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Challenging Currently Accepted Surgical Scrub Regimens to a Control: Are These Protocols Truly Advantageous and Cost Effective?

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Abstract

Background: Scrubbing prior to invasive surgical procedures has been an area that has been devoted to great amounts of research. Unfortunately, after numerous studies, there still is no agreed upon regimen for scrubbing prior to entering the operating room. Numerous methods have been used such as the chlorhexidine and povidone iodine scrub brushes, chlorhexidine/ethyl alcohol liquid scrub, and ethyl alcohol alone. Although all have shown some benefits, data shows that there still exists room for improvement. The goal of this study was to determine the need, if any, for antiseptics and antiseptic scrub brushes in a scrubbing regimen with hands having a larger than normal bacterial load. It compares the decrease in positive aerobic swab culture growth caused by two minute hand scrubbing regimens using a 2% chlorhexidine/ 61% ethyl alcohol liquid scrub, a 4% chlorhexadine scrub brush, non -antibacterial soap, and simply running water.

Methods: Four scrub trials were conducted and fifty aerobic swabs were used to take a specimen of the investigator's hand. The trials consisted of scrubbing for two minutes with running water, with non-antibacterial soap, SURGICEPT (2% chlorhexidine/61% ethyl alcohol liquid scrub), and a 4% chlorhexidine scrub brush. The amount of positive aerobic cultures was compared between the four trials.

Results: The trial consisting of just running water had statistically significant greater positive aerobic growth; ($p=0.0005$ with a RR of 2.5) when compared to non-antibacterial soap, ($p=0.0011$ with a RR of 2.31) when compared with SURGICEPT, and ($p=0.0002$ with a RR of 2.73) when compared with the chlorhexidine scrub brush. There was no statistically significant difference in the number of positive aerobic swabs in the scrub trials with the non-antibacterial soap, SURGICEPT, and a chlorhexidine scrub brush, ($p=0.8961$).

Conclusions: Plain running water was statistically less effective at decreasing the number of positive aerobic cultures when compared to scrubbing with non-antibacterial soap, SURGICEPT, and a chlorhexidine scrub brush. There was no statistical significance in the effectiveness at decreasing the number of positive aerobic cultures between non-antibacterial soap, SURGICEPT, and a chlorhexidine scrub brush.

Level of Evidence: Therapeutic Level 2. See instructions to Authors for a complete description of levels of evidence.

INTRODUCTION

Operating room staff members are required to perform various regimens of hand and forearm scrubbing prior to surgical procedures in hopes of reducing the transfer of microorganisms to patients during surgery that may result in postsurgical infections. Despite the fact that surgical hand scrubbing has been a part of pre-surgical procedure for decades, the optimum scrubbing regimen, such as scrubbing duration, which antiseptics or detergents to use, and whether to use a brush, is still subject to debate [1,2].

Normal human skin contains bacteria, usually about 102 to 106 colony forming units (CFU) per cm2 [3]. prior to operating, scrub team members try to remove extraneous organisms, or transient flora, and minimize the amount of their own skin organisms, or resident flora, with a scrubbing regimen [3,4].

Recommended practices for surgical hand scrubbing vary widely across organizations and countries. Existing North American guidelines on surgical hand scrubbing do not indicate a specific scrubbing duration or which antiseptic agents to use. In the United States, the Association of Operating Room Nurses (AORN) does not recommend a specific scrubbing duration [5]. however, based on study findings [6,7,8], aorn does recognize the advantages of shorter scrubbing duration. the association for professionals in infection control and epidemiology recommends a handwash followed by scrubbing for at least 120 seconds [1]. apic also recognizes the use of a european technique that is essentially a handwash followed by an alcohol rub for at least 20 seconds [1]. the centers for disease control and prevention recommend a 2- to 6-minute scrub with a brush, while the british hospital infection society (his) working group recommends that a 2-minute wash using aqueous disinfectants is required before any procedure is regarded as sterile [9]. in addition, a recent british medical journal editorial recommends that alcohol hand rubs are an acceptable alternative to repeated washing [10].

Ideally, the optimum antiseptic agent used for scrubbing should significantly reduce microorganisms on intact skin, be broad spectrum as well as fast-acting, and have a persistent effect [9]. in several european countries, alcohol is considered the agent of choice for surgical hand preparation [11,12]. in addition, alcohol is required to be used for surgical hand scrubbing after handwashing in both germany and austria [4,13]. in the united states, antiseptic agents that contain alcohol, chlorhexidine, iodophors, parachlorometaxylenol or triclosan are widely used for scrubbing [1,9,14]. currently, povidone iodine and chlorhexidine gluconate are the agents of choice for most surgical teams in the united states [15]. however, each agent is different, and none is ideal for all uses.

Immediate (i.e. within 60 seconds after scrubbing), persistent (i.e. up to 6 hours postscrub), and residual (i.e. determined after scrubbing over 5 days) antimicrobial activity need to be considered when determining scrubbing agent efficacy [1,9]. in proper concentrations, alcohols provide the greatest microbial reduction immediately after scrubbing [1,11]. a vigorous 1-minute scrub with enough alcohol to wet hands thoroughly has been demonstrated to be the most effective way to produce hand antisepsis [16]. alcohols have been found to evaporate quickly from the skin, and thus do not have persistent antimicrobial activity [17]. however, several studies report that alcohol-based preparations containing 0.5% or 1% chlorhexidine gluconate have equal or better persistent antimicrobial efficacy than 4% chlorhexidine gluconate preparation [17,18]. persistent antimicrobial activity of a scrubbing agent is greatest for those containing chlorhexidine gluconate [8,17]. comparing chlorhexidine gluconate and povidone iodine in a surgical hand scrub protocol found that chlorhexidine gluconate resulted in a lower reduction of bacterial counts than did povidone iodine [8]. the sequential use of chlorhexidine gluconate followed by an agent containing 70% isopropanol alcohol and 0.5% chlorhexidine gluconate has been found to be an effective scrubbing agent [8,17].

Mechanical scrubbing with friction and brushes has been standard procedure for many decades [19]. despite the need for surgical hand scrubbing, more scrubbing with a brush is not necessarily better or clinically effective in reducing microbial counts [9,14,19,20]. evidence shows that frequent and prolonged use of antiseptics, and a scrubbing brush or sponge may result in damage to the skin [20,21]. compromised skin integrity may become more heavily colonized by microorganisms, such as increased colonization with gram-negative bacteria and candida species [13,19,21]. it is therefore imperative to demonstrate scientifically the minimal, and thus optimal, surgical hand scrubbing regimen.

One of the major approaches to reducing skin damage is to minimize scrubbing duration. The length of time spent on surgical hand scrubbing has been reduced from 10 minutes to 5 minutes as a result of experimental evidence [22,23,24], and this remained as the standard for many years. studies have found that 2- or 3-minute surgical hand scrubs are as effective as 5-minute scrubs [7,8]. research has shown that 2- and 3-minute surgical hand scrubs are both clinically effective [25]. a second major approach to reducing skin damage is to minimize use of harsh antiseptics and/or detergents.

After doing a thorough literature research, to our knowledge no study or review has ever addressed the magnitude of effect, if any, of antiseptic scrubs with or without scrub brushes, when compared to a control such as simply scrubbing one's hands with running water without any antiseptics or brushing. In addition, to our knowledge, no surgical scrub study or review has ever investigated scrubbing and its effect on hands with a larger bacterial load than the normal hand. Most surgeons have post-operative patients that are admitted to the hospital. A normal practice is to round on these patients, examine them, and change surgical dressings, all which have the potential to increase the bacterial load on the surgeon's hands. Therefore, we believe it would be interesting to see how the approved surgical scrub techniques fair against a larger than normal bacterial load when compared to a control, such as simply washing one's hands under running water.

This study was designed to determine the need, if any, for antiseptics and antiseptic scrub brushes in a scrubbing regimen with hands having a larger than normal bacterial load. It compares the decrease in positive aerobic culture swabs caused by two minute hand scrubbing regimens using a chlorhexidine/ethyl alcohol liquid scrub, a chlorhexadine scrub brush, non-antibacterial soap, and simply running water.

MATERIALS AND METHODS

To determine the validity of using an aerobic swab in detecting bacterial growth a preliminary trial was conducted. One cc of saliva was applied sterilely to the investigator's left hand. The saliva was thoroughly rubbed into both hands for thirty seconds. Next, five swabs were used to take aerobic cultures of the left hand. All five swabs resulted in positive bacterial growth. Thus, the conclusion was made that swabbing is sensitive enough to detect bacteria in saliva. Next, in order to make sure resident hand flora would not alter our results the investigator's hands were scrubbed for two minutes with a cholorhexidine scrub brush. Five swabs were used to take specimens of the left hand. All five swabs resulted in no growth. Thus, the conclusion was made that aerobic swabs were not sensitive enough to detect resident flora after scrubbing with a chlorhexidine scrub brush. Thus, resident flora would not factor in altering the results of this study.

For a power analysis another preliminary trial was conducted. On Day 1, one cc of saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into both hands for thirty seconds. Next, the hands were scrubbed under plain running water for two minutes. After the hands were dried with a sterile towel, ten swabs were used to take specimens of the left hand. On Day 2, one cc of saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into both hands for thirty seconds. Next, the hands were scrubbed with non-antibacterial soap and running water for two minutes. After the hands were dried with a sterile towel, ten swabs were used to take specimens of the left hand. On Day 3, one cc of saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into both hands for thirty seconds. Next, the hands were scrubbed with SURGICEPT (2% chlorhexidine/61% ethyl alcohol) for two minutes. After the hands were air dried, ten swabs were used to take specimens of the left hand. On Day 4, one cc of saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into the hands for thirty seconds. Next, the hands were scrubbed with a 4% chlorhexidine scrub brush for two minutes. After the hands were dried with a sterile towel, ten swabs were used to take specimens of the left hand.

Figure 1

Water	Soap	Surgicept	Chlorhexidine
2/10 (20%) Strep	1/10 (10%) Strep	2/10 (20%) Strep	1/10 (10%) Strep
1/10 (10%) Staph	0/10 (0%) Staph	0/10 (0%) Staph	1/10 (10%) Staph
1/10 (10%) Enterococcus	1/10 (10%) Enterococcus	0/10 (0%) Enterococcus	0/10 (0%) Enterococcus
2/10 (20%) Growth of more than one organism	0/10 (0%) Growth of more than one organism	0/10 (0%) Growth of more than one organism	0/10 (0%) Growth of more than one organism
6/10 (60%) Total Positive Aerobic Cultures	**2/10 (20%) Total Positive Aerobic Cultures**	**2/10 (20%) Total Positive Aerobic Cultures**	**2/10 (20%) Total Positive Aerobic Cultures**
4/10 (40%) Total Negative Aerobic Cultures	**8/10 (80%) Total Negative Aerobic Cultures**	**8/10 (80%) Total Negative Aerobic Cultures**	**8/10 (80%) Total Negative Aerobic Cultures**

Once this power analysis was complete the study was able to begin.

On Day 1, one cc of human saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into the hands for thirty seconds. Next, the hands were scrubbed under plain running water for two minutes. After the hands were dried with a sterile towel, fifty swabs were used to take specimens of the left hand.

On Day 2, one cc of human saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into the hands for thirty seconds. Next, the hands were scrubbed with non-antibacterial soap and water for two minutes. After the hands were dried with a sterile towel, fifty swabs were used to take specimens of the left hand.

On Day 3, one cc of human saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into the hands for thirty seconds. Next, the hands were scrubbed with SURGICEPT for two minutes. After the hands were air dried, fifty swabs were used to take specimens of the left hand.

On Day 4, one cc of human saliva was sterilely applied to the investigator's left hand. The saliva was thoroughly rubbed into the hands for thirty seconds. Next, the hands were scrubbed with a 4% chlorhexidine scrub brush for two minutes. After the hands were dried with a sterile towel, fifty swabs were used to take specimens of the left hand.

RESULTS

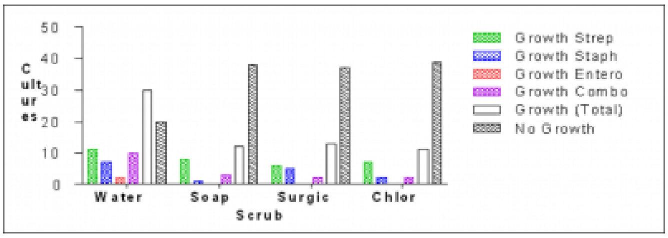
In the preliminary trial to conduct a power analysis it was determined that forty-six swabs for each trial would need to be performed in order to show any statistical significance. Fifty swabs for each trial were used. The Day 1 trial, running water, resulted in 11 (22%) positive aerobic swabs for strep species, 7 (14%) positive aerobic swabs for staph species, 2 (4%) positive aerobic swabs for enterococcus species, and 10 (20%) positive aerobic swabs for growth of more than one organism. This resulted in 30 (60%) total positive aerobic cultures and 20 (40%) total negative aerobic cultures. The Day 2 trial, non-antibacterial soap, resulted in 8 (16%) positive aerobic swabs for strep species, 1 (2%) positive aerobic swabs for staph species, 0 (0%) positive aerobic swabs for enterococcus species, and 3 (6%) positive aerobic swabs for growth of more than one organism. This resulted in 12 (24%) total positive aerobic cultures and 38 (76%) total negative aerobic cultures. The Day 3 trial, SURGICEPT, resulted in 6 (12%) positive aerobic swabs for strep species, 5 (10%) positive aerobic swabs for staph species, 0 (0%) positive aerobic swabs for enterococcus species, and 2 (4%) positive aerobic swabs for growth of more than one organism. This resulted in 13 (26%) total positive aerobic cultures and 37 (74%) total negative aerobic cultures. The Day 4 trial, chlorhexidine scrub brush, resulted in 7 (14%) positive aerobic swabs for strep species, 2 (4%) positive aerobic swabs for staph species, 0 (0%) positive aerobic swabs for enterococcus species, and 2 (4%) positive aerobic swabs for growth of more than one organism. This resulted in 11 (22%) total positive aerobic cultures and 39 (78%) total negative aerobic cultures.

Figure 2

Water	Soap	SURGICEPT	Chlorhexidine
11/50 (22%) Strep	8/50 (16%) Strep	6/50 (12%) Strep	7/50 (14%) Strep
7/50 (14%) Staph	1/50 (2%) Staph	5/50 (10%) Staph	2/50 (4%) Staph
2/50 (4%) Enterococcus	0/50 (0%) Enterococcus	0/50 (0%) Enterococcus	0/50 (0%) Enterococcus
10/50 (20%) Growth of more than one organism	3/50 (6%) Growth of more than one organism	2/50 (4%) Growth of more than one organism	2/50 (4%) Growth of more than one organism
30/50 (60%) Total Positive Aerobic Cultures	**12/50 (24%) Total Positive Aerobic Cultures**	**13/50 (26%) Total Positive Aerobic Cultures**	**11/50 (22%) Total Positive Aerobic Cultures**
20/50 (40%) Total Negative Aerobic Cultures	**38/50 (76%) Total Negative Aerobic Cultures**	**37/50 (74%) Total Negative Aerobic Cultures**	**39/50 (78%) Total Negative Aerobic Cultures**

Statistical analysis of the above four trials: Fisher's test of growth versus no growth for water versus non-antibacterial soap; p=0.0005. Relative risk = 2.50. Fisher's test of growth versus no growth for water versus Surgicept; p=0.0011. Relative risk = 2.31. Fisher's test of growth versus no growth for water versus the chlorhexidine scrub brush; p=0.0002. Relative risk= 2.73. Chi Square analysis of growth versus no growth for non-antibacterial soap, SURGICEPT, and a chlorhexidine scrub brush; p=0.8961

Figure 3



DISCUSSION

Numerous studies and trials have been performed to elucidate the optimal scrub regimen. The hopes of an optimal scrub regimen in ridding the surgeon's hands of bacteria may possibly lead to a decreased rate of post-operative infection. Unfortunately, as one does a thorough literature search it is obvious that every scrub regimen possesses its own positives and negatives. Some regimens are excellent at antimicrobial activity but evaporate quickly and therefore its positive microbial effects may not last the length of the entire surgery. Other regimens possess antimicrobial activity along with mechanical properties to remove organisms from the surgeon's hands ie. chlorhexidine scrub brush. However, some data does show that this regimen may be too harsh to the skin and therefore lead to colonization of the surgeon's hands by organisms.

Certain regimens such as SURGICEPT possess excellent antimicrobial qualities. Unfortunately, there is data showing that the ingredients may be caustic to the skin allowing colonization by organisms. Therefore, at this time it is fair to say that we have not discovered a scrubbing regimen that is a panacea for bacterial eradication.

This study was conducted to determine if any scrub agent is necessary at all, and if so, does a less damaging substance to the skin ie. non-antibacterial soap have any benefit. In addition, it is to our knowledge that no study has tested recognized scrub regimens to a control ie. water, or water with non-antibacterial soap. There is also no published study that tests the recognized scrub regimens to hands with a higher than average bacterial load. No one would argue that surgeons after they round on their post-operative patients and change surgical dressings obtain a greater than normal bacterial load on their hands. Therefore, it would be interesting to see how certain scrub techniques fair against a higher than average bacterial load.

From the data obtained it is obvious that just water alone is inferior in decreasing the number of positive aerobic cultures when faced with a high bacterial load. This suggests that mechanically removing bacteria alone is insufficient, and some anti-microbial properties in a scrub regimen are necessary. SURGICEPT and a 4% chlorhexidine scrub brush were statistically more effective in decreasing the number of positive aerobic cultures in the face of a high bacterial load when compared to water alone. These regimens, were not perfect, however, as still greater than 20% of aerobic cultures returned with positive growth. What is most interesting is that non-antibacterial soap fared just as well as SURGICEPT and a chlorhexidine scrub brush in decreasing the number of positive aerobic cultures when faced with a high bacterial load. Hypotheses for this phenomenon are that soap and water, is better than water alone at mechanically removing aerobic bacteria. In addition, soap is likely less damaging to one's skin and thus less likely to cause colonization by aerobic bacteria. Finally, soap may have inherent anti-microbial properties that have not been studied.

Assuming that non-antibacterial soap is as efficacious as the two scrub regimens tested could have an enormous economical impact on health care in the United States. When bought in bulk 4% chlorhexidine scrub brushes cost on average $1.72/brush. Each 800ml container of SURGICEPT allows for approximately 63 scrubs, which on average would lead to $1.84/scrub. In this study, each 250ml bottle of non-antibacterial soap cost $3.49 and allowed for15 scrubs on average leading to $0.23/scrub. Thus, there is approximately $1.50 saved per scrub when using non-antibacterial soap. In 2005 the NIH stated that, “Twenty million invasive surgical procedures were performed in the United States that year.” Multiplying twenty million by $1.50 leads to thirty million dollars per year that could be possibly saved if non-antibacterial soap was used instead of the other two regimens.

Although the data and results are impressive, one must keep in mind the limitations inherent in this study. First, the study proved that there was a statistically significant decrease in the number of positive aerobic culture swabs when scrubbing with non-antibacterial soap, SURGICEPT, or a chlorhexidine scrub brush when compared to just water. It also proved that there was no statistical significant difference in the number of positive aerobic culture swabs when scrubbing with non-antibacterial soap, SURGICEPT, or a chlorhexidine scrub brush. One must keep in mind that this study proved statistical and non-statistical significance. However, is this at all clinically significant? From the data obtained we cannot extrapolate anything about the reduction of post-operative infection rate. Further research in this area would need to be conducted. Second, this study used aerobic culture swabs to determine the presence or absence of bacteria. Unfortunately, scrubbing and ridding bacteria from hands is not an all or none phenomenon ie. Yes/Positive or No/Negative. Measuring bacterial load via colony forming units would likely give a more accurate and thorough evaluation of each scrub techniques' effectiveness. Third, this study only looked at the growth of aerobic organisms. Human saliva certainly contains other organisms, especially anaerobes, and thus extrapolations on anaerobic, fungal, or atypical organisms cannot be made. Fourth, this study was only conducted in one microbiology laboratory. Can we assume that the results obtained from this laboratory would be replicated in other laboratories? Finally, the investigator was not blinded leaving room for possible selection bias. He was aware of which trial consisted of water, non-antibacterial soap, SURGICEPT, and the chlorhexidine scrub brush.

Despite the limitations mentioned in this study there are certainly strengths worth mentioning. First, the same investigator's saliva, hands, and experimental protocol were used throughout the study. By doing this, the bacterial load was kept as constant as possible. Second, there was adequate power as demonstrated by the power analysis. Third, there was strict attention to detail so that each step of each trial was conducted in the exact same fashion. Fourth, those in the microbiology lab were blinded as to which trial was being tested which would minimize any possible selection bias. Finally, highly statistically significant results were obtained making chance alone unlikely to be a factor.

SUMMARY

It is obvious that as one dissects the literature there is much controversy as to what is the optimum scrub regimen. In the United States there currently is no agreed upon or required scrub regimen. Numerous studies show that the scrub regimens used in the United States may actually be detrimental, and thus there is much room for improvement. To our knowledge no study has ever compared the various scrub regimens used worldwide to a control such as water or water with non-antibacterial soap. In our study we proved that water alone was statistically less effective at reducing the rate of positive aerobic cultures than two widely used United States scrub regimens. It also proved that non-antibacterial soap is statistically as effective at reducing the rate of positive aerobic cultures than the same two widely used United States scrub regimens.

Knowing that non-antibacterial soap is just as effective can have an enormous impact on many areas of surgery and health care. Despite some limitations in this study it does at least illustrate that more research in the field of surgical scrubbing would be invaluable. Future research projects that should be considered are, 1. Expanding this study to include anaerobic, fungal, and atypical organisms. 2. Using colony-forming units to determine the effect that non-antibacterial soap has on bacterial load when compared to the currently recognized scrub regimens' effect on bacterial load. 3. Determining whether a decrease in bacterial load is actually clinically significant (To our knowledge there is no data in the literature that shows a decreased bacterial load on a surgeon's hands leads to less post-operative infections.)

In conclusion, this study not only suggests that the use of non-antibacterial soap may be as efficacious as more costly scrub regimens currently being used, but also illustrates the need for further research to be conducted.

References

1. Larson, E.L. APIC guideline for handwashing and hand antisepsis in health care settings. Am J Infect Control, 1995. 23(4): p. 251-69.
2. Grabsch, E.A., Mitchell, D.J., Hooper, J. and Turnidge, J.D. In-use efficacy of a chlorhexidine in alcohol surgical rub: a comparative study. ANZ Journal of Surgery, 2004. 74(9): p. 769-772.
3. Trampuz, A. and Widmer, A.F. Hand hygiene: a frequently missed lifesaving opportunity during patient care. Mayo Clin Proc, 2004. 79(1): p. 109-16.
4. Larson, E.L., Butz, A.M., Gullette, D.L. and Laughon, B.A. Alcohol for surgical scrubbing? Infect Control Hosp Epidemiol, 1990. 11(3): p. 139-43.
5. AORN. Standards, Recommended Practices, and Guidelines. 2004, Association of Operating Room Nurses Inc: Denver. p. 291-299.
6. Babb, J.R., Davies, J.G. and Ayliffe, G.A. A test procedure for evaluating surgical hand disinfection. J Hosp Infect, 1991. 18 Suppl B: p. 41-9.
7. Hingst, V., Juditzki, I., Heeg, P. and Sonntag, H.G. Evaluation of the efficacy of surgical hand disinfection following a reduced application time of 3 instead of 5 min. Journal of Hospital Infection, 1992. 20(2): p. 79-86.
8. Pereira, L.J., Lee, G.M. and Wade, K.J. An evaluation of five protocols for surgical handwashing in relation to skin condition and microbial counts. J Hosp Infect, 1997. 36(1): p. 49-65.
9. Hsieh, H.F., Chiu, H.H. and Lee, F.P. Surgical hand scrubs in relation to microbial counts: systematic literature review. J Adv Nurs, 2006. 55(1): p. 68-78.
10. Teare, L., Cookson, B. and Stone, S. Hand hygiene. BMJ, 2001. 323(7310): p. 411-412.
11. Ayliffe, G.A. Surgical scrub and skin disinfection. Infect Control, 1984. 5(1): p. 23-7.
12. O'Shaughnessy, M., O'Malley, V.P., Corbett, G. and Given, H.F. Optimum duration of surgical scrub-time. Br J Surg, 1991. 78(6): p. 685-6.
13. Hobson, D.W., Woller, W., Anderson, L. and Guthery, E. Development and evaluation of a new alcohol-based surgical hand scrub formulation with persistent antimicrobial characteristics and brushless application. Am J Infect Control, 1998. 26(5): p. 507-12.
14. Gruendemann, B.J. and Bjerke, N.B. Is it time for brushless scrubbing with an alcohol-based agent? AORN Journal, 2001. 74(6): p. 859-73.
15. Mangram, A.J., Horan, T.C., Pearson, M.L., Silver, L.C. and Jarvis, W.R. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Am J Infect Control, 1999. 27(2): p. 97-132.
16. Larson, E. Guideline for use of topical antimicrobial agents. Am J Infect Control, 1988. 16(6): p. 253-66.
17. Rotter, M.L. and Koller, W. Surgical hand disinfection: effect of sequential use of two chlorhexidine preparations. J Hosp Infect, 1990. 16(2): p. 161-6.
18. Mulberrry, G., Snyder, A.T., Heilman, J., Pyrek, J. and Stahl, J. Evaluation of a waterless, scrubless chlorhexidine gluconate/ethanol surgical scrub for antimicrobial efficacy. American Journal of Infection Control, 2001. 29(6): p. 377-382.
19. Berman, M. One hospital's clinical evaluation of brushless scrubbing. AORN Journal, 2004. 79(2): p. 349-54; 357-8.
20. Larson, E. Hygiene of the skin: when is clean too clean? Emerg Infect Dis, 2001. 7(2): p. 225-30.
21. Larson, E.L., Hughes, C.A., Pyrek, J.D., Sparks, S.M., Cagatay, E.U. and Bartkus, J.M. Changes in bacterial flora associated with skin damage on hands of health care personnel. Am J Infect Control, 1998. 26(5): p. 513-21.
22. Dineen, P. An evaluation of the duration of the surgical scrub. Surg Gynecol Obstet, 1969. 129(6): p. 1181-4.

23. Galle, P.C., Homesley, H.D. and Rhyne, A.L. Reassessment of the surgical scrub. Surg Gynecol Obstet, 1978. 147(2): p. 215-8.
24. O'Farrell, D.A., Kenny, G., O'Sullivan, M., Nicholson, P., Stephens, M. and Hone, R. Evaluation of the optimal handscrub duration prior to total hip arthroplasty. J Hosp Infect, 1994. 26(2): p. 93-98.
25. Wheelock, S.M. and Lookinland, S. Effect of surgical hand scrub time on subsequent bacterial growth. AORN Journal, 1997. 65(6): p. 1087-92; 1094-8.

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