THE GERMICIDAL ACTION OF ALCOHOL.

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THE discrepant results which different investigators have obtained in studying the disinfectant properties of alcohol, and the fact that ordinary commercial alcohol (94% by volume) and absolute alcohol (99% by volume) are used very extensively as skin disinfectants, particularly in the practice of vaccination and in several of the processes followed in attempting to ensure sterility of the hands in the practice of surgery, suggested to us the advisability of determining the germicidal properties of different concentrations against some of the more common pathogenic bacteria, with different periods of direct contact.

Before reporting our own results, a brief *résumé* of the more important investigations already published and an outline of the history of alcohol as a disinfectant are in order.

Alcohol has long been known as an efficient preservative of organic matter, and has been employed as a local application in surgery from time immemorial. Its disinfectant properties were studied first by Koch and his associates, who used as test objects anthrax spores, which were exposed to the action of different concentrations for weeks at a time, with no result. In his elaborate report on disinfectants, Koch¹ speaks incidentally of absolute alcohol and sterilized water as indifferent liquids ("... indifferente Flüssigkeit, z. B. durch sterilisiertes Wasser, absoluten Alkohol, u. s. w."). Not until 1888 was alcohol brought forward as an agent in producing sterility of the hands, and then it was recommended by Fürbringer² for the removal of fatty matters from the skin and consequent promotion of penetration of aqueous solutions of carbolic acid or of corrosive sublimate to the deeper parts.

In 1894 Reinicke³ announced that not only does alcohol remove fatty matters and thus promote penetration of disinfectants to the deeper parts, but acts also as a germicide; and Petruschky,⁴ in the report of his investigations of infection by pyogenic cocci, asserted that disinfection of the skin by means of ether and alcohol was not only possible, but easy of attainment. Krönig,⁵ however, failed in his attempt to kill dried *Staphylococcus pyogenes aureus* with 96% alcohol in five minutes, although he was successful in less time with the moist organisms, and stated his belief that alcohol, through its astringent action and by the withdrawal of moisture, causes bacteria to be held in the shrunken particles of skin.

The first important investigation of the subject was made by Epstein,⁶ who experimented with *B. pyocyaneus*, *B. prodigiosus* and *Staph. pyogenes aureus*, dried on silk threads for from one to four weeks, and then exposed to the action of six different concentrations of alcohol for periods

of three, five and ten minutes. He found that a preliminary wetting of the threads with water was essential to favorable results; but success was by no means constant. Epstein was followed by Minervini,⁷ who employed *Staph. pyogenes aureus*, *B. pyocyaneus*, *B. coli communis*, *B. subtilis* and anthrax spores, all dried on silk threads and on needles, which were exposed to five concentrations of alcohol at ordinary and boiling temperatures and, under pressure, at higher temperatures. His results led him to conclude that alcohol has, in general, a very slight bacterial influence, and that the best effects are attained by the use of concentrations of 50 and 70%.

In this he was in accord with Stremberg, who found that alcohol was effective against some species and powerless against others, no matter what strength was used, and that against the species which were affected, different concentrations acted with varying power.

Minervini's findings were corroborated by those of Bertarelli,⁸ who employed 25, 50, 70, 80 and 99% alcohol against *B. prodigiosus*, *B. pyocyaneus*, *Staph. pyogenes aureus*, *Sp. cholerae*, *B. pestis*, *B. typhosus* and anthrax spores, all dried on silk threads. His conclusion was that the most effective strength is 50%, which, however, must be considered as hardly entitled to a position above mediocrity. Salzwedel and Elsner⁹ experimenting with dried *Staph. pyogenes aureus*, found 55% alcohol to be the most efficient of the several concentrations used and inferior to 1:1000 corrosive sublimate. Absolute alcohol was found to be inert against dried bacteria, even after an exposure of days, although very efficient against those acted upon in a moist state.

The experiments of W. von Brunn¹⁰ with the vapors of varying strengths of alcohol against very richly sporing agar cultures of anthrax demonstrated that, whereas those of 51% and 74% alcohol at 79° C. were very effective within a few minutes, that of 95% alcohol produced no result at the end of an hour, and hence that the water present must be credited with playing a very essential rôle. Frank¹¹ obtained the most satisfactory results with vapor from 40% alcohol (boiling point 90° C.), with which he destroyed anthrax spores in five minutes. The vapors of 50 and 80% alcohol were also effective, but those of 90 to 99% and of weaker strengths than 40% were ineffective.

In the experiments of Weigl,¹² who found that 80 and 90% alcohols show greater bactericidal power than lower concentrations, bouillon cultures of *Sp. cholerae* and *Staph. pyogenes aureus* were mixed directly with different amounts of absolute alcohol, and then the influence of constant shaking in the thermostat was determined. In the tubes which were incubated at rest, coarse coagula were observed, while in those which were shaken the coagula formed were very fine. Naturally, the best results were yielded by the latter; but in problems of disinfection it is of no great importance to ascertain whether under special conditions a substance may act as a germicide, but rather whether

¹ Mitthell. a. d. kaiserlichen Gesundheitsl., 1881.² Untersuchungen und Vorschriften über die Desinfection der Hände des Arztes, Wiesbaden, 1888.³ Centrallbl. für Gynäk., 1894, No. 47.⁴ Zeltschr. für Hyg. u. Infektionskrankh., xvii, p. 59.⁵ Centrallbl. für Gynäk., 1894, No.⁶ Zeltschr. für Hyg. u. Infektionskrankh., xxiv, p. 1.⁷ Zeltsch. für Hyg. u. Infektionskrankh., xxix, p. 117.⁸ 11 Pollicinico, Oct. 1, 1900, p. 488.⁹ Berl. klin. Woch., 1900, No. 23, p. 496.¹⁰ Centrallbl. für Bakteriolog., xxviii, 1900, p. 309.¹¹ Munch. med. Woch., 1901, No. 4, p. 134.¹² Archiv für Hyg. xlv, 1902, p. 273.

under ordinary conditions of practice it may so act. His experiments with threads impregnated with bouillon cultures of *Staph. aureus* or with pus yielded conflicting results, which cannot be regarded as favorable to the practical application of alcohol in surgical technique.

In planning our own experiments we determined to employ a wider variety of pathogenic organisms, which include those generally recognized as weakly, moderately and strongly resistant to chemical disinfectants, and, in both the moist and dried conditions, to test their resistance to 15, 20, 25, 30, 40, 50, 60, 70, 75, 80, 85, 90, 94 and 99% alcohols, exposing them for periods of varying duration. In the first series of experiments these were of 5, 10, 15, 30 and 45 minutes, 1, 2, 7, and 24 hours; in the second series, the species which had been found to be destroyed within 5 minutes by certain of the preparations were exposed again for periods of 1, 2, 3, 4 and 5 minutes, and three different cultures of each organism were so tested.

The cultures employed were grown for 24 hours in bouillon from 48-hour-old agar cultures kindly furnished by Prof. H. C. Ernst. The bacteria were exposed to the alcohols on silk threads, which were introduced into the bouillon at the time of inoculation. The threads were used partly in the moist state on withdrawal from the bouillon, and partly after being dried at incubator temperature for 48 hours. The experiments were conducted at room-temperature. After being immersed for the required time the threads were withdrawn from the alcohol, then planted in tubes of sterile bouillon, and incubated for 24 hours or longer at 37° C.

The results of the various experiments are presented below in tabular form. Growth is indicated by + and sterility by —.

BACILLUS COLI COMMUNIS (MOIST).

ALCOHOL.	TIME OF EXPOSURE								
	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.
15	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+

BACILLUS COLI COMMUNIS (DRIED).

ALCOHOL.	TIME OF EXPOSURE								
	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.
15	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+

From the above we observe that dryness has a most important influence, for while the moist organisms are destroyed within five minutes by every strength above 50 %, the dried are affected within the same time by only 50 and 60 %, and show a

progressive resistance to the action of the stronger preparations, the two highest of which are absolutely inert even with 24 hours' contact.

In the second series of experiments three cultures were exposed in the moist state to 50 and 60 % alcohols for periods of one, two, three, four and five minutes, and in not one instance did growth occur; but the dried bacteria, exposed to 50, 60 and 70 %, yielded results which indicate that the strongest of the three concentrations was the slowest in action, and also that the several cultures differed slightly in resistance.

ALCOHOL.	Culture A.				
	1	2	3	4	5
60%	+	—	—	—	—
70%	+	—	—	—	—
ALCOHOL.	Culture B.				
	1	2	3	4	5
50%	+	—	—	—	—
60%	+	—	—	—	—
70%	+	+	+	+	—
ALCOHOL.	Culture C.				
	1	2	3	4	5
50%	+	+	—	—	—
60%	+	+	+	+	—
70%	+	+	+	+	—

BACILLUS PYOCYANEUS (MOIST).

ALCOHOL.	TIME OF EXPOSURE								
	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.
15	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+

BACILLUS PYOCYANEUS (DRIED).

ALCOHOL.	TIME OF EXPOSURE								
	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.
15	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+

Here again is shown the power of resistance conferred by dryness and the absolute inertness of the higher concentrations.

The second series showed the following results :

MOIST THREADS.

ALCOHOL.	Culture A.				
	1	2	3	4	5
40%	+	+	—	—	—
50%	+	+	—	—	—
ALCOHOL.	Culture B.				
	1	2	3	4	5
40%	—	—	—	—	—
50%	—	—	—	—	—
ALCOHOL.	Culture C.				
	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+

DRIED THREADS.

ALCOHOL.	Culture A.				
	1	2	3	4	5
40%	+	—	—	—	—
50%	+	—	—	—	—

Culture B.					
40%	=	=	=	=	=
50%	=	=	=	=	=

Culture C.					
40%	+	+	+	+	+
50%	+	+	+	+	+

Here we note that whereas the cultures differed in resistance from one another, the moist and dried organisms of each culture yielded practically the same results.

STAPHYLOCOCCUS PYOGENES ALBUS (MOIST).

ALCOHOL.	TIME OF EXPOSURE									
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.	
15	+	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+	+

STAPHYLOCOCCUS PYOGENES ALBUS (DRIED).

ALCOHOL.	TIME OF EXPOSURE									
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.	
15	+	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+	+

It will be noted that all the preparations stronger than 30 % destroy the moist organisms within five minutes, but against the dried the power begins to fail at 75 %, and as before, the strongest preparations are as powerless as the weakest.

The second series yielded results as follows :

MOIST THREADS.

Culture A.					
ALCOHOL.	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+
60%	+	+	+	+	+
70%	+	+	+	+	+
80%	+	+	+	+	+
90%	+	+	+	+	+
94%	+	+	+	+	+
99%	+	+	+	+	+

DRIED THREADS.

Culture A.					
ALCOHOL.	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+
60%	+	+	+	+	+
70%	+	+	+	+	+
80%	+	+	+	+	+
90%	+	+	+	+	+
94%	+	+	+	+	+
99%	+	+	+	+	+

The moist cultures were destroyed in each case by 50 % within one minute; two succumbed to 40 % within two minutes, and the other not in five minutes. The dried organisms showed in two

instances a greater resistance, but all were destroyed by 50 and 60 % within five minutes.

STAPHYLOCOCCUS PYOGENES AUREUS (MOIST).

ALCOHOL.	TIME OF EXPOSURE									
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.	
15	+	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+	+

STAPHYLOCOCCUS PYOGENES AUREUS (DRIED).

ALCOHOL.	TIME OF EXPOSURE									
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.	
15	+	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+	+

These results, it will be noted, agree with those which have gone before.

The one-minute interval tests follow :

MOIST THREADS.

Culture A.					
ALCOHOL.	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+
60%	+	+	+	+	+
70%	+	+	+	+	+
80%	+	+	+	+	+
90%	+	+	+	+	+
94%	+	+	+	+	+
99%	+	+	+	+	+

DRIED THREADS.

Culture A.					
ALCOHOL.	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+
60%	+	+	+	+	+
70%	+	+	+	+	+
80%	+	+	+	+	+
90%	+	+	+	+	+
94%	+	+	+	+	+
99%	+	+	+	+	+

These results indicate not only that the three cultures differ from one another in resistance, but that all were more resistant than the one with which the first series of tests was performed.

BACILLUS TYPHOSUS (MOIST).

ALCOHOL.	TIME OF EXPOSURE									
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.	24 h.	
15	+	+	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+	+	+

BACILLUS TYPHOSUS (DRIED).

ALCOHOL.	TIME OF EXPOSURE							
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.
15	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+

B. typhosus, as is well known, is destroyed by chemical disinfectants much more easily than the pyogenic cocci, and the results obtained were not wholly unexpected. But from what has been written concerning the injurious effect of dryness on its vitality it was not to be supposed that it would offer so much resistance in the dried state to the higher concentrations.

The second series yielded results which indicate that the three cultures employed were, as was the case with the *Staph. aureus*, less easily killed than that used in the first. But it is interesting to note that the dried bacteria yielded more quickly than the moist to the influence of 30% alcohol.

MOIST THREADS.

Culture A.

ALCOHOL.	MINUTES.				
	1	2	3	4	5
30%	+	+	+	+	+
40%	+	+	+	+	+

Culture B.

30%	+	+	+	+	+
40%	+	+	+	+	+

Culture C.

30%	+	+	+	+	+
40%	+	+	+	+	+

DRIED THREADS.

Culture A.

30%	+	+	+	+	+
40%	+	+	+	+	+

Culture B.

30%	+	+	+	+	+
40%	+	+	+	+	+

Culture C.

30%	+	+	+	+	+
40%	+	+	+	+	+

BACILLUS DIPHTHERIÆ (MOIST).

ALCOHOL.	TIME OF EXPOSURE							
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.
15	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+

BACILLUS DIPHTHERIÆ (DRIED).

ALCOHOL.	TIME OF EXPOSURE							
%	5 m.	10 m.	15 m.	30 m.	45 m.	1 h.	2 h.	7 h.
15	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+
30	+	+	+	+	+	+	+	+
40	+	+	+	+	+	+	+	+
50	+	+	+	+	+	+	+	+
60	+	+	+	+	+	+	+	+
70	+	+	+	+	+	+	+	+
75	+	+	+	+	+	+	+	+
80	+	+	+	+	+	+	+	+
85	+	+	+	+	+	+	+	+
90	+	+	+	+	+	+	+	+
94	+	+	+	+	+	+	+	+
99	+	+	+	+	+	+	+	+

B. diphtheriæ appears to be about equally resistant with *B. typhosus* in the moist state and considerably less to the stronger concentrations when dried.

In the second series the results obtained, using 40% alcohol, were practically the same as with *B. typhosus*, but the comparison cannot be carried farther because 50% alcohol was tried in place of 30%. The results follow:

MOIST THREADS.

Culture A.

ALCOHOL.	MINUTES.				
	1	2	3	4	5
40%	+	+	+	+	+
50%	+	+	+	+	+

Culture B.

40%	+	+	+	+	+
50%	+	+	+	+	+

Culture C.

40%	+	+	+	+	+
50%	+	+	+	+	+

DRIED THREADS.

Culture A.

40%	+	+	+	+	+
50%	+	+	+	+	+

Culture B.

40%	+	+	+	+	+
50%	+	+	+	+	+

Culture C.

40%	+	+	+	+	+
50%	+	+	+	+	+

BACILLUS ANTHRACIS.

The results obtained with this organism need no tabulation, for it is sufficient to say that, as has been demonstrated repeatedly by Koch and others, alcohol of any strength whatever has absolutely no influence against it. Every tube showed luxuriant growth within twelve hours.

CONCLUSIONS.

(1) Against dry bacteria, absolute alcohol and ordinary commercial alcohol are wholly devoid of bactericidal power, even with twenty-four hours' direct contact, and other preparations of alcohol containing more than 70%, by volume, are weak in this regard, according to their content of alcohol,—the stronger in alcohol, the weaker in action.

(2) Against the commoner, non-sporing, pathogenic bacteria in a moist condition, any strength of alcohol above 40%, by volume, is effective within five minutes, and certain preparations within one minute.

(3) Alcohol of less than 40% strength is too slow in action or too uncertain in results against pathogenic bacteria, whether moist or dry.

(4) The most effective dilutions of alcohol against the strongly resistant (non-sporing) bacteria, such as the pus organisms, in the dry state, are those containing from 60 to 70%, by volume, which strengths are equally efficient against the same organisms in a moist condition.

(5) Unless the bacterial envelope contains a certain amount of moisture, it is impervious to strong alcohol; but dried bacteria, when brought into contact with dilute alcohol containing from 30 to 60% of water by volume, will absorb the necessary amount of water therefrom very quickly, and then the alcohol itself can reach the cell protoplasm and destroy it.

(6) The stronger preparations of alcohol possess no advantage over 60 to 70% preparations, even when the bacteria are moist; therefore, and since they are inert against dry bacteria, they should not be employed at all as a means of securing an aseptic condition of the skin.

(7) Provided the skin bacteria in the deeper parts can be brought into contact with disinfectants, alcohol of 60 to 70% strength may be depended upon usually, but not always, to destroy them within five minutes.

REPORT OF FIVE CASES OF FRACTURE OF THE HIP IN CHILDREN.¹

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NOTWITHSTANDING the general impression in regard to the rarity of fractures of the neck of the femur in children, there have been a sufficient number brought to our attention, through reports of cases, to lead us to consider that this form of injury, though relatively infrequent, considering the large number of fractures of all types, is in reality more common than is appreciated; and a fracture which has been regarded as coincident with adult life and old age is found in childhood in a surprising number of cases, which would undoubtedly be increased if cases of apparently slight injuries to the hip were more carefully examined and the results interpreted with the aid of modern appliances for the study of bone surgery.

CASE I. — On Sept. 5, 1902, the patient, a girl of thirteen years of age, gave a history of dull pain in the left thigh below the groin, which commenced in April, 1902. History of previous good health. One month later the pain was so severe that she fell while walking; since that time she has had dull pain on motion, being free from it when quiet. At that time she was being treated for nervousness, and was in bed for four weeks; upon getting up a limp was noticed, she complained of slight pain at times, and she resorted to the use of crutches for ten

Fig. I

weeks. General condition good. Left leg shortened 1.5 cm., atrophy of left thigh 3.5 cm., atrophy of calf .5 cm. Patient walks with left leg rotated outward, possibly inward rotation of 10°. Abduction limited, adduction resisted. Skiagram showed fracture of the neck of

¹ From the Orthopedic Department of the Carney Hospital.

the femur with considerable depression of the angle, illustrated in tracing Fig. 1.

CASE II. — On March 23, 1901, a girl of eleven years, perfectly well up to seven months ago, complained of weakness and attacks of pain in her left leg; she stated that the leg would "give out" when standing. No injury recalled at this time. Physically a very stout girl, who had gained rapidly in weight. Examination of spine negative. Left leg rotated outward, motions of knee and ankle normal. Motion of left hip in flexion 45°, in abduction 30°; practically no atrophy of thigh or calf. On April 15, 1901, very little change. On May 18, 1901, motions unchanged; a photograph which was taken three years ago confirms the report that there was no eversion of the left leg at that time. Patient now recalls that she had a fall from her bicycle, and one from a wharf two years ago, which agrees in respect to time with the duration of her symptoms; but she apparently sustained no injuries. In June, 1901, a skiagram suggested an old fracture of the femoral neck. In July, 1901, motion in flexion of the hip is free; no abduction possible; tires easily. Jan. 18, 1902, good general condition; shortening of left leg 1 cm., flexion to extreme possible limit with slight abduction; outward rotation free, inward rotation limited. Sept. 20, 1902, maximum shortening 1 cm., motions very much freer, dips a little in walking; shoe raised 1 cm. The skiagram of this case suggested an impaction of the neck near its junction with the shaft, which, however, was not definite; the history is suggestive and interesting, but one cannot be dogmatic in distinguishing it from coxa vara.

CASE III. — Boy, sixteen years of age, previously well, fell into an elevator pit about Feb. 1, 1900. He had severe pain in his hip, and was unable to walk for several weeks; was in bed with extension. Left leg shortened 2.3 cm., atrophy of thigh 1.3 cm., atrophy of calf 1 cm.; inward rotation of the hip limited, without spasm. Left trochanter 2.5 cm. above Nélaton's line; right tro-

Fig. II

chanter on Nélaton's line. March 21, 1901, for seven months the patient has been working in a factory. Left leg flexed and abducted 15°; shortening of left leg 5 cm., atrophy of thigh 1.3 cm., atrophy of calf 1.5 cm. Left trochanter 5.5 cm. above Nélaton's line. Skiagram showed a fracture of the femoral neck. Tracing Fig. 2 shows considerable distortion of the pelvis, with line of fracture through the femoral neck near its junction with the shaft.

CASE IV. — Boy, fifteen years old; history of father having died of lung trouble seven years ago. Mother and brothers well. The patient has always been perfectly well; he was stout until the present year, when he began to grow tall. In April, 1902, when playing ball, he noticed a weakness of his left leg, apparently without any preceding injury. He was lame, and was obliged to use a cane, which permitted him to be up and about. Appetite good, sleeps well, no cough nor pain at