

# Comparison of Two Surgical Hand Antiseptic Techniques: Hand Rubbing and Hand Washing With Alcohol-Based Agent and 7.5% Povidone Iodine

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## Abstract

**Background:** Hand disinfection is a major part of infection control during a surgical procedure. In contrast to developed countries, where the use of alcohol-based solutions (ABS) is routine, the usual practice in Iran is hand scrubbing using Povidone Iodine Solution (PVI). Most researchers have concluded that ABS might be superior to PVI, but others have found no differences. In this study the disinfection efficacy of ABS was compared to PVI.

**Methods:** Thirty-one volunteers including surgeons and operating room nurses (OR-nurses) participated in this cross over design study. For one week they used ABS and the next week they used PVI for pre-surgical hand disinfection. Samples were obtained from the hands of all participants before, immediately after and two hours after hand washing. The bacterial contamination rate was evaluated by a microbiologist.

**Results:** Our results demonstrated that ABS led to significantly lower mean Colony Forming Units (CFU) immediately after hand disinfection, but no significant differences were found between the two groups after two hours. Also, alcohol-based solution revealed a significantly higher logarithmic reduction factor (RF) of skin flora as an instantaneous effect. Both solutions were effective against *Staphylococcus aureus*, but the minimum reduction rate was in eliminating the *Bacillus* group.

**Conclusions:** In conclusion, ABS can be promoted as the best choice for surgical hand disinfection solution amongst emergency situations, in that it has a time saving character and better instantaneous effect on bacterial skin flora reduction.

**Keywords:** Infection, Hand Disinfection, Cross Infection, Patient Safety

## 1. Background

Surgical site infection (SSI) is one of the major causes of post-operative morbidity and mortality, which increases economic problems in hospitals (1, 2). It has been proved that micro-organisms are mainly transmitted through the healthcare worker's hands at the hospitals (3, 4). Bacterial migration through unnoticed micro-perforations in surgical gloves does occur under real practical surgical conditions, and it is a risk factor for postoperative surgical site infections (5, 6). Consequently, hand disinfection by surgical team members is considered to be the most effective way of breaking the chain of Health Care-Associated Infection (HCAI) transmission, and it can contribute to a lower risk of SSI (7). Requirements are different in each health system, but all of them need to meet the same essential standards. The common surgical hand disinfection style in Iran consists of two parts: washing and disinfection. In the first step, they apply plain liquid soap for up to one minute, and in the second step, scrubbing with 7.5% povidone iodine solution (PVI) up to three minutes is performed. It has been

reported that alcohol hand rubs are more effective than PVI on account of the fact that it has a broader spectrum of activity, better skin tolerance and faster action on skin (8, 9); however, some studies have revealed no difference between two the products (7). In this study, we analyzed the efficacy of the two products in surgical hand disinfection: alcohol hand rub and 7.5% povidone iodine. Furthermore, we used questionnaires to determine their tolerability and acceptability as surgical hand disinfectants. In this study, we analyzed the efficacy of two products in surgical hand disinfection: alcohol hand rub and 7.5% povidone iodine. Furthermore, we used questionnaires to determine their tolerability and acceptability as surgical hand disinfectants.

## 2. Methods

This prospective study was conducted at a general surgery department. The study was approved by the ethics committee of the hospital. Written informed consent for

participation in the study was obtained from all participants. Thirty-one healthy volunteers participated in this cross over design study (eight males and 23 females). Their ages ranged from 23 to 49 years with a mean of  $31 \pm 6$ . All members of the surgical team (surgeon, surgery assistant and nurse) took part in the trial.

Participants did not use any kind of antibiotic drugs one week prior to sampling, nor did they apply topical products to the test area. All participants were checked for lack of any skin breaks such as cuts or abrasions as well as other skin disorders. Nails were short and clean.

Two products were used for this study: 1) 7.5% povidone iodine (PVI) (7.5% Behsadin scrub, Behsa pharmaceutical, 1228046704 (IRC), Iran), each 100 mL contains 7.5 g povidone iodine; 2) Non-rinse alcoholic hand disinfectants (ABS) (Micro zed H.D; Atrineh Saziba 1228120626 (IRC) Iran) each 100 cc contains 96% ethyl alcohol, 70 PCG isopropanol, dodecyl dimethyl ammonium chloride, and coco imidazoline betaine.

Sampling was done at the beginning of two consecutive workweeks, to allow the recovery of the resident skin flora over the weekend. Before the experiment, standard procedures of hand washing and hand rubbing were taught to the participants, according to the world health organization (WHO) guidelines (10). All participants washed their hands up to their wrists with non-antibacterial liquid soap for one minute and rinsed for 15 seconds (sec). Then, they dried their hands with a sterile paper towel.

In order to obtain the pre-values, the distal phalanges of the right and left hands, including thumbs were separately rubbed one minute on the bottom of two petri dishes (diameter of 9 cm) each containing 10 mL of tryptic soy broth (TSB).

The participants rubbed their hands with 10 - 15 mL ABS for 1.5 minute up to the elbow, according to the WHO guidelines. They used as much ABS as necessary to keep their hands wet for 1.5 minute, as it was shown that if the hands are kept wet with the alcohol for the total application time, the applied volume can vary, but this does not alter the efficacy; therefore, considering the size and temperature of hands, the total volume of alcohol was variable. The hands got dried spontaneously after evaporation of the alcohol.

Once the hand antiseptic was used, the first bacterial post value sample was taken from fingertips. Surgical team members put on gloves for two hours. The second post value sampling was taken as soon as gloves were removed. The gloves were then filled with tap water to check if there are any damages and perforations.

This study had a crossover design, for which two experimental runs were necessary for comparison of the bacterial reduction. On the next week, participants washed their

hands with non-antibacterial liquid soap up to their wrists for one minute, and hands were rinsed for 15 seconds under running tap water, the same as the previous week. After hands were dried with a sterile paper towel, the pre-value samples were obtained from the fingertips. Volunteers washed their hands up to their elbows with 15 - 20 mL PVI for three minutes. Then, participants rinsed their hands with running tap water, and they dried them with a sterile paper towel.

Immediately after disinfection, the first samples were taken from fingertips. Once the gloves were taken off, sampling was done in the same way as the alcohol-based solution. There was no elapsed period of time (more than 30 minutes) between sampling and preparing the cultures. The differences between the log<sub>10</sub> pre and post-treatment values were calculated individually for each participant.

### 2.1. Microbiological Analysis

As mentioned above, for sampling (n = 186), the distal phalanges of right and left hands, including thumbs were separately rubbed one minute on the bottom of two petri dishes (diameter of 9 cm), each containing 10 mL of tryptic soy broth (TSB). After six hours, samples from TSB were transferred to tryptic soy agar (TSA) at 37°C under aerobic and sterile conditions. Volumes of 0.1 mL from the sampling fluids and 1:1000 dilutions in TSB were spread on TSA with a sterilized spatula. The number of colony forming units (CFU) on agar plates was counted after 72 hours of incubation at 37°C. Smear was taken from colonies. Subsequently, biochemical tests were done to determine the strain of microorganisms (all were from Micromedia Trading House, Pest, Hungary).

All pre and post-values were expressed as log<sub>10</sub> values. For each volunteer, the logarithmic reduction factors (RF) were obtained by determining the difference of log<sub>10</sub> pre-treatment minus log<sub>10</sub> post-treatment values separately, for immediate and two-hour effects.

### 2.2. Statistical Analysis

To present data, we used mean, standard deviation, median, range, frequency and percentages. To compare results between the two groups, we used the Mann-Whitney test. To evaluate the changes within groups, we used the Wilcoxon-Signed rank test. P values of less than 0.05 were considered statistically significant. All statistical analysis were performed by the SPSS software (Version 21.0, IBM Co, Chicago, USA).

### 2.3. Sample Size Calculation

$$n = \frac{\left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2 (p_1(1-p_1) + p_2(1-p_2))}{(p_1 - p_2)^2} \quad (1)$$

$\alpha = 5\%$ ,  $1 - \beta = \text{Power} = 85\%$ ,  $P_1 = 30\%$ ,  $P_2 = 75\%$  and  $n = 31$ .

#### 2.4. Acceptability Assessment

A skin tolerance and acceptability assessment was evaluated by a questionnaire given to all participants at the end of the trials. The surgeons and OR-nurses answered specifically developed questionnaires consisting of two questions on: [I] their preferred technique between scrubbing and rubbing, and [II] their reasons for distinction (less time consuming, disinfectant efficacy, skin tolerance and safety).

### 3. Results

The whole surgical team ( $n = 31$ ) completed the questionnaire on acceptability and skin tolerance. Overall, 67.74% of total participants, habitually performed hand rubbing and 32.25% regularly performed hand scrubbing. Eighteen individuals (58.06%) considered that ABS is more time saving than PVI. However, the alcohol-based solution was most commonly preferred between surgeons; only one surgeon believed that hand rubbing is very efficacious in preventing SSI. Two participants reported that their skin condition improved with hand rubbing, and this was the most important reason for preferring the alcohol-based solution. In comparison to females, all males in this study preferred hand rubbing.

In the assessment of skin tolerance, there was no difference between the two groups (surgeons and nurses) in preference to both solutions. Only two surgeons said that their skin conditions improved with hand washing like nurses, respectively (6.45% versus 6.45%). Interestingly, two nurses mentioned that they were worried about the unknown side effects of alcohol-based solution and do not use it routinely.

#### 3.1. Immediate Effect

The Logarithmic Reduction (RF) of skin flora was measured immediately after hand disinfection. The RF range of 7.5% povidone iodine was between  $0.12 \pm 0.35$  and  $1.36 \pm 0.35$ . Alcohol-based solution revealed a significantly higher RF, between  $0.06 \pm 0.56$  and  $1.94 \pm 0.56$  in volunteers ( $n = 31$ ). Therefore, a significant difference was found between mean RFs of 7.5% povidone iodine and alcohol-based solution (mean  $\pm$  SD  $0.47 \pm 0.35$  vs  $0.89 \pm 0.56$ ;  $P < 0.001$ ) (Table 1).

#### 3.2. Sustained Effect

The RF of skin flora was measured two hours after hand disinfection. The results obtained in this study showed

that there was a significant reduction from baseline bacterial counts after two hours in 7.5% povidone iodine and alcohol-based solution (mean  $\pm$  SD  $0.32 \pm 0.4$  vs  $0.47 \pm 0.52$ ;  $P < 0.001$ ); however, this difference was not significant between mean RFs of both groups ( $P = 0.245$ ) (Table 2).

#### 3.3. Comparison of efficacy of two methods by mean log number of bacterial Colony-Forming Units (CFU)

Through this study, we observed that there was a significant difference between the two groups in mean log number of bacterial counts, immediately after hand disinfection ( $P \leq 0.05$ ). Considering the time needed for hand washing, no remarkable differences were found between the two groups in the number of colony-forming units (CFU) before hand disinfection. Both disinfection methods had the greatest effect on *S. aureus* bacteria and least effect on the bacillus group. There was a significant difference between the two groups in mean log CFU immediately after hand disinfection, but no significant differences were found between the two groups after two hours (Table 3).

### 4. Discussion

Microorganism's transference from the hands of the surgical team to patients is one of the main factors that develop SSI, which occur during 30 days after the operation (or up to one year after operation in patients receiving implants) and effect either the skin or deep tissue at the surgery site (11). Hand disinfection by surgical team members is considered to be the most effective way of breaking the chain of health care-associated infection transmissions and can contribute to a decreased risk of SSI.

In Iran, the old-fashioned scrub method is still being practiced using 7.5% PVI for three minutes. Many other countries frequently use alcohol-based solutions. There are controversial results in the literature indicating that alcohol-based hand rubs are superior to 7.5% PVI (8, 9), but others have found no differences (7).

Our results demonstrated that alcohol-based solution is superior to povidone iodine in the immediate effect (by CFU and RF), but we did not find any remarkable difference in sustained effect between the two groups (by CFU and RF). It should be noted that the difference in the number of colony-forming units of bacteria immediately and two hours after hand disinfection was significantly lower than the baseline of each group ( $P < 0.001$ ).

Verwilghen et al. compared the mean number of bacterial colony-forming units and the reduction factors between PVI, Chlorhexidine Gluconate (CHG) and hydroalcoholic hand rub. Their results revealed that hydroalcoholic hand rub and CHG had a similar instant effect.

**Table 1.** Comparison of the Efficacy of 7.5% Povidone Iodine and Alcohol-Based Solution in Immediate Effect for Surgical Hand Disinfection, Presented as the Log Mean Reduction of the Resident Skin Flora (RF)

Preparation	Type of Procedure	Application Time, min	Volunteers (N)	Mean RF $\pm$ SD	P Value
7.5% Povidone Iodine	Hand scrubbing	3	31	0.47 $\pm$ 0.35	0.001
Alcohol-based solution	Hand rubbing	1.5	31	0.89 $\pm$ 0.56	

Abbreviations: RF, reduction factor; SD, standard deviation  $P < 0.05$ .

**Table 2.** Comparison of the Efficacy of 7.5% Povidone Iodine and Alcohol-Based Solution in Sustained Effect (After Two Hours) for Surgical Hand Disinfection, Presented as the Mean Log Reduction of the Resident Skin Flora (RF)

Preparation	Type of Procedure	Application Time, min	Volunteers (N)	Mean RF $\pm$ SD	P Value
7.5% Povidone Iodine	Hand scrubbing	3	31	0.32 $\pm$ 0.4	0.245
Alcohol-based solution	Hand rubbing	1.5	31	0.47 $\pm$ 0.52	

Abbreviations: RF, reduction factor; SD, standard deviation  $P < 0.05$ .

**Table 3.** Comparison of Efficacy of Hand Scrubbing and Hand Rubbing by the Mean Log Number of Bacterial Colony Forming Units (CFU)<sup>a</sup>

	Hand Scrubbing (n = 31)	Hand Rubbing (n = 31)	P Value
Before hand disinfection	1.55 $\pm$ 0.33	1.55 $\pm$ 0.29	0.783
Immediately after hand disinfection	1.09 $\pm$ 0.52	0.66 $\pm$ 0.62	0.005
After two hours	1.23 $\pm$ 0.48	1.09 $\pm$ 0.5	0.159

Abbreviations: SD, standard deviation.

<sup>a</sup>Values are expressed as mean  $\pm$  SD ( $P < 0.05$ ).

Whereas, hydro-alcoholic solution had better sustained effect, PVI had a meaningfully lower immediate and sustained effect. In their study, evaluation of mean RFs of the two groups in immediate effect revealed that PVI is not as efficient as alcohol-based solution (8).

Carro et al. compared the microbiological efficacy of hand scrubbing by povidone iodine solution with hand rubbing by an alcohol-based solution. Their results confirmed that the mean number of bacterial colony-forming units, at the end of the operation was significantly lower in the alcohol-based solution group compared to the PVI group; in contrast, they did not observe any significant differences between the two groups immediately, two and four hours after hand disinfection in logarithmic reduction of skin flora (7).

In a research, which was done in Japan, it was concluded that sterile water is not necessary for pre-surgical hand scrubbing. In fact, it seems that tap water (the concentration of free chloride in the water should be maintained at over 0.1 PPM) does not alter the efficacy of hand

washing (12).

In Iran, the cost-effectiveness analysis and availability of products could play a pivotal role in the preferences of choosing these two products. Furthermore, the time-saving aspect is an important factor, especially in emergency operations, in which surgical hand disinfection should be as fast as possible without decreasing efficacy. Taken together, it can be inferred that time saving and efficiency of hand disinfection technique is very important to surgeons and it is critical in emergency situations. Apparently, an alcohol-based solution contributes to the achievement of these goals.

It was shown that a pre-surgical hand wash significantly reduces the number of bacterial spores and increases skin hydration (13). According to other studies and our results, we recommend carrying out a short hand wash with soap at the beginning of the preoperative hand disinfection.

It is noteworthy to mention that some studies used two hand antiseptic solutions in a sequence (14). In addition, conjunction of two hand antiseptic solutions was also examined (15). It seems that preoperative surgical hand disinfection with a combination solution such as chlorhexidine-alcohol for preventing surgical-site infection after surgery may be a good choice and needs more studies.

#### 4.1. Conclusions

Our results demonstrated that alcohol-based solution is superior to povidone iodine in immediate effect, but there is no crucial difference in sustained effect between the two hand hygiene products (CFU and RF). This study revealed that the difference in number of CFUs of bacteria immediately and two hours after hand disinfection

was significantly lower than the baseline in both groups. In brief, the ABS can be introduced as a choice for surgical hand disinfection solution in emergency situations, in that it has time saving characteristics and has better instantaneous effect on bacterial skin flora reduction. The lack of definite side effects, especially skin irritation, is a principal factor in using either PVI or ABS. Based on our experience, acceptability of different hand disinfection techniques among the surgical team has an important role on hospital policies to prevent SSI. In addition, flawed hand disinfection techniques such as using an insufficient amount of product and an inadequate duration of hand hygiene action leads to poor hand decontamination; therefore, training is the main part of surgical hand disinfection.

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### Footnotes

**Authors' Contribution:** Study concept and design: Ziba Asadpoor-Dezaki and Dariush Abtahi; analysis and interpretation of data: Ziba Asadpoor-Dezaki, Afsaneh Barabady and Dariush Abtahi; drafting of the manuscript: Asadpoor-Dezaki; critical revision of the manuscript for important intellectual content: Ziba Asadpoor-Dezaki, Afsaneh Barabady and Dariush Abtahi; statistical analysis: Ziba Asadpoor-Dezaki.

**Conflicts of Interests:** The authors hereby declare that there was no conflict of interest.

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