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REVIEW ARTICLE

# Hand disinfectants and surgical site infections: A narrative review

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## Abstract

Surgical site infection is one of the most common health-related infections, which can cause problems for health care providers by increasing morbidity and mortality, length of hospital stay, and costs. Undoubtedly, one of the most efficient and cost-effective ways to fight infection is to prevent it. An essential measure in infection control is the disinfection of the hand of surgical team members to remove fat and contamination, eliminate transient microorganisms, and prevent the growth and proliferation of resident microorganisms on the skin. This study aimed to introduce different types of soap and alcohol disinfectant solutions for surgical scrub and describe the advantages and disadvantages of each by reviewing several recent research studies. This study is a brief overview of the recently conducted articles as searched in library resources, the Google Scholar Search Engine, Pubmed, UpToDate, Cochran, and Scopus databases using the English keywords of *"hand hygiene", "infection control", "hand disinfection/methods", "hand disinfection/standards",* and *"Surgical Procedures, Operative"* as well as the Persian keywords of *"surgical scrub", "Povidone-iodine", "alcohol", and "hand disinfection"*. After reviewing 76 articles and eliminating the duplicate sources, 43 studies published from 2007 to 2019 were fully reviewed. Finally, 26 sources were selected as eligible with substantial relevance to the subject matter and subsequently reviewed. Based on the review of articles, it can be concluded that alcoholic solutions are often effective alternatives to soap scrub solutions due to their high disinfecting properties, safety, rapid effectiveness, and greater compliance with instructions.

**Key words:** Alcohol rub, Hand disinfection, Infection control, Surgical scrub, Surgical site infection

## Introduction

The surveillance and control of nosocomial infections is now a global priority. The purpose of infection control is to prevent or minimize the possibility of transmitting infectious diseases in health care facilities. Insufficient infection control leads to the spread of microorganisms in medical centers, which may lead to healthcare-acquired infections (1). One of the most common infections associated with medical care in patients undergoing surgery is surgical site infection (SSI). Unintentional transfer of microorganisms, such as bacteria, to the patient's wound site during surgery can lead to SSI. The SSI leads to delayed wound healing, increased length of hospital stay, increased use of antibiotics, unnecessary pain, and in severe cases, the death of the patient (2). Approximately, 2%-5% of 30 million people who undergo surgery each year suffer from SSI. In the United States, for example, 1 in 24 patients develop SSI after surgery. Some surgical infection control interventions to reduce the risk of SSI include hand hygiene, and use of gloves, as well as other protective equipment by operating room

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staff, decolonization of the patient, disinfection of the skin, and surgical site shaving. These interventions reduce patient contact with the personnel flora, including hands, hair, skin, and oropharynx, which can be potential sources of SSI microorganisms (3).

The skin is a place for the growth of transient microorganisms that are in direct contact with the skin and often destroyed by mechanical movements while the skin is washed with soap and water. However, resident microorganisms that are located below the surface of the skin in hair follicles, sebaceous glands, and sweat glands, have a higher adhesion strength and are resistant to removal. The goal of hand hygiene in surgery is to reduce the number of resident microorganisms and keep the population of microorganisms to a minimum during surgery by suppressing their growth, and therefore, reducing the risk of microbial contamination of the surgical wound (4). Joseph Lister was the one who understood the connection between bacteria and surgical infections. He introduced hand washing with carbolic acid as well as conditioning and topical application of antiseptics to control and prevent infection (5).

An ideal disinfectant is safe and has a high effectiveness rate, long-lasting effect for several hours, a wide range of impacts, and cumulative effects. Repeated use can prevent the growth of bacteria for several days. Soap disinfectants (Povidone-iodine, chlorhexidine gluconate) and alcohol are two of the most common hand disinfectants with a long history of preoperative hand disinfection (2, 6).

Iodophors were discovered in 1812. One of the most widely used iodophors is povidone-iodine that contains iodine along with Polyvinylpyrrolidone (PVP), which is also known as Povidone.

Povidone-iodine is a surfactant and rapidly reduces the microbial load and temporary bacterial colonies. Its disadvantages are the possibility of skin inflammation and the short-term persistence on the skin (2, 4). Chlorhexidine Gluconate (CHG) is a cationic bisbiguanide that is developed in the United Kingdom in the early 1950s and has been in use in the United States (US) since the 1970s. The CHG is difficult to dissolve in water; however, its digluconate form is water-soluble. The antimicrobial properties of CHG appear at a delated time but are more durable (4, 7). Ethyl alcohol or isopropyl alcohol is usually prefabricated and is available at disinfectant concentrations between 60% and 90%. Ethanol, isopropanol, and n-propanol are the three most common alcohols used in alcohol-based solutions (2, 4). Ethanol is more active against viruses than isopropanol (7). Since 1994, the US Food and Drug Administration has declared ethanol at a concentration between 60% and 95% completely safe and effective for hand rubs. However, its safety aspect has been reexamined since 2015. Recent studies suggest that ethanol may be dangerous due to systemic absorption in long-term use (8). Based on the results of several studies and experience of the authors, there are discrepancies regarding the type of disinfectant solutions as well as the efficiency and effectiveness of their method of use. Therefore, this study aimed to introduce a variety of soap and alcohol disinfectant solutions for surgical scrub and mention the advantages and disadvantages of each. Moreover, it was attempted to review several recent studies on these solutions, and take steps to resolve clinical contradictions in this regard.

## Methods

This brief review evaluated the articles related to hand sanitizers for SSI prevention. The search process was initiated on 1 August 2019 using the library resources, scientific databases, and the website of the World Health Organization along with the English keywords of *"hand hygiene", "infection control", "hand disinfection/methods", "hand disinfection/standards"*, and *"Surgical Procedures, Operative"* as well as the Persian keywords of *"surgical scrub", "Povidone-iodine", "alcohol", and "hand disinfection"* included in the keywords, titles, abstracts, and the main text of the articles.

To retrieve the research articles, searches were conducted continuously to obtain the latest research conducted until the end of January 2020. Accordingly, 76 articles were obtained of which 43 studies remained upon the removal of the duplicates. The papers were published in the period from 2007 to 2019. After a complete review, a total of 26 sources were found qualified with a high degree of relevance to the subject.

## Results

The disinfection technique of the hands was performed using scrub and alcohol rub. The surgical scrub is the process of washing and disinfecting hands with soap and water, and alcohol rub is the disinfection of the hands using alcohol-based solutions (7). Scrub and alcohol rub is performed after ensuring the hygiene of the hand and forearm skin, removing jewelry and artificial nails, completely covering the hair, and wearing personal protective equipment (PPE), such as head coverings, masks, glasses, slippers, and surgical

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aprons. Table 1 summarizes the reasons for each preparation (4):

Surgical scrubbing is performed using two procedures of temporal and stoke. In both methods, one needs first to wet the hands up to five cm above the elbow with water and uses a sterile brush or sponge from the package with some disinfectant solution. Based on an anatomical pattern, scrubbing initiates from the thumb and continues with other fingers toward the outer margin of the fifth finger. Subsequently, the dorsal surface of the hand, palm, wrist, forearm, and finally five cm above the elbow is scrubbed. During and after cleansing, the hands should be held upwards so that the path of water flow is from the cleanest part of the hands (i.e., fingers and palms) to the arms. Table 2 shows the way to perform the 6-minute and stroke procedures (9).

The brush is used for its mechanical effects in removing pus and germs from the skin. Studies have shown that brush abrasion causes damage and small abrasions that are a good place for microorganisms to grow and multiply. Therefore, it is not recommended to use a brush or sponge to prepare the hands before surgery (10). If the hands are visibly soiled, before preparing the hands for surgery, they should be washed with soap and water, and the crumbs under the nails should be removed under running water using disposable nail picks (7).

***Scrubbing via hand rubbing should be performed using the following steps***

1) Wet the hands up to 2 inches above the elbows.
2) Pour a sufficient amount of solution into the palms of the hands, and massage them together.
3) Massage the back of each hand with the palm and fingers of the opposite hand so that the fingers are locked together.
4) Massage between the fingers so that the fingers are locked together.
5) Lock both hands and rotate them to massage the

**Table 1: Preparations before scrub and alcohol rub**

| Item | Caution |
|---|---|
| Healthy skin | The bacterial serum is more likely to spread if you have cuts, burns, or skin lesions. An open skin lesion may act as a transmission pathway for blood pathogens. |
| Taking jewelry off | Bacteria and fungi can grow under the jewelry and prevent the hands from being washed properly. Rings are a source for the growth of gram-negative bacilli since moisture is trapped beneath them causing inflammation and healing. Moreover, rings can cause gloves to tear due to their sharp edges. Jewelry may touch the sterile field causing contamination. |
| Lack of long nails or artificial nails | Long nails can act as a huge source of organisms. Studies have shown that artificial nails facilitate the transmission of organisms, especially fungi and gram-negative bacilli. |
| Covering the hair | Hair is the main source of Staphylococcus. Hair follicles contain resident and transient flora. Hair can act as a mechanical stimulus in the wound healing process and cause a tissue reaction to the foreign body. Therefore, a head covering should be used to completely cover the hair. |
| Mask | The mask is used to prevent microorganisms from leaving the mouth and nasopharynx during breathing, talking, sneezing, and coughing. |
| Glasses | It is used in cases where there is a possibility of blood to split, as well as bone particles and secretions to throw. |
| Slippers and aprons | In surgeries where there is a high risk of bleeding and washing, members of the surgical team use slippers and aprons to protect the barrier. |

**Table 2: Surgical scrub procedures**

| Surgical scrub | | | |
|---|---|---|---|
| **Stroke procedure** | | **6-minute procedure** | |
| Nails | 20 strokes | Nails | 30 seconds |
| Fingers | 10 strokes | Fingers | 1 minute |
| Hand's dorsal surface | 10 strokes | Hand's dorsal surface | 15 seconds |
| Palm | 10 strokes | Palm | 15 seconds |
| Forearm to 5 cm above the elbow | 40 strokes | Forearm to 5 cm above the elbow | 1 minute |

The steps should be reiterated on the other hand.



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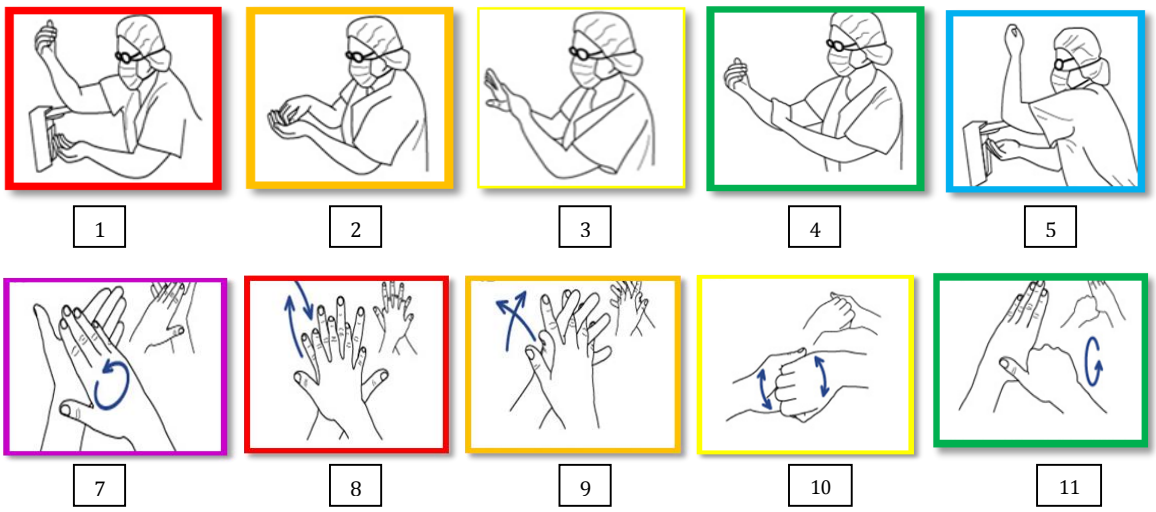



**Figure 1: Alcohol rub procedure**

back of the fingers.

6) Massage the thumb of each hand with the palm of the opposite hand using rotational movements.
7) Massage the fingertips of each hand in the palm of the opposite hand with a circular motion in the palm.
8) Immerse the forearm in the solution with rotational movements up to 2 inches above the elbow in both hands.
9) Rinse the hands and forearms from the fingertips to the elbows (11).

The American College of Surgeons recommends at least two min for a surgical scrub. Numerous studies in Europe and Australia also show that a three- to four-minute scrub is as effective as a five-minute scrub (10). The results of other studies also show that a lengthy scrub is not more effective. However, according to the recommendations of the Centers for Disease Control and Prevention, it is better to follow the manufacturer's instructions. The results of a study conducted by Zandieh et al. showed a significant relationship between the duration of scrub and the type of surgery. Therefore, orthopedic, neurological, and cardiac procedures, which have a higher risk of infection, have a longer scrub time, whereas the scrub time is shorter in otolaryngology-head and neck surgeries, which are often in non-sterile areas, such as mouth, throat, and the nose (12).

Products used for alcohol rubs must meet the EN12791 (It is a European standard in which 60% propanol is used for immediate and 3-hour effect to determine the stability of the product.) standard. The label of the solutions includes both the EN12791 standard and specifications, such as company name, date of manufacture, serial number of the product, and ingredients, as well as the phrases “For external use only” and “Out of reach of children” along with flammability and method of the product use.

According to the World Health Organization, alcohol rub procedure is as follows:

1) Use the elbow of the right hand and pour 5 cc or 3 doses of the alcoholic solution in the left palm (Figure 1-1).
2) Dip your fingertips in the solution for 5 seconds (Figure 1-2).
3) Dip your right forearm with the solution in a circular motion from the wrist to the elbow for 10 to 15 seconds (Figure 1-3).
4) Continue rubbing until the disinfectant solution evaporates from the hand (Figure 1-4).
5) Use the left elbow, pour 5 cc or 3 doses of the alcoholic solution in the palm of the right hand. Repeat steps 2 to 4 for the left hand (Figure 1-5).
6) Use the elbow of the right hand, pour 5 cc or 3 doses of alcohol solution in the left palm.
7) Massage the palms together so that all their surfaces are impregnated with the solution (Figure 1-7).
8) Massage the dorsal surface of each hand with the palm and fingers of the opposite hand so that the fingers are locked together (Figure 1-8).
9) Place the palms of the hands on top of each other and massage between the fingers so that the fingers are locked together (Figure 1-9).
10) Lock both hands and rotate to massage the back of the fingers (Figure 1-10).
11) Rub the thumb of each hand with the palm of the opposite hand in a circular motion (Figure 1-11).
12) When the hands are completely dry, wear sterile surgical clothes and gloves (7).

One of the important factors in the scrub is the type of disinfectant solution. The solutions used in

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scrub have advantages and disadvantages (13).

***• Iodine and iodophor***

Iodophors are iodine derivatives that may combine with detergents to kill microorganisms by oxidizing vital enzymes. Iodophors rapidly reduce microbial load and transient bacterial colonies. It is available in concentrations of 10%, 7.5%, 2%, and 5%. Moreover, they are moderate antimicrobial solutions for tuberculosis, fungi, and viruses. Povidone-iodine is a type of iodophor solution, which has a surfactant. The disadvantages include the possibility of skin inflammation and low persistence (4).

***• Chlorhexidine gluconate***

The antimicrobial activity of chlorhexidine is mediated by the binding and disintegration of the cytoplasmic membrane of the cell leading to the deposition of cell contents (7). A 4% aqueous solution of CHG in the soap or 5% alcohol has an antimicrobial effect on gram-positive and gram-negative bacteria, fungi, and viruses. The antimicrobial properties of 4% CHG present at a more delayed time than alcohol-based solutions. However, its impact lasts for a longer time for over 6 hours. It is because it binds to the outer layer of the skin or the stratum corneum. Prolonged exposure to this substance over time results in cumulative effects and reduces transient and resident bacteria. Moreover, it has little effects on tuberculosis. The CHG rarely causes skin allergies; however, it is very toxic to the ears and can cause inflammation if sprayed on the eyes. This solution can cause permanent damage to the cornea. Care should be taken when scrubbing with this solution (2, 4).

***• Alcohol-based solution***

Alcohol-based disinfectants have the fastest and strongest effect in reducing microbial load (2). The most effective alcohol-based solutions contain 60-80% alcohol. A higher concentration of alcohol leads to less potency. This is due to the fact that proteins do not coagulate easily in the absence of water (7). Alcohols are not good cleansers and are not recommended when the hands are dirty or visibly contaminated with protein since they do not have surfactants and are unable to create foam (2).

A large meta-analysis and a randomized controlled trial have shown that scrubs with CHG and alcohol-based solutions have a stronger and more effective antimicrobial effect than povidone-iodine soap solutions (14, 15). In a study conducted by Iwakiri et al., the time and cost of alcoholic rubs with alcohol-based CHG solutions were less than those of the traditional scrub solutions. Moreover, alcohol rubs with alcohol-based CHG solution can be safe and have rapid disinfection (16).

Other studies have shown that alcohol-based solutions can replace scrub solutions due to lack of damage to the skin, high disinfection, and greater compliance with instructions (14,17-19). The surgical scrub method is a traditional procedure that is performed everywhere without exception. It is estimated that 18.5 liters of water per person are consumed during the scrub before surgical procedures (20).

It is understood that a large volume of water is used for an operation, compared to the simple alcohol rub method. Water conservation is a very important issue in developing countries where surgical procedures are performed. The studies covered in this review indicate that alcohol rub is as good as the routine surgical scrub (21). However, in another published article, it was shown that SSI increased by replacing alcohol-based solutions (22). Nevertheless, in a 2016 Cochrane article, there was no evidence that a particular type of disinfectant was superior to other types in reducing SSI (2).

In a study performed by Liu and Mahigan, it was revealed that the alcohol rub method was as effective as a scrub in preventing SSI (17). After investigations, it was found that the reason for the increase in SSI was the incorrect use of the solution, which is probably due to unfamiliarity with the product instructions or lack of formal training, which overshadows the results of surgery (22). The effectiveness of alcohol-based hand sanitizers is affected by many factors, including the type of alcohol consumed, alcohol concentration, contact time, volume of alcohol consumed, and wetness or dryness of the hands when alcohol is used (7, 23). Larson et al. demonstrated that 1 ml of alcohol was significantly less effective than 3 ml. The ideal volume of products to be added onto the hands is not yet known and may vary for different formulations (7). In 2017, Wilkinson et al. reported that the drying time was highly correlated with dose and hand area (24). Although hands generally dry after less than 10 to 15 seconds of rubbing against each other, it is likely that the amount of the product has not been enough (7).

Similarly, Pars et al. showed no difference between 15 and 30 seconds of hand rub using alcohol. Moreover, no other benefit was found to extend this time to more than 30 seconds (25). There are no differences among the forms of disinfectants (i.e., liquid, gel, or foam) in terms of antibacterial activity; however, they only differ slightly regarding the drying time (26). The main mechanism of purification of alcohol-based solutions is chemical, and these solutions do not

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remove particles and contaminants under the nails and skin.

In case of visible contamination, hands should be washed and dried in the usual way and rubbed thoroughly on the skin, in bends, and between the fingers. The solution should be thoroughly dried before wearing sterile gauze and gloves. It is worth mentioning that towels or other objects should not be used to dry the solution (4).

## Conclusions

To sum up, the SSI is a serious problem, and failure to prevent it can cause problems and costs for the patient and the health care system. The use of hand sanitizers before surgery is one way to prevent SSI. Among these, alcohol-based solutions have been welcomed due to the lack of water consumption, no damage to the skin, high antiseptic properties, and rapid action. However, in order to increase the effectiveness of hand hygiene with alcohol-based solutions, it is better to pay attention to the surgical team, teach the principles of their use, and follow the manufacturer's instructions for using any kind of disinfectant solution. One of the limitations of this study was the lack of access to all studies despite performing an extensive search. This study is merely a narrative review article that introduced each solution along with advantages, disadvantages, and their effectiveness. Therefore, data analysis was not conducted in detail in this study. Accordingly, it is suggested that a systematic review be conducted based on the recently performed clinical trials.

## Conflict of Interest

The authors have no conflicts of interest to declare.

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