicillin-resistant *Staphylococcus epidermidis*; MSSA, methicillin-sensitive *S. aureus*; MSSE, methicillin-sensitive *S. epidermidis*.

[a] Thirteen individuals had a polymicrobial breast tissue expander (TE) infection.

[b] Timing of TE infection from date of TE placement until date of infection.

centages for categorical variables. The statistical analyses were performed using SAS (ver. 9.1; SAS Institute).

RESULTS

Baseline Demographics and Clinical Characteristics

Of the 1,982 patients who had a breast TE reconstructive procedure, 260 patients developed a postsurgical site inflammatory process. Of these, a total of 101 patients required having the TE removed, of which 75 had a positive intraoperative culture, meeting inclusion criteria for our analysis (Table 1). At the time of presentation, the mean age for the 75 studied patients was 50.4 ± 11.8 years. The rate of smoking, cerebrovascular disease, coronary artery disease, malignant lymph node involvement, as well as bra and cup size were relatively similar among those patients who developed a TE infection within the first 30 days of placement and the total study population. Obesity, diabetes, renal insufficiency, and hypertension were commonly observed risk factors among patients who developed an infection within the first 30 days of TE placement than the overall study population. Approximately one-third of the patients received preoperative chemotherapy, while two-fifths received postoperative radiotherapy. None of the patients were either tested preoperatively for methicillin-resistant *Staphylococcus aureus* (MRSA) nasal carriage or decolonized for this specific microorganism. Betadine was the standard topical antiseptic utilized before surgery during the studied period. All patients had their breast reconstruction procedure performed in an elective fashion and had an American Society of Anesthesiology score of 2 or lower. More than 90% had an immediate breast tissue reconstruction, while approximately 70% had a skin-sparing surgical procedure. Only 20% of the patients had a bioprosthetic mesh placed. More than one-third of the breast reconstructions were complicated with the development of postsurgical seroma, hematoma, or skin flap necrosis.

Time to Infection and Subsequent Reconstruction

TE infections occurred at a median of 48 days (range, 13–309 days). Thirty-two percent of the infections occurred within the first 30 days, while 68% occurred within the first 90 days. Once the infected TE was explanted and the skin soft tissue infectious process resolved, only 36 (48%) patients

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TABLE 3. Perioperative Systemic Antimicrobials

		Infection occurred within <30 d		Infection occurred within <90 d	
Antibiotics	Total, *n* (%)	Concordant	Discordant	Concordant	Discordant
Cefazolin	56 (75)	4	15	9	32
Ciprofloxacin	3 (4)	0	1	0	2
Cefazolin and ciprofloxacin	1 (1)	0	0	0	0
Ampicillin sulbactam	5 (7)	0	1	3	1
Ampicillin sulbactam and gentamicin	2 (3)	0	0	2	0
Clindamycin	3 (4)	0	0	0	0
Clindamycin and gentamicin	2 (3)	2	0	2	0
Vancomycin	1 (1)	0	0	0	1
Vancomycin and ceftazidime	2 (3)	0	2	0	2
Total	75 (100)	6	19	16	38

NOTE. Data are no., unless otherwise indicated.

had a subsequent TE reconstruction within a median of 287 days (range, 96–1,470 days).

Microorganisms

Overall, we observed 13 cases (17%) of polymicrobial TE infections. Except for methicillin-susceptible *Staphylococcus aureus* (MSSA), the proportion of microorganisms causing TE-related infections, stratified by time to infection, was relatively similar (Table 2). Gram-positive and negative organisms were responsible for 67% and 26% of all TE infections, respectively. The most commonly isolated gram-positive organisms, in descending order, were methicillin-resistant *Staphylococcus epidermidis* (MRSE; 29%), MRSA (15%), MSSA (12%), and *Corynebacterium* spp. (3%), while the most common gram-negative organisms were *Pseudomonas aeruginosa* (13%), *Klebsiella* spp. (5%), and *Proteus* spp. (2%). Three rapidly growing mycobacterial as well as 3 fungal infections were also identified (2 cases of *Candida* spp. and 1 case of *Aspergillus* spp.).

Perioperative Systemic Antimicrobials

All patients received perioperative systemic antimicrobial prophylaxis within the time frames recommended by the American Society of Health System Pharmacists report (Table 3).[11] The most commonly utilized agent was cefazolin, which was used in 56 cases (75%). Of concern, within the first 30 and 90 days postoperatively, 15 and 32 of the patients, respectively, that received cefazolin were considered to have received discordant antimicrobial prophylaxis. In other words, throughout this time period, an organism resistant to cefazolin emerged in 27% and 54% of the times, respectively. The main reason cefazolin was deemed to be discordant was due to the development of MRSE, MRSA, *Pseudomonas* and *Klebsiella* infection. These organisms occurred within the first 30 days postoperatively in 8, 2, 4, and 1 occasion, respectively, while it occurred within the first 90 days postoperatively in 15, 7, 7, and 3 occasions, respectively.

Intraoperative Antimicrobial Pocket Irrigation

There were 16 (21%) patients that developed a TE-related infection who did not receive any intraoperative antimicrobial pocket irrigation (Table 4). The most commonly utilized antimicrobial solution was the combination of bacitracin and polymyxin, which was used 57% of the times. Although this combination provided broad-spectrum antimicrobial coverage, there were several cases of breakthrough infections. In other words, although the offending organism was susceptible to the antimicrobial regimen, within the first 30 and 90 days postoperatively, in more than 32% and 60% of occasions, respectively, an infectious process developed.

Postoperative Oral Antimicrobials

Twenty-nine (39%) patients who developed an infection did not receive any immediate postoperative oral antimicrobials (Table 5). The most frequent organisms encountered within this subgroup were MRSE (7 cases), MRSA (5 cases), MSSA and MSSE (4 cases each), *Pseudomonas* (3 cases), and *Corynebacterium* (2 cases). Cephalexin, the predominant postoperative antimicrobial prescribed up to 7 days after surgery, was utilized in 29 occasions (39%). In the first 30 and 90 days postoperatively, cephalexin was deemed to be discordant in 5 (17%) and 19 (66%) episodes, respectively. The main reason cephalexin was deemed to be discordant within the first 30 days postoperatively was due to the development of an infection with MRSE (2 cases) as well as *P. aeruginosa*, *Morganella*, and *Klebsiella* (1 case each). Cephalexin was deemed to be discordant within 90 days postoperatively, as a result of development of an infection with MRSA (6 cases), MRSE (4 cases), as well as *Pseudomonas*, *Klebsiella*, *Fusobacterium*, and *Mycobacterium mageritense* (1 case each).

DISCUSSION

To our knowledge, this is one of the largest studies to evaluate and analyze in a real-life scenario the complex prophylactic antimicrobial regimens provided to patients during the place-

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TABLE 4. Intraoperative Antimicrobial Pocket Irrigation

Antibiotics	Total, *n* (%)	Infection occurred within <30 d		Infection occurred within <90 d	
		Concordant	Discordant	Concordant	Discordant
None	16 (21)	...	...	...	...
Bacitracin and polymyxin	43 (57)	14	1	26	2
Bacitracin, gentamicin, and cefazolin	9 (12)	2	0	7	0
Bacitracin	3 (4)	1	0	1	1
Bacitracin, polymyxin, and cefazolin	2 (3)	1	0	1	0
Vancomycin and ciprofloxacin	2 (3)	0	0	2	0
Total	75 (100)	18	1	37	3

NOTE. Data are no., unless otherwise indicated.

ment of TE. After analyzing 75 patients who developed a definite breast implant–related infection and required having their TE removed, it is apparent that the numerous prophylactic antimicrobial regimens currently utilized as well as the high rate of infections caused by resistant microorganisms require a change in our antimicrobial recommendations.

Overall, the rate of infection following breast reconstruction remains excessively high, ranging between 2.5% and 24%.[7,12-16] There are multiple risk factors for infectious complications in patients undergoing TE breast reconstruction, including (1) tobacco use,[17] (2) breast cup size C or larger as well as body mass index greater than 25,[15,17] (3) radiation history,[7,15,18] (4) axillary lymph node dissection,[7,15] (5) immediate breast reconstruction,[13,15] (6) placement of a second breast implant,[15] (7) bilateral breast reconstruction,[13,15] (8) use of surgical drains,[19,20] and (9) adjuvant chemotherapy after immediate reconstruction.[3,21] Approximately 35% of our patients had developed a skin flap necrosis, which has been commonly observed with the most aesthetically pleasing skin-sparing mastectomy followed by immediate breast reconstruction. This combined surgical approach and postoperative complications are likely to be an additional risk factor for developing an underlying TE-related infection.[22-24]

One of the most critical factors in preventing a periprosthetic infection is the administration of a single dose of perioperative antibiotic directed against the most likely pathogens.[9,25-27] Unfortunately, because of the increased rate of infections with resistant organisms occurring within the immediate postoperative period, the most commonly used perioperative antimicrobial (cefazolin) seems to be outdated.[28] The rising rate of hospital visits, patient comorbidities, and extensive use of antibiotics appear to have all contributed toward this phenomenon.

Additionally, because more than 80% of patients postoperatively will have a drainage catheter in place, potentially increasing the rate for infection, more than 70% of surgeons decide to proceed with postoperative oral antimicrobial coverage.[29] Approximately 50% of these surgeons decide to extend the use of antibiotics for 5–7 days postoperatively, while the remaining continue until the drainage catheter has been removed.[29] However, extending the duration of antimicrobials has not been shown to reduce the rate of breast implant infections but to increase the rate of drug-related complications.[26,29] The Centers for Disease Control and Prevention recommends that after a clean elective surgery, all antimicrobials should be discontinued within 24 hours of the operation.[30] The high proportion of patients within our study that developed an infection within the first 30 and 90 days postoperatively while receiving discordant immediate postoperative oral antimicrobials suggests a lack of appropriate postoperative antimicrobial coverage, a lack of efficacy of this antimicrobial preventive measure, or both.

Of interest, several in vitro and in vivo studies have favored the use of intraoperative antimicrobial irrigation within the breast pocket.[31-34] The basic perception is that systemic perioperative antibiotics along with a high concentration of an antimicrobial solution irrigated into the surgical pocket may decrease the probability for infection seems reasonable. Nevertheless, the high proportion of patients in our study that developed a breakthrough infection within the immediate postoperative period places this practice into question. The lack of adequate randomized controlled studies,[35] use of several anti-infectious modalities, and historical changes in both medical and surgical techniques may have influenced the results of this preventive antimicrobial approach.

Several clinical studies and economic models have compared the use of β-lactam and glycopeptides prophylactic antimicrobials. Although the effectiveness of both these antimicrobials has been shown to be adequate, glycopeptides have been considered to be the preferred prophylactic regimen for those institutions that have a high prevalence of MRSA infections.[30,36-40] Unfortunately, there is insufficient evidence to determine whether there is a threshold prevalence of MRSA at which vancomycin would be considered clinically and cost effective.[38,39] Nonetheless, taking into account the environmental selective pressure and potential for developing glycopeptide-resistant organisms, because our hospital has a very high rate of methicillin-resistant infections (more than 40%), we believe that our patients may benefit from the provision of a regimen containing glycopeptide prophylactic antimicrobials. Furthermore, because all of our breast cancer patients are healthcare-experienced individuals, the probability of being colonized by resistant hospital-acquired organisms is higher than healthcare-naive patients. Therefore, an alternative ap-

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TABLE 5. Postoperative Oral Antimicrobials Provided for Up to 7 Days after Surgery

		Infection occurred within <30 d		Infection occurred within <90 d	
Antibiotics	Total, *n* (%)	Concordant	Discordant	Concordant	Discordant
None	29 (39)	...	...	...	...
Cephalexin	29 (39)	1	5	2	19
Amoxicillin clavulanate	7 (9)	0	2	1	4
Ciprofloxacin	3 (4)	0	0	0	2
Levofloxacin	1 (1)	0	0	0	0
Ciprofloxacin and amoxicillin clavulanate	1 (1)	0	1	0	1
TMP-SMX	1 (1)	0	1	0	1
TMP-SMX and cephalexin	1 (1)	0	1	0	1
Clindamycin	2 (3)	0	0	0	0
TMP-SMX, clindamycin, and linezolid	1 (1)	0	0	0	1
Total	75 (100)	1	10	3	29

NOTE. Data are no., unless otherwise indicated. TMP-SMX, trimethoprim-sulfamethoxazole.

proach would be to decolonize as well as provide perioperative prophylactic antimicrobials targeting those organisms colonizing each specific patient—specifically, those organisms colonizing the axillary region, which are in close proximity to the drainage catheter and temporary breast implant.

Although this is a single-center retrospective study subjected to numerous limitations, it has several strengths. First, we included only those patients that were found to have a definite breast implant–related infection. Second, even though discordant antimicrobial coverage may be responsible for the development of a TE infection within the first 30 days of placement, because less virulent organisms can cause an infectious process within the first 90 days of placement, we decided to independently analyze both time frames. Third, this is one of the largest studies to evaluate, in an unbiased clinical setting, the complex prophylactic regimens provided to patients during the placement of foreign medical devices. Unfortunately, because of the utilization of several and diverse prophylactic regimens, it is difficult to determine with certainty the effectiveness of each prophylactic regimen used either alone or in combination. Nevertheless, because of the recent changes in microbiological flora, it is apparent that the current prophylactic antimicrobials commonly utilized throughout the past several years are not adequate.

In summary, as breast reconstructive procedures continue to increase, the number of TE-related infections will continue to remain unnecessarily elevated. These infections are responsible for causing significant emotional, physical, and financial distress. Several antimicrobial approaches have been implemented, including the administration of perioperative systemic antibiotics, intraoperative antimicrobial irrigation within the breast pocket, and immediate postoperative oral antibiotics. Except for the former, all other prophylactic modalities seem to be an inadequate component of our preventive armamentarium; hence, the continued use of these antimicrobial regimens should be reevaluated. Also, because methicillin-resistant staphylococcal and pseudomonal TE infections occurred in approximately 60% of the times, the current perioperative antimicrobial regimens appear to be outdated. Therefore, at institutions that have observed an increase rate of these organisms, it may be prudent that preventive antimicrobial regimens target these microorganisms.

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Address correspondence to George M. Viola, MD, MPH, University of Texas MD Anderson Cancer Center, 1515 Holcombe Boulevard, Unit 1460, Houston, TX 77030 (gmviola@mdanderson.org).

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REFERENCES

1. McGuire KP, Santillan AA, Kaur P, et al. Are mastectomies on the rise? a 13-year trend analysis of the selection of mastectomy versus breast conservation therapy in 5865 patients. *Ann Surg Oncol* 2009;16(10):2682–2690.
2. Damle S, Teal CB, Lenert JJ, Marshall EC, Pan Q, McSwain AP. Mastectomy and contralateral prophylactic mastectomy rates: an institutional review. *Ann Surg Oncol* 2011;18(5):1356–1363.
3. Warren Peled A, Itakura K, Foster RD, et al. Impact of chemotherapy on postoperative complications after mastectomy and immediate breast reconstruction. *Arch Surg* 2010;145(9):880–885.
4. American Society of Plastic Surgeons (ASPS). *2012 Plastic Surgery Statistics Report.* Arlington Heights, IL: ASPS, 2012. http://www.plasticsurgery.org/Documents/news-resources/statistics/2012-Plastic-Surgery-Statistics/full-plastic-surgery-statistics-report.pdf. Accessed August 2, 2013.
5. Halvorson EG, Disa JJ, Mehrara BJ, Burkey BA, Pusic AL, Cordeiro PG. Outcome following removal of infected tissue expanders in breast reconstruction: a 10-year experience. *Ann Plast Surg* 2007;59(2):131–136.

https://doi.org/10.1086/674390 Published online by Cambridge University Press

6. Radovan C. Breast reconstruction after mastectomy using the temporary expander. *Plast Reconstr Surg* 1982;69(2):195–208.
7. Nahabedian MY, Tsangaris T, Momen B, Manson PN. Infectious complications following breast reconstruction with expanders and implants. *Plast Reconstr Surg* 2003;112(2):467–476.
8. Pittet B, Montandon D, Pittet D. Infection in breast implants. *Lancet Infect Dis* 2005;5(2):94–106.
9. Khan UD. Breast augmentation, antibiotic prophylaxis, and infection: comparative analysis of 1,628 primary augmentation mammoplasties assessing the role and efficacy of antibiotics prophylaxis duration. *Aesthetic Plast Surg* 2010;34(1):42–47.
10. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008;36(5):309–332.
11. Bratzler DW, Dellinger EP, Olsen KM. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *Am J Health Syst Pharm* 2013;70(3):195–283.
12. Cordeiro PG, McCarthy CM. A single surgeon's 12-year experience with tissue expander/implant breast reconstruction. I. A prospective analysis of early complications. *Plast Reconstr Surg* 2006;118(4):825–831.
13. Armstrong RW, Berkowitz RL, Bolding F. Infection following breast reconstruction. *Ann Plast Surg* 1989;23(4):284–288.
14. Spear SL, Majidian A. Immediate breast reconstruction in two stages using textured, integrated-valve tissue expanders and breast implants: a retrospective review of 171 consecutive breast reconstructions from 1989 to 1996. *Plast Reconstr Surg* 1998; 101(1):53–63.
15. Francis SH, Ruberg RL, Stevenson KB. Independent risk factors for infection in tissue expander breast reconstruction. *Plast Reconstr Surg* 2009;124(6):1790–1796.
16. Handel N, Jensen JA, Black Q, Waisman JR, Silverstein MJ. The fate of breast implants: a critical analysis of complications and outcomes. *Plast Reconstr Surg* 1995;96(7):1521–1533.
17. Disa JJ, Ad-El DD, Cohen SM, Cordeiro PG, Hidalgo DA. The premature removal of tissue expanders in breast reconstruction. *Plast Reconstr Surg* 1999;104(6):1662–1665.
18. Cordeiro PG, Pusic AL, Disa JJ, McCormick B, VanZee K. Irradiation after immediate tissue expander/implant breast reconstruction: outcomes, complications, aesthetic results, and satisfaction among 156 patients. *Plast Reconstr Surg* 2004;113(3): 877–881.
19. Araco A, Gravante G, Araco F, Delogu D, Cervelli V, Walgenbach K. Infections of breast implants in aesthetic breast augmentations: a single-center review of 3,002 patients. *Aesthetic Plast Surg* 2007;31(4):325–329.
20. Degnim AC, Scow JS, Hoskin TL, et al. Randomized controlled trial to reduce bacterial colonization of surgical drains after breast and axillary operations. *Ann Surg* 2013;258(2):240–247.
21. Vandeweyer E, Deraemaecker R, Nogaret JM, Hertens D. Immediate breast reconstruction with implants and adjuvant chemotherapy: a good option? *Acta Chir Belg* 2003;103(1):98–101.
22. Piper M, Peled AW, Foster RD, Moore DH, Esserman LJ. Total skin-sparing mastectomy: a systematic review of oncologic outcomes and postoperative complications. *Ann Plast Surg* 2013.
23. Reish RG, Damjanovic B, Austen WG Jr, et al. Infection following implant-based reconstruction in 1952 consecutive breast reconstructions: salvage rates and predictors of success. *Plast Reconstr Surg* 2013;131(6):1223–1230.
24. Mortenson MM, Schneider PD, Khatri VP, et al. Immediate breast reconstruction after mastectomy increases wound complications: however, initiation of adjuvant chemotherapy is not delayed. *Arch Surg* 2004;139(9):988–991.
25. Tejirian T, DiFronzo LA, Haigh PI. Antibiotic prophylaxis for preventing wound infection after breast surgery: a systematic review and metaanalysis. *J Am Coll Surg* 2006;203(5):729–734.
26. Throckmorton AD, Hoskin T, Boostrom SY, et al. Complications associated with postoperative antibiotic prophylaxis after breast surgery. *Am J Surg* 2009;198(4):553–556.
27. Bratzler DW, Houck PM. Antimicrobial prophylaxis for surgery: an advisory statement from the National Surgical Infection Prevention Project. *Am J Surg* 2005;189(4):395–404.
28. Feldman EM, Kontoyiannis DP, Sharabi SE, Lee E, Kaufman Y, Heller L. Breast implant infections: is cefazolin enough? *Plast Reconstr Surg* 2010;126(3):779–785.
29. Phillips BT, Wang ED, Mirrer J, Lanier ST, Khan SU, Dagum AB, Bui DT. Current practice among plastic surgeons of antibiotic prophylaxis and closed-suction drains in breast reconstruction: experience, evidence, and implications for postoperative care. *Ann Plast Surg* 2011;66(5):460–465.
30. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR; Hospital Infection Control Practices Advisory Committee. Guideline for prevention of surgical site infection, 1999. *Infect Control Hosp Epidemiol* 1999;20(4):250–278.
31. Adams WP Jr, Conner WC, Barton FE Jr, Rohrich RJ. Optimizing breast-pocket irrigation: the post-betadine era. *Plast Reconstr Surg* 2001;107(6):1596–1601.
32. Adams WP Jr, Conner WC, Barton FE Jr, Rohrich RJ. Optimizing breast pocket irrigation: an in vitro study and clinical implications. *Plast Reconstr Surg* 2000;105(1):334–338.
33. Adams WP Jr, Rios JL, Smith SJ. Enhancing patient outcomes in aesthetic and reconstructive breast surgery using triple antibiotic breast irrigation: six-year prospective clinical study. *Plast Reconstr Surg* 2006;118(7 suppl):46S–52S.
34. Pfeiffer P, Jorgensen S, Kristiansen TB, Jorgensen A, Holmich LR. Protective effect of topical antibiotics in breast augmentation. *Plast Reconstr Surg* 2009;124(2):629–634.
35. Washer LL, Gutowski K. Breast implant infections. *Infect Dis Clin North Am* 2012;26(1):111–125.
36. Zanetti G, Goldie SJ, Platt R. Clinical consequences and cost of limiting use of vancomycin for perioperative prophylaxis: example of coronary artery bypass surgery. *Emerg Infect Dis* 2001; 7(5):820–827.
37. Elliott RA, Weatherly HL, Hawkins NS, et al. An economic model for the prevention of MRSA infections after surgery: non-glycopeptide or glycopeptide antibiotic prophylaxis? *Eur J Health Econ* 2010;11(1):57–66.
38. Cranny G, Elliott R, Weatherly H, et al. A systematic review and economic model of switching from non-glycopeptide to glycopeptide antibiotic prophylaxis for surgery. *Health Technol Assess* 2008;12(1): iii-iv, xi-xii, 1–147.
39. Crawford T, Rodvold KA, Solomkin JS. Vancomycin for surgical prophylaxis? *Clin Infect Dis* 2012;54(10):1474–1479.
40. Alexander JW, Solomkin JS, Edwards MJ. Updated recommendations for control of surgical site infections. *Ann Surg* 2011; 253(6):1082–1093.

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