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An evaluation of antiseptics used for hand disinfection in wards

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SUMMARY

The antibacterial effectiveness of hand antiseptics commonly used in wards was studied by laboratory and in-use tests and their acceptability assessed by means of a questionnaire passed to hospital staff. To determine the immediate and long-term antibacterial effects of the preparations the in-use tests were performed by groups of students. The greatest immediate reduction in bacterial counts on hands was obtained by products containing chlorhexidine. The long-term antibacterial effect was recorded with emulsions containing 3% hexachlorophane, 2% Irgasan CF3^{R} or 4% chlorhexidine when used constantly on several consecutive days. Considerable discrepancies were recorded in the antibacterial effectiveness of some preparations when comparing laboratory and in-use test results. Therefore it is suggested that antiseptics should be tested by in-use tests which more closely resemble practical conditions before their use, or further trial, in hospital.

INTRODUCTION

It is an established fact that meticulously washing the hands before an operation is of utmost importance since accidental glove puncture allows micro-organisms to make their way directly into a wound and may cause infection. The use of antiseptics reduces the amount of bacteria on the hands and so the risk of infection. Many publications have dealt with skin disinfection in hospital. Most of them, however, evaluate disinfection of the skin at the site of operation or pre-operative surgical hand washing of long duration (Lowbury & Lilly, 1960; Lowbury, Lilly & Bull, 1960, 1964*a*,*b*; Joress, 1962; Lilly & Lowbury, 1971).

The need for hand antiseptics in wards is not as self-evident, although great quantities of antiseptics are used every year in wards to combat cross-infection. Few studies (e.g. Bruun, Bøe & Solberg, 1968; Wilson, 1970) deal with the evaluation of hand antiseptics used in wards. According to several investigations, the use of preparations containing hexachlorophane diminished the rates of cross-infection (Gillespie, Simpson & Tozer, 1958; Gezon *et al.* 1964; Plueckhahn & Banks, 1964; Hirvensalo, Rantasalo & Tiisala, 1965; Baber *et al.* 1967). On the other hand, many hospitals still successfully use only soap for hand washing on wards.

The purpose of the present study has been to assess the value of some hand disinfectants by a test simulating the routine hand wash in wards. The bactericidal effectiveness and the acceptability of the preparations were also studied.

MATERIAL AND METHODS

The following antiseptic preparations were included in the study:

(1) a detergent iodophor containing 0·75–0·81% available iodine (Betadine^R),

(2) an emulsion containing 2% Irgasan CF3^R (3-trifluoromethyl-4,4′dichloro-*N*,*N*′-diphenylurea) and 0·1% beta-phenoxyethanol (Erisept^R),

(3) a 4% chlorhexidine gluconate emulsion (Hibiscrub^R),

(4) an aqueous 1% chlorhexidine gluconate solution (Hibitane^R),

(5) a medicated bar soap containing 0·6% Irgasan DP 300^R (2,4,4′-trichloro-2′-hydroxydiphenyl ether),

(6) a 3% hexachlorophane emulsion (pHisoHex^R),

(7) a 3% hexachlorophane emulsion with 0·3% chlorocresol (Ster-Zac DC^R),

(8) an unmedicated bar soap as a control.

The *in vitro* tests were performed by suspending a loopful of overnight culture of bacteria in saline to give a bacterial count of about 10^7/ml.; 0·1 ml. of this suspension was mixed with 0·9 ml. of undiluted disinfectant, except in the case of chlorhexidine preparations which were diluted 1/10 for complete inhibition of the disinfectant. After varying times the disinfectants were neutralized by the appropriate inhibitor (see Rubbo & Gardner, 1965), whose neutralizing effect was checked. The number of surviving bacteria was determined by dilution. Subcultures were made on blood agar plates, incubated for 18 hr. at 37° C. and the colonies were counted; 99·99% kill of bacteria was used as an end-point. The test microbes were *Staphylococcus aureus* 209 (Oxford strain), *Pseudomonas aeruginosa* (pyocine type 7, Public Health Laboratory Service, London) and *Escherichia coli* (a strain isolated from a patient with urinary infection).

In-use tests were performed by groups of medical students. Each group consisted of about 15 students and every preparation was tested by a different group. No other antiseptics were used during the test week or immediately before it. The students washed their hands five times a day with the test preparation and the bacterial samples were taken from the hands daily. The sample was taken 4 hr. after the last application of disinfectant.

The bacterial samples were taken according to a modification of the scheme introduced by Lowbury & Lilly (1960) and Lowbury, Lilly & Bull (1960, 1964*b*). The hands were first washed in running water and dried gently on a paper towel. The bacterial sample was taken by rubbing the hands with 100 ml. of a mixture containing 10% broth in saline. The hands were rubbed in a standard manner to keep this constant. The hands were then rinsed in running water and washed with the antiseptic preparations for 30 sec. This time was selected after a preliminary questioning among hospital staff and represented the average duration of meticulous hand washing in ward practice. No brush was employed. Special care was taken to rinse the hands with water after disinfection. The hands were then dabbed dry with a paper towel and the second bacterial sample was taken from the hands in exactly the same manner as before, and 0·1 ml. of the sample was cultured on a phenolphthalein phosphate agar plate containing Tween 80 to inhibit any residual disinfectant. Bacteriological testing confirmed that no detectable

Table 1. *Bactericidal effectiveness of the antiseptics studied*

(The antiseptics were undiluted except for the preparations 3 and 4 that were diluted 1 to 10 with water.)

	Killing time for		
	Staph. aureus	*E. coli*	*Ps. aeruginosa*
Iodophor surgical scrub (1)	15 sec.	15 sec.	15 sec.
2% IrgasanCF3^{R} with beta-phenoxyethanol (2)	30 sec.	20 min.	20 min.
4% chlorhexidine emulsion (3)	15 sec.	30 sec.	15 sec.
1% aqueous chlorhexidine (4)	15 sec.	15 sec.	15 sec.
3% hexachlorophane emulsion (6)	30 sec.	24 hr.	24 hr.
3% hexachlorophane emulsion with chlorocresol (7)	30 sec.	60 min.	3 hr.

quantities of antiseptics were transferred into the sample fluid. The plates were incubated at 37° C. overnight and at 22° C. for another 24 hr. The colonies were counted visually by the same person throughout the study.

The acceptability trials were conducted among ward staff. Each of the wards was given an antiseptic preparation for a 2-week period. A questionnaire was then circulated inquiring about the properties of the preparations. The staff was also asked to compare the properties of the preparation with those of the preparation used earlier. After 2 weeks a further inquiry took place. The names of the preparations used during the study were unknown to the participants.

RESULTS

The results of the microbicidal tests of the antiseptic preparations are shown in Table 1. All preparations killed *Staph. aureus* strains within 30 sec. in this test. The microbicidal effectiveness of the chlorhexidine preparations and the detergent iodophor against the strains of *Ps. aeruginosa* and *E. coli* was also rapid. The addition of chlorocresol to hexachlorophane in Ster-Zac DC^{R} was found to render the medium free from gram-negative bacteria within a few hours.

The immediate antibacterial effects of the antiseptics measured by hand washing technique are presented in Table 2. Both chlorhexidine-containing preparations had a good immediate killing effect on bacteria. The next best results were obtained with the preparation containing Irgasan CF3^{R} with beta-phenoxyethanol. The in-use effect of detergent iodophor was rather poor compared to the laboratory results. For the statistical analysis the logarithmic transformation was made to correct the skewness in the distribution of the bacterial reduction variable A/B (A = the initial bacterial counts of hands, B = the bacterial counts after the treatment). With one-way analysis of variance, statistically highly significant difference was found between the preparations (F (7,101 = 17·05, $P < 0{\cdot}001$)). When the differences between the logarithmical mean values were further analysed with Student t test (Siegel, 1956) the treatment with Hibiscrub^{R} was found to be statistically very significantly more effective than those with other preparations

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Table 2. *Reduction of bacteria on hands after a single application of the antiseptic preparation*

(The figures are percentages of the initial bacterial counts. The last column consists of logarithmic mean values ± S.E. of the ratio A/B (A = the initial bacterial count, B = the bacterial count after the treatment) used in the statistical analysis.)

	N	Mean	Median	Log mean ± SE
Iodophor surgical scrub(1)	21	42·0	55·0	0·36 ± 0·07
2% Irgasan CF3^R with beta-phenoxyethanol (2)	13	66·8	70·3	0·54 ± 0·08
4% chlorhexidine emulsion (3)	15	89·1	98·4	1·56 ± 0·21
1% aqueous chlorhexidine (4)	9	73·3	89·6	0·98 ± 0·23
Medicated bar soap containing 0·6% Irgasan DP 300^R (5)	12	17·0	33·2	0·21 ± 0·10
3% hexachlorophane emulsion (6)	12	41·3	51·3	0·31 ± 0·08
3% hexachlorophane emulsion with chlorocresol (7)	16	3·0	17·1	0·21 ± 0·12
Unmedicated bar soap (8)	14	−22·2	0·0	0·02 ± 0·03

t-values for pairs of means

1	2	3	4	5	6	7	
2	1·71	—	—	—	—	—	—
3	6·24*	4·37*	—	—	—	—	—
4	3·41*	2·10	1·83	—	—	—	—
5	1·23	2·73	5·48*	3·42*	—	—	—
6	0·42	2·16	5·19*	3·12*	0·80	—	—
7	1·06	2·22	5·63*	3·26*	0·05	0·61	—
8	3·40†	6·16*	6·63*	4·85*	1·80	3·40†	1·42

* $P < 0·001$. † $P < 0·01$.

($P < 0·001$) with the exception of 1% solution of Hibitane^R (Table 2). The latter treatment was significantly better than those with medicated bar soap and hexachlorophane preparations ($P < 0·01$). All the preparations except medicated bar soap and Ster-Zac DC^R were statistically better than unmedicated bar soap ($P < 0·01$).

It was found that the preparations containing hexachlorophane or Irgasan CF3^R and the preparation Hibiscrub^R considerably reduced the initial bacterial counts of hands after their repeated use over a couple of days (Fig. 1). Since the hand washing took place 4 hr. after the last use of the antiseptic treatment the results should reflect the actual long-term antibacterial effect of the preparations. The trial with Hibiscrub^R was stopped after 4 days, several students of this group having to leave the trial because of unforeseen reasons.

The questionnaire to the hospital staff revealed that 80% of the persons of this hospital washed their hands for ½–1 min. more than six times a day. No preparation was superior in the acceptability trial. The least approved of was Betadine^R, all the others being graded as equally good. The most common untoward effect complained of was dryness of the hands. The smell of Ster-Zac DC^R was disliked as was that of the aqueous solution of Hibitane^R, 'not being as pleasant as an emulsion'. One nurse exhibited a reaction after Hibiscrub^R; this disappeared after she stopped using it.

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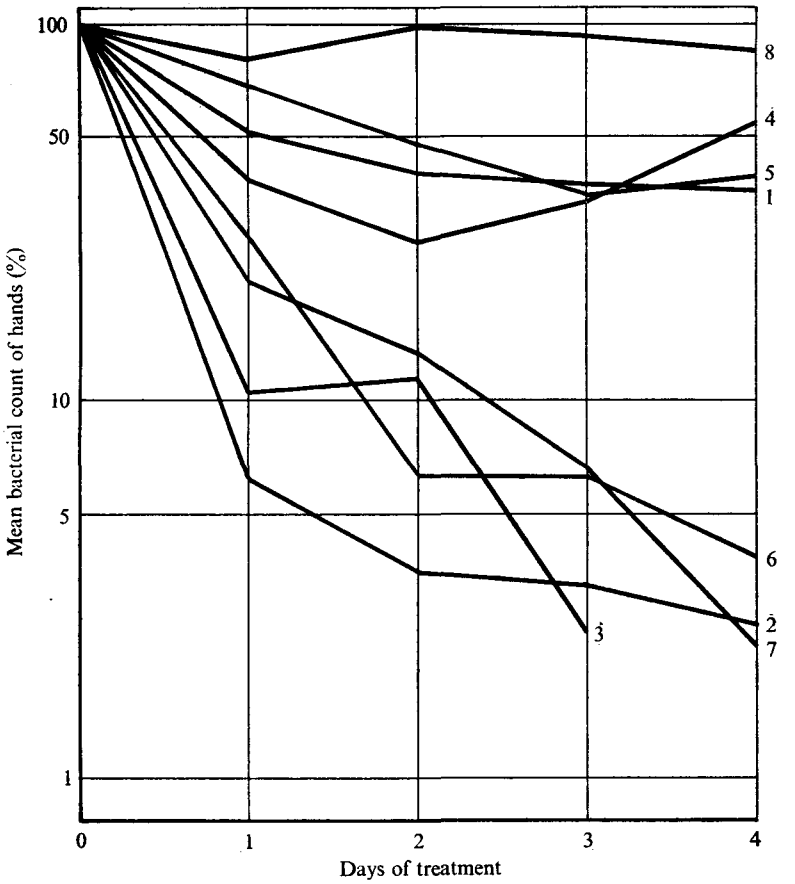

Fig. 1. Mean bacterial counts of hands during the constant use of the preparations studied. The hands were washed five times a day and the bacterial samples taken at noon before washing of the hands. The figures are expressed as percentages of the original counts. 1, iodophor surgical scrub; 2, Irgasan CF3^{R} with beta-phenoxyethanol; 3, chlorhexidine emulsion; 4, aquous chlorhexidine; 5, medicated bar soap; 6, hexachlorophane emulsion; 7, hexachlorophane emulsion with chlorocresol; 8, unmedicated bar soap.

DISCUSSION

New products for the disinfection of surfaces, the skin of patients or the hands of the nursing staff are introduced to hospitals every year. It is not thoroughly understood whether the antiseptic treatment of the hands of the nursing staff in wards is really necessary to prevent cross-infection. It has been shown, however, that the constant use of hexachlorophane preparations for hand washing reduces cross-infection rates, although the danger of increasing the proportion of Gram-negative infections has also been pointed out (Forfar, Gould & Maccabe, 1968). In Scandinavia, on the other hand, many hospitals still use the customary method of mechanical hand washing with soap followed by a rinse in 70% spirit. It may be reasonable to use hand antiseptics in wards, at least in some special wards and situations. More difficult is the question of choice, since only few comparative studies exist dealing with hand antiseptics used in wards.

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The simple determination of the minimum inhibitory concentration to assess the antiseptic properties of the preparation is not enough. Even when the bactericidal tests are performed on the active ingredient, the inhibition of antiseptics by detergents or other additives may be forgotten. It has been shown, for example, that the activity of hexachlorophane is dependent upon its vehicle (Lowbury, Lilly & Bull, 1963; Bruun *et al.* 1968; Gibson, 1969). In the present study the iodophor surgical scrub was found to have a good antibacterial effect *in vitro*, but it did not yield as good results in in-use tests. As the outcome of the test was unexpected the latter test was repeated by a new group, but the results remained unchanged.

When tested later, another preparation of iodophor (Disadine^{R}) gave a 60% reduction of bacteria after one treatment and the variation of the results was smaller than with Betadine^{R}. The solution of Betadine^{R} (without detergent) also gave better results in later tests compared with those obtained with Betadine^{R} surgical scrub. The poor results of the iodophor scrub could be due to the interaction of the detergent and the disinfectant iodophor. Smylie, Logie & Smith (1973) similarly discovered that in surgical scrub technique the iodophor Disadine^{R} failed to achieve the cumulative antibacterial action shown by both pHisoHex^{R} and Hibiscrub^{R}.

The long-term effect of hexachlorophane was confirmed in the present study. Unfortunately the dermal absorption of hexachlorophane into the blood of infants (Curley *et al.* 1971) and its toxicity have limited its use. It may also become contaminated by Gram-negative bacteria in containers (Burdon, & Whitby, 1967; Ayliffe, Barrowcliff & Lowbury, 1969; Collins, & Deverill, 1971). The addition of chlorocresol to hexachlorophane in Ster-Zac DC^{R} seems to keep the product free from contamination by Gram-negative bacteria. The emulsions containing Irgasan CF3^{R} with beta-phenoxyethanol or 4% chlorhexidine were found to exert a sustained antibacterial effect and may thus offer an alternative to hexachlorophane when a long term antisepsis is needed.

The good immediate antibacterial effect of chlorhexidine emulsion makes it superior for use in out-patient clinics or before surgical procedures. It seems that the 4% emulsion form ensures a longer and more thorough disinfectant action than the 1% aqueous form. When 70% spirit was tested in a few tests the same kind of large variation in bacterial reduction among individuals was noticed as with aqueous Hibitane^{R}. The average reduction of bacteria on hands was about 50%. When the participants were urged to use the spirit in ample amounts the reduction in bacterial count was over 80%, emphasizing the importance of scrupulous technique when using spirit for hand antisepsis.

The medical soap containing 0·6% Irgasan DP 300^{R} was rather poor in reducing bacteria on hands and it is probably not much better than ordinary soap in practice. The bacteriostatic effect preserves the soap free from bacteria, but can hardly be supported as 'an effective preparation for disinfection of hands' or as 'the soap when ordinary soap is not enough'. The 2% Irgasan soap, however, has been compared favourably with 3% hexachlorophane and 4% chlorhexidine in its cumulative action on repeated use (Lilly & Lowbury, 1974).

The further assessment of the benefits of antiseptic preparations can be made after their use in hospital. The preliminary in-use tests have, nevertheless, helped in pointing out new preparations with a poor antibacterial effect. They are not too laborious to perform. If possible, they should be conducted using a Latin-square design to eliminate the effect of individual variation. In the present study the absence of the Latin-square design was compensated for by including a greater number of participants in each group.

There should be a considerable difference in the antiseptic effects of the preparations to be of significance in ward practice. On the other hand the variation among individuals in the in-use test should not be large to ensure a good antiseptic effect of a preparation under all conditions. The in-use test can well be performed by different groups of individuals and would still give sufficiently reliable results to act as a guide to the use of new antiseptic preparations in the hospital.

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