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Antibacterial efficacy of surgical scrubbing solutions

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Abstract

Surgical scrubbing with antibacterial solutions is an important step in surgical operations to reduce the incidence of surgical site infection. The aim of study is to evaluated superiority of one of three surgical scrubbing solutions commonly used (povidone iodine, chlorhexidine and aqueous alcohol) by studying their antibacterial action on the skin of the hands of the operating personal. Ninety hands of surgeons, assistants and nurses were included in this study at Al Kindy Teaching Hospital from 1 June, 2011 to 1 Feb, 2012. Divided into three groups each with 30 hands according to the antiseptic solution used for scrubbing (chlorhexidine (group 1); povidone iodine (group 2) and ethanol alcohol (group 3), hand prints were cultured as a baseline, immediately and 30 minutes after scrubbing for both gram +ve and gram –ve bacteria and a total of 540 culture medias were studied. In our study Staphylococcus aureus was the only gram positive transient bacteria found in the culture medias with a baseline ranged (0-5) colonies in group 1, (0-5) colonies in group 2 and (0-7) colonies in group 3 and all were removed immediately after scrubbing with all antiseptic solutions. Staphylococcus epidermidis was the only resident's bacteria found in all the hands with a baseline ranged (10-60) colonies in group 1, (12-62) colonies in group 2 and (10-56) colonies in group 3. This bacterium was reduced to low levels immediately after scrubbing with all antiseptic solutions and completely removed after 30 min in group 2, 3 and reduced to lowest level in group 1. Gram –ve bacteria was not found in the entire three groups. In addition to that, fungi were found in all our study groups in a range of (0-7) colonies in groups 1, (0-8) colonies in group 2 and (0-8) colonies in group 3 and all of them were removed by scrubbing with all antiseptic solutions. We concluded that Povidone iodine was more effective in eradicating or reducing of both gram +ve resident and transient bacteria and fungi.

Keywords: Chlorhexidine; Povidone iodine; Ethanol alcohol; Scrub

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Introduction

Surgical scrub solutions ensure that microbial loads on hands are reduced significantly (i.e., 90% to 99%). This reduction in microbial loads decreases the potential for surgical site infections. In addition, surgical scrubs should provide persistent antimicrobial action, which helps keep microbial load to a minimum as surgical staff members perform surgery. The moist environment of surgical gloves allows microorganisms to grow on the hands within, and these gloves frequently are damaged during surgical procedures, thus increasing the risk for surgical site infections [1].

The two principles of surgical scrubs (i.e., reduction in microbial load, persistent antimicrobial action) are dependent on the length of time and how a person scrubs. It also depends on what antimicrobial agent is used [2]. When changing surgical scrub policies, it is important to remember these two key principles [1, 2].

Microorganisms transfer from the hands of health care workers to patients is an important factor in health care-associated (i.e. nosocomial) infections and has been recognized since the observations of Semmelweis and others more than 100 years ago (2). Skin is a major potential source of microbial contamination in the surgical environment. Hand hygiene is a critical step in preventing infections and the spread of infections, is of critical importance for the entire health care team, and remains the most effective and least expensive measure to prevent the transmission of microorganisms and health care-associated infections [3].

The term general hand hygiene refers to decontamination of the hands by one of two methods--hand washing with either an antimicrobial or plain soap and water or use of an antiseptic hand scrub (4).

Although scrubbed members of the surgical team wear sterile gloves, the skin of their hands and forearms should be cleaned preoperatively to significantly reduce the number of microorganisms. The purpose of surgical hand antisepsis/hand scrubs is to:

* Remove debris and transient microorganisms from the nails, hands, and forearms.
* Reduce the resident microbial count to a minimum.
* Inhibit rapid rebound growth of microorganisms [3, 4].

Each surgical hand antisepsis/scrub procedure should follow a standardized protocol established and approved by the health care facility and the manufacturer's written directions for use, regardless of method. A standardized protocol should be adopted for each method used in the facility. A traditional, standardized, surgical hand antisepsis scrub procedure should include, but may not be limited to, the following:

1-Wash hands and forearms with soap and running water immediately before beginning the surgical scrub.

2-Cleans the subungual areas of both hands.

3- Rinse the hands and forearms [3].

The use of a brush for surgical hand scrubs is not necessary for adequate reduction of bacterial counts Skin damage from scrubbing with brushes can lead to an increased number of gram-negative bacteria and Candida. Scrubbing with a brush is associated with an increase in skin cell shedding [4-7].

A traditional, standardized, anatomical, timed method or a counted stroke method may be used for surgical hand antisepsis/ hand scrubs. The degree of microbial reduction necessary for effective prophylaxis of surgical wound infections has not been characterized fully.

European and Australian studies have evaluated scrub times between two and six minutes, concluding that with specific products, scrub times of three to four minutes are as effective as five-minute scrubs. [4, 8]. Facilities are encouraged to follow scrub agent manufacturers' written directions for use when establishing policies and procedures for scrub times [4, 8].

For the purposes of disinfection, the skin flora may be divided into “residents”&”transient” The resident floras colonize the skin &are removed with difficulty by usual washing procedures &are removed

incompletely by most disinfectants. Resident flora consists mainly of coagulase-negative staphylococci, micrococci, diphtheroids & propionibacter acnes. On other hand, the transient flora, e.g., intestinal gram-negative bacilli, *Staphylococcus* aureus do not usually colonize normal skin &are more easily removed than the resident. Since the composition of the skin flora in an individual is rarely known. Preoperative skin disinfection is expected to remove or kill “transient” and as many of resident floras possible [9, 10].

The major antimicrobial solutions used for surgical hand scrub are:

1. Chlorhexidine Gluconate:

It is a topical, aqueous antiseptic cleanser which is effective in destroying certain bacteria and removing impurities. It is stored at room temperature between 15-30°C. Composed of a cationic agent (biguanide group; 4-chlorophenyl radical), which exhibits antibacterial activity. The cationic nature of the compound promotes connection with anionic compound at the bacterial surface (phosphate groups from teicoic acid at Gram-positive and lipopolysaccharide at Gram-negative bacteria) capable of altering its integrity. The potassium ion, being a small entity, is the first substance to appear when the cytoplasmic membrane is damaged. The alteration of the cytoplasmic membrane permeability promotes precipitation of cytoplasmic proteins, alters cellular osmotic balance, interferes with metabolism, growth, cell division, inhibits the membrane ATPase and inhibits the anaerobic process [11].

2. Povidone iodine (betadine):

It is an amber-colored foaming liquid with a characteristic iodine smell. It is a multivalent broad spectrum local antiseptic having bactericidal and fungicidal properties. The effect on vegetative cells of various bacteria and fungi is due to the liberation of free iodine from the complex. Many viruses, protozoa, yeasts, cysts and spores are also susceptible. Used in the disinfection of the hands prior to surgery procedures or in the operating theatre, preparing the patient's skin prior to surgical procedures or operations, acts by destroying microbial protein and DNA [11].

3. Aqueous alcohols:

Ethyl alcohol (ethanol, alcohol), isopropyl alcohol (isopropanol, propan-2-ol) are the most widely used. Alcohols exhibit rapid broad-spectrum antimicrobial activity against vegetative bacteria (including mycobacterium), viruses, and fungi but are not sporicidal. They are, however, known to inhibit spore germination; alcohols dehydrate cells, disrupt membranes and cause coagulation of protein. A 70% aqueous solution is more effective at killing microbes than absolute alcohols. Its disadvantages are Skin irritant, volatile (evaporates rapidly), and inflammable. Generally, the antimicrobial activity of alcohols is significantly lower at concentrations below 50% and is optimal in the 60 to 90% range [11].

Materials and Patients

This is a descriptive cross-sectional study done in Al-Kindy teaching hospital from 1 June 2010 to 1 Feb. 2011 depends on taking hand print on agar media for culturing the bacteria and studying their type and number of colonies for both gram +ve bacteria using blood agar and gram -ve bacteria using macconky agar. Ninety hands were chosen from surgeons, assistant and scrub nurses were studied in this method divided into 3 groups each with 30 hands according to the type of antimicrobial solutions

as (chlorhexidine (group1); povidone iodine (group 2) and ethanol alcohol (group 3))and total of 540 culture medias were studied.

Baseline bacterial types and counts were recorded by culturing hand prints before starting scrubbing procedures then hands were washed for 2 minutes as follows:

1-Wash hands and forearms with soap and running water immediately before beginning the surgical scrub.

2-Cleans the subungual areas of both hands.

3- Rinse the hands and forearms.

Then; 10 mls of either chlorhexidine gluconate 2%; povidone iodine 10% or ethanol alcohol 70% is applied to the hands followed by one minute rubbing of the hand & forearm thoroughly then hand prints were taken on the culture media after that the surgeon wears the sterile gloves and starts surgical procedure, 30 minutes after that the gloves were removed and hand prints were taken again.

Cultures were kept inside the isotemperature incubator (Fisher scientific no.808NO178) at 35° c in the labs of Al-kindy teaching hospital for 48 hours and then studied regarding types of micro-organisms and number of the colonies by a specialist bacteriologist and the researcher.

In addition to that we considered p-value less 0.05 significant.

Results

Chlorhexidine Gluconate 2% scrubbing group :(group 1)

In this group (30 hands) the baseline showed growth of gram +ve *Staphylococcus* epidermidis and *Staphylococcus* aureus in addition to fungi. Regarding *Staphylococcus* epidermidis the number of colonies ranged (10-60) colonies with an average of 27, immediately after the scrubbing the number of colonies ranged (2-10) colonies with an average of 5.3 and to range (0-3) with average of 0.4 after 30 minutes from scrubbing.

Regarding *Staphylococcus* aureus the number of colonies ranged (0-5) colonies with an average of 1.2. After the scrubbing the bacteria completely eradicated immediately. Regarding fungi the number of colonies ranged (0-7) colonies with an average of 2.5. Immediately after the scrubbing the number of colonies ranged (0-2) colonies with an average of 0.5 completely eradicated after 30 minutes from scrubbing. (As shown in table 1 and 4).

No gram –ve bacteria were detected in any culture media studied in this group.

Table 1.

Showing results of chlorhexidine surgical scrubbing

	Type of bacteria	No. of colonies	Average
Baseline	Staph.epidermidis Staph.aureus Fungi	10-60 0-5 0-7	27 1.2 2.5
immediately	Staph.epidermidis Staph.aureus Fungi	2-10 0 0-2	5.3 0 0.5
30 mins	Staph.epidermidis No fungi	0-3 Nil	0.4 Nil

Povidone iodine 10% scrubbing group: (group 2)

In this group (30 hands) the baseline showed gram +ve *Staphylococcus* epidermidis and *Staphylococcus* aureus in addition to fungi.

Regarding *Staphylococcus* epidermidis the number of colonies ranged (12-62) colonies with an average of 32. Immediately after the scrubbing the number of colonies ranged (0-2) colonies with an average of 0.5 and completely eradicated after 30 minutes from scrubbing.

Regarding *Staphylococcus* aureus the number of colonies ranged (0-5) colonies with an average of 0.9. After the scrubbing the bacteria completely eradicated immediately and nil growth after 30 minutes.

Regarding fungi the number of colonies ranged (0-8) colonies with an average of 2.7. Immediately after the scrubbing the number of colonies ranged (0-1) colonies with an average of 0.1 and completely eradicated after 30 minutes from scrubbing (As shown in table 2 and 4)

No gram –ve bacteria were detected in any culture media studied in this group.

Table 2.

Showing results of povidone iodine surgical scrubbing

	Type of bacteria	No. of colonies	Average
Baseline	Staph.epidermidis Staph.aureus Fungi	12-62 0-5 0-8	32 0.9 2.7
immediately	Staph.epidermidis Staph.aureus Fungi	o-2 0 0-1	0.5 0 0.1
30 mints	No bacteria No fungi	Nil Nil	Nil Nil

Aqueous alcohol (ethanol alcohol 70%) scrubbing group: (group 3)

In this group (30 hands) the baseline showed gram +ve *Staphylococcus* epidermidis and *Staphylococcus* aureus in addition to fungi.

Regarding *Staphylococcus* epidermidis the number of colonies ranged (10-56) colonies with an average of 28.6. Immediately after scrubbing the number of colonies ranged (2-10) colonies with an average of 5.3 and completely eradicated after 30 minutes from scrubbing.

Regarding *Staphylococcus* aureus the number of colonies ranged (0-7) colonies with an average of 0.9 of bacteria and completely eradicated after 30 minutes from scrubbing.

Regarding fungi the number of colonies ranged (0-8) colonies with an average of 2.7. Immediately after scrubbing the number of colonies ranged (0-2) colonies with an average of 0.1 and completely eradicated after 30 minutes from scrubbing (As shown in table 3 and 4).

No gram –ve bacteria were detected in any culture media studied in this group.

Table 3.

Showing results of aqueous alcohol surgical scrubbing

	Type of bacteria	**No. of colonies**	**Average**
Baseline	Staph.epidermidis Staph.aureus Fungi	10-56 0-7 0-8	28.6 0.9 2.7
immediately	Staph.epidermidis Staph.aureus Fungi	o-8 0 0-2	5.3 0 0.1
30 mins	No bacteria No fungi	Nil Nil	Nil Nil

Two ways ANOVA statistical analysis shows significant P value in comparing the use of three different surgical scrubbing solutions, but not significant in comparing the persistent activity of the solutions as all the three solutions showed almost complete eradication of bacteria and fungi after 30 minutes (As shown in table 4).

Table 4.

Average of colonies numbers in each type of solution pre, post, and after 30 minutes of scrubbing

Bacteria	Timing	Chlorhexidine	Povidone Iodine	Alcohol	P Value
Staph. Epidermidis.	Baseline	27	32	28.6	0.00
	Immediate	5.3	0.5	1	
	After 30 Min.	0.4	0	0	
	P Value	0.873			
Staph. Aureus.	Baseline	1.2	0.9	0.9	0.00
	Immediate	0	0	0	
	After 30 Min.	0	0	0	
	P Value	0.444			
Fungi	Baseline	2.5	2.7	2.7	0.00
	Immediate	0.5	0.1	0.1	
	After 30 Min.	0	0	0	
	P Value	0.915			

Discussion

The present study was designed to evaluate the bactericidal efficacy of chlorhexidine gluconate 2%; povidone iodine 10% and ethanol alcohol 70% in surgical hand scrubbing. The criteria of scrubbing is to kill or remove all transient bacteria on the hands of the surgeons (most common one is Staphylococcus aureus) and reduces the residents bacteria to low level (9, 10). In our study Staphylococcus aureus was the only gram positive transient bacteria found in the culture media and all were removed immediately after scrubbing with all antiseptic solution. And Staphylococcus epidermidis was the only resident's bacteria found in all hands. Staphylococcus epidermidis represent part of our normal flora consequently it is an opportunistic pathogen, as it requires a major breach in the hosts innate defenses .it contributes to major part of nosocomial infection, particularly associated with foreign body infection. Most susceptible are intravenous drug users, newborn and elderly (9). This bacterium was reduced to low levels immediately after scrubbing with all antiseptic solutions and completely

removed after 30 min in group 2, 3 and reduced to lowest level in group 1. Although gram –ve bacteria has been found in other studies (9, 10), in our study, it was not found in the entire three groups. In addition to that, fungi were found in all our study groups and all of them were removed by scrubbing with all antiseptic solutions. Also our study shows no significance in comparing the time between the cultures of the hand prints in reduction rate as far as the time is concerned. (As shown in table 4 and figure 1). Povidone iodine was found to eradicate and reduce the bacterial colonies counts more than the other solutions (as shown in table 4 and figure 4) in contrast to two studies done in USA, the first one comparing these three antiseptic solutions in which alcohol was the most effective one than the others although this study depended on counting viable bacterial cell counts by the method of dilution rather than the number of colonies (12).And the second one studying the rate of surgical site infection after scrubbing with aqueous alcohol solution and other traditional scrubbing solution had found that aqueous alcohol solution has better and more sustain action than others(13). And also in contrast to other study done in UK showed Preoperative cleansing of the patient's skin with chlorhexidine–alcohol is superior to cleansing with povidone–iodine for preventing surgical-site infection after clean-contaminated surgery (14).

Conclusion

Our study showed that Povidone iodine was more effective in eradicating or reducing of gram + resident & transient bacteria and fungi on the hands of the surgical operating team whether immediately or by its maintained action throughout the operative procedure than aqueous alcohol and chlorhexidine.

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