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Breast

Antimicrobial Irrigation and Technique during Breast Augmentation: Survey of Current Practice

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Background: Breast augmentation is among the most common procedures performed in the United States. Though bacterial contamination of breast prostheses is associated with adverse sequelae, there are no universally accepted guidelines and limited best practice recommendations for antimicrobial breast pocket irrigation. We designed a survey to identify pocket irrigation preferences and antimicrobial techniques during implant-based breast augmentation among American Society of Plastic Surgeons (ASPS) members.

Methods: In January 2018, a random cohort of 2,488 ASPS members was surveyed. Questions queried breast pocket irrigation methods and surgical techniques including implant placement, incision location, and implant soaking agents. An extensive literature review of breast pocket irrigation practices was completed and used as a basis for the survey.

Results: The survey response rate was above the ASPS average at 16% (n = 407). Respondents preferred an inframammary incision (90%) and submuscular implant placement (92%). Triple antibiotic solution (TAS) and TAS + Betadine ± Bacitracin were preferred by 61% and Betadine variants by 11%. Preferred dwell times stratified to 30 seconds (39%), 1 minute (18%), 2–5 minutes (21%), and >5 minutes (22%). Among those employing a TAS variant, 53% preferred a suboptimal dwell time of ≤1 minute. Prostheses were soaked in TAS (42%), TAS + Betadine ± Bacitracin (15%), a Betadine variant (12%), or other (31%).

Conclusions: Periprosthetic bacterial contamination leads to comorbidity following breast augmentation. Our results reveal significant variability regarding breast pocket irrigation techniques among ASPS members during cosmetic breast augmentation. These data suggest the need for best practice guidelines regarding breast pocket irrigation and implant soaking agents. *(Plast Reconstr Surg Glob Open 2019;7:e2310; doi: 10.1097/GOX.0000000000002310; Published online 5 August 2019.)*

If bacterial contamination eventually is confirmed as the cause of capsular contracture—and this will obviously require substantiation—what are the future directions for surgical development?

—Boyd Burkhardt, MD[1]

Breast augmentation surgery is among the most common plastic surgery procedures performed in the United States, with over 300,000 breast augmentations performed each year.[2] Despite improvement of surgical outcomes in recent decades, breast augmentation remains plagued by bacteria-related sequelae. Antimicrobial breast pocket irrigation solutions and techniques regarding their use have evolved since Burkhardt et al[1] first described the relationship between bacterial contamination and implant-related comorbidity and continue to be a source of debate.

In 1986, Burkhardt et al[1] demonstrated that the use of local antimicrobial agents in and around retromammary implants improved surgical outcomes, with an incidence of capsular contracture 7 times less than the control group.[1] Pocket irrigation with Betadine (Purdue Freder-

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ick, Stamford, Conn.) became a standard in practice as the literature increasingly supported the role of microorganisms as the basis of capsular contracture.[3,4] In 2000, the FDA deemed the use of Betadine for breast pocket irrigation contraindicated, citing that exposure may lead to early implant failure.[5]

Following the 2000 FDA ban on Betadine, Adams et al proposed a triple antibiotic solution (TAS) composed of 50,000 U Bacitracin, 1 g Ancef, and 80 mg Gentamicin and recommended a pocket contact (dwell) time of 5 minutes.[5] Subsequent studies demonstrated that TAS is associated with a rate of capsular contracture 4 to 5 times lower in breast augmentation patients.[6]

The FDA subsequently removed the warning on the use of Betadine with breast implants in 2017.[7] Consequently, in early 2018, Jewell and Adams[8] updated a 14-point plan originally published in 2013 designed to decrease bacterial bioburden in breast implant surgery, including pocket irrigation with TAS, TAS + Betadine, or ≥50% Betadine.[9] Adams[10] suggests the need for consensus among plastic surgeons regarding pocket irrigation and further recommends that surgeons "should simply utilize the proven ingredients and ratios as recommended."

There remain few guidelines and a lack of universally accepted best practice recommendations concerning pocket irrigation during breast augmentation surgery. The present study is designed to identify the current landscape of surgical irrigation preference and technique among American Society of Plastic Surgery (ASPS) members during implant-based breast augmentation.

MATERIALS AND METHODS

ASPS Member Survey

A comprehensive literature review was completed by the senior author in October 2017 to create a list of pocket irrigation solutions currently described in the literature. Based on this review, we designed a survey assessing antimicrobial techniques and irrigation preferences during breast surgery using SurveyMonkey (See figure, Supplemental Digital Content 1, which displays the analyzed ASPS survey questions, http://links.lww.com/PRSGO/B147). In January 2018, the survey was sent a total of 3 times to the same random cohort of 2,488 ASPS members by email. Before dissemination, the survey was peer reviewed by ASPS leadership.

ASPS surveys are typically sent to approximately half (n = 2,500) of the active ASPS membership. The random cohort was chosen using a randomization program that selected survey recipients based on member ID number. The cohort was then reviewed to ensure that it was representative of the entire ASPS active membership (ie, sex, age, practice demographic, practice type).

The survey was composed of multiple-choice questions with the option for free-text responses. The provided response options were exhaustive and mutually exclusive. Questions were designed to assess respondent breast pocket irrigation preference and dwell time (exposure time) of preferred solutions during different types of breast surgery (cosmetic, reconstructive, and implant salvage) and demographics, incision type, implant placement, and implant soaking agents. Questions 1–9 assessing demographic and cosmetic surgery preferences were analyzed for this study (See figure, Supplemental Digital Content 1, which displays the analyzed ASPS survey questions, http://links.lww.com/PRSGO/B147).

Statistical Analysis

As our focus is cosmetic breast pocket irrigation, survey responses from surgeons who perform only reconstructive surgery or no breast surgery at all were excluded. Qualitative data were represented using frequencies and percentages, and Pearson chi-square tests were used to compare the groups when applicable. Statistical analyses were performed using IBM SPSS v24.0 software.

RESULTS

Demographics

The survey had an overall response rate of 16% (n = 407), which is above average for the ASPS survey mechanism.[10] The survey had a margin of error of ±5% at a 95% confidence level, indicating that the sample accurately reflected the views of active ASPS members. The survey population reflected a cross-section of practice types and experience levels, with 99% of respondents performing breast surgery in their practice (n = 357). Thus, the responses of 14% of survey recipients were analyzed. Demographic data are represented in Table 1.

Incision Type and Implant Placement

The majority of respondents preferred an inframammary incision (90%). The remaining respondents preferred a periareolar incision (7.4%) or a transaxillary incision (2.7%). There was a significant difference in incision preference based on number of years in practice (Fig. 1). Among respondents with less than 20 years of experience, 97% preferred an inframammary incision, compared with 83% of respondents with ≥20 years of experience. No respondents with less than 20 years of expe-

Table 1. Demographics of Respondents Who Perform Cosmetic Breast Surgery

Practice type	
Private practice	90.5%
Academic	7.0%
Employed physician	2.5%
Years in practice	
Less than 5	12.0%
5–9	13.7%
10–14	13.7%
15–19	10.9%
20–24	16.2%
25 or more	33.3%
Approximate time spent on cosmetic surgery	
100%	24.9%
75%	24.9%
50%	23.5%
25%	26.6%
0%	0%

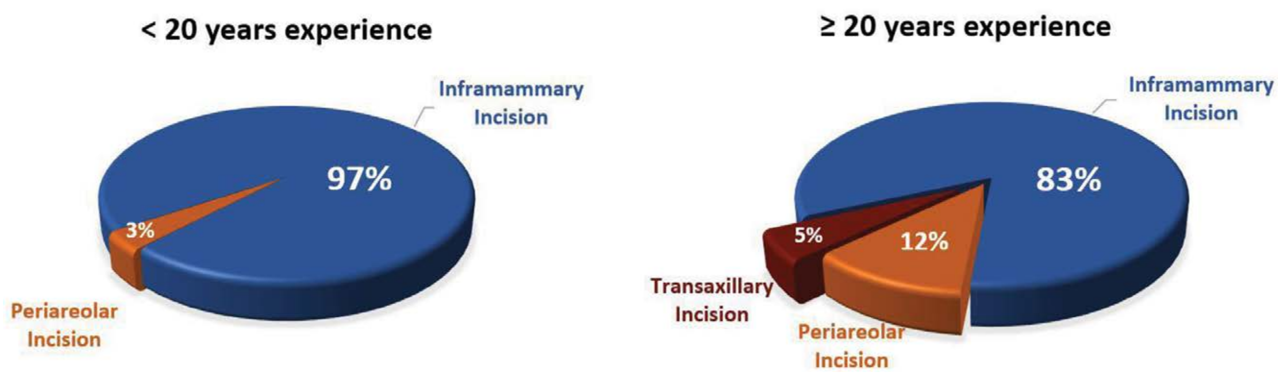

Fig. 1. Incision type preference.

rience utilized a transaxillary incision, whereas 5% with 20 or more years of experience preferred this incision.

Submuscular implant placement was preferred by the majority of respondents (92%). Others also reported using a subglandular implant placement (6.5%) or a subfascial placement (1.5%).

Breast Pocket Irrigation

Pocket irrigation solution preferences are summarized in Table 2. Forty percent of respondents use TAS and 21% report using TAS with Betadine with and without Bacitracin. A Betadine variant was preferred by 12.7% of respondents with 3.7% using a 0.5% povidone-iodine solution and 7.5% using a 5% povidone-iodine solution. A variety of other solutions are also used including, but not limited to, Bacitracin variants, Ancef, dilute Hibiclens, PhaseOne, and Gentamycin. In all, 35 distinct solutions were identified.

Preferred dwell times stratified to 30 seconds (39%), 1 minute (18%), 2–5 minutes (21%), and >5 minutes (22%). Among respondents employing TAS or one of its Betadine-containing variants, 53% preferred a suboptimal dwell time of 1 minute or less. A representative list of pocket irrigation solutions and correlated dwell times is summarized in Table 3.

Implant Soaking

Breast prostheses (expanders/implants) were most commonly soaked in TAS (42%), TAS + Betadine with and without Bacitracin (15%), a Betadine variant (13%), or other (31%), including Bacitracin alone. Prosthesis soaking solution preferences are summarized in Table 2.

DISCUSSION

Subclinical infection, biofilm, and capsular contracture diminish results in implant-based breast augmentation. The routine use of antimicrobial pocket irrigation and implant soaking agents, inframammary fold incision technique, and submuscular implant placement have led to decreased rates of capsular contracture.[5,12,13]

Incision and Implant Placement Preference

The most preferred incision location among all survey respondents was within the inframammary fold. This finding is supported by the literature which demonstrates that the inframammary approach has been associated with a statistically significant reduction in capsular contracture.[12,14–17]

Interestingly, incision preference seems to be generational. As depicted in Figure 1, of those who had been in practice for 20 years or more, 12% use a periareolar incision and 5% use a transaxillary incision. Of those in practice for less than 20 years, 3% prefer a periareolar incision and none appear to prefer a transaxillary incision. This could be due to recent data showing that transaxillary incisions are associated with higher complication rates due to infection and a higher incidence of reoperation.[17]

Also in accordance with the literature, the most favored implant placement was in a submuscular pocket. This is likely due to its association with lower rates of infection and capsular contracture as predicted by Burkhardt et al[1] in 1986.[17,18]

Pocket Irrigation during Breast Augmentation Surgery

Despite the strong association between bacteria and surgical complications, there appear to be no universally accepted, evidence-based best practice guidelines regarding antimicrobial breast pocket irrigation practices and only a grade D (level V evidence) guidelines for perioperative antibiotic practices.[19] The current literature regarding pocket irrigation presents a confusing and conflicting picture regarding recommended solutions.

A review of literature in October 2017 revealed numerous pocket irrigation solutions and techniques of use with limited clarity regarding efficacy, toxicity, or cost. Table 4 attempts to summarize the mechanisms of action of the individual antimicrobial agents that comprise these irrigations found in the literature. Much of the recent literature on pocket irrigation and implant soaking practices supports the use of TAS. However, studies have identified superior efficacy of Betadine-containing irrigations.[20] Additionally, 1 study found non-Betadine containing TAS and 0.05% chlorhexidine to be most effective.[21] Despite numerous subsequent commentaries regarding pocket irrigation by Sieber, Adams, Fisher, and Wixtrom, there are still no universally accepted guidelines. An article by Jewell and Adams[8] attempts to clarify this confusion by offering 3 recommended solutions in their updated version of the 14-point plan. These solutions included TAS, TAS + Betadine, and ≥50% Betadine.[10,22–24]

Table 2. ASPS Survey: Antimicrobial Techniques and Preferences During Breast Augmentation Pocket Irrigation and Implant Soaking Solutions

Solution	Respondents Who Use Solution as Breast Pocket Irrigation (%)	Respondents Who Use Solution as an Implant Soaking Agent (%)
Sterile water	0	0.3
Normal saline	3.4	4.6
TAS (Adams' solution: Ancef, Gentamycin, Bacitracin)	**40.5**	**42.0**
TAS + Betadine	**16.1**	**10.6**
TAS, without Bacitracin, + Betadine	4.9	4.6
Dilute Betadine 1:20 ratio of stock solution (10% povidone-iodine)	3.7	3.2
Dilute Betadine 1:10 ratio of stock solution (10% povidone-iodine)	0.6	0.6
Dilute Betadine 1:1 ratio of stock solution (10% povidone-iodine)	**7.5**	**8.3**
Betadine (10% povidone-iodine)	0.9	0.9
Dakin's solution (0.25% sodium hypochlorite)	0.3	0.3
Clorpactin wcs-90 (0.4% sodium oxychlorosene; hypochlorous acid derivative; Dakin's solution alternative)	0.6	0.3
PhaseOne wound irrigation (0.025% hypochlorous acid)	0.3	0.6
Irrisept (0.05% aqueous chlorhexidine gluconate)	0.6	0.3
Dilute Hibiclens (0.05% chlorhexidine gluconate soap)	0.9	1.1
Prontosan wound irrigation (Polyhexanide/Betaine soap)	0.3	0.3
50,000 units Bacitracin (1 A) in 1 L of saline	**5.2**	**6.3**
50,000 units Bacitracin (1 A) in 500 cc saline + 500 cc Betadine solution (≈1:1 ratio 10% Betadine stock:saline)	0	0
50,000 units Bacitracin (1 A) in 1 L saline + 50 cc Betadine solution (≈1:20 ratio 10% Betadine stock:saline)	0.6	0.6
Vancomycin	0.3	0.9
Gentamycin	0.9	0.9
Ancef	2.0	2.3
Hydrogen peroxide	0	0
Other (solutions in normal saline)	**9.8**	**7.8**
Ancef + Bacitracin		
Ancef + Polymyxin		
Bacitracin + Polymyxin		
Bacitracin + Gentamycin		
Bacitracin + Vancomycin		
Bacitracin, Gentamycin, Vancomycin		
Bacitracin, Gentamycin, Clindamycin		
Bacitracin + Neomycin		
Bacitracin, Vancomycin, Tobramycin, PhaseOne		
Betadine, Gentamycin, Kefzol		
Polymyxin		
Vancomycin and Ciprofloxacin		
N/a (no irrigation)	0.9	3.4

The 5 most preferred responses are listed in bold.

Table 3. Dwell Time Preferences for Irrigation Solutions Used by 10 or More Respondents

Solution	n	30 Seconds	1 Minutes	2 Minutes	3 Minutes	5 Minutes	Left
Normal saline (sodium chloride)	8	6 (50.0%)	1 (8.3%)	1 (8.3%)			
Triple antibiotic solution (ie, "Adam's solution": Ancef, Gentamycin, Bacitracin)	136	54 (38.3%)	22 (15.6%)	21 (14.9%)	2 (1.4%)	5 (3.5%)	32 (22.7%)
Triple antibiotic solution with Betadine (ie "Super-charged Adam's solution": Ancef, Gentamycin, Bacitracin, Betadine)	55	19 (33.9%)	11 (19.6%)	8 (14.3%)	1 (1.8%)	3 (5.4%)	13 (23.2%)
Triple antibiotic solution with Betadine, but without Bacitracin (Betadine, Ancef, Gentamycin)	15	5 (29.4%)	3 (17.6%)	1 (5.9%)	1 (5.9%)	2 (11.8%)	3 (17.6%)
Betadine solution (0.05% povidone-iodine); 1:20 ratio 10% Betadine stock:saline	13	3 (23.1%)	2 (15.4%)	4 (30.8%)		2 (15.4%)	2 (15.4%)
Betadine solution (5% povidone-iodine); 1:1 ratio 10% Betadine stock:saline	26	11 (42.3%)	3 (11.5%)	3 (11.5%)		1 (3.8%)	8 (30.8%)
50,000 units Bacitracin (1 A) in 1 L of saline	15	7 (38.9%)	5 (27.8%)		1 (5.6%)		2 (11.1%)
Overall	268	105 (39.2%)	47 (17.5%)	38 (14.2%)	5 (1.9%)	13 (4.9%)	60 (22.4%)

Table 4. Antimicrobial Agents Preferred Among ASPS Survey Respondents

	Brand Name	Mechanism of Action	Bactericidal versus Bacteriostatic	Spectrum
Quaternary salts				
Benzalkonium chloride	Bactisure wound irrigation	Degrades cell wall causing leakage of cellular contents; surfactant properties[34]; solution uses mechanical debridement with a pulse lavage device	Concentration dependent[33]	More effective against Gram positive than Gram negative[33]
0.1%/0.1% Polyhexanide/Betaine soap	Prontosan wound irrigation		Bactericidal	Gram-negative and Gram-positive organisms
0.05% aqueous chlorhexidine gluconate	Irrisept	Biguanide that disrupts cell walls and precipitates cellular proteins; binds to cell walls and alters osmotic equilibrium[21,35]	Bactericidal	Broad coverage
0.05% chlorhexidine gluconate soap	Dilute Hibiclens	At physiological pH, chlorhexidine slats dissociate and release positively charged chlorhexidine cation which binds to negatively charged bacterial cell walls	Concentration-dependent; bacteriostatic at low concentration[36]	Broad antimicrobial coverage
Oxidizing agents				
Hydrogen peroxide		Oxidant; causes tissue toxicity via corrosive damage, oxygen gas formation, and lipid peroxidation[37]		Broad coverage against viruses, bacteria, yeasts, and bacterial spores[38]
Iodine-containing salts				
10% povidone-iodine: I-PVP	Betadine	Causes protein denaturation and precipitation of bacteria; toxic toward human fibroblasts[39]	Bactericidal	Viruses, bacteria, spores, fungi, and protozoa[38]
Ammonium chlorides (bleaches)				
0.25% sodium hypochlorite	Dakin's solution	Increases pH and interferes with cytoplasmic membrane integrity; interferes with cellular metabolism and phospholipid degradation[38]	Bactericidal	Broad coverage; dose-dependent toxicity against macrophages[40]
0.4% sodium oxychlorosene	Clorpactin wcs-90	Oxidation and hypochlorination, and thereby destruction, of protoplasmic contents	Bactericidal	Broad coverage
0.025% hypochlorous acid	PhaseOne wound irrigation	Replicates oxidative burst that occurs in white blood cells with the release of hypochlorous acid[41]	Bactericidal	Broad coverage against Gram-positive and Gram-negative bacteria and fungi
Antibiotics				
Cefazolin	Ancef	Inhibits cell wall synthesis	Bactericidal	Broad coverage
Gentamicin		Binds the 30S subunit of bactericidal ribosome, interrupting protein synthesis[41]	Bactericidal	Broad coverage against Gram-negative and Gram-positive organisms; concentration dependent
Bacitracin		Disrupts bacterial cell wall synthesis and inhibits cell enzymes	Concentration dependent	Most Gram-positive organisms
Polymyxin B		Binds to cell membrane and alters structure, making it permeable	Bactericidal	Resistant Gram-negative microbes except Proteus and Neisseria genera
Vancomycin		Inhibits cell wall synthesis	Bactericidal	Gram-positive bacteria
Diluting agents				
Sterile water				
Sterile normal saline (sodium chloride)				

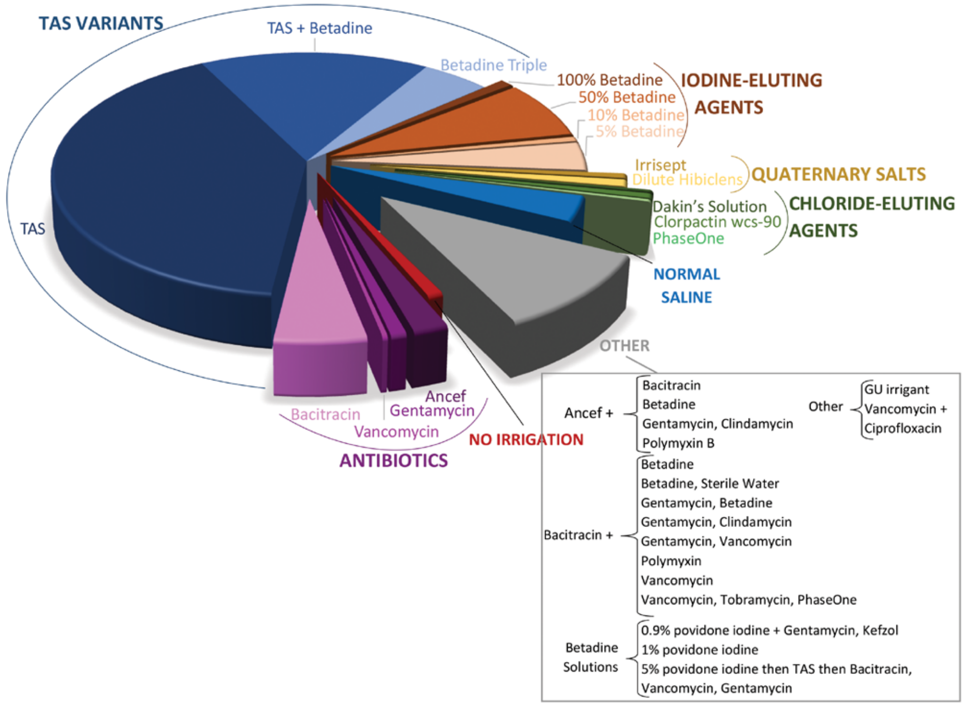

Fig. 2. Preferred pocket irrigation preference by solution type.

The results of our survey demonstrate a clear lack of consensus or demonstrable standard of practice.

Despite support in the literature for the use of TAS and TAS + Betadine,[8,21,25] only 63% of respondents utilize TAS, TAS + Betadine ("Betadine Quadruple"), or TAS + Betadine without Bacitracin ("Betadine Triple") as a pocket irrigant in their cosmetic cases.[8,10] In all, over 35 distinct pocket irrigation solutions were identified among ASPS members during augmentation mammaplasty. The solutions range from antibiotic cocktails to single antibiotic solutions to antiseptics to soaps to no irrigation at all (Table 2; Fig. 2). Current irrigation preferences appear to be roughly split with respect to those who follow protocols by Adams and those who use alternative solutions, including multiple combinations of Betadine-containing TAS variants. Despite specific recommendation by Adams against them based upon scientific evidence, single antibiotic agents are used by over 8% of survey respondents.[8,10] Notably, this is the first time that Hibiclens, a soap form of chlorhexidine, has been reported as pocket irrigation. Additionally, after multiple reports of efficacy in biofilm penetration,[26] PhaseOne (Integrated Healing Technologies, Nashville, Tenn.) was identified as a preferred pocket irrigation solution by some respondents.

Some newly developed commercial products, including Bactisure (Zimmer Biomet, Jacksonville, Fla.), were not preferred by any respondents. This may be due to a lack of long-term evidence regarding safety and efficacy in comparison to TAS and Betadine.

Implant Soaking Agents

Our results also demonstrated marked variation in implant soaking agents, comparable to that seen in pocket irrigation solutions (Table 2). Respondents (57.2%) soak the implant in TAS, "Betadine triple," or "Betadine Quadruple" before insertion. A small number of respondents (8.3%) reported soaking the implant in stock Betadine despite the FDA only recently retracted warning against the use of Betadine with breast implants. Again, single antibiotic solutions are being utilized despite recommendations by Adams. As would be predicted, there is a statistically significant correlation between the solution used to irrigate the breast pocket and the solution used to soak the prosthesis.

Dwell Times

In 2017, Fisher reintroduced the concept of time-dependent efficacy of irrigation solutions in breast augmentation.[26] Pharmacologically, the efficacy of some antibiotics, such as Ancef, is dependent on time rather than concentration, such as with Gentamycin.[27] In contrast to reconstructive and implant-salvage procedures where evacuative drain placement is routine, pocket irrigation dwell time may be less significant in augmentation mammaplasty when the solution is left in the pocket, as suggested by Adams, thereby achieving prolonged exposure times.[8]

Our survey results show that 56.7% of respondents prefer a pocket irrigation dwell time of 1 minute or less, regardless of the irrigation solution used. These data include respondents utilizing TAS, which disagrees with Adams' recommendation of a 5-minute contact time.[8] Zhadan and Becker[21] found that TAS required a minimum of 30 minutes to eliminate some strains of bacteria. Leaving the solution in the pocket during augmentation mammaplasty theoretically allows an exposure time of longer than 30 minutes, thus allowing TAS to be more effective. Regarding the need for prolonged exposure or dwell times, it should be noted that there is some time limitation regarding antimicrobial activity, as these irrigation solutions are still subject to the effects of drug absorption and metabolism. Here, our data would suggest that there is a cohort of surgeons who leave the irrigation in place which had to date not been quantified.

An additional limitation to leaving the irrigation in the breast pocket is the risk of damage to the implant or surrounding tissue due to prolonged exposure. There have been reports of harmful reactions to many reportedly used irrigation solutions including chlorhexidine and hypochlorous acid.[10,28] Additionally, povidone-iodine can be highly toxic to fibroblasts and has been shown to have antineoplastic properties as a cytotoxic lavage agent against both malignant pleural mesothelioma and colon cancer cells.[29–31]

Future Directions

As a field, we need to work toward a consensus regarding antimicrobial breast pocket irrigation based upon rigorous scientific method. Our results show that there is significant heterogeneity in plastic surgeons' approach to antimicrobial techniques in augmentation mammaplasty. Additionally, the literature continues to lack clarity with respect to the efficacy and toxicity of commonly used irrigation solutions. Bench research is warranted to investigate the effectiveness of each of the over 30 reportedly used solutions against bacteria and biofilms, the leading causes of capsular contracture.[3,4] Other avenues of investigation include use of soaps or time-release antimicrobial products that may act to protect the implant from endogenous ductal bacterial contamination, including the use of antibiotic beads which have been reported to be easy and inexpensive to manufacture even in a resource-poor environment.[32] Absorbable antibiotic beads, when placed in the submuscular pocket, demonstrated an 8-fold reduction in breast reconstruction comorbidities.[33]

Limitations

Limitations of this study include the potential for selection bias regarding the survey respondents and differences in question interpretation among respondents. Some respondents skipped questions which could also have influenced the results. Despite this, the results are still interesting and significant as they point to the immense variability in preference, emphasizing the need for standard, evidence-based best practice guidelines regarding antimicrobial technique in cosmetic breast surgery.

CONCLUSIONS

Bacterial infection has been linked to the development of implant infection, capsular contracture, and BIA-ALCL. Despite more than 30 years of overwhelming evidence of the role of bacterial bioburden in implant-related sequelae, there appears to be no consensus among ASPS members regarding antimicrobial pocket irrigation method or implant soaking agent preferences. Yet, other techniques aimed at reducing bacterial contamination including submuscular implant placement and inframammary fold incision appear to be implemented. These results further underscore the importance of relating current clinical practices with new breast microflora bench work research and suggest a need for consensus and formal best practice guidelines. We hope this study drives awareness of current pocket irrigation recommendations during breast augmentation surgery and helps promote continued evidence-based science toward universally accepted best practice guidelines within our field.

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