
Preoperative Shower Revisited: Can High Topical Antiseptic Levels Be Achieved on the Skin Surface Before Surgical Admission?

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- BACKGROUND:** Skin asepsis is a sentinel strategy for reducing risk of surgical site infections. In this study, chlorhexidine gluconate (CHG) skin concentrations were determined after preoperative showering/skin cleansing using 4% CHG soap or 2% CHG-impregnated polyester cloth.
- STUDY DESIGN:** Subjects were randomized to one of three shower (4% soap)/skin cleansing (2% cloth) groups (n = 20 per group): (group 1 A/B) evening, (group 2 A/B) morning, or (group 3 A/B) evening and morning. After showering or skin cleansing, volunteers returned to the investigator's laboratory where CHG skin surface concentrations were determined at five separate skin sites. CHG concentrations were compared with CHG minimal inhibitory concentration that inhibits 90% (MIC₉₀) of staphylococcal skin isolates.
- RESULTS:** CHG MIC₉₀ for 61 skin isolates was 4.8 parts per million (ppm). In group 1A, 4% CHG skin concentrations ranged from 17.2 to 31.6 ppm, and CHG concentrations were 361.5 to 589.5 ppm (p < 0.0001) in group 1B (2%). In group 2A (4%), CHG levels ranged from 51.6 to 119.6 ppm and 848.1 to 1,049.6 ppm in group 2B (2%), respectively (p < 0.0001). CHG levels ranged from 101.4 to 149.4 ppm in the 4% CHG group (group 3A) compared with 1,484.6 to 2,031.3 ppm in 2% CHG cloth (group 3B) group (p < 0.0001). Effective CHG levels were not detected in the 4% CHG group in selected sites in seven (35%) subjects in group 1A, three (15%) in group 2A, and five (25%) in group 3A.
- CONCLUSIONS:** Effective CHG levels were achieved on most skin sites after using 4% CHG; gaps in antiseptic coverage were noted at selective sites even after repeated application. Use of the 2% CHG polyester cloth resulted in considerably higher skin concentrations with no gaps in antiseptic coverage. Effective decolonization of the skin before hospital admission can play an important role in reducing risk of surgical site infections. (J Am Coll Surg 2008;207:233–239. © 2008 by the American College of Surgeons)
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Preoperative antiseptic shower has long been considered an important strategy for reducing risk of surgical site infection. The CDC has “strongly recommended” (Category 1B) that patients shower with an antiseptic agent before undergoing an elective surgical procedure.¹ In an earlier era when patients were admitted 24 to 48 hours before an elective surgical procedure, the preoperative bath or shower using an antiseptic soap was considered part of a traditional patient-care regimen. The perceived value of this practice was to reduce surface skin colonization, especially in those areas of high surface humidity, such as the axilla or inguinal regions, harboring selected microbial populations that could play a role in wound contamination. This practice has recently been called into question with publication of a Cochrane Collaboration suggesting that evidence-based data does not justify continuation of this practice.² A careful review of this analysis has suggested several potential

Abbreviations and Acronyms

CHG = chlorhexidine gluconate
 PPM = parts per million
 MIC = minimal inhibitory concentration.

shortcomings associated with selected studies cited by the Cochrane investigators.

Although previous studies investigating the role of preoperative skin antisepsis in reducing risk of surgical site infection might have been fraught with design and methodologic shortcomings, a number of well-conducted, randomized clinical studies published during the past 30 years have clearly shown that chlorhexidine gluconate (CHG) is a safe and efficacious agent, reducing risk of microbial contamination in a myriad of clinical applications, including surgical hand scrub, skin prep for vascular access, oral hygiene, and as a cleansing agent within patient-care environments (eg, ICU) contaminated by drug-resistant microbial populations.³⁻⁹ CHG exhibits an antimicrobial spectrum, which is similar to iodophor-containing formulations. Because CHG is not inactivated by blood or serum protein and demonstrates a persistent surface activity for several hours on the surface of prepared skin, it is an ideal patient preoperative skin preparation.¹⁰

The present study was conducted to validate effective skin surface concentrations of CHG using a standardized, timed protocol. The study compares skin surface concentrations of CHG achieved after showering with a 4% CHG liquid soap or cleansing the skin surface with an innovative 2% CHG-impregnated polyester cloth, which has been shown in clinical trials to substantially reduce microbial burden on both the inguinal and abdominal skin surfaces.¹¹ The current investigation was reviewed and approved by the Institutional Human Subjects Review Board.

METHODS

Recovery of staphylococcal skin surface flora

At the time of study enrollment, a moist swab was used to obtain a skin culture from the inside surface of the forearm of each study participant. All staphylococcal isolates were identified according to standard protocol.¹² The CHG minimal inhibitory concentration (MIC) for each isolate was determined using a Clinical Laboratory Standards Institute recommended broth susceptibility method.¹³

Preliminary pilot study

Ten subjects were chosen to participate in a small pilot study to assess skin surface concentrations of CHG after antiseptic shower. No specific instructions were given to

the subjects as to application technique or exposure time, as per selected studies cited in the Cochrane Collaboration.²

Subjects were given a 4-ounce bottle of 4% CHG antiseptic solution and instructed to shower with the antiseptic soap in the morning. Subjects returned to the investigator's laboratory within 2 to 3 hours of showering for determination of CHG skin surface concentration at five selected skin sites (right/left antecubital fossa, right/left popliteal fossa and abdomen).

Randomization study

Sixty subjects were randomized into one of three standardized skin antisepsis groups (n = 20 per group):

- Group 1: evening application of CHG using (A) 4% CHG soap or (B) 2% CHG-impregnated cloth
- Group 2: morning application of CHG using (A) 4% CHG soap or (B) 2% CHG-impregnated cloth
- Group 3: evening and morning application of CHG using (A) 4% CHG or (B) 2% CHG-impregnated cloth

Standardized protocol 4% CHG shower (groups 1, 2, and 3): subgroup A

Volunteers in subgroup A were instructed to apply 4% CHG soap (Scrub Care Exidine, Cardinal Health) to their body using a clean wash cloth, covering all body surface areas, excluding face and scalp. Subjects were instructed to, without rinsing, reapply the antiseptic soap solution insuring total coverage of arms, legs (including the antecubital and popliteal fossas), and abdomen (including the umbilicus), using the wash cloth. After the second application, the 4% CHG was allowed to remain on the skin surface for a timed 2-minute interval, followed by rinsing and towel-drying. Subjects were instructed to report to the investigator's laboratory according to a timing schedule for determination of CHG skin surface concentration. Subjects in group 3A were required to shower twice (evening and morning) before reporting to the laboratory for determination of CHG skin surface concentration.

Standardized protocol 2% CHG-impregnated cloth (groups 1, 2, and 3): subgroup B

After a 7-day washout period (previous pilot study documented no residual CHG on skin surface 7 days post application) subjects in groups 1, 2, and 3 were instructed to shower according to the previous group assignments, using regular (nonmedicated) soap or body wash. After towel-drying, volunteers were instructed to scrub for 2 minutes, both arms (shoulder to wrist, including antecubital fossa), legs (hip to ankle, including popliteal fossa), and total abdominal surface including umbilicus using three 2% CHG-impregnated polyester cloths, one for each body site

Table 1. Mean Time from Last Application of Chlorhexidine Gluconate to Measurement of Chlorhexidine Gluconate Skin Concentrations in the Laboratory

Group	n	2% CHG-impregnated		p Value
		4% CHG soap	cloth	
1*	20	661.3 ± 88.6	683.5 ± 156.9	NS
2†	20	150.3 ± 100.7	172.3 ± 136.4	NS
3‡	20	146.1 ± 70.8	141.6 ± 71.2	NS

Time in minutes reflects mean time interval (±SD) between CHG applied to surface of skin and chlorhexidine gluconate (CHG) skin concentration assay performed in laboratory.

*Shower/cleansing with CHG evening.

†Shower/cleansing with CHG morning.

‡Shower/cleansing with CHG evening and morning.

(Sage Products, Inc). After application of the 2% CHG, the skin was allowed to air dry for a few minutes before dressing. Study subjects reported to the investigator's laboratory according to a timing schedule for determination of CHG skin surface concentration. In both A and B subgroups, subjects were requested to record the precise time of CHG application and to refrain from applying any additional lotions or gels to their skin before skin sampling. All subjects were required to record any adverse events associated with use of the 4% CHG antiseptic soap or the 2% CHG-impregnated cloth.

Determination of CHG skin surface concentration assay

The CHG skin surface concentration assay is based on an adaptation of a US Official Monograph for the Identification of Chlorhexidine Gluconate Solution.¹⁴ In brief, a Bio-Swab (Arrowhead Forensics Inc) was used to sample a defined skin area (3 cm²) on both antecubital and popliteal fossas and abdomen by rubbing the swab back and forth across the skin for 10 seconds. The swab was immediately placed in a screw-cap container to prevent desiccation before analysis. One hundred microliters of a freshly prepared indicator solution (five parts 1% cetyltrimethylammonium bromide [Sigma-Aldrich Co] and two parts sodium hypobromite [Fisher Scientific]) was added to each swab. A light pink to intense red color indicated the presence of CHG, with intensity of the color reflective of the relative concentration of CHG on the surface of the skin. The color reaction on the swab was compared with a freshly prepared CHG standard, which ranged from 2.5 parts per million (ppm) to 10,000 ppm. The assay was read by an independent, blinded observer, who compared test swabs with the CHG standard before recording the relative CHG skin surface concentration.

Statistical analysis

ANOVA and paired *t*-test were used to analyze the differences between the relative mean CHG skin surface concen-

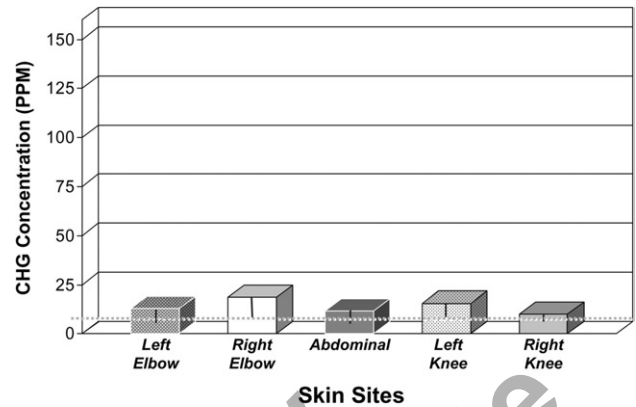


Figure 1. Pilot study of mean chlorhexidine gluconate (CHG) skin concentrations from five separate skin sites in subjects who showered using 4% CHG in the morning. MIC₉₀ dashed line, CHG concentration that inhibits 90% of skin staphylococci. MIC₉₀ = 4.8 ppm; n = 10. MIC, minimal inhibitory concentration; ppm, parts per million.

trations in groups 1, 2, and 3 and between subgroups involving (A) 4% CHG and (B) 2% CHG application at the 0.05 level of significance. Statistical analysis was conducted using the MINITAB Release 13 Statistical Program (MINITAB Inc).

RESULTS

A total of 70 subjects participated in the study (10 in pilot, 60 in the randomization protocol). A total of five subjects (7.2%) reported an adverse (minor skin irritation) event after use of the 4% or 2% CHG formulations (three [4.2%] with 4% CHG soap and two [3.3%] with the 2% CHG polyester cloth). A total of 61 staphylococcal strains were recovered from 60 study subjects, 95% (58) of the isolates were characterized as coagulase-negative staphylococci and 3 (5%) of the isolates were identified as coagulase-positive staphylococci. The CHG MIC₉₀ (concentration which inhibits 90%) of staphylococcal skin isolates was 4.8 ppm.

Table 1 reports the mean time and standard deviation after application of CHG to measurement of skin surface CHG concentration in groups 1, 2, and 3 for subjects showering with 4% CHG soap or use of the 2% CHG-impregnated polyester cloth. No substantial difference was observed in time between application of CHG to determination of CHG skin concentration in the 4% CHG soap (A) or 2% CHG-impregnated cloth (B) arms of the study.

In the pilot study, CHG skin concentrations were measured in 10 subjects at five selected sites (right/left antecubital fossa, right/left popliteal fossa and abdomen). These individuals received no specific instructions, only to shower in the morning using the 4% CHG soap, returning

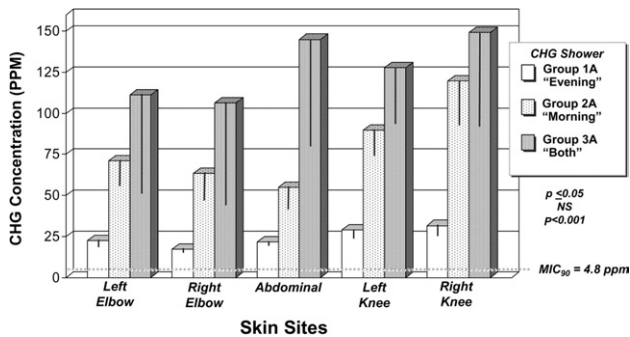


Figure 2. Mean chlorhexidine gluconate (CHG) skin concentration from five separate skin sites in volunteers who showered with 4% CHG-antiseptic soap evening (group 1A), morning (group 2A), and both evening and morning (group 3A). MIC_{90} dashed line, CHG concentration that inhibits 90% of skin staphylococci. $MIC_{90} = 4.8$ ppm; $n = 20$ per group. MIC, minimal inhibitory concentration; ppm, parts per million.

within 2 to 3 hours to the laboratory for determination of CHG skin surface concentration. Mean detectable CHG concentrations (Fig. 1) ranged from a low of 9.8 ppm (right popliteal fossa) to a high of 18.6 ppm (right antecubital fossa). Although these levels were above the MIC_{90} (4.8 ppm) for recovered skin staphylococci, subinhibitory levels (below the level of assay detection < 2.4 ppm) of CHG were observed in one or more selected skin sites in six of the pilot study subjects (60%).

Mean CHG skin concentrations in subjects who showered after a standardized, timed protocol with 4% CHG antiseptic soap in groups 1A, 2A, and 3A are reported in Figure 2. In group 1A (evening) detectable CHG skin surface concentrations ranged from 17.2 to 31.6 ppm; in

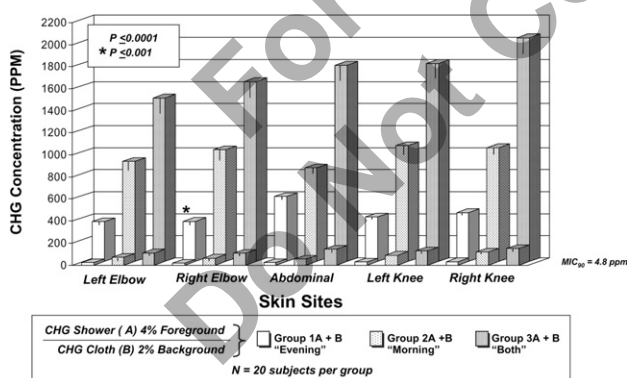


Figure 4. Composite comparison of mean chlorhexidine gluconate (CHG) skin concentration from five separate skin sites in volunteers who showered with 4% CHG-antiseptic soap (foreground) or used 2% CHG-impregnated polyester cloth (background) evening (group A), morning (group B), and both evening and morning (group C). MIC_{90} dashed line, CHG concentration that inhibits 90% of skin staphylococci. $MIC_{90} = 4.8$ ppm; $n = 20$ per group. MIC, minimal inhibitory concentration; ppm, parts per million.

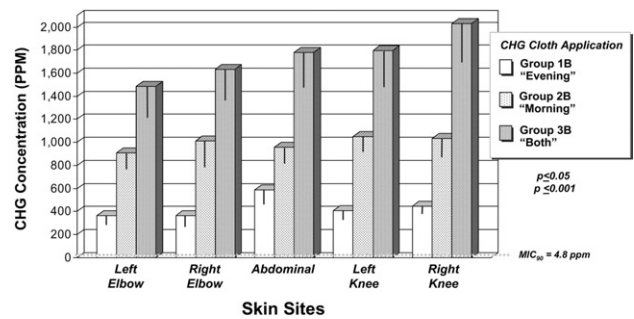


Figure 3. Mean chlorhexidine gluconate (CHG) skin concentration from five separate skin sites in volunteers who used 2% CHG-impregnated polyester cloth evening (group 1B), morning (group 2B), and both evening and morning (group 3B). MIC_{90} dashed line, CHG concentration that inhibits 90% of skin staphylococci. $MIC_{90} = 4.8$ ppm; $n = 20$ per group. MIC, minimal inhibitory concentration; ppm, parts per million.

group 2A (morning) CHG-skin surface concentrations ranged from 51.6 to 119.6 ppm, and in group 3A CHG skin surface concentrations ranged from 101.4 to 149.6 ppm. A major difference in CHG skin surface concentrations was observed between group 1A (evening) and group 2A (morning) ($p \leq 0.05$). No statistical difference was noted in CHG skin concentration in patients who showered once with 4% CHG soap in group 2A or twice as in group 3A ($p > 0.05$). Mean CHG skin levels in group 3A subjects were considerably ($p < 0.001$) higher than levels observed in group 1A. Overall mean CHG skin concentrations ranged from 5.1 times the CHG- MIC_{90} in group 1A to > 26.6 times the MIC_{90} in those subjects who showered twice with CHG (group 3A). The number of subjects who presented with CHG skin concentrations below the limit of assay detection (< 2.4 ppm) in one or more sampled sites were seven subjects in group 1A (35%), three subjects in group 2A (15%), and five subjects in group 3A (25%).

Figure 3 documents the mean CHG skin concentrations obtained in subjects who cleansed their skin surface after a standardized, timed protocol using the 2% CHG-impregnated polyester cloth in groups 1B (evening), 2B (morning), and 3B (evening/morning). In group 1B (evening) CHG-skin surface concentrations ranged from 361.5 to 443.8 ppm; in group 2A (morning) CHG-skin surface concentrations ranged from 907 to 1,049.6 ppm, and in group 3A CHG skin surface concentrations ranged from 1,484.6 to 2,031.3 ppm. A major difference in mean CHG skin concentration was observed between groups 1B, 2B, and 3B ($p \leq 0.05$ to $p \leq 0.001$). Overall mean CHG skin concentration ranged from 90.2 times the CHG- MIC_{90} in group 1B (evening), to 363.7 times the MIC_{90} in those volunteers who applied CHG twice using the 2%-impregnated polyester cloth (group 3B). It is important to note that compared with showering with the 4% CHG

Table 2. Comparative Mean Chlorhexidine Gluconate Skin Concentrations in Volunteers Showering with 4% Chlorhexidine Gluconate Soap or Cleansing with 2% Chlorhexidine Gluconate-Impregnated Polyester Cloth

Group	n	Subgroups		p Value
		A	B	
		4% CHG soap	2% CHG-impregnated cloth	
1*	20			0.001
LA		22.5	361.5	
RA		17.2	379.8	
ABD		21.5	589.5	
LP		29.0	405.3	
RP		31.6	443.8	
2 [†]	20			0.0001
LA		71.6	907.0	
RA		63.4	1,013.2	
ABD		51.6	958.2	
LP		89.8	1,049.6	
RP		119.6	1,028.5	
3 [‡]	20			0.0001
LA		113.3	1,484.6	
RA		101.4	1,633.1	
ABD		140.1	1,781.7	
LP		127.9	1,797.8	
RP		149.4	2,031.3	

*Shower/cleansing with CHG evening.

[†]Shower/cleansing with CHG morning.

[‡]Shower/cleansing with CHG evening and morning.

ABD, abdomen; CHG, chlorhexidine gluconate; LA, left antecubital; LP, left popliteal; RA, right antecubital; RP, right popliteal.

antiseptic soap, no gaps (no subinhibitory activity) in CHG coverage were observed on any skin surfaces post application in groups 1B, 2B, or 3B when CHG was applied using the 2% CHG-impregnated cloth.

Statistical analysis of the CHG skin surface concentrations between the 4% CHG antiseptic soap versus the 2% CHG-impregnated cloth groups (1A versus 1B; 2A versus 2B; 3A versus 3B), revealed a highly notable difference in mean CHG skin surface concentrations ($p \leq 0.001$) at all selected skin sites (Fig. 4). The comparative mean CHG concentrations between both study arms are noted in Table 2. Mean CHG skin concentrations ranged from 12.7 to 27.4 times higher in the 2% CHG-impregnated cloth arm of the study compared with the 4% CHG antiseptic soap groups.

DISCUSSION

A “systems” approach to reducing risk of postoperative surgical site infections requires the marriage of preoperative antiseptic cleansing (reducing skin surface microbial colonization before hospitalization) with the perioperative skin

preparation performed within the operating room.¹⁵ A recent Cochrane Collaboration publication has called the practice of preoperative showering into question.² The conclusions of this document are questionable because of numerous design flaws identified in the cited clinical studies.

First, in the six studies cited in this analysis, no routine standard of practice was applied to implementation of the preoperative shower; some patients showering multiple times, and others subjects showered only once with an antiseptic soap. Second, no attempt was made to standardize a timed duration of the antiseptic shower. Third, the surgical population was highly heterogeneous, encompassing patients undergoing elective clean, clean-contaminated, and contaminated surgical procedures. Finally, there is no indication based on review of the six studies as to the level of patient compliance to study protocols.

The preliminary findings of our pilot study (Fig. 1) confirm that failure to implement a standardized, validated strategy for preoperative showering will likely result in potential gaps in effective CHG concentrations on the surface of the skin. Optimal skin asepsis requires not only an effective concentration, but an appropriate timed interval of skin exposure to the antiseptic agent. The intent of the preoperative shower is to reduce microbial skin burden (decolonization) before hospital admission and should not be viewed as a replacement of the traditional perioperative skin preparation occurring in the operating room, before establishing the sterile operative field. In the present investigation, study participants were provided with specific instructions for applying the antiseptic agent, ensuring total body exposure, involving a timed application to maximize antimicrobial activity on the skin surface.

Mean CHG concentrations exceeded the MIC₉₀ in groups 1, 2, and 3 with a maximal concentration observed in volunteers who applied the antiseptic agent twice. In the 4% CHG arm of the study there were several subjects where the CHG skin concentration fell below the MIC₉₀ for skin staphylococcal isolates, suggesting a subinhibitory activity in selected anatomic sites. Failure to achieve effective skin antiseptic activity would likely contribute to a persistent microbial burden, especially in areas of high bacterial colonization (groin, perineum, and axilla) at the time of admission. Alternatively, use of the 2% CHG-impregnated polyester cloth resulted in mean skin surface concentrations of CHG that were considerably higher ($p < 0.001$) than observed in the 4% CHG arm of the study. In addition, no gaps in antimicrobial activity were noted in any of the selected sampled sites compared with those volunteers who showered with the 4% CHG soap formulation. Specifically, the relative mean skin concentrations of CHG ranged from 12.7 to 27.4 times higher in the 2%

CHG cloth arm of the study compared with the 4% CHG shower groups. The CHG antimicrobial skin surface activity in volunteers who used the 2% impregnated cloth ranged from 90.2 times the CHG MIC₉₀ in group 1B (evening application) to 363.7 times the MIC₉₀ in group 3B (evening and morning application).

Several factors can explain the substantially higher CHG skin surface concentrations in the 2% CHG cloth cleansing group compared with the 4% CHG shower group. First, in the traditional (4% CHG) preoperative shower, the activity of the CHG is diluted in the process of rinsing, even though the antiseptic agent was allowed to remain in place for a minimum of 2 minutes before rinse. This dilution factor was in part mitigated by having the subject shower in the morning before testing or after two applications of the antiseptic agent. Gaps (subinhibitory activity) in antimicrobial activity were still noted in both of these study populations. Second, application of the 2% CHG occurred after the subjects showered, so antiseptic activity was not diluted nor dissipated in the process of rinsing. Finally, as demonstrated in a previous clinical trial, the 2% CHG-impregnated polyester cloth was more efficacious at reducing the inguinal microbial burden ($> 3.0 \log_{10}$ reductions exceeding FDA requirements) compared with traditional 4% CHG topical antiseptic soap used as a patient preoperative skin preparation ($p < 0.01$).¹¹ The design of the polyester cloth, having a relatively tight weave (compared with gauze or a cotton wash cloth) was likely more efficient at exfoliating the skin surface, allowing greater penetration of the active agent into the deeper recesses of the skin.

At this time, it would be appropriate to introduce a cautionary comment when considering implementation of a preoperative showering or cleansing strategy in selected surgical patient populations. None of the volunteers in this study would have been, by definition (body mass index ≥ 40), considered morbidly obese and did not present with excessive skin folds, challenging the effective application of CHG on all body surfaces. Excessive skin folds observed in morbidly obese patients are often associated with a higher microbial burden and special instructions, including multiple applications of CHG (minimum of two to three times) might well be warranted in patients presenting with a body mass index > 40 .

Although the impact of a carefully administered preoperative skin decolonization regimen on reduction of surgical site infection is currently unknown, patient morbidity and the substantial economic impact of postoperative surgical site infections suggest that any strategy to reduce microbial skin colonization before hospital admission is warranted. Recent evidence strongly suggests an intrinsic

benefit does exist for adopting a thoughtful, timed preoperative shower strategy, especially for those surgical procedures with a high postoperative risk for infectious complications, such as implantation of selected prosthetic devices.¹⁶ Although a gap might currently exist between preoperative skin antisepsis and evidence-based outcomes for reducing risk of surgical site infection, this study validates the efficacy of a timed standardized preoperative shower to achieve high skin surface levels of CHG, exceeding the concentration required to inhibit the growth (MIC₉₀) of *Staphylococcus aureus* and *S epidermidis*. Efforts to achieve a high, sustained level of skin antisepsis should be considered an important component of any preoperative decolonization regimen, especially in an environment where emerging multidrug-resistant microbial populations, including methicillin-resistant *S aureus*, have become a substantial source of infectious morbidity for patients undergoing elective surgical procedures.¹⁷⁻²¹

Author Contributions

Study conception and design: Edmiston, Krepel, Seabrook

Acquisition of data: Edmiston, Krepel

Analysis and interpretation of data: Edmiston, Seabrook, Lewis, Brown, Towne

Drafting of manuscript: Edmiston, Seabrook

Critical revision: Edmiston, Seabrook, Lewis, Brown, Towne

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