under ordinary circumstances, and by its character enables an opinion to be given that the child had no separate existence, for in every such case the limbs and body generally become drawn into the position in which it lies normally in the mother's womb.

Just as in the infant, when death occurs before delivery and a separate existence, rigor mortis draws up the limbs into the intrauterine position, so when a chicken dies in the shell the rigidity draws the chick into the position in which it lay in the egg. If the child or chick has had a separate existence, has breathed fully, and used and exercised its limbs for a time, and then dies, the attitude produced by the rigidity changes in character, and becomes the ordinary attitude of cadaveric rigidity, the limbs not being drawn up. Therefore, if the child or chick is watched, and the rigor mortis draws the limbs into the position in which it lay *in utero* or *in ovo*, it can be safely asserted that it was stillborn, and had no separate existence; on the other hand, if the infant or chick is laid out at length, and the limbs when they become rigid are extended or in the same position as laid when limp, this would negative stillbirth.

My first point is that rigor mortis is not a sign of live-birth; and my second, that the character of the rigor mortis enables one to decide whether or not the child was stillborn.

I am conscious that this is a very unsatisfactory report, and as I have not been in general practice for some seven years the cases are all old; but my excuse for publishing it is that the points I raise are of great value in cases of supposed infanticide. I hope better-placed observers will press the matter forward in the public interest.

ON THE USE OF CHEMICALS IN ASEPTIC SURGERY.*

By C. B. LOCKWOOD, F.R.C.S.,
SURGEON TO ST. BARTHOLOMEW'S HOSPITAL.

To some the title of this communication may seem paradoxical. But the end of our surgery is sterility—a logical and scientific standard of perfection. I do not hope to satisfy surgical ritualists, who look to the means and not to the end, nor to discover their standard of excellence. Clinical statistics are, to say the least, oft-times wanting in scientific precision. So much depends upon the optimism of the statistician and the credulity of the audience.

At the present time attempts are being made to conduct surgery without the use of chemicals, or, as Messrs. Dudgeon and Sargent say in their admirable communication to this Society, "without the use of chemical antiseptics for the hands, patient's skin, instruments, lotions, or dressings." But there are many surgeons, myself amongst the number, who still use chemicals, and for reasons which I am about to give.

I concede at once that chemicals may be harmful, and that the ideal would be reached if we could dispense with them altogether. Some who have gone far in this direction say that they have got better results. Probably they have, but this may not be saying much. How is it possible to tell when their previous clinical results are not set forth, and may have been indifferent; but, besides, whilst ceasing to apply excessively strong chemicals to the tissues, they used them more scientifically for the disinfection of the skin? Their ligatures, too, and sutures have been better prepared, and, perhaps, applied. Nor does it follow that because one surgeon, who operates under certain conditions and amidst a certain environment, thinks that he can dispense with chemicals, another who operates under different conditions and different environments would be wise in following his example. They may be urged to do so, perhaps, by an impression in their minds that in using dilute chemicals for their instruments and sponges, and for washing blood from the wound, they acknowledge a certain want of confidence in the accuracy of their methods of operating. They may have seen it written that "they remain condemned to the use of antiseptics"—no one likes to be condemned. Condemnation follows upon crime, and crime leads to punishment. Perhaps the fashion of the

moment may have an influence upon some minds. It is possible, too, that they accept the statements which have been made as to the harmful effects of dilute chemicals upon the tissues, although these statements have not been verified and are usually based upon second-hand evidence.

Now, whatever means surgeons adopt, we assume that their aim is the same—namely, to banish bacteria from the field of operation, from everything brought in contact with the wound, and from the wound itself. Nothing short of this will ever content me. Although their wounds may not have suppurated, I do not believe patients to have passed safely through the ordeal of an operation when colon bacillus, streptococci, *Staphylococcus pyogenes aureus*, or such-like pathogenic bacteria had been found in the vicinity of their wounds. Disasters will ensue, and when suppuration does occur it will be, I believe, of a most serious type.

Let us glance at some of the sources of infection and at the means used to cope with them.

As far as possible, heat is used by everyone to kill bacteria. When heat can be properly applied its effects are asepsis. Nevertheless, to prevent carelessness in its application, constant tests are needed. Not long ago, for reasons which cannot be divined, bacteria grew on several occasions when the small suture needles were dropped into broth. After that was known the needles were always sterile. Systematic tests of everything brought in contact with the wound, of the skin, and of the wound itself, brings to light the sources of wound infection. Should by chance infection have occurred, the cultural tests would trace it to its source. If, for instance, colon bacillus had grown from the skin of the hands, and if the colon bacillus had been grown from the wound, the presumption would be strongly in favour of the hands as the source of infection.

A long series of tests performed regularly for fifteen years leads to the conclusion that bacteria very seldom reach wounds from anything to which heat can be properly applied. Wound infection comes from other sources, and has to be fought by other agencies. But even things treated with heat ought to be tested lest the heat has not been properly applied. The needle incident is a case in point. Wound infection also comes from the patient's own skin, from the hands and person of the surgeon and his assistants, and from the atmosphere. Obviously, heat cannot be applied to these. Here the use of chemicals begins; and this is the branch of aseptic surgery which I propose to discuss, and shall begin with the application of chemicals to the skin.

Now we ought to know how the chemicals which are applied to the skin act. If they act perfectly, then no bacteria can enter wounds from the hands or from the patient's skin; but if they are imperfect in their action, we ought to recognize the fact and take additional precautions until we learn how to disinfect the skin, unless we choose to assume that bacteria from these sources are harmless, which is to assume a great deal. But the hands and the patient's skin are not the only sources of wound infection. "Air infection" is a correct term, but does not imply quite enough. "Environment infection" would be better. The air which bathes a wound made in a gigantic city is not the same as that of a small town by the sea, or one in Switzerland. A private room is not the same as that to which students and visitors have free access. As Dr. Gordon and others have proved, throat bacteria are coughed long distances; and boots bring in much filth, full of equine intestinal bacteria. Clearly these are sources of wound infection which cannot be fought with heat. Are we to assume that bacteria from such sources are harmless and may be ignored?—for of course they revel in salt solution—or ought the question of environment to be taken into consideration in the treatment of wounds?

With regard to the skin of the hands and the skin of the patient, we have here two clear and distinct issues to face. First, to decide how far we can succeed in disinfecting by means of chemicals; and secondly, if we fail, what additional precautions can be taken to ensure asepsis.

Let us begin with the disinfection of the hands. It has been said over and over again that the hands cannot be disinfected. If this means that every one who tries will succeed every time, then the statement is true;

*A paper read at the meeting of the Medical Society of London on January 27th, 1908.

but if it means that the hands can never be disinfected, then it is untrue.

It is by no means easy to state the grounds for the belief that by using our present chemical methods properly the hands can be disinfected, not occasionally, but at least fifty times out of one hundred, and that disinfection is so nearly attained in the remaining fifty that extra rigorous tests are required to prove the escape of occasional bacteria. The scientific evidence is based upon a long series of tests made with culture media. The scientific results might not have impressed the mind had the improvement not been invariably accompanied by an improvement in the clinical results; by a larger proportion of wounds healing by first intention; and by a vast diminution in inflammation and suppuration when infection did unfortunately occur.

During the last fifteen years there has been a steady and continuous improvement in the results of our tests of the skin of the hands. At first bacteria grew on every occasion; then sepsis was 1 in 10; then 1 in 15; and then 1 in 37, and lately once in a series of 66. During this improvement the methods of testing remained the same. A piece of skin has been placed in broth, which is recognized to be a delicate and reliable testing fluid. Nor has the disinfectant varied. I have continued to use the 1 in 500 spirit and biniodide of mercury lotion.* Doubtless equally good results could be got with other disinfectants if properly used, but biniodide happens to suit my own hands and is a powerful germicide. As Fürbinger taught us, such good results cannot be obtained without the use of alcohol. That in itself is a potent germicide, but it has the additional advantage of removing and penetrating the cutaneous grease. Also its dehydrating properties afford a further advantage. After skin has been dehydrated by alcohol it readily absorbs water, or water with disinfectants in solution. Thus we cannot attribute the improvement in results to an alteration in the tests nor to an alteration in the chemicals applied. We have, therefore, to seek for the cause of the improvement in the way in which the chemicals have been used; there small but important alterations have been made. After the hands have been cleansed in the usual way, they are soaked for not less than two minutes in a bowl of spirit and biniodide lotion. This is what has been done hitherto; but, after the spirit and biniodide lotion, the hands are repeatedly transferred—four or five times—from the spirit lotion into a watery solution of mercury biniodide, 1 in 2,000. Presently I shall explain why the strength of the watery solution has been increased to 1 in 500. The effect of this mode of application is not only to disinfect a much larger proportion of hands, but it actually causes the biniodide to enter into a close alliance—but not into chemical combination—with the skin. This is proved by chemical tests which Dr. Hurlley very kindly performed. He found mercuric iodide in the pieces of the skin of my hands soon after their preparation. Furthermore, twenty-seven hours after I had prepared my hands with spirit and mercury biniodide, and after they had been repeatedly washed I snipped off some pieces of epidermis down to the dermis, and gave them to Dr. Hurlley, who reported that they contained an appreciable quantity of mercuric iodide. Others have, I believe, performed similar experiments, and with the same result. Obviously the presence of the mercury in the skin must have an effect upon the broth tests. Such chemical-laden skin would be as unlikely to infect broth or a wound as a piece of chemically-laden gauze, and, having tried, we know that the latter does not infect broth or a wound, provided it has no dust upon it.

Another series of tests shows that after treating with 1 in 500 spirit and biniodide, 1 in 2,000, or 1 in 4,000 watery solution, the skin of the hands has no living bacteria upon its surface. Incidentally these experiments throw light upon the asepticity of the silk which is buried in the tissues. After the hands had been disinfected the lotion was washed off by repeated ablutions with sterile water, which, I may remark, is obtained from the ordinary hot-water supply of the hospital. A small scrap of skin is then put into broth, and has been invariably sterile. Then a piece of No. 1, 2, or 3 twisted silk was pulled off a reel previously sterilized by heat, and roughly dragged again and again through the fingers and palms of the hands, and afterwards some of it was put into broth.

* More correctly a solution of mercuric iodide in potassium iodide.

This test is similar to that used by Haegler,² and is probably more rigorous than that by means of snipped off pieces of epidermis.

We found that silk could usually be drawn through the fingers and escape infection, but that it could seldom be dragged roughly through the palms of the hands. Silk for ligatures or sutures is not subjected to such rough treatment. But nevertheless the test disclosed a flaw in asepsis of the hands, and therefore a possibility of silk implantation infection.

So far, a watery solution of biniodide—1 in 2,000 or 1 in 4,000—had been used in alternation with 1 in 500 spirit and biniodide. So the strength of the watery solution was increased to 1 in 500, with the result that in about two-fifths of tests silk drawn roughly through the palms of the hands remains sterile. Of course, I am not contented with this, although it marks an improvement in methods. We hope some day to attain asepsis. It is to be noted, however, that the improvement in results is coincident with an improvement in our methods of saturating the skin with the chemical.

Clearly, the disinfection of the hands is exceedingly difficult and not likely to be carried out by the inexperienced. The object which we now have in mind is to get as much as possible of the antiseptic into the skin itself. This requires care, accuracy, and technical knowledge. Therefore, inexperienced assistants should wear rubber gloves. But rubber gloves do not afford ideal safety, and are only an additional safeguard. Some seem to think that gloves absolve them of the necessity of disinfecting their hands. But gloves may have holes in them, and are very liable to laceration or perforation. Personally I find that they interfere with delicacy of touch, and cannot therefore be used for many abdominal operations, especially those in which pelvic adhesions have to be overcome. They are, however, indispensable for septic operations or for septic dressings. But as an additional safeguard against hand infection I use mercury biniodide lotion throughout the operation for rinsing the hands and sponges, and, when necessary, to wash blood from the wound. There are, however, additional reasons for this extra precaution, for I have not yet dealt with infection from the skin of the patient or that from environment.

Difficult as the hands are to disinfect, the patient's skin is infinitely more difficult; indeed it is questionable whether the skin of parts with large and abundant sebaceous glands—such as the skin of the scalp—can be disinfected by the methods we have hitherto used.

The chances of asepsis depend upon the region from which the piece of test skin is taken. By our former methods of disinfection the skin of the limbs afforded the highest proportion of asepsis; then the skin of the abdomen (about 1 in 7 septic), then the skin of the breast (about 1 in 6 septic), and then the groin (about 1 in 3 septic). The skin of the scalp has not been disinfected yet. We are now making fresh attempts to do so. Acting on the assumption that asepsis depends upon saturating the skin itself, down to the cutis vera, with disinfectant, we have made more strenuous efforts. After washing and cleansing, the spirit and biniodide 1 in 500, and watery solution of biniodide 1 in 500, have been used alternately for not less than three minutes. Dr. Hurlley has with great kindness made a chemical analysis of skin after it had been treated in this manner, and found that he could obtain from it a distinct sublimate of mercuric iodide. Dr. Hurlley is also of opinion that the mercuric salt is not in combination with the skin; so that it is there in the form of a powerful antiseptic and disinfectant. When this process of saturation of the skin is properly carried out, it must be difficult for cocci or bacilli to live upon its surface or within its glands and hair follicles; and this antiseptic skin ought not to infect sutures or anything else. Much depends upon the way in which the process is carried out, and there is still room for improvement.

Skin which has been successfully saturated with biniodide ought not to infect buried ligatures or buried sutures. I regret that I have no evidence upon this point. For buried ligatures, the finest twisted silk (No. 000) is generally used, and is not seen again. It is quite unusual, too, for the thicker silks (Nos. 1 to 3) used for ligatures or buried sutures, as in the radical cure of hernia, or for pedicles, to appear again. Unfortunately,

on the very rare occasions when, perhaps weeks or months after the wound had healed, a piece of silk has been extruded, we have not had the opportunity of learning the kind of infection. Out of thirty-seven skin sutures taken out on the eighth day, ten were sterile. On each of these ten occasions the piece of skin snipped off before the suture was put in was sterile. Twenty-four sutures were infected with *Staphylococcus epidermidis albus*, two with *Staphylococcus pyogenes*, and one with colon bacillus. In this instance the intestine may have been injured. In the twenty-four infected with *Staphylococcus epidermidis albus*, the bacteria may have come from either the skin of the patient or from the hands of the surgeon. In eight instances the skin of the patient had *Staphylococcus epidermidis albus* in it when the suture was put in, so that in these we need not look further for the source of infection. In the other nineteen there was only one occasion when the surgeon's hands infected broth, and this with *Staphylococcus epidermidis albus*, so that might have been the source of the silk infection. They might, as we have seen, been the source on others had the silk been roughly dragged through the palms, but it was not. But it seems to me likelier the patient's skin at the operation had living *Micrococcus epidermidis albus* in it, or micrococci which had been merely stunned by the antiseptic. But whichever explanation is right, the conclusion is the same—namely, that we have still to learn how to disinfect the skin of both the patient and of the surgeon every time; and, further, that until we learn how to do so, in my opinion, chemicals should be used as an additional protection. It is true that wounds heal by first intention although *Staphylococcus epidermidis albus* or other more virulent microbes are present. But something depends upon the quantities left in the skin. No one can doubt that the nearer we have got towards the asepis of the skin the more certain have been the results. Short of causing suppuration, *Staphylococcus epidermidis albus* causes slight inflammation of the skin around the sutures, some inflammation along the line of incision, and also, I believe, the growth of keloid. I used to think that these were caused by the antiseptics, but they continued although the strength of the antiseptic has been diminished, and although it has been replaced by the mildest antiseptic possible—namely, saline solution. But, after all, the point in question now is not whether healing took place by first intention, but whether our methods achieve asepis—which they do not.

But there are other sources of wound infection besides the hands and skin, which cannot be dealt with by means of heat. The air of our cities, dwellings, and hospitals has in it bacteria from the skin and from the air passages of human beings, and from the alimentary tracts of men and animals. Dr. Gordon, in his admirable reports to the Local Government Board, has given us new and striking information. *Staphylococcus epidermidis albus* was found in the air of a barber's shop, and in that of an operating theatre which was being used. So that air may have been the source of some of the *S. epidermidis albus* met with in our skin tests and of that of ligatures and sutures. But the air of cities, dwellings and hospitals may have in it bacteria much more dangerous than *S. epidermidis albus*. Even in the suburbs pathogenic bacilli and more than one kind of streptococci were found by Dr. H. Gordon in the air. Virulent *Staphylococcus pyogenes aureus* and virulent intestinal bacilli were also obtained from air.

The bacteria in the air of dwellings and hospitals are recruited from the mouths of human beings. During ordinary conversation none are exhaled or ejected. Dr. Gordon repeated and amplified Flüge's experiments and confirmed what we already knew about the showers of throat bacteria which are scattered broadcast during loud speaking, coughing, or sneezing. Loud speaking sent bacteria 40 ft. At shorter distances large numbers fell upon the floor. When any one coughs or sneezes in the audience it is quite safe to assume that the wound is bombarded with bacteria. Dung bacteria are carried about upon the boots and in spite of wipings and cleansings may be carried long distances. *Bacillus prodigiosus* was found by Dr. Gordon 576 ft. from the place wherein it had been placed, having been carried by the boots. "Moist mud cries and becomes dust and is stamped into the air by the exits and entrances of an audience. The mere enumeration of the pathogenic bacteria of mud would take a long time.

Doubtless some of the dangers which depend upon the environment of a wound can be met by skilful organization. The coughing audience can be screened off, which also cuts off the dust brought in on their feet. The air of the theatre can be improved by filtration. Then those upon the floor of the theatre can be suitably clad. But this elaborate organization and installation is not always at our command. Merely to obtain it demands much time and money. And then it cannot be taken about to cases elsewhere. Besides, when it has been obtained, it has to be properly worked by erring man and erring woman. So that here we have another reason for using dilute chemicals as an additional safeguard.

It is often said—usually, as I have remarked, in second-hand evidence—that dilute antiseptics are harmful to the tissues, and may even promote suppuration. Solutions of carbolic acid and of sublimate combine with the tissues, and cause superficial necrosis, and are harmful in a certain degree; but, as many will agree, excellent results follow their use. Judging from the clinical results of my own operations, I cannot allow that ill results follow the use of dilute solutions—1 in 2,000 or 1 in 4,000 mercury biniodide. In 100 consecutive cases of radical cure of hernia the amount of suppuration was 3 per cent. One was due to an oversight on the part of the house-surgeon, who left in a silk suture which held down a transposed testicle; another followed a serious recurrent hæmorrhage in a man with aortic disease, and another followed operation upon a large irreducible inguinal hernia. The cause of the suppuration was never traced, but admits of no excuse on my part. Next, in these 100 cases the dressing was hardly ever renewed until the eighth or tenth day, when the wound was healed, the stitches removed, and collodion applied.

I believe that at St. Thomas's Hospital the wounds are usually treated with salt solution, which is also used for the instruments, and plain sterilized gauze is used to cover the wound. So that I note that for a similar kind of operation, namely, the high operation for varicocele, Messrs. Corner and Nitch³ report 4 per cent. of suppuration. Certainly a comparison of the two sets of cases does not tend to show that the use of dilute chemicals lessens the clinical results.

The effects of some chemicals upon the tissues is seen with the naked eye; 1 in 20 carbolic lotion or 1 in 1,000 sublimate speedily made the cut tissues, especially cut muscle, look as though they had been pickled in brine. It is unnecessary to use a microscope to verify the naked-eye appearances. But I have not yet come across any scientific evidence that dilute biniodide lotion injures the tissues. Besides being antiseptic, the biniodide lotion approximates normal saline solution in its physical and physiological properties. Mr. Trapnell very kindly demonstrated to me that 1 in 4,000 solution merely swells red blood cells, but does not crenate them like 0.6 per cent. saline solution. Mr. Kendrew very kindly made microscopical specimens of portions of fat and muscle which were removed at the beginning and at the end of an operation. I was unable to tell which had been washed with lotion and which had not. It is possible that damage, such as superficial necrosis, might have been seen had carbolic acid or sublimate been used.

So that until the hands can be sterilized or efficiently protected; until the patient's skin can be disinfected; until the science of architecture gives us an ideal environment, and until we learn never to cough or gesticulate, I shall continue to use chemicals.

REFERENCES.

¹ Transactions, Medical Society of London; also *Lancet*, November 17th, 1906, p. 1335. ² *Händereinigung*, Basel, 1900, p. 9 et seq. ³ *BRITISH MEDICAL JOURNAL*, January 27th, 1906, p. 186.

MEDICAL PRACTITIONERS IN GERMANY.—The total number of medical practitioners in Germany this year is given in Boedner's *Medicinal-Kalender* as 31,416; of this number Prussia claims 18,985. In the largest cities the proportion of practitioners to population is 2.5 per 1,000; Wiesbaden has the largest proportion of all. In Berlin and its suburbs the proportion is 1.14 per 1,000. The number of specialists in the whole of Germany is about 6,300, being about 20 per cent. of the total number of doctors. Numerically their provinces of practice are in the following order: Gynaecology, ophthalmology, otorhino-laryngology, urology and dermatology, surgery, neurology, and psychiatry.