

HAND DISINFECTION.

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Every day since aseptic surgery began to replace anti-septic surgery, the question of how to disinfect the hands has increased in importance and to-day no other subject interests us more, because not only have we not heretofore possessed an agreeable method or means of rendering our hands sterile, but also no absolutely efficient method to affect this has been at our command. I wish to call attention to a means of hand disinfection, which not only is new, but also is more certain than those commonly employed, while at the same time, it is less disagreeable than these and much cheaper than the best of them.

In the matter of hand disinfection the ideal result of course would be, absolute sterilization. This perfection has not yet been attained. Of the many methods that have been suggested for sterilizing the hands, only three are used to any extent. These are Fürbringer's method by means of hot water, alcohol and mercury bichlorid; Kelly's modification of Schatz's method, which calls for potassium permanganate and oxalic acid; and the method of soft soap and chlorid of lime and soda. Any one and all of these methods leave much to be desired.

In investigating the subject of hand disinfection it is necessary first to inquire into the possibilities of obtaining sterilization. If bacteriology should prove that absolute sterilization of the hands, for at least the time

necessary to perform any operation, is possible and would show us how this possibility can be realized, then the theoretical and practical aspects of the case would become one and the same. If, however, bacteriology should make it clear that absolute sterilization of the hands by any method that does not injure the texture of the hands, is impossible, then the question arises, can the hands be rendered sufficiently clean to preclude danger of infecting the patient by the hands of the operator?

It is the prevailing opinion among medical men that any one of the ordinary methods of hand sterilization is, at least, sufficiently effective to render the patient safe from the hands of the operator, while many believe that absolute disinfection can be had. A knowledge of the facts, therefore, is important, for thereby we know the limits of what can be done and precaution can be used when the technic may be weak, while an index is furnished of the way along which advance can be made; at the same time the criteria are furnished by which a just estimate of new methods may be made.

HISTORICAL REVIEW.

In 1898 Landrer and Kramer¹ pointed out that the method of disinfecting the site of a proposed operation by scrubbing and the application of ether and some antiseptic solution, acted merely on the surface of the skin and did not attack the micro-organisms which existed in the cutaneous glands.

To-day bacteriology proves that absolute sterility of the hands by any of the methods of disinfection, now in use, is impossible. Furthermore, paradoxical as it may seem, it is also shown that after the application of many of the methods of so-called sterilization, more germs could be obtained from the hands than before any disinfection was attempted. This is on account of the greater ease with which bacteria can be detached, and the releasing of subepidermal germs by the macerating action of the fluids in which the hands are scrubbed.

1. Centrbl. f. Chir., No. 8, 1898.

Still further, it is proved that sterility, immediately after the process of disinfection, is not the rule, while in those cases from which no positive culture can be had immediately, infection rapidly develops when the hands are allowed to remain dry, and very rapidly when they are moistened with water, while the growth is prolific if they are bathed in sterile serum and this serum becomes infected from the hands.

This matter has been thoroughly investigated in America, Great Britain and on the continent of Europe. In Germany alone, up to 1904, one hundred and seventy-five important works on the subject have been printed. While all this literature can not be reviewed here, it is essential to take a bird's-eye view of the matter, which can be done best by considering the findings of Charles Leedham-Green,² surgeon, of Birmingham, England. After conducting a most thorough experimental review of the whole subject, he shows that "no mechanical cleansing of the hands even after the most prolonged and energetic washing of the hands in soap and hot water" is able "materially to diminish the number of microbes on them," and this, even if "sea sand, marble dust, or Schleich's soap is employed." Fat solvents, like turpentine, benzolene, xylol or ether, gave uniformly bad results. He says:

The aqueous solutions of carbolic acid, lysol, perchlorid or biniodid of mercury are practically powerless to affect the micro-organisms situated on the hands, and the use of these antiseptics after a thorough preliminary washing of the hands utterly fails to render them sterile. . . . The use of a saturated solution of permanganate of potassium followed by the application of strong oxalic acid (Kelly's method) gives wholly inadequate results. . . . The combination of an antiseptic like lysol or biniodid of mercury with a soap does not increase the power of the antiseptic, but rather tends to lower it. Such soaps are practically valueless for the cleansing of the hands. . . . Alcohol possesses a remarkable power of sterilizing the hands, far surpassing that of all other agents. . . . Spirit soap is greatly inferior to plain alcohol

2. "Sterilization of the Hands," 1904, p. 90.

as a cleansing agent. . . . Absolute alcohol has little or no germicidal action. . . . When diluted it does possess a certain power varying according to the degree of dilution, 70 per cent. being the most powerful. . . . It has a much greater bactericidal action on the pyogenic cocci than a 1 to 1,000 aqueous solution of either biniodid or bichlorid of mercury.

Very extensive experiments were carried on with Fürbringer's method, which proved far from satisfactory, the best results being obtained by a modification of Fürbringer's method. The technic of this consists in first scrubbing the hands for five minutes with soap and very hot water (122 F.), the water being frequently changed. A nail brush with the addition of sterile sea sand was used. After this the hands are rubbed with methylated alcohol for three minutes, when they are scrubbed for two minutes in a solution composed of one part mercury bichlorid to one thousand parts of a 70 per cent. alcohol and after this they are "rubbed until dry and polished with a sterile cloth."³

All Leedham-Green's review experiments were very thorough. As growth at body temperature was important, he used agar-agar instead of gelatin and made inoculations not only from normal hands, but also from those artificially infected with the *B. pyocyaneus*, sarcine, and the more resistant potato bacillus. Taking each series of experiments, his percentages of favorable results, which included not only negative cultures, but also those showing only slight infection, are remarkably small, ranging from 0 per cent. through 9, 10, 18, 37, 40, 50, 64, 65 to 79 per cent. In the light of these bacteriologic facts it is evident that an ideal means of disinfecting the hands has not yet been obtained.

FORMALDEHYD.

In 1886, Loew and Fischer published a monograph in which they announced the discovery of the germicidal properties of formaldehyd. Two years later Trillat published the results of his exhaustive study of this

³ Loc. cit., p. 93.

subject and showed that formaldehyd acted by chemical combination with the albuminoids of the bacteria and that the resulting compounds were wholly soluble, and, therefore, in no way interfered with the penetration of the antiseptic. He further proved that although it was practically non-toxic as regards mammalia, it was destructive to bacteria and other microorganisms in solutions as weak as 1 part in 50,000.

Although the attention of the medical profession was turned immediately to this new disinfectant which soon, in a practical way, proved itself to be the most speedy, most penetrating and least harmful of disinfectants, formaldehyd has not been used for hand disinfection because all the solutions that, up to the present time, have been available, are more or less unstable and the liberated gas is very irritating to mucous membrane, while it hardens the skin and renders it very rough, not only favoring infection, but perverting its sensibility. Furthermore, its use is painful on account of the formic acid which is present. The solutions usually contain 40 per cent. of formaldehyd, 0.2 of 1 per cent. of formic acid, 10 per cent. of methyl alcohol and 49.8 per cent. of water. Formic acid is constantly present, although its quantity is variable. Its presence at first was thought to be due to an error in the process of manufacture, by which the methyl alcohol was over-oxidized, but in these solutions the formaldehyd itself is continuously oxidizing into formic acid. The United States Pharmacopeia allows 0.1 of 1 per cent. of formic acid, but, even if other conditions did not preclude its effective use, smaller proportions than this render the ordinary solutions too irritating and painful for use on the hands.

VEROPORM ANTISEPTIC.

Recent experimentation has revealed a process of dissolving formaldehyd by which all the difficulties heretofore attached to its solutions have been overcome. The value of these new solutions as a skin disinfectant far

surpasses that of all other antiseptics. This new procedure consists in dissolving the gas in a solution of absolutely neutral soap. The formic acid decomposes part of the soap and combines with the alkali, leaving the fatty acid free; by filtration a clear, stable solution of pure formaldehyd in soap, is obtained. There exists then a solution which is more efficacious than any previous one, from which all irritating properties have been removed. This demethylated-saponified-formaldehyd, free from formic acid is called for brevity, Veroform Antiseptic.

OBJECTIONS TO STANDARD DISINFECTANTS.

But before considering in detail its value as a hand disinfectant, it will be advantageous to call to mind, briefly, some of the difficulties that are inherent in the chief standard disinfectants of the present day. Chlorid of lime deliquesces and loses its virtue, but in its best condition it renders the skin rough and sore, a condition which is not only disagreeable but also makes sterilization impossible, if the chlorid is used frequently by the same person. Carbolic acid, long before any appreciable disinfection can exist, renders the hands numb and anesthetic, not to mention the danger of vasomotor paralysis. Potassium permanganate, at best, is only a mild disinfectant and has no appreciable effect on the skin. Mercury bichlorid forms with albumins insoluble compounds and instead of destroying the germs, encases them in an impenetrable capsule of mercury albuminate or other insoluble compound, thereby protecting them until they are released by some physiologic serum. A solution of 50 to 70 per cent. alcohol has considerable in its favor, but aside from its expensiveness, leaves much to be desired.

EXCELLENCE OF VEROFORM ANTISEPTIC.

The use of saponified formaldehyd, i. e., veroform antiseptic, justifies the statement that it is open to no objections and at the same time is the most efficient

means of hand disinfection we possess to-day. Strassman* says:

Resistant spores of anthrax dried on silk threads, can be destroyed by a 3 per cent. solution of this deformed saponified formaldehyd within twenty-four hours.

Such a solution contains less than 0.2 per cent. of formaldehyd. Surgeon-General Pfuhl reports that a 1 per cent. solution destroys the *Staphylococcus pyogenes aureus* and the *B. typhus*, even when dried, in from one to three hours. Dr. Bruno Promnitz* says that by the use of a 2 per cent. solution of the antiseptic, on the *B. cholerae gallinarum* of Krause, the *B. pyocyaneus*, *B. adematis maligni* and the *B. anthracis*, all germs were dead in ten minutes. When a 5 per cent. solution was used, all germs were dead after three minutes. Such data are substantiated by experiments in this country as the following typical tests show, all of which were made for me by Dr. C. W. F. Muenchehofe, well known as a bacteriologist in this country and abroad; late bacteriologist at Western Reserve University; now in connection with the Museum of Natural History in New York City, and who formerly worked with Virchow and other eminent scientists. In all these experiments the hands were first scrubbed for five minutes with warm water and soap, the U. S. P. soft soap of Squibb being invariably employed, and then after the gross matter had thus been removed, the hands were scrubbed with a solution of veroform antiseptic for five minutes.

EXPERIMENTAL TESTS.

SERIES 1.—In the first series of these experiments a solution of two ounces of antiseptic to two quarts of water at a temperature between 25 C. and 30 C. (about 85 F.), was employed, i. e., a 3.1 per cent. solution of the antiseptic. Twenty inoculations were made, all from the finger nails and the nail folds; 10 of these were from the right hand and 10 from the left. Of those from the right hand 6 cultures were negative

4. Centrbl. f. Gyn., 1901, No. 11, pp. 263, and 270.

5. Centrbl. f. Bact., 1902, No. 3.

while 4 showed scanty growths. Of the 10 cultures from the left hand all proved negative.

Series 2.—In the second series the same technic was used except that a 1.5 per cent. solution of veroform antiseptic somewhat stronger in soap was employed. From hands and fingers 80 inoculations were made, but not from the finger nails. Of these cultures 93 per cent. proved sterile.

Series 3.—A third series with the same solution as the second consisted of 12 inoculations from finger nails only, of which 9, or 75 per cent., proved negative.

In discussing this remarkably satisfactory showing, attention may be called to the care with which the scrapings were made. In all instances it was thorough, with a large, not too smooth sterilized platinum needle and care was taken not to wound the skin. In taking cultures from the skin, error may enter in one of two ways, either from a too light rubbing with a perfectly smooth instrument, or from scraping too hard with a sharp point or blade by which the tissues are wounded. Leedham-Green is right in condemning as "inadequate" Kummel's method of dipping the finger tips in the media, and also Schleich's "stroking of the dry hand with a platinum loop." He is also correct in calling the method of Bunge and others "too severe." This consists in "scraping all the superficial layers of the epidermis with a sharp spoon" or "the excision of small portions of them and the incubation of these in the liquid media," as practiced by Lauenstein. Wounded or granulating skin tissue can not be sterilized satisfactorily. A middle course is therefore essential, the skin should be scraped thoroughly, but this should be done so as not to effect any solution of continuity.

In order to appreciate the significance of the results mentioned, let us compare them with those obtained by the review experiments of Leedham-Green.

Mechanical cleansing of the hand gave 0 per cent. of sterility; washing for six minutes in a 1/1000 aqueous solution of mercury bichlorid, also gave 0 per cent. of sterility, while a scrubbing for eight minutes in a 1/20 solution of carbolic acid showed an average growth of

about sixty colonies when normal hands were tested, but with hands artificially infected with sarcinæ only 12.5 per cent. proved sterile.

In 10 experiments with sublamin (the mercuric-sulphate-ethylenediamin of Schering) only one proved almost sterile. This test was an artificial infection with sarcinæ, but when the *Staphylococcus aureus* or the *B. pyocyaneus* was put to the test, no culture proved negative. In 25 experiments with alcohol on normal hands, 9 or 36 per cent. proved sterile, while 28 per cent. more were found nearly so, but in 15 experiments with alcohol on hands artificially infected with the *B. pyocyaneus* only 4 or 28 per cent. proved sterile. In 8 tests with alcohol and hands artificially infected with sarcinæ, none proved sterile, and only 50 per cent. were nearly so while of 11 infected with the potato bacillus only 2 or 25 per cent. were nearly sterile. None showed no growth. In 8 experiments with spirit soap on hands artificially infected with sarcinæ, all showed countless growths.

In considering Fürbringer's method, out of 19 tests of normal hands, only 12 or 63 per cent. were sterile and out of 16 tests of hands artificially infected with the *B. pyocyaneus*, only 37 per cent. were sterile. Further, when sarcinæ were tested on 8 hands only 12.5 per cent. showed no growth, while out of 11 experiments on hands artificially infected with the potato bacillus only 1 or 9 per cent. proved sterile.

Since so much depends on technic and there is so much difference in the hands of different individuals, all figures must fall short of absolute accuracy. Nothing short of completely removing the entire skin of the hands could give an exact comparison of the number of germs present, while a hairy skin or one with large pores may retain more germs than a skin of the opposite nature. In a large number of experiments, however, many of the disturbing causes become constant factors and for general results may be ignored. The best result

in the figures presented above, outside of veroform antiseptic, is 63 per cent. of negative cultures. This was by Fürbringer's method. Haegler reports 82 per cent. of sterile hands from use of alcohol, but he shows also that if he soaked the hands in warm sterile serum for ten minutes, not only was the surface of the skin always infected, but after the soaking there were large numbers of microbes in the serum. Leedham-Green's best showing is about 80 per cent.

Bearing these facts in mind, let us return to the experiments with veroform antiseptic. In the first set of experiments, cultures from the finger nails of the left hand showed 100 per cent. of sterility, all that could be desired. From the right hand there were only 60 per cent. of absolutely sterile cases. The difference can be accounted for by the fact that all the persons tested were right-handed and none were ambidextrous. They could scrub their left hands satisfactorily, but could not do the same to the right. This condition, of course, could be improved by practice.

In the 80 experiments of the second series, 87.5 per cent. were sterile, but the conditions were such that they led to a suspicion of contamination from the air, a conclusion that proved true by the character of the microorganisms found in the positive cultures, most of which were yeast fungi which, under the circumstances, could have come only from the air. This result, even as it stands, surpasses Haegler's wonderful result of 89 per cent with Fürbringer's method, and of which Leedham-Green. Paul and Sarwey say that they consider it to represent practically "the utmost of which the method under the most favorable circumstances is capable."

In the third set of 12 inoculations from the finger nails, 75 per cent. were sterile, but the 25 per cent. of failures should be grouped with the 12 per cent. of the

second series, as mostly yeast fungi were found and most of this per cent. at least, must be referred to contamination from the air. Four minutes had elapsed between the washing of the hands and the taking of the cultures. Doederlein first emphasized the fact that the air could be a fertile source of infection. He believed that the infection of sterilized cotton gloves during an operation could be accounted for in this way. It was thought by some that all the microbes came from the pores of the skin. In order to prove this point, the hands were cleansed in the most effectual way, and over one hand a sterile rubber glove was drawn, while over this glove and over the other hand, which was naked, a boiled cotton glove was drawn. At the end of an aseptic operation both cotton gloves were found infected, although the one worn over the rubber glove was the less contaminated of the two.

The high percentages of sterility obtained from the use of veroform antiseptic in all the experiments, especially when considered in the light of the cause of the failures, are significant of the importance of this new antiseptic as a hand disinfectant.

REASON FOR ITS EXCELLENCE.

The reason of the superiority of this special saponified formaldehyd, as an agent for the sterilization of the hands is, of course, primarily the chemical nature of the formaldehyd itself. With the exception of moist heat above 100 C., or dry heat above 205 C., formaldehyd is the only speedy and absolutely reliable antiseptic known. Its physical property of penetrability is also an important factor, enabling it to reach germs in the hair follicles, pores, and deeper recesses under finger nails, that no liquid antiseptic could enter. Its efficiency and stability, however, is greatly enhanced by the saponaceous medium in which it is held. This dissolves all

fats and oils and exposes the germs to the immediate destructive action of the gas. Further, this saponification of formaldehyd in no way interferes with its nature as an antiseptic. Professor Loeffler,³ of the Hygienic Institute, of Berlin, reports that "the saponification of formaldehyd in no way changes the germicidal power of formaldehyd." On the other hand, such a fat solvent is necessary if the full bactericidal action of the gas is to be realized. Haegler, Leedham-Green and others have shown that if the infected test objects be dipped into oil or other fatty matter before being exposed to the antiseptic, they might remain in the chemical for hours, even days together, without the slightest effect following. The effect then of this new antiseptic is the exposing of all bacteria to the destructive action of the formaldehyd which, although in itself very volatile, is held by the solvent in contact with the germ, for veroform antiseptic is a stable solution. Further, it is a noteworthy fact, that artificially infected hands are easier to sterilize than normal hands. This is because the bacteria and other microorganisms on normal hands are imbedded in fat and albuminous compounds, and also are buried beneath the sebaceous plugs in the pores and hair follicles. All this fatty and other protective material is dissolved by veroform antiseptic and the formaldehyd is brought into contact with the microorganisms under circumstances most favorable for their destruction.

No less important is the freedom of this antiseptic from formic acid, as it is thereby rendered non-irritating. The soap itself also is absolutely neutral. The United State Pharmacopeia makes rigid demands for a neutral soap. If to a solution of 5 gm. of soft soap in 50 cc. of water, 2 drops of phenolphthalein test solution

3. *Centrbl. f. Bact.*, No. 3, 1902.

be added, a red tint is produced which will require a certain amount of oxalic acid to discharge. This free alkali is allowed by the U. S. P. If, however, to an equivalent of veroform antiseptic, 2 drops of the phenolphthalein solution be added, no red tint will appear, although no oxalic acid be added, proving the absolutely neutral nature of the soap. These two characteristics, freedom from formic acid and neutrality, enable its use on the most sensitive and delicate tissues of the body and no harm can come to the patient if some of the solution remains on the hands.

Having felt the inadequacy of all methods of sterilization heretofore in use, I have used a technic as complete as I could advise. This has been Kelly's process thoroughly applied and followed by a washing with sterilized water, and finally with a 1/1000 mercury bichlorid solution. This process also, however, I find objectionable for the skin of my hands and arms is rendered very sore by it, and when such a condition is present the process of disinfection becomes too painful. I find a similar result from the employment of chlorid of lime and soda, but all these difficulties are obviated by formaldehyd disinfection as produced by the use of veroform antiseptic. The following technic is reliable:

1. Each hand with the finger nails cut moderately short should be scrubbed for five minutes with a good soft soap, such as Squibb's, and hot water which should be repeatedly changed.

2. Each hand should be scrubbed from three to five minutes with a 1.5 per cent. to 3 per cent. solution of veroform antiseptic, which is two to four fluid drachms of veroform antiseptic to a pint of water, after which the hands, as desired, may or may not be rinsed with sterile water.

When used in this way veroform antiseptic offers the

best means of sterilizing the hands. It does all that other disinfectants will do under the most exacting circumstances and it will do more than any other will do. It destroys germs and spores more quickly than any other antiseptic, and will penetrate and kill microbes which no other disinfectant can reach. It does not roughen the hands nor harden the skin, it is unirritating, leaves no unpleasant after effects, and in other respects it is more agreeable than the disinfectants now in use.

DISCUSSION.

DR. J. H. CARSTENS, Detroit, stated that although he has not tried this method, Dr. Boldt's statements and the reports of his cases show that these disinfectants are no good. Dr. Carstens thinks that bichlorid is good for the hands, as is also alcohol and lime and soda. There is no doubt that the man who will use soap and water and bichlorid can attend a case of obstetrics a great deal better and with more safety to the woman than the person who uses simply soap and water. Dr. Carstens uses soap and water, then lime and soda, followed by alcohol and bichlorid. There is something better than this, he said, and that is not to attend any obstetric cases if one's fingers are infected. It is advisable to stay away from anything that may infect the hands if one is practicing abdominal surgery. A man can not put his finger into dirty places and do good clean abdominal surgery.

DR. F. F. LAWRENCE, Columbus, Ohio, concurred in what Dr. Carstens said. He said that it is strange that one man insists that the only possible way to secure surgical cleanliness is by the use of corrosive sublimate and alcohol and boiled water, and another says that we must use permanganate of potash and oxalic acid, and so on. He has gone through the entire list from the Lister carbolic spray down, but now he does not use any chemical antiseptic. These facts, he said, demonstrate that too much time is spent on non-essentials; for instance, if gloves are worn in all pus cases, the hands can be kept in good condition to be made surgically clean by a very simple method. Dr. Lawrence uses turpentine to dissolve out the fat and to loosen the dead epithelium, and then washes with soap and water, which is the essential.

DR. H. J. BOLDT, New York, said that all disinfectants and cleansing agents are good, to a greater or lesser extent. But,

he said, there was no such thing as absolute cleanliness. The question is how to get rid of the microbes. By wearing gloves it is possible to be rid of them in 99 per cent. of the cases. While there are a number of good agents, he believes, so far as bacterial results are concerned, that what Dr. Carstens said is the best way, with the exception, perhaps, of formaldehyd gas. He has been working on this matter for months, and has had cultures taken from the hands of his assistants and nurses, and staphylococci were more frequently found on his hands than on those of his assistants. Formaldehyd gas in neutral soap will give the best results. In using it in the way he has suggested it is possible to get on an average of from 85 to 95 per cent. sterility.