

of this system in Mr. Lister's hands. This will not only be interesting but instructive, as showing how aseptic surgery may be carried out in circumstances where spray, gauze, &c., cannot be obtained.

The first cases in which the treatment was tried were compound fractures, and the first attempt recorded by Mr. Lister was made in March 1865. This attempt was unsuccessful, as Mr. Lister subsequently believed, from mismanagement.¹ The next case was a compound fracture of the tibia, caused by the wheel of a waggon passing over the leg. The external wound in this case was $1\frac{1}{2}$ inch long, and $\frac{3}{4}$ inch broad. A piece of lint dipped in carbolic acid (which was at that time only got as an impure liquid known as German creosote) was placed upon the wound. Four days later this lint was removed, and the wound dressed with lint soaked in water in which this impure carbolic acid was diffused. Five days afterwards a solution of one part of carbolic acid in from 10 to 20 parts of olive oil was used for four days, and then ordinary water dressing was resorted to.

The aim in this case was to form a crust consisting of lint, carbolic acid, and blood, which would protect the deeper parts from putrefaction. In this instance, however, the scab came off on the fourth day, and in order to avoid this occurrence, Mr. Lister, in his next cases, applied a piece of lint dipped in pure carbolic acid as before, large enough to overlap the sound skin for a quarter of an inch all round, and covered with oiled paper, applying for the first four days outside this arrangement a piece of lint soaked in pure carbolic acid. The crust was left untouched till the eleventh day, and then water dressing was used.

It now became evident that, owing to the volatility of the carbolic acid, means were required to prevent its evaporation. Accordingly, in the next cases a layer of sheet lead or of block tin was applied outside and overlapping the crust.

Up to this time there was no attempt made to purify the interior of the wound in the first instance. How was it, then, that no putrefaction occurred? Probably for the following reasons. It may have been that no septic particles had got

¹ See numbers of the *Lancet* for 1867.

into the interior of the wound because the blood flowing constantly out would prevent the entrance of solid particles, which would thus only be present if dirt was introduced at the time of the accident, or if much movement of the fragments occurred afterwards, with consequent introduction of air. Further, if any septic particles were present they may not have been able to produce any effect in the presence of healthy living blood clot. (This will be discussed hereafter.) Lastly, the strong carbolic acid, though applied only to the surface, rapidly spreads into the interior even to a depth of one or two inches.

The necessity for purifying the deeper parts of the wound soon became evident. A case was admitted in which, when the tissues around the wound were pressed, bubbles of air escaped along with the blood. Here Mr. Lister squeezed out as much of the clotted blood and air as he could, and then applied a piece of lint dipped in pure carbolic acid, slightly larger than the wound, and over this the piece of block tin. The crust was daily painted with carbolic acid, the tin cap being reapplied on each occasion. This treatment was continued for three weeks.

This purification of the deeper parts was carried out more thoroughly in the next case, in which it was necessary to saw off a portion of the ulna, and here the whole of the interior of the wound was swabbed out with pure carbolic acid. In this case Mr. Lister first became acquainted with 'antiseptic suppuration,' *i.e.* suppuration due to the irritation of the antiseptic applied. (The evil effects of the pure caustic carbolic acid in causing excoriation of the skin had been already noticed.)

Finding that no harm resulted from the free application of pure carbolic acid to the interior of the wound in the last case, the next which came under notice was more thoroughly treated, the contused parts being well manipulated and squeezed, so as to induce the liquid carbolic acid, which was introduced, to penetrate into all the interstices of the wound. At a later period, in order to permit cicatrisation, the crust was clipped away around the margin, and a solution of sulphite of potash (5 grains to the ounce) applied.

In future, the method of introducing strong carbolic acid into wounds by means of a piece of lint soaked in the undiluted acid, held in dressing forceps, was adopted. The blood clots were as far as possible removed.

In order to obtain a more substantial crust and one less likely to be detached, in cases where there was too little blood, a paste was made use of, composed of starch, moistened with carbolic acid placed outside a piece of calico soaked in pure acid, and applied next the wound. As a rule, however, there is enough blood to form a substantial crust if several layers of calico are used.

A great risk of putrefaction was, all along experienced, owing to the fact that the pure acid could not be made to overlap the skin around the wound because of the excoriation caused by it. This risk was especially great in the first twenty-four hours, during which there was a profuse flow of blood and serum. Hence attempts were made to obtain some sort of dressing containing the acid in a more diluted form, and the first-fruits of these attempts was the formation of various pastes, of which the chief was long known as carbolic putty. This consisted of a 1 in 5 solution of carbolic acid in boiled linseed oil mixed with common whiting (CaCO_3), to the consistence of a firm paste or putty. This was then spread on a sheet of block tin, forming a layer of about a quarter of an inch in thickness. A piece of lint dipped in 1-5 oily solution was retained permanently next the wound so as to prevent its exposure during the changing of the dressings. The whole dressing was firmly fixed down by means of a continuous series of strips of plaster, which, however, were absent at the most dependent part, so as to allow the escape of discharge, which was received on a towel. After some time it was found better to apply this putty between two layers of calico, and then the block tin outside all.

The advantages of this dressing are: the tin applied outside prevents the escape of the carbolic acid, the acid in the putty is just sufficiently diluted not to excoriate the skin, while the paste serves as a reservoir for the acid during the interval which elapses between the changing of the dressings; the discharge, as it flows out beneath the putty, taking up only a

certain amount of the acid in its course. If necessary the strength of the acid in the putty may be reduced.

Its disadvantages are that it is clumsy and inconvenient to manipulate, and that it is very apt, when subjected to movement, to crumble away, and thus become an uncertain dressing. Attempts were therefore made to improve it, and recourse was had to various forms of plasters. The first of these was the *lead plaster*.¹

The following is the mode in which this is prepared:—

Take of olive oil	12 parts by measure
„ „ litharge (finely powdered)	12 parts by weight
„ „ beeswax	3 „ „ „
„ „ crystallised carbolic acid	2½ „ „ „

Heat half the oil over a slow fire; then add the litharge gradually, stirring constantly till the mass becomes thick or a little stiff. Then add the other half of the oil, stirring the mass as before, till it becomes thick. Then add the wax gradually till the liquid again thickens. Remove from the fire and add the acid, stirring briskly till thoroughly mixed. Cover up close and set aside, and let the litharge settle, then pour off the fluid and spread on calico. The large quantity of litharge in this mixture was introduced for the purpose of preventing the melting of the plaster at the temperature of the body.

The wound was dressed with layers of lint soaked in carbolic oil, and this dressing was covered in all directions with the plaster. This plaster was renewed daily.

As with the putty, so here, the deep dressing was apt to become displaced, and therefore Mr. Lister used lead plaster as the outermost layer of the deep dressing, in the hope that it would adhere to the skin and prevent lifting of the edges of the dressing. In order to prevent the outer layer of the plaster from sticking to this inner portion, a piece of calico moistened in the watery solution was interposed. But though the plaster does very well for the outside layer, it does not do for the permanent dressing, for it allows the watery solution from the calico to soak through to the wound beneath. At the same time this deep layer, not having formed a crust, is apt to shift its place, and to leave the wound more or less exposed.

¹ *Brit. Med. Journal*. October 31, 1878.

Mr. Lister accordingly tried other sorts of plaster, and at length in shell lac he seemed to have found all that he wanted. This lac mixes in any proportion with carbolic acid, and is more or less fluid or tenacious, according to the quantity of acid present. The shell lac parts but slowly with its acid, and thus forms a good dressing. It is, however, very apt to stick, and in order to prevent this Mr. Lister interposed a layer of gutta-percha between it and the skin. The carbolic acid passes through the gutta-percha with extreme readiness, while the latter prevents the lac from sticking to the deeper parts. Gutta-percha tissue, however, proved apt to crack, and then the discharge got between it and the lac plaster, and thus the fluid beneath it received but little carbolic acid. Hence the same result happens with this cracked gutta-percha as when protective extends to the edge of the dressing—viz., a deep layer of the fluid is more or less protected from the action of the acid, and putrefaction can spread inwards.

After several experiments he ultimately employed a solution of gutta-percha in bisulphide of carbon to brush over the surface of the lac plaster.

The following is the method of preparing the plaster:—

'Take of shell lac	3 parts
„ „ crystallised carbolic acid	1 part

'Heat the lac with about one-third of the carbolic acid over a slow fire till the lac is completely melted, then remove from the fire and add the remainder of the acid, and stir briskly till the ingredients are thoroughly mixed. Strain through muslin and pour into the machine for spreading plaster, and when the liquid has thickened by cooling to a degree sufficient, spread to the thickness of one-fiftieth of an inch. Afterwards brush the surface of the plaster with a solution of gutta-percha in about 30 parts of bisulphide of carbon. When the bisulphide has all evaporated the plaster may be piled in suitable lengths in a tin box without adhering, or rolled up and kept in a canister.'

For the permanent dressing in compound fracture adhesiveness is wanted, and this is obtained by rubbing off the gutta-percha and brushing liquid carbolic acid over the surface.

At this time (1868) the necessity for protecting the healing parts from the direct action of the carbolic acid was beginning

to be recognised, and Mr. Lister first speaks of the use of block tin or sheet lead as a protective.

At the same time, having obtained a purer carbolic acid soluble in water, he gives up the application of the 'pure acid' to the interior of the wound in compound fractures, and syringes it out with a solution of 1-20 instead.

In the 'British Medical Journal' for March 19, 1870, a description is given of the method then used. The wound was in the first instance thoroughly syringed out with 1-20 carbolic lotion. Then oil silk covered with a layer of dextrin was applied in one or two layers, and outside this the lac plaster. If much discharge was expected lint or a towel was placed outside the lac plaster in order to absorb the discharge. Where the dressing was left undisturbed for a week two layers of plaster were used. Where a small piece of lac plaster was applied as a deep dressing, and where consequently the gutta-percha was rubbed off to allow the plaster to adhere to the skin, the gutta-percha was left at one part so as to afford a channel for the escape of discharge.

In changing these dressings a solution of carbolic acid 1-20 was thrown over the wound by means of a syringe, as the dressing was raised, and then a guard soaked in the lotion was applied.

In 1869 catgut ligatures were introduced.

The objections to the lac plaster are that the discharge putrefies outside the plaster and irritates the skin, that the lac keeps the surface beneath it moist with what is really a film of watery solution of carbolic acid, and this again makes its way under the protective and irritates the wound.

Very shortly after the use of the aseptic method in the treatment of compound fractures it was applied to abscesses.

The first publication on this subject appeared in the 'Lancet' for July 27, 1867. The method of opening the abscess and of changing the dressings employed with the means at that time at disposal are very important with reference to the question of operating and dressing without a spray. A piece of rag dipped in 1-5 carbolic oil is laid on the skin where the incision is to be made. The lower edge of this rag being raised, a knife dipped in the oil is at once plunged into the abscess, and the rag immediately dropped over the orifice through which the pus is pressed out. A piece of lint

soaked in the oily solution is then introduced into the opening in order to stop bleeding and to prevent it from closing. This is done by slipping the strip of lint under the antiseptic rag. With regard to the dressing, the putty is here described and used outside a deep dressing of carbolic oiled lint, a layer of calico being interposed between the putty and the deep dressing to prevent them from sticking together. The putty is changed once in twenty-four hours, or oftener if necessary. In doing so a rag dipped in the oily solution is placed over the wound or the deep dressing the instant the old putty is removed. If a plug of lint has been introduced in the first instance it is after a time (two or three days) withdrawn by pushing oiled forceps under the piece of oiled rag, seizing hold of the plug and pulling it out, the oiled rag being pressed thoroughly around the forceps. If a probe is introduced it must be oiled and then slipped in between the folds of the oiled rag. As the various means described under compound fracture were introduced they were applied to abscesses on the principles already described.

The first example of efficient aseptic treatment in the case of wounds published by Mr. Lister will be found in 'The British Medical Journal' for October 31, 1868.¹ The case narrated is one of operation for badly united Pott's fracture.

'On the 11th inst. (April, 1868), the man being under the influence of chloroform, I made a curved incision behind and below the prominent end of the tibia, a solution of carbolic acid in four parts of olive oil being dropped into the wound during the progress of the operation. I detached the soft parts from the bone sufficiently to enable me to insinuate behind the callus one blade of a pair of cutting pliers smeared with the same oil, and then having placed pieces of lint soaked with the oil around the blades of the pliers, so as to prevent the chance of septic air entering the joint when the bone gave way, divided the callus, and at once covered the wound with the antiseptic lint. . . . The wounds were then dressed with a weak oily solution of carbolic acid, and covered with the antiseptic (lead) plaster. Fresh plaster was applied daily.'

I need not repeat the various modifications in the treatment

¹ Reports published during the same year by Drs. Heron and Malloch will be found in the *Glasgow Medical Journal*.

of wounds, as they are similar to those just described under compound fractures.

In the 'British Medical Journal' for January, 1871, Mr. Lister first mentions the gauze dressings, and also refers to the use of oakum. The spray is also tried. In August, 1871, this method has been established, the present protective was completed, and macintosh was substituted for gutta-percha tissue below the outer layer of the gauze. The drainage tube is first mentioned in August, 1871, in the treatment of wounds, though it had been used for a short time previously in the case of abscesses. At that time the piece of gauze next the wound was not wet. It was some two or three years later that the necessity for wetting the deep layer was recognised, and since that time the results have been much more constant. With the introduction of the steam spray, of the elastic bandage, of the improved gauze, &c., there has been a marked improvement in results, and the avoidance of putrefaction, in cases where the wound is made by the surgeon, is now reckoned on as a matter of course.