Reducing the Rate of Surgical Site Infections After Breast Surgery With the Use of Larger Volumes of 4% Chlorhexidine Gluconate Solution as Preoperative Antiseptic Showering

Surgical site infections (SSIs) increase morbidity and mortality in patients and contribute to significant clinical and economic burden.[1,2] Breast surgery has one of the highest SSI rates (2.8%–38.3%) especially in patients undergoing mastectomies.[2–4] Recommendations for SSI prevention practices include showering or bathing with an antiseptic agent before the operative day.[1,5] Preoperative showering with 4% chlorhexidine gluconate has broad antiseptic activities, reduces skin microbial colony counts, and is associated with significantly fewer SSIs compared to iodine.[6–8] Exact concentration, volume, and number of applications for optimal chlorhexidine use have not been established.[5]

At Riverside University Health System Medical Center, breast surgeries had the highest SSI rates (2.1%–8.6%) from January 2011 to June 2014. Our preoperative antiseptic showering consisted of only 15-mL soap packages of 4% chlorhexidine gluconate product (HIBICLENS, Molnlycke Health Care US, LLC, Norcross, GA) daily for 3 days. We hypothesized that each 15-mL volume was insufficient to achieve maximal antiseptic concentrations, especially for obese patients with larger breasts. An intervention was implemented to have all breast surgical patients shower or bathe with 118-mL solution bottles of 4% chlorhexidine gluconate product for application on breasts daily for 3 days prior to surgery starting in July 2014.

A retrospective chart review of patients who underwent breast surgery from January 2011 to December 2015, identified through the National Healthcare Safety Network database, was conducted at our institution. We compared SSI rates of patients before and after the use of larger volumes of 4% chlorhexidine gluconate product. Multiple regression analyses were used to identify independent risk factors for SSIs. All statistical analyses were performed using Epi Info 7.0 (Centers for Disease Control and Prevention, Atlanta, GA).

A total of 829 patients underwent breast surgery during the study period, and 31 patients (3.7%) were identified with SSIs. Breast surgery comprised of 246 mastectomy procedures (30%) and 583 non-mastectomy procedures (70%). All patient received intravenous antimicrobial prophylaxis before surgery, and all surgeries were performed by senior faculty surgeons. In total, 807 patients (97%) were women and 65% were diagnosed with breast cancer. All SSI patients were female with breast cancer diagnoses. Demographic and clinical characteristics of infected and non-infected patients undergoing mastectomy and non-mastectomy surgery are shown in Table 1.

Our study results show that larger volumes of 4% chlorhexidine gluconate product significantly reduced SSI rates in mastectomy patients (n = 24 [13.1%] vs n = 2 [3.2%]; $P = .027$); however, they did not significantly reduce the rate of SSIs in non-mastectomy surgery (n = 2 [0.45%] vs n = 3 [2.1%]; $P = .18$) and in all breast surgeries (n = 26 [4.2%] vs n = 5 [2.4%]; $P = .25$). Infected patients underwent simple or modified radical mastectomy followed by tissue expander placement; they were subjected to a longer duration of surgery; and they had a higher body mass index (BMI). Using multiple logistic regression analyses, the independent risk factors for SSIs among mastectomy surgery were BMI (OR, 1.1172; 95% CI, 1.0348–1.2062; $P = .0046$), tissue expander placement (OR, 9.751; 95% CI, 3.2542–29.2181; $P < .0001$), and smaller volumes of 4% chlorhexidine gluconate product (OR, 6.5487; 95% CI, 1.3113–32.7052; $P < .022$).

Most SSIs (68%) were deep and organ space infections, which are reflective of invasive disease. Surprisingly, we found that gram-negative organisms were the predominant cause (58%) of these deep and organ SSIs. All cultures from superficial SSIs (32%) showed *Staphylococcus aureus*. Even though *Staphylococcus aureus* is the leading cause of SSIs after breast surgery, our results agree with a study in which gram-negative organisms were most frequently isolated from cultures of breast SSIs.[1,3] This observation could partially be explained by the known decreased activity of chlorhexidine against gram-negative organisms.[9] However, our study results indicate that larger volumes of 4% chlorhexidine enhanced antiseptic activity against gram-negative organisms. Larger volumes did not significantly reduce the rate of SSIs in all breast surgeries. Nonmastectomy procedures comprised of 70% of all breast surgeries in our cohort. We believe that these procedures are considered less invasive with shorter surgery durations and did not include tissue expander placements.

To our knowledge, there are no published studies assessing the relationship between SSIs and simple mastectomy surgery; thus, our unusually high rates of SSIs after simple mastectomy (92%) followed by tissue expander placement (39%) need further exploration and confirmation.

However, we postulate that these patients developed more SSIs due to cross-contamination of bacteria from the skin to the tissue expander during surgical placement. Given that a tissue expander remains in place for 1–2 months, we feel that it is a major contributor to the higher rates of deep and organ SSIs seen after placement. In addition, higher BMI is associated with larger breast size and greater skin surface area for bacterial growth, which may contribute to more SSIs.[10] Studies have shown that repeated preoperative antiseptic showers with 4% chlorhexidine gluconate solution have resulted in significant reductions of skin microbial colony counts before surgery and SSIs.[8] This cross-contamination process may have been reduced with the implementation of the larger-volume solution.

Our study has several limitations. First, it is a retrospective cohort of patients at a single public academic medical center. Further studies are warranted to confirm our findings. Second, we were unable to ascertain the compliance rate of using both

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TABLE 1. Demographic and Clinical Characteristics of Infected and Noninfected Patients Undergoing Breast Surgery

	Mastectomy Surgery			Nonmastectomy Surgery		
	Infected (n = 26)	Noninfected (n = 220)	*P* Value	Infected (n = 5)	Noninfected (n = 578)	*P* Value
Age, y (SD)	55.9 (7.6)	52.5 (10.7)	.11	57.6 (12.1)	47.4 (13.2)	.09
Body mass index, kg/m^2 (SD)	33.0 (6.1)	29.7 (6.0)	.009	27.6 (7.5)	29.2 (6.3)	.57
Hemoglobin A1c, % (SD)	8.3 (1.4)	7.6 (1.8)	.44	N/A	7.3 (1.0)	N/A
Surgery duration, min (SD)	199.5 (158.9)	153.5 (83.0)	.019	96.2 (73.7)	101.4 (102.6)	.9
Tissue expander, %	38.5	6.8	<.0001	20	5.5	.67
Wound class, %	…	…	.38	…	…	<.0001
C	92.3	96.8	…	80	92.2	…
CC	N/A	N/A	…	25	0.52	…
CO	7.7	2.7	…	N/A	3.5	…
D	N/A	0.45	…	N/A	3.8	…
ASA class, %	…	…	.73	…	…	.9
1	3.9	1.8	…	20	15.9	…
2	26.9	31.4	…	40	55.5	…
3	69.2	66.8	…	40	28.0	…
4	N/A	N/A	…	N/A	0.52	…
Surgery type, %	…	…	.0014	…	…	…
Simple	92.3	55.9	…	…	…	…
Modified	7.7	23.6	…	…	…	…
Radical	N/A	20.5	…	…	…	…
Intervention, %	…	…	.027		…	.18
Pre	13.1	86.9	…	0.45	99.6	…
Post	3.2	96.8	…	2.1	97.9	…

NOTE. SD, standard deviation; min, minutes; C, clean; CC, clean-contaminated; CO, contaminated; D, dirty; ASA, American Society of Anesthesiologists; N/A, not applicable.

antiseptic showering regimens of 4% chlorhexidine gluconate before breast surgery. Finally, we did not control for the various operative techniques performed by the surgeons. However, despite our limitations, we believe that larger volumes of 4% chlorhexidine gluconate may be as effective a strategy as preoperative antiseptic showering in reducing the rate of SSIs in patients after mastectomy.

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