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ORIGINAL ARTICLE

Comparative antimicrobial efficacy of alcohol-based hand rub and conventional surgical scrub in a medical center



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KEYWORDS

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Background: Hand hygiene is the cornerstone of aseptic techniques to reduce surgical site infection. Conventional surgical scrub is effective for disinfecting a surgeon's hands. However, the compliance of conventional scrub may be hindered by skin damage, allergy, and time. Alcohol-based hand rub has a satisfactory antimicrobial effect, but mostly in laboratory settings. Our aim was to compare a conventional surgical scrub with an alcohol-based hand rub to evaluate antimicrobial efficacy.

Methods: From June 1, 2010 to July 31, 2011, 128 healthcare workers were enrolled in the study. They used an alcohol-based hand rub or a conventional surgical scrub as preoperative hand antiseptics during their routine practice. Hand sampling for cultures were performed before and after operations. Positive culture plates were further processed for pathogen identification.

Results: The culture positive rate of the alcohol-based hand rub was 6.2% before operations and 10.8% after operations. Both rates were lower than the conventional surgical scrub [47.6% before operations ($p < 0.001$) and 25.4% after operations ($p = 0.03$)]. The most identified pathogens were Gram-positive with coagulase-negative staphylococci being the major pathogen. Multivariate analysis showed that prior hand condition ($p = 0.21$) and type of surgery such as cardiovascular surgery ($p = 0.12$) were less relevant, but the alcohol-based hand rub was a significant protective factor for positive hand cultures.

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Conclusion: The alcohol-based hand rub was more efficacious for surgical antisepsis and had sustained efficacy, compared to conventional surgical scrub. We suggest that alcohol-based hand rubs could be an alternative surgical antiseptic in the operative theater.

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Introduction

Surgical site infection is a globally recognized problem that results in significant morbidity.¹ Joseph Lister was among the first to demonstrate the effect of skin disinfection on reducing surgical site infections.² Thus, washing hands with antimicrobial soaps, warm water, and frequently with a brush became the primary protocol for surgical hand preparation. Antiseptic soaps should rapidly eliminate transient skin flora and reduce resident flora on the hands to a minimum during a surgical procedure, and thus lower the risk of surgical site contamination if surgical gloves are perforated or torn during surgery.³

Conventional surgical hand antisepsis consists of an aqueous scrub with a brush by using povidone iodine (PVP-I) or chlorhexidine-based detergents. However, scrubbing with these detergents strips skin oils, compromises skin integrity, and (if a brush is used) often causes micro-abrasions, thereby increasing the risk of subsequent colonization by pathogens.⁴ As a result, conventional surgical scrub has the disadvantages of skin damage and allergic skin reaction. It is also time consuming to use them. In the laboratory setting, an alcohol-based hand rub is as effective as conventional surgical scrub in its antimicrobial ability.^{5,6} In addition, skin irritation or dermatitis happened less frequently with an alcohol-based hand rub in a small series of case studies. This can also help increase the compliance of hand washing by healthcare providers in hospitals.^{7–9}

Several alcohol-based hand rubs have been licensed for the commercial market, although there are few clinical studies to compare the antisepsis efficacy against conventional surgical scrub in a routine operating practice environment.^{10,11} The World Health Organization (WHO) guidelines also state that surgical antisepsis is a state of art, suggesting that there are no optimal antiseptics.¹² We conducted a prospective, observational study in our hospital with the aim of comparing a conventional surgical scrub with an alcohol-based hand rub to evaluate their antisepsis efficacy before and after operations.

Materials and methods

Hospital setting

The National Taiwan University Hospital (NTUH) is a medical center with 2388 beds. It comprises three operation theaters with 52 functioning operating rooms (including five delivery rooms). More than 140 surgical procedures were performed daily during 2010 and 2011. The entrance of each operating room is equipped with a sensor sink or a step-operated sink

that contains two sets of antisepsis scrubbing facilities. The study was approved by the surgical committee and by the institutional review board of the National Taiwan University Hospital (NTUH-IRB; No. 201109015RC).

Inclusion criteria

This prospective observational study was conducted from June 1, 2010 to July 31, 2011. The volunteer participants were practicing doctors and nurses who had previous experience with the conventional surgical scrub protocol in the operating environment. They were allocated to the intervention group (i.e., alcohol-based hand rub) or the control group (i.e., conventional surgical scrub), based on their choice (rather than by randomization). All participants were educated and rehearsed in the alcohol-based hand rub protocol prior to this study. The participants' characteristics such as having an allergy to conventional surgical scrub or having wounds on their hands and the characteristics of the surgeries such as surgical specialty, surgical site, surgical wound classification, type of surgery, blood loss amount, operation duration, and glove wearing duration were recorded.

Exclusion criteria

Participants were excluded if they did not complete providing samples for culture before the operation (T0) and after the operation (T1). Participants with missing baseline characteristics data were also excluded.

Hand preparation and sampling

The alcohol-based hand rub contained 1% chlorhexidine gluconate and 61% ethyl alcohol (Avagard; 3M, MN, USA). The standard hand rub protocol was as follows: (1) one pump (2 mL) of lotion was dispensed into the palm of the left hand; (2) the fingertips of the right hand were dipped into the lotion to decontaminate under the nails; (3) the remaining lotion was spread over the right hand and up to just above the elbow; and (4) a second pump (2 mL) of lotion was then placed into the palm of the right hand. This process was repeated by dipping the fingers tip of the left hand into the lotion, followed by spreading it over the left hand and up to just below the elbow. Another 2 mL of lotion was finally placed into cupped hands and reapplied to all aspects of the hands up to the wrists. This solution was then allowed to dry. The three-step application of the alcohol-based hand rub (Avagard) was completed within 2 minutes.

The conventional surgical scrub contained 4% chlorhexidine gluconate (Hibiscrub; Janson's Medical Co., Taipei,

Taiwan) or 7.5% povidone-iodine. The standard conventional surgical scrub protocol was as follows: (1) three full squirts (6 mL) of PVP-I or chlorhexidine were placed into the cupped hands; (2) this was followed by a five-minute hand scrubbing just up to the elbow by using a sterile scrub brush; and (3) the lotion was rinsed away by tap water. All aforementioned steps were repeated, except the hands were dried with sterile towels, instead of being rinsed with tap water, to avoid recontamination.

After hand scrubbing or rubbing protocol, every participant was sampled immediately before the operation (T0). They then performed the scheduled operations. Another sample was obtained after the operation (T1). We used normal saline-moistened sterile cotton swabs to obtain

specimens for cultures by wiping through every part of the hand (including the ventral and dorsal side of the hands), the fingertips, and the lateral sides of the fingers and the wrists. The samples were immediately inoculated onto 5% sheep blood agar plates.

Microbiology

The causative pathogens were identified with conventional methods in accordance with the Clinical Laboratory Standard Institute (CLSI) guidelines.¹³ The 5% sheep blood agar culture plates were maintained at 37°C until sufficient growth had occurred. The plates were subsequently read by a bacteriologist who was blinded to the method of

Table 1 Baseline characteristics of participants in the alcohol-based hand rub and the conventional surgical scrub groups

	Total	Alcohol-based hand rub	Conventional surgical scrub	<i>p</i>
Healthcare workers	128	65	63	
Attending physician	22	13	9	0.392
Residents	52	24	28	0.386
Interns	9	3	6	0.320
Nurses	45	25	20	0.426
Allergy to povidone-iodine	15	12	3	0.025
Presence of wounds on hand	23	10	13	0.439
Have both allergy to povidone-iodine and presence of wounds on hand	10	8	2	0.096
Surgeon specialty				
General surgery	40	21	19	0.793
Chest surgery	16	7	9	0.548
Cardiovascular surgery	17	10	7	0.476
Plastic surgery	11	4	7	0.360
Neurosurgery	9	0	9	0.001
Ear-nose-throat surgery	13	7	6	0.816
Ophthalmologic surgery	3	2	1	0.999
Orthopedic surgery	6	6	0	0.028
Urologic surgery	13	8	5	0.413
Surgical site				
Head	25	9	16	0.099
Chest	28	8	20	0.008
Abdomen	34	18	16	0.769
Pelvis	20	14	6	0.061
Spine	4	0	4	0.056
Extremities	17	16	1	<0.001
Wound classification				
Clean	81	48	33	0.012
Clean-contaminated	45	15	30	0.004
Contaminated	2	2	0	0.496
Type of surgery				0.016
Emergency	12	2	10	
Elective	116	63	53	
Blood loss amount, median (mL)	10 (10–237.5)	10 (10–80)	20 (10–400)	0.036
Blood loss amount > 300 mL	25	9	16	0.099
Surgery duration, median (min)	105 (40–241)	70 (35–160)	140 (43–241)	0.071
Gloves wearing duration, median (min)	96 (42–164)	80 (42–151)	105 (47–181)	0.072
Attending physician	84 (45–152)	66 (37–103)	135 (66–162)	0.102
Resident physician	100 (42–198)	79 (40–159)	105 (44–252)	0.174
Intern	77 (41–163)	103 (90–119)	59 (32–211)	0.439
Operating room nurse	102 (53–165)	90 (48–165)	113 (72–172)	0.392

Table 2 Comparison of the sample cultures and the identified pathogens before and after the operation

	Before the operation (T0)			After the operation (T1)		
	Alcohol-based hand rub % (n/N)	Conventional surgical scrub % (n/N)	p	Alcohol-based hand rub % (n/N)	Conventional surgical scrub % (n/N)	p
Positive rate (T0)	6.15 (4/65)	47.62 (30/63)	<0.001	10.77 (7/65)	25.4 (16/63)	0.031
Identified pathogens						
Gram-positive	6.15 (4/65)	42.86 (28/63)	<0.001	1.54 (6/65)	23.81 (15/63)	0.026
Coagulase-negative staphylococci	1.54 (1/65)	42.86 (27/63)	<0.001	6.15 (4/65)	14.29 (9/63)	0.152
<i>Bacillus</i>	1.54 (1/65)	3.17 (2/63)	0.616	1.54 (1/65)	1.59 (1/63)	0.999
<i>Staphylococcus aureus</i>	1.54 (1/65)	0	0.999	1.54 (1/65)	3.17 (2/63)	0.616
Gram-positive bacilli	1.54 (1/65)	0	0.999	0	1.59 (1/63)	0.492
<i>Micrococcus</i> spp.	1.54 (1/65)	3.17 (2/63)	0.616	0	3.17 (2/63)	0.24
<i>Corynebacterium</i> spp.	1.54 (1/65)	3.17 (2/63)	0.616	0	1.59 (1/63)	0.492
Gram-negative	1.54 (1/65)	3.17 (2/63)	0.616	1.54 (1/65)	3.17 (2/63)	0.616
<i>Roseomonas</i> spp.	0	1.59 (1/63)	0.492	0	1.59 (1/63)	0.492
<i>Acinetobacter baumannii</i>	0	0	0.999	0	1.59 (1/63)	0.492
<i>Moraxella</i> spp.	0	0	0.999	0	1.59 (1/63)	0.492
<i>Pseudomonas aeruginosa</i>	0	1.59 (1/63)	0.492	0	0	0.999
<i>Klebsiella oxytoca</i>	1.54 (1/65)	0	0.999	0	0	0.999
<i>Sphingomonas paucimobilis</i>	0	0	0.999	1.54 (1/65)	0	0.999
Multi-pathogens	1.54 (1/65)	4.76 (3/63)	0.361	0	3.17 (2/63)	0.24

T0 = before surgery; T1 = after surgery.

antiseptics. The positive culture plates were further processed with standard biochemical methods to identify the pathogens.

Statistical analysis

Data were analyzed by using the PASW Statistics version 18 software (SPSS Inc., Chicago, IL, USA). Proportion comparisons for categorical variables were performed by using Chi-square test. Fisher's exact test was used when data were sparse. Statistical significance was set at $p < 0.05$. Variants with $p < 0.05$ or with clinical importance were further taken into multivariate logistic regression model analysis by using the backward selection to predict the protective factors for positive sample cultures.

Results

During the study period, 154 healthcare providers were invited. Twenty-six participants were excluded because of not providing sample cultures after completing surgeries. Therefore, 128 healthcare providers were enrolled for analysis—65 participants were in the interventional group and 63 participants were in the control group. In the interventional group, there were 13 attending physicians, 24 residents, 3 interns, and 25 operating room nurses. In the control group, there were 9 attending physicians, 28 residents, 6 interns, and 20 operating room nurses. There were no significant differences in demographic characteristics between these two groups. However, surgical specialty was a variant, and most people in both groups were involved in general surgery [32.31% (interventional group)

and 30.16% (control group); $p = 0.793$; Table 1]. The alcohol-based hand rub group was involved in more orthopedic surgeries than the conventional surgical scrub group ($p = 0.002$) and the conventional surgical scrub group was involved in more neurologic surgeries than the interventional group ($p = 0.014$). There was a significant difference in the skin condition between the two groups for an allergic reaction to the povidone-iodine scrub ($p = 0.016$). The median blood loss amount was 10 mL in the interventional group and 20 mL in the control group ($p = 0.036$). The median surgery duration was 70 minutes in the interventional group and 140 minutes in the control group ($p = 0.071$). The median glove wearing duration was 80 minutes in the interventional group and 105 minutes in the control group ($p = 0.072$; Table 1). Of the sample cultures

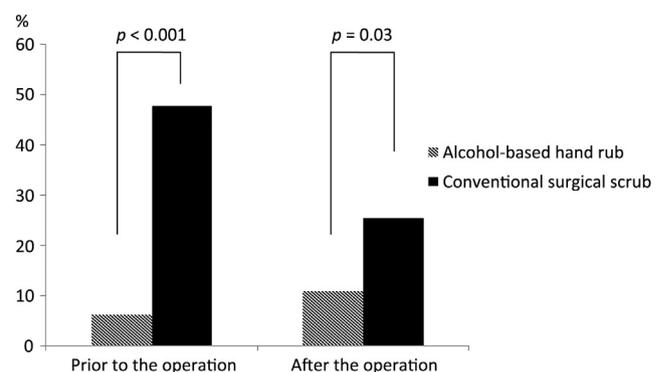


Figure 1. Positive rate of sample cultures obtained before the operation and after the operation for alcohol-based hand scrub and conventional surgical scrub groups.

obtained before the operations (T0), four (6.15%) cultures in the interventional group were positive and 30 (47.62%) cultures in the control group were positive with a clinically significant difference ($p < 0.001$). Most identified pathogens were Gram positive. Of the cultures sampled after the operations (T1), seven (10.77%) cultures in the

interventional group were positive and 16 (25.40%) cultures in the control group were positive with a clinically significant difference ($p = 0.031$). In both groups, Gram-positive pathogens comprised most of the identified pathogens. There was no significant difference for other identified pathogens (Table 2).

Table 3 Risk factors for positive sample cultures by using multivariate regression analysis for the prediction of positive cultures

	Positive culture (<i>n</i> = 57)	Negative culture (<i>n</i> = 199)	Univariate analysis <i>p</i>	Multivariate analysis <i>p</i>
Type of surgical hand antisepsis				
Alcohol-based hand rub	11	119	<0.001	<0.001
Conventional surgical scrub	46	80		
Sampling time				
Before the operation (T0)	34	94	0.098	
After the operation (T1)	23	105		
Healthcare workers				
Attending physician	13	31	0.202	
Residents	22	82	0.724	
Interns	0	18	0.016	0.998
Nurses	22	68	0.537	
Allergy to povidone-iodine	7	23	0.881	
Presence of wounds on hand	16	30	0.024	0.543
Have both allergy to povidone-iodine and presence of wounds on hand	7	13	0.154	0.210
Surgery specialty				
General surgery	21	59	0.302	
Chest surgery	5	27	0.334	
Cardiovascular surgery	3	31	0.047	0.119
Plastic surgery	4	18	0.792	
Neurologic surgery	6	12	0.242	
Ear-nose-throat surgery	10	16	0.036	0.499
Ophthalmologic surgery	1	5	0.999	
Orthopedic surgery	1	11	0.31	
Urologic surgery	6	20	0.916	
Surgical site				
Head	18	32	0.009	0.726
Chest	9	47	0.207	
Abdomen	18	50	0.331	
Pelvis	8	32	0.708	
Spine	1	7	0.689	
Extremities	3	31	0.047	0.463
Wound classification				
Clean	27	135	0.005	0.555
Clean-contaminated	28	62	0.012	0.636
Contaminated	2	2	0.215	
Type of surgery				
Emergent operation	8	16	0.171	0.915
Elective	49	183		
Blood loss amount (mL)	10 (10–200)	10 (10–250)	0.908	
Surgery duration (min)	96 (40–238)	108 (40–241)	0.935	
Gloves wearing duration (min)	88 (47–154)	96 (45–170)	0.8	
Attending physician	105 (66–151)	78 (40–153)	0.52	
Residents	48 (40–141)	105 (42–206)	0.152	
Interns	0	77 (44–148)	NA	
Nurses	123 (67–178)	95 (48–160)	0.31	

Data are presented as *n* or median (range).

NA = non-applicable; T0 = before surgery; T1 = after surgery.

The culture positive rate was higher in the control group at T0 and at T1 (Fig. 1). We found a trend that the culture-positive rate of the interventional group increased from T0 to T1, whereas the trend of the control group declined from T0 to T1.

For outcome analysis, 256 sample cultures were further stratified according to culture results. We had 57 positive sample cultures and 199 negative sample cultures. Most sample cultures in the interventional arm had negative results with a significant difference ($p < 0.001$). All sample cultures of the interns had negative results ($p = 0.019$). We also found that participants who were involved in cardiovascular surgeries had more negative sample cultures ($p = 0.043$), whereas participants who were involved in ear-nose-throat surgeries had more positive sample cultures ($p = 0.036$). The participants were more likely to have positive sample cultures when they operated over the patient's head ($p = 0.009$), were involved in surgeries with clean-contaminated wounds ($p = 0.012$), or had wounds on their hands ($p = 0.024$). By contrast, participants were more likely to have negative sample cultures when they operated over a patient's extremities ($p = 0.043$) or were involved in surgeries with clean wounds ($p = 0.005$; Table 3). We used variants with $p < 0.05$ or with clinical importance into multivariate regression model analysis. Only the alcohol-based hand rub was a protective factor in the positive sample cultures ($p < 0.001$). Table 3 summarizes the results.

Discussion

In this prospective observational study, we found that the two-minute three-step alcohol-based hand rub had a lower culture positive rate before and after the operations. Our results suggest that the alcohol-based hand rub is efficient and less time consuming.

The increasing use of alcohol-based hand rubs has led to trials studying its efficacy as an alternative to traditional hand scrubbing for hand antisepsis. Olson et al¹⁴ conducted a prospective, randomized *in vivo* study and found that an alcohol-based hand rub was not inferior to alcohol-only products at all sampling points. Burch et al¹⁰ compared the efficacy of an alcohol-based hand rub to the traditional 4% chlorhexidine scrub in a cardiac operating room environment. The alcohol-based hand rub showed no difference in comparison to the traditional scrub. A larger study conducted by Weight et al¹⁵ evaluated the use of an alcohol-based hand rub or conventional surgical scrub as surgical antisepsis in 3600 pediatric urological operations. The surgical site infection rates between the two groups were similar [2 of 1800 (alcohol-based rub) procedures vs. 3 of 1800 procedures (conventional scrub); $p > 0.99$]. The insignificant difference may have resulted from the relatively low incidence of surgical site infections. A large sample size is needed to statistically reveal the difference between the two types of hand rub.

Another reason for the insignificant difference may be that a different measurement method was used. Larson et al¹⁶ focused on different bacterial colony-forming units, whereas our study focused on a positive culture rate and on identifying a specific pathogen. By contrast, our study chose an intermediate end point (i.e., the positive rate of the hand culture), which effectively revealed a significantly lower risk

of hand contamination before and after using an alcohol-based hand rub than after using a conventional PVP-I-based or chlorhexidine-based hand rub. In addition, our study involved the most common surgery specialties in the clinical setting, instead of being limited to a specific surgical department; this increased the generalizability of the study results. The positive culture rate of our study was therefore significantly lower with the alcohol-based hand rub. Between the two different hand rub regimens, there was also no difference in the culture rate of highly pathogenic pathogens (e.g., *Staphylococcus aureus* or *Pseudomonas aeruginosa*).

To date, few studies have evaluated the sustained effect of alcohol-based hand rubs. Mulberry et al¹⁷ conducted two randomized, blinded, well-controlled clinical studies involving 137 healthy study participants and proved that the antimicrobial effect of an alcohol-based hand rub could persist more than 3 hours. Choi¹⁸ compared an alcohol-based hand rub against a traditional 7.5% PVP-I scrub and found the alcohol-based hand rub had a lower positive culture rate after operations, compared to the traditional scrub.

In our study, the positive rate was higher after operations than before operations in the alcohol-based hand rub group. This indicates that the sustained antimicrobial effect of the alcohol-based hand rub may be insufficient.

Our study has several limitations. First, our prospective study was a nonrandomized cohort that used volunteer participants. We also excluded volunteers who did not have postoperative microbial surveillance. However, we adapted a standardized sampling method and the microbiology results were observed by a microbiologist who was blinded to the antiseptic regimens. In this way, we could reduce selection bias to a minimum. Second, the average operation duration in our study was relatively short (median time, 1.5 hours). As a result, the data should be generalized with caution for operations of longer duration. Third, our case number was small. Large randomized studies on operations with longer durations are furthermore needed.

In conclusion, our results showed that an alcohol-based hand rub was more efficacious than a conventional surgical scrub for surgical antisepsis with sustained efficacy. The rapid bactericidal effect also suggested that an alcohol-based hand rub could be an alternative surgical antiseptic in the operative theaters.

Conflict of interest

All authors declare that there is no conflict of interest.

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