DISINFECTION BY ACIDS.

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ALTHOUGH disinfection by chemical means has been practised at least since the days of Homer, yet hitherto it has been based on purely empirical grounds. Only within the last few years, sharing in the increased interest taken in sanitary science, has it been made the subject of exact research. Considering the complexity and breadth of the question, the diverse methods by which inquirers have approached and dealt with it, their aggregate results, though as yet small, have the unity and precision of scientific truth. Of late years, perhaps, no material has been so largely used in disinfection as carbolic acid. This may in great part be attribute to the character given it as a surgical application, on the grounds that septic phenomena are caused by bacteria and their allies; that no body is so fatal to these organisms as carbolic acid; and that hence carbolic acid is the most powerful antiseptic. The ardent and painstaking zeal with which these views have been advocated, has evoked a spirit of inquiry both into the natural history of bacteria and into the alleged antiseptic and disinfectant powers not only of carbolic acid, but of many other chemical bodies. Of late, also, much has been said and written to show that bacteria form the infecting principle of zymotic poison. If it be argued that the number of zymotic and of infective inflammatory diseases far exceeds the number of species of bacteria, the reply is, that a single species of these organisms can originate these various distempers, according to the environment. This is tantamount to saying that the environment is rather the cause of the disease, and affects the bacteria, and not the bacteria, as they do not affect the environment; or, in other words, that bacteria are merely passive, harmless, zymotic, and inflammatory products, not active, poisonous, zymotic, and septic causes. However this may be, it is the case that carbolic acid is largely used as a disinfectant in zymotic disease, presumably on the same grounds as it is used as an antiseptic in surgery.

The following remarks being on the destruction of infective matter—on disinfection, and not on the preservation of organic matter, or antiseption as practised in surgery—I shall deal chiefly with facts and inferences having a direct bearing on the annihilation of zymotic virus. In an experimental inquiry on this subject, the results of which were published (*Glasgow Medical Journal*, November 1872 and February 1873), I found that fresh liquid vaccine lymph, which is true infective matter, contains no bacteria, and ceases to infect when it does contain bacteria, if exposed to the fumes of certain volatile acid bodies *till it had an acid reaction*, permanently lost its infecting power. Moreover, I found that carbolic acid was not one of those bodies; i.e., that lymph exposed for about thirty-six hours to an atmosphere saturated with its vapour did not acquire thereby an acid reaction, and had not lost its infecting power. I further mechanically incorporated about forty parts of carbolic acid with about sixty parts of fluid vaccine, and found that this mixture, after being kept from the air for two days, failed to vaccinate; while a portion of the same preparation, after being freely exposed to the air for twelve days, succeeded in vaccinating. These experiments were repeated with the same results. It was found also that no amount of exposure retrieved the lost infecting power of the lymph, which had been exposed to the other acid fumes until it was acid. These results, I felt, justified me in concluding that carbolic acid was not a disinfectant, not a destroyer of organic matter, but rather an antiseptic, a preserver of organic matter—arresting and preventing putrescent and fermenting change, and suspending zymotic action, for a time proportioned to the quantities of the acid and organic matter mixed, but latterly becoming volatilised, and leaving such matter, whether infective or otherwise, in its original state. From these results, I also felt justified in holding that the volatile acid bodies which had permanently annulled the infecting power of the lymph—viz., chlorine, hydrochloric, nitrous, acetic, and sulphurous acids— independent of any antiseptic powers they might have, were at least reliable disinfectants of that substance, and therefore, by inference, of all infective matters.

In Mr. Simon's *Public Health Report*, No. vi, 1875, these views are largely expanded and remarkably confirmed. Here are recorded the details and results of an elaborate and interesting series of experiments to test the disinfecting powers of heat, carbolic acid, permanganate of potash, chlorine, and sulphur-dioxide, on vaccine lymph, liquid and

dry, virus of infective inflammation, and virus of glanders. These experiments were planned by Drs. Burdon Sanderson and Baxter, and ostensibly performed by the latter. In eight experiments with a mixture of chlorine and liquid vaccine, it was found that the lymph vaccinated successfully while the mixture was alkaline; but in the ninth, in which the quantity of chlorine incorporated with the lymph had been much increased and the mixture thereby rendered acid, the lymph was deprived of its infective energy. In four experiments in which dry vaccine was exposed to the fumes of sulphurous acid for only ten minutes, its infecting power was destroyed. This acid was also found to be destructive of the virus of infective inflammation, of glander virus, and to be fatal to the growth and multiplication of microzymes, bacteria, and their allies. Mecklenburg (*Berlin. Klin. Wochenschrift*, June 21st, 1869) also found that lymph mixed with an equal volume of acetic acid lost its infecting power; and Davaine (*Comptes Rendus*, Oct. 13th, 1873), that chromic and sulphuric acids were powerful destructives of *charbon virus*. In the course of these experiments, chlorine is also shown to be a good disinfectant, if used in large quantity. Vaccine, as already noticed, is acidified by it, and only then is it rendered inert. Whether the acid formed in the lymph be hypochlorous or hydrochloric, I cannot say; but I am inclined to think it the latter. The rationale of its action seems explained by saying that the chlorine decomposes the water present, seizing its hydrogen to form hydrochloric acid, while its oxygen is liberated in an uncombined state. Chlorine may thus be said to have a double action: a caustic destructive one, by virtue of the acid it forms; and an oxidising one, from the oxygen it liberates. The fumes of burning sulphur are, however, far more easily obtained, used, prompt, and effective. Permanganate of potash is also shown to be a disinfectant; this, of course, is entirely owing to its oxidising properties. At the end of the report, it is stated, as an inference drawn from the results of the experiments, that, "when the permanganate is used to disinfect a virulent fluid containing much organic matter, there is no security for the effectual fulfilment of disinfection short of the presence of undecomposed permanganate in the liquid after all chemical action has had time to subside". Some rough experiments I made many years ago with the permanganate, in the form of Condry's fluid, led me to discard it as a disinfectant, and to use it only as a deodoriser. Its oxidising powers, though prompt and sure, are very limited, and are quickly exhausted by mere hydrogen-sulphide and ammonium-sulphide, which of course are not infective; while its price limits its consumption to a quantity from which it is very improbable any real benefit as a disinfectant is obtained. About two years ago, I performed an experiment suggested to me by the inferences above quoted, and drawn by Dr. Baxter from his experiments with the permanganate. I had a measured quantity of Condry's fluid conveyed to a house where I was attending a bad case of typhoid fever. To a newly passed characteristic enteric stool of unknown quantity, a portion of this fluid was added; the mixture was stirred, and set aside for a short time. The pink hue of the permanganate-fluid having become brown, more was added; and this process was continued until the lapse of nearly a week, when the fluid retained its pink colour for twelve hours. At this point, it was assumed that the organic matter forming the enteric stool was fully oxidised. The whole mixture was then measured, and, the quantity of Condry's fluid added being known, it was easy to find the relative proportion of oxidised faecal matter and deoxidised Condry's fluid. These were as follow. Avoiding fractions, one fluid-ounce of enteric faeces deoxidised not less than ten ounces of Condry's fluid. The same plan was tried with the patient's urine, and it was found that one ounce deoxidised two ounces of Condry's fluid. Taking these results as a basis for calculation, it will be seen how ridiculous it is to expect any real benefit from the dribbles of Condry's fluid which are used, and how objectionable it is when employed in such quantities, from the false sense of security from infection which it is calculated to produce. Supposing that a typhoid patient pass twelve ounces of faecal matter and twenty ounces of urine during each twenty-four hours—say for a week—which, it will be conceded, are not excessive quantities; and supposing that Condry's fluid sold to the public in eight-ounce bottles at one shilling each is used, it follows that two hundred and eighty ounces of Condry's fluid are required to oxidise or disinfect the week's urine, which, at one shilling per eight ounces, amounts to £1 15s.; and that 840 ounces are required to oxidise or disinfect the week's faeces, which, at one shilling per eight ounces, amounts to £5 5s.; in all, £7 per week, or at the rate of £365 per annum. Now, supposing a hospital with thirty enteric patients on an average constantly under treatment, on these data, it would take £10,950 worth of Condry's fluid to disinfect their yearly excretions.

In the report alluded to, carbolic acid is also stated to be a disinfectant, although it further says "that the use of carbolic acid as an aerial disinfectant should be abandoned, owing to the relative feeble-

ness and uncertainty of its action". But the results on which Dr. Baxter ascribed disinfectant powers to carbolic acid are vitiated, especially those with the acid and vaccine, from the fact that the mixture was used in vaccinating *at once or soon* after its preparation, and was kept sealed in capillary tubes till required. As it seemed that two per cent. of the acid added to moist vaccine, and exposure of dry vaccine to the fumes of the acid, prevented it from vaccinating, it was therefore concluded that carbolic acid is a disinfectant. Now, I myself have obtained the same results with moist lymph under similar conditions, and was on the point of forming the same conclusions; but, observing that the carbolised lymph was milky from coagulation when vaccinating, it occurred to me that the reason why it did not vaccinate successfully might be that the infecting particles of the lymph had become covered with the coagulated vaccine fluid in which they are suspended; also that the free acid in the mixture coagulated the contents of the dermal capillaries which are ruptured during vaccination, and so transformed their contents into embola, while at the same time their walls, being made impervious by the same means, presented an obstacle to endosmotic action. Thus both the vaccine and the nidus of its insertion seemed put in a most unfavourable condition for absorption and absorbing.

To further test this view, I again recently mixed about forty parts of carbolic acid liquefied by a minimum of water with about sixty parts of vaccine. The mixture was then divided in two equal portions on glass slides, and set aside uncovered. In two days afterwards, a child was vaccinated with one portion, but without success; this child was successfully vaccinated two weeks subsequently with pure vaccine. The other portion, after it had been intentionally very freely exposed to air and light for fourteen days, vaccinated successfully. This shows that the acid had only temporarily suspended the infecting power of the lymph, and not permanently destroyed it. Dr. Baxter, therefore, in assuming that carbolic acid is a disinfectant at all, has not unnaturally, from the mode of his experiments, mistaken antiseption or preservation for disinfection or destruction. In the able and interesting report by Drs. Braidwood and Vacher on the *Life-History of Contagium*, presented to the Scientific Grants Committee of the British Medical Association, and lately published, are detailed a number of experiments to ascertain the effect of various alleged germicides on vaccine; *i.e.*, as to whether these destroyed its infecting power. Chief among the substances used were carbolic acid, sulphurous acid, permanganate of potash, and chlorine. The reporters say that "Dr. Baxter's conclusions regarding the influence of carbolic acid, sulphur-dioxide, and chlorine (on vaccine), coincide to a great extent with those at which we have arrived". These conclusions are, that "sulphurous acid, chlorine, carbolic acid, and permanganate of potash, destroy the activity of vaccine". With the exception of carbolic acid, I am also of the same opinion, but have the same objections to urge even more strongly against Drs. Braidwood and Vacher's mode of experimenting with vaccine and carbolic acid as already made in regard to Dr. Baxter's. The reporters state, as the results of their experiments, "that the immediate inoculation of a freshly prepared mixture of vaccine with an equal portion of a one-to-twenty aqueous solution of carbolic acid succeeded (in vaccinating) in some instances" (about 70 per cent. of the inoculations failed). "Such a mixture, preserved for seventeen days to six weeks, failed to produce vesicles." "A mixture of six tubes of vaccine with four drops of a one-to-four aqueous solution of carbolic acid failed to produce vesicles." "A mixture of six tubes of vaccine and four drops of carbolate of glycerine containing 20 per cent. of carbolic acid failed to vaccinate."

As regards the first set of these results, it is easy to account for the success which followed inoculation. (The cause of non-success has been already explained.) The mixture of the acid and lymph had simply not been sufficiently long in contact to coagulate the latter, or the two bodies were not thoroughly incorporated previously to inoculation, so that some pure lymph was left in the mixture. It is stated, that in the other experiments with carbolic acid and vaccine, the mixtures were either used at once after their preparation, or kept hermetically sealed in capillary tubes for seventeen days, three weeks, four weeks, and six weeks before being used. It will thus be seen that in every instance the greatest care was taken that the carbolic acid should be kept in close contact with the lymph until the mixture was used for vaccinating. Why all this care? Did the experimenters suspect that, if the mixture were exposed to the atmosphere, the acid would become volatilised and leave the vaccine intact? It will at least be admitted that, although the vaccine had been made permanently inert, the experiments have no practical value in disinfection, in consequence of the relative excessive quantities of the acid used as compared with the amount of vaccine employed; also of the absolute seclusion to which the mixtures were subjected, hermetically sealed in capillary glass tubes; and likewise of the

great length of time they were kept in these tubes—seventeen days, three weeks, four weeks, and six weeks. A one-to-twenty aqueous solution of carbolic acid is saturated, and is so strong, that few or none acquainted with its properties would think of using it as a disinfectant for sinks or sewers, for which it is only applicable. This solution contains one pound of pure acid to two gallons of water; and if the hand were wet with it for half a minute, it would be numb for a day after. But if this 5 per cent. solution be strong, the other two solutions far surpass it, both containing 20 per cent., being 1 in 5 of the acid, or two pounds of acid to a gallon of water. As the acid requires twenty parts of water for its solution, obviously three-fourths of it must have remained undissolved in these preparations; so that it may almost be said that the lymph was mixed with pure acid. Some of it must have been.

Then, again, in practical aerial disinfection—for example, disinfection of a room in which a patient had died of smallpox—the apartment would require to be, on these data, kept closed for from seventeen days to six weeks; while it would be impracticable to volatilise the quantity of acid in the room required by these experiments, and impossible to confine it as it was done in the tubes.

But although I entirely disapprove of the use of carbolic acid as a disinfectant, I believe, nevertheless, that in virtue of its antiseptic powers, it may be added to assist in preventing zymotic disease. If it be assumed that decaying organic matter is capable of originating *de novo* infective poison, or of forming a favourable nidus for its multiplication (and that the latter is the case there can be no doubt), then carbolic acid may be added to such matter with benefit, as by its antiseptic properties it will, for a time, prevent decomposition. Should, however, any infective material be present, then the acid will have an antiseptic action, will serve it, and though it may for a certain period arrest its power of infection, it will ultimately, as with the vaccine, become volatilised, leaving the poison free to act.

The experiments of Dr. Baxter generally, but especially those with vaccine, chlorine, and the fumes of sulphur-dioxide, have a much more practical bearing than those of Drs. Braidwood and Vacher. The former exposed one portion of dry vaccine to chlorine gas for thirty minutes, and found its infective power destroyed; and another to the vapour of sulphur-dioxide for ten minutes, with the same result in four different trials. The latter submitted one portion of liquid vaccine to the influence of chlorine gas; and another to the fumes of ignited sulphur *all night* (I presume twelve hours) with the same result. But dried vaccine must obviously be more difficult to disinfect than liquid vaccine; and, as this was done in ten minutes in the one case and thirty minutes in the other, it is manifest that Drs. Braidwood and Vacher exposed their liquid vaccine much too long. If every infected apartment required from twelve hours to six weeks for its disinfection, it is very probable that the process would seldom be done efficiently. Fortunately, however, such is not the case, as it is seen that sulphurous acid and chlorine disinfect with a promptitude easily utilised.

From the general tenour of the preceding, it will be seen that acids are prompt and efficient antizymotics, omitting carbolic acid, of course, which partakes more of the character of an alcohol, and is called an acid because it forms salts with alkalies, while it does not redden blue litmus. It is but natural to think that acids should act thus, from the fact that, so far as known, all infecta have a neutral, but chiefly an alkaline reaction. Such is the case with vaccine, variolæ, virus of infective inflammation, virus of glanders, enteric and choleraic fæcal matter.* Hence acids may act as disinfectants not only by destroying the molecular arrangement of the poisonous substance, but also by changing the nature of its environment.

Disinfection by acids is far from new, sulphurous acid or the fumes of burning sulphur having been used by the Greeks to fumigate their temples after sacrificial rites, and also to destroy the parasites which infested their sheep.

Dr. Lind,† who, considering the state of sanitary science at the time he wrote, must have had very much greater opportunities of seeing the ravages of infectious disease than any of the present generation, says: "It gives me the highest satisfaction to affirm that I seldom or never knew a proper application of fumes of sulphur to be unsuccessful in effectually purifying all tainted places, materials, and substances. I have known, in several ships where there are the fairest opportunities of trying things of this nature, that the contagion of small-pox has been entirely stopped by means of wood fires sprinkled with brimstone, kept burning and closely confined in the infected place." The following is a crucial experiment. The commission at Moscow, in the year 1770, invented a fumigating odoriferous powder, which, from several lesser

* Stale healthy urine and fæcal matter are also alkaline; but, when newly voided, acid. This is an example of nature using acids as antiputrefactives.

† *Philosophy of Medicine*; London, 1799: quoted from his *Dissertation on Fevers and Infection*, page 225.

experiments, proved efficacious in preventing the infection of the plague. In order more fully to ascertain its virtue in that respect, it was determined towards the end of the year that ten malefactors under sentence of death should, without undergoing any other precautions than the fumigation, be confined three weeks in a lazaretto, be laid upon the beds and dressed in the clothes which had been used by persons sick, dying, and even dead, of the plague in the hospital. The experiment was accordingly tried, and none of the ten malefactors were then infected or afterwards became ill.* The chief ingredients in the fumigating powder were nitre and sulphur.

Acetic acid has also been long used as a disinfectant. It is related that Cardinal Wolsey was in the habit of carrying a sponge soaked with this substance and various aromatics, in an orange-skin, when passing through the crowds which his fame attracted, in order to preserve him from infection. The reputation of acetic acid as a disinfectant is said to have arisen from the confession of four thieves, who, during the plague of Marseilles, plundered the dead bodies with perfect security, and, on being arrested, stated, on condition of their lives being spared, that the use of aromatic vinegar had preserved them from the influence of the contagion. It is on this account sometimes called "Le vinaigre des quatre voleurs". Muratori, an Italian physician of the seventeenth century, advocates the use of vinegar as a disinfectant. This substance is also in great favour with the Arabians as such. The late Dr. Mead, who was somewhat sceptical regarding the benefits of fumigation and advocated the keeping of houses cool and airy, was nevertheless favourable to the use of vinegar and burning sulphur as disinfectants.

In the year 1773, Gayton Morveau brought forward hydrochloric acid as a disinfectant. The gas was to be made by pouring sulphuric acid on common salt, and was recommended as an efficient mode of disinfecting military hospitals, for which it was largely used, and undoubtedly with great success, as the Chancellor of the Legion of Honour in 1805 writes to him as follows, in the name of the Emperor Napoleon. "Europe and America know that since 1773 you have employed your discovery of the application of muriatic acid fume to arrest the effects of contagious and direful diseases."† So high was this discovery valued, that for it he was made brevet officer of the Legion of Honour, and a decree was passed by the National Assembly ordering its use in military hospitals where infection prevailed.

In 1780, Dr. Carmichael Smyth began to use nitrous acid fumes as a disinfectant. Fever had broken out among the prisoners in Winchester, which attracted the attention of Parliament. Several eminent London physicians were asked to take charge of the prisoners, but refused. Dr. Smyth latterly agreed to do so. One hundred and eighty of the prisoners, with most of the officers and servants, had already died, and the disease was daily increasing. In Dr. Smyth's own words, "When I arrived at Winchester, I found the hospital in the following state.

Table of Deaths.

Date of Weekly Accounts.					Number of Spanish Prisoners		
					In Custody.	Sick.	Dead.
March 26, 1780	..	..	..	..	1247	60	1
April 2, "	..	..	..	..	1243	106	4
" 9, "	..	..	..	..	1475	150	10
" 16, "	..	..	..	..	1457	172	18
" 23, "	..	..	..	..	1433	142	21
" 30, "	..	..	..	..	1412	171	21
May 7, "	..	..	..	..	1388	191	25
" 14, "	..	..	..	..	1351	197	27
" 21, "	..	..	..	..	1523	205	30
" 28, "	..	..	..	..	1494	226	31
					Total..	..	188

Immediately on the admission of the nitrous acid vapour, the deaths fell on June 17th to nine; on the 27th, to five; July 1st, to five; and July 8th, to one, when the contagion ceased. None after its admission caught it, and the disease immediately showed a milder aspect." A Dr. McGregor, of the 88th Regiment, having about this time lost from forty to fifty patients during an outbreak of fever, tried, on a subsequent outbreak of the same disease, nitrous fumigation, and, of sixty-four men seized, did not lose one. The results of Dr. Smyth's application of nitrous acid fumes, not only in Winchester Prison, but in hospitals and ships, produced such an effect on the public mind, that Parliament in 1802 voted him £5,000, and he was appointed physician extraordinary to the King.

[To be concluded.]

A NEW METHOD OF APPLYING A PLASTER-OF-PARIS JACKET IN THE RECUMBENT POSTURE.

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DR. SAYRE is entitled to the gratitude of the profession for having shown how by the use of plaster-of-Paris jacket it is within the power of every practitioner to employ the treatment by artificial support in cases of spinal disease, and for establishing clearly how great is the benefit thus conferred upon the patient. It would be difficult to say how many cases are now treated in this manner for one which 'was so treated previously to Dr. Sayre's publication of his method, and for this great extension of practical knowledge we are wholly indebted to him. While however we fully recognise this, it does not follow that his method must be adopted in every detail as always the best in every case, and I think there can be no doubt that there are at least inconveniences in the method by suspension. It is at all events desirable to have an alternative; and Dr. Walker's paper in the JOURNAL of March '81 was a gratifying contribution to our knowledge, in showing how the jacket can be applied in the recumbent posture, with good results. After alluding to the success of the treatment of these cases by artificial support, which he has proved during a seventeen years' experience, he goes on to say, "But, in order that such a jacket shall be effectual, it is a *sine quâ non* that it shall be applied when the spine is in such a position that the diseased vertebrae shall be free from all pressure, and the deformity, if any deformity exist, be reduced to a minimum. This condition is found, it is true, when the patient is suspended by the head and shoulders, as recommended by Sayre, but it also obtains in an equal degree when the patient is laid flat on his back; and the same result as to increase of height, diminution of the deformity of the spine, and relief to pain and functional disturbance follows the application of the bandage, when the patient is in the recumbent posture, as when he is suspended."

There is sometimes a difficulty, however, in Dr. Walker's plan, in getting the jacket completed before the plaster has begun to set; at least, I have found it so, even with the use of gum to delay the setting. Thinking by what means the procedure might be hastened, the simple expedient suggested itself to me which I am about to describe; of which the great advantage is, that so much can be done before water is employed, that about five minutes' time after the first wetting of plaster suffices to complete the jacket; this also renders unnecessary the mixture of any substance with the plaster to delay the setting. My method, it will be observed, is only a modification of Dr. Walker's.

The best material for the bandages is Victoria lawn, but not too close in texture; and four yards is a convenient length for them. The plaster should be well rubbed into the bandages, but it is desirable to have a considerable quantity besides loose on the surface of the bandages. Shortly before the jacket is to be put on, the patient should have a full meal, thus putting "a pad" of the correct size inside, instead of Sayre's "dinner-pad" outside. The patient, having put on a thin closely fitting woollen shirt, is laid on his back in bed, or on a table covered with a folded blanket, a waterproof under him, and his arms extended at right angles to his body. The requisite depth of jacket is marked on the bed by any appropriate means, such as pins inserted in the waterproof or blanket, two on each side, one opposite the axilla and another opposite a point about an inch below the crest of the ilium. The patient is now made to sit, and after doing so must be careful not to change his place on the bed, in order that, when he again lies down, he may resume exactly his former situation. The length of bandage having been ascertained, which is requisite to encircle the body and overlap in front to the extent of four or five inches, pieces of bandage cut to this length are laid down in succession across the bed, each piece overlapping the preceding by two-thirds of its breadth, as Dr. Walker directs, until a sufficient number are laid down to give the required depth of jacket. The first and the last piece laid down should, however, be about a third of their breadth beyond the marks, and should be then folded in, as otherwise the jacket at its upper and lower edges would be only twofold. The ends of the bandages are now fastened together by being fixed on each side between two slips of wood, which are clasped by three American clothes-pins. These slips of wood should be about fourteen inches long, one inch broad, and three-sixteenths of an inch thick, and the wood should be left in its rough state on one side, in order to grip the bandages more firmly. If any of these were to slip out after being wet, the whole operation would be spoiled; this could be effectually guarded against by one of the pieces of wood being pierced by a row of

* *Philosophy of Medicine*. London, 1799.

† *Travé des moyens de désinfecter l'air, de prévenir la Contagion, et d'en arrêter les Progrès*. 1805.