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Major article

Effect of surgical site infections with waterless and traditional hand scrubbing protocols on bacterial growth

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Background: Alcohol-based antiseptic scrub formulation has long been used for hand cleansing in the operating room. Recently, a waterless surgical scrub formulation containing 1% chlorhexidine gluconate was developed to provide a comparable antiseptic effect. The present study explored the scrub time required when using waterless hand scrub and traditional hand scrub formulations for operating room staff and compared bacterial growth on the hands after surgical hand scrubbing in the 2 groups.

Methods: Operating room staff members (n = 100) were recruited randomly from medical centers in Taiwan. Two days in July 2010 were chosen for testing in advance, and the participants were assigned equally to use either a waterless scrub or traditional scrub formulation on 2 separate days. Scrub times were recorded and microorganisms on hands after scrubbing were sampled on 2 separate days. Two days after sampling, the colonies grown on bacterial culture plates were counted and expressed as colony-forming units (CFU) per plate.

Results: At 48 hours after sampling, microorganisms were found on 7 of the 50 plates in the waterless scrub group (1-9 CFU) and on 7 of the 50 plates in the traditional scrub group (1-5 CFU). The difference between the groups was no statistically significant (95% CI, 0.85-1.71). Nine surgical patients were found to have contact with the 14 participants with microorganisms found after scrubbing in the operating room. Among these 9 patients, 1 patient with diabetes who underwent amputation developed local reddish swelling suggestive of surgical site infection necessitating a 7-day course of cefalexin. The incidence of surgical site infection was not signifcantly different in the 2 groups.

Conclusions: Our findings suggest that waterless hand scrub is as effective as traditional hand scrub in cleansing the hands of microorganisms and more efficient in terms of scrub time.

Various interventions have been used to prevent surgical site infections, including showering with antiseptic soaps or solution before surgery and installing filtered air- conditioning equipment in the operating room. Hand scrubbing remains the cornerstone of prevention measures in the modern operating room.[1,2] A traditional hand scrubbing protocol uses an aqueous alcohol solution containing 70% isopropyl alcohol and 4% chlorhexidine gluconate (CHG) and involves scrubbing for 3-5 minutes to clean the hands, nails, and subunguinal areas. A pump dispenses the solution in the operating room. Alcohol-based antiseptic scrub is known to inhibit the growth of resident microorganisms and to reduce the risk of surgical site infection after surgery.[3,4] Hand rubbing with aqueous alcoholic solution has been found to be as effective as a traditional hand scrubbing protocol in preventing 30-day surgical site infection.[5] The use of alcohol-based hand scrub is currently the most important infection control measure, and it has significantly reduced the rate of surgical site infections caused by contact with operating room staff.[6] Waterless hand scrub formulation contains 1% CHG and 61% ethyl alcohol. After 5 mL of the solution is dipped into a cupped hand, the nails and fingers of the opposite hand are dipped into the solution for 3 minutes; the solution is then transferred to the other hand, and the procedure is repeated for another 3 minutes.[3,7,8] This is a more efficient and less cumbersome method of hand cleansing compared with the traditional protocol.

Previous studies found that a 5-minute protocol using a 4% CHG solution was associated with the lowest postscrub microorganism counts of colony-forming units (CFU). The 4% CHG solution was

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found to be a more effective antiseptic than povidone-iodine scrubs and CHG in 70% isopropyl alcohol both immediately and at different time points (3 minutes, 2 hours, 3 hours, 6 hours, and 48 hours) after hand scrubbing.[3,9]

The superiority of 4% CHG over 0.5% CHG and 5% povidone-iodine has been reported in previous studies.[7,8,10-12] Although waterless hand scrubs are widely used in Taiwan, there are no available data supporting its superiority in terms of scrub time and antiseptic effect. The present experiment was designed to explore the required scrubbing times using waterless hand scrub and traditional hand scrub formulations for operating room staff and to compare bacterial growth on the hands after surgical hand scrubbing with these 2 protocols in Taiwan.

MATERIALS AND METHODS

Study population and sampling

One hundred surgical staff members, both surgeons and scrub nurses, were recruited randomly from medical centers in Taiwan and assigned to either a waterless hand scrub or a traditional hand scrub protocol (each n = 50). Two separate days in July 2010 were chosen in advance: 1 day dedicated to waterless hand scrub, and the other day dedicated to traditional hand scrub. All participants received training and were acquainted with the predefined protocols for waterless scrub and traditional scrub by 4 months before the study.

Scrubbing time was measured and recorded individually using a digital stopwatch. Immediately after completion of the scrubbing protocol, samples were collected from hands using synthetic media and plated. The plates were incubated at 25-28°C for 48 hours, and CFU counts were determined under a dissection microscope.

Traditional scrub protocol

The traditional hand scrub protocol used 2 brushes, towels, and 4% CHG in 70% isopropyl alcohol and 10% povidone-iodine. The 5-minute procedure was as follows:

1. Remove all jewelry (rings, watches, and bracelets).
2. Wash hands and arms to 2 inches above the elbow with the proper amount of Hibiscrub (Shining Company, Taipei, Taiwan) or povidone-iodine scrub.
3. Add Hibiscrub or povidone-iodine to the surface of the brush.
4. Scrub each side of the fingertips, each finger, the hand, and the arm.
5. Repeat the process on the other hand and arm, keeping the hands above the elbows at all times.
6. Drop the brush into the sink after finishing the first hand scrub.
7. Rinse the hands and arms by passing them through the water in one direction only, from the fingertips to the elbow. Do not move the arm back and forth through the water.
8. Repeat the same procedure for a second hand scrub, except scrub above the elbows. Then scrub the hands from the fingertips to the elbows.
9. Rinse the hands and arms by passing them through the water in one direction only, from the fingertips to the elbow.
10. If a hand touches anything except the brush at any time, the scrub must be redone.
11. On entering the operating room suite, dry the hands and arms using a sterile towel and aseptic technique. Put on a gown and sterile gloves.

For the waterless hand scrub protocol, a solution containing 1% CHG and 61% ethyl alcohol was used, and a 3-minute procedure was followed:

1. Remove all jewelry (rings, watches, and bracelets).
2. Apply the solution to clean, dry hands and nails using 3 pumps of solution in the following order:
   a. Dispense one pump (2 mL) of waterless antiseptic with moisturizer into the palm of one hand. Dip the fingertips of the opposite hand into the hand prep and work it under the nails. Spread the remaining waterless antiseptic hand prep evenly over the hand and up to just above the elbow, covering all surfaces.
   b. Dispense another 2 mL of waterless antiseptic, and repeat the foregoing procedure with the other hand.
   c. Dispense another 2 mL of waterless antiseptic into either hand and reapply to all aspects of both hands up to the wrist. Do not touch any surfaces. Allow the preparation to dry before donning sterile gloves.

Table 1
Characteristics of the study sample in the operating room (n = 100)

Item	Traditional (n = 50), mean ± SD	Waterless (n = 50), mean ± SD	χ^2	*P* value
Work year in the OR	10.6 ± 8.2	7.54 ± 6.69	2.02	.07
Hand scrub, seconds	122 ± 60.1	48.56 ± 15	8.36	<.001*

*Significant ($P \leq .001$).

Table 2
CFU counts with the 2 hand scrubbing protocols

Protocol	Mean CFU	95% CI	*P* value
Traditional (n = 50)	7	0.85-1.71	1.00
Waterless (n = 50)	7		

Statistical methods

The difference in scrub time between the waterless scrub and traditional scrub groups was analyzed using the χ^2 test. Observed interrater agreement (κ values) ranged from 0.90 to 1.00 for both the traditional hand scrub group and the waterless hand scrub group. Statistical analyses were performed with odds ratios (OR) and 95% confidence intervals (CIs). Statistical comparisons were done using the 2-tailed Mann-Whitney *U* test. A *P* value >.01 was considered to indicate statistical significance.

RESULTS

Scrub time

A total of 100 participants were analyzed. The participants have continuous work experience in the operating room. The average working years of all operating room staff were 1 to 23 years long. The mean time needed to complete hand cleansing was 48.56 ± 15 seconds in the waterless hand scrub group and 122 ± 60.1 seconds in the traditional hand scrub group (Table 1). The results were statistically significant using the χ^2 test ($P < .001$).

CFU count after scrubbing

Microorganism CFU counts of 1-9 CFU were detected in 7 of the 50 plates from the waterless hand scrub samples, and counts of 1-5 CFU were detected in 7 of the 50 plates from the traditional hand scrub group (Table 2). Our analysis found no significant differences in microorganism CFU count between the waterless hand scrub and traditional hand scrub groups (OR, 1; 95% CI, 0.85-1.71; $P = 1.00$).

Table 3
The comparative hand scrubs with microorganisms CFU on 48 hours using the Mann Whitney *U* test

Protocol	Mean	U	Z	*P* value
Traditional (n = 50)	50.26	1,238	−.14	.89
Waterless (n = 50)	50.74			

Table 4
The result of microorganisms CFU in preventing surgical site infections in 9 patients

Item	n	χ^2	*P* value
Duration of antibiotic therapy, days		0.11	.73
0	4		
1	2		
3	2		
7	1		
Surgical site		0.90	.34
Leg	1		
Shoulder	1		
Abdomen	2		
Breast	1		
Scopy (2 colonscopy, 2 brochoscopy)	4		

We found no statistical differences between these 2 groups using the Mann-Whitney *U* test ($P > .01$) (Table 3).

During the study, 9 patients were found to have contact with the 14 staff members with detectable CFU counts (Table 4). Five of these 9 patients received a 1- to 7-day course of prophylactic antibiotics. Of these 9 patients, only 1 patient with diabetes mellitus who underwent amputation developed a local reddish swelling suggestive of surgical site infection, necessitating a 7-day course of cefalexin. There was no statistically significant difference in the rate of surgical site infections between the 2 hand scrub groups ($P > .05$).

DISCUSSION

In this study we investigated the difference in the time needed to perform preoperative hand scrubbing and the difference in microorganism CFU counts on operating room staff hand after hand scrubbing following 2 different protocols. CHG at various concentrations is widely used for gingivitis treatment, preoperative skin preparation, and catheter insertion.[13-17] Previous studies have shown that the inclusion of alcohol gel base and CHG preparations in preoperative surgical hand scrubs can reduce the risk of surgical site infection.[6,13,14] Both waterless and traditional scrub formulations containing CHG also have been shown to prevent the growth of microorganisms.[8,11,13-15] Grabsch et al[12] reported that CHG provides a better antiseptic effect than povidone-iodine. CHG is a simpler ingredient that should be incorporated in surgical scrub preparations.

In this study, significantly less time was needed to complete the scrub protocol in the waterless scrub group compared with the traditional scrub group. Moreover, additional consumables, including towels, brushes, and tap water, are needed in the traditional hand scrub protocol. Moreover, to maintain a functioning solution dispensing system, more personnel are required for tube cleaning, refilling, and so on.[3,9,11]

The antiseptic effect was evaluated by CFU counts in samples obtained immediately after completion of preoperative hand scrubbing. The waterless hand scrub and traditional hand scrub protocols were equally effective with similar rates of surgical site infection in the 2 study groups. During the study period, we found that surgical locations with leg, shoulder, and abdomen patients received prophylactic antibiotic treatment, which might have provided further protection against surgical site infection. The single antibiotic drug was as effective as in the prevention of surgical site infections.[18] The risk factors in our study cohort are consistent with those reported in previous series. Further studies are needed to address this issue with the category of antibiotic drugs in the prevention of surgical site infections. Operation time is another important factor that may affect the incidence of perioperative surgical site infection and should be taken into account in future studies.

Future studies also should investigate the antiseptic effect of different hand scrub protocols on an individual basis, to better reflect the actual benefits to patients' welfare—fewer surgical site infections. The antiseptic effect of hand scrub formulations with varying concentrations of CHG should be tested separately to determine the optimal hand scrub formulation.

CONCLUSION

This study provides evidence that both the waterless and traditional hand scrub protocols effectively control microorganisms on the hands after preoperative cleansing. The 2 hand scrubbing protocols provide comparable protection against resident skin microorganisms and perioperative surgical site infections. The waterless hand scrub protocol is a more efficient method of preoperative hand cleansing.

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