these 23 non-antiseptic cases lived. Hence the percentage mortality was 95·6.)

Thus, of 18 aseptic cases 15 recovered, all with movable joints. The causes of death in the 3 aseptic cases are given on p. 449.

Of 63 cases treated otherwise, 7 recovered (5 after amputation, 1 with a stiff knee, and in 1, I think, the knee was movable).

These results are surely convincing. Reyher truly remarks, 'Das scheint mir eben das Bemerkenswerthe zu sein! Nicht dass Knieschüsse conservativ heilten, sondern dass von 18 Knieschüssen welche mir ohne Auswahl auf dem Verbandplatz zugingen und welche an Schwere der Verletzung den andern nicht nachstehen, ein so grosser Procentsatz, nämlich 83·3 pro cent. mit Erhaltung und Beweglichkeit des Gelenkes geheilt ist.'

Bergmann[1] also got some remarkable results by a smilar method of treatment during the same war. When the wound was valvular he did not wash it out at all, but simply purified the exterior and applied an aseptic dressing. 'After the storming of Telisch and Gorni-Dubnik 15 cases of compound fracture of the knee-joint came under treatment, mere injury of the capsule being excluded from the list. Of these 14 recovered, 2 after amputation, and 1 died, also after amputation.' (MacCormac.)

In comparing these results from gunshot injuries with those obtained by other surgeons, MacCormac says: 'Hennen, Larrey, and Guthrie all agree that gunshot wounds of the knee-joint demand amputation, as the result is otherwise fatal. Guthrie states in his book that he cannot recollect a case of recovery after gunshot fracture of the articular ends of the bones. Longmore tells us that in the Crimea not a single man wounded in the knee-joint recovered without amputation.' Such statements at once do away with any objection which might be made to Reyher's cases, to the effect that 18 is a very small number of cases; for among these there were no less than 15 recoveries with movable joints, a result not obtained at all according to Longmore throughout the Crimean war, and not

[1] *Ueber die Behandlung der Schusswunden des Kniegelenks in Kriege.* Stuttgart, 1878.

obtained in the 63 other cases mentioned by Reyher. Indeed, if we were to work out Reyher's tables, we should find that of 600 cases of gunshot wound of the knee-joint treated with antiseptics, but not aseptically, only 15 would retain unmutilated limbs, and the joints would be stiff. On the other hand, we only require to take 18 cases and treat them aseptically in order, not only to retain 15 limbs entire, but also to retain movement in the joints.

The proper proportions would perhaps be got by comparing Reyher's aseptic results with those obtained during the Franco-Prussian war, as published by Heintzel.[1] These cases were treated in a variety of ways; by antiseptics, aseptically, by the water-bath or irrigation, by the open method, &c. Thus the results are by no means so unfavourable as during the Crimean and other wars. The sanitary arrangements were also better. In fact the treatment was much more antiseptic than formerly. Heintzel gives details of 529 cases of gunshot wounds of the knee-joint which were treated at the first conservatively. In 288 instances amputation was afterwards necessary; of these 225, or 78·2 per cent., died; of the 241 in which conservative treatment was carried out to the end, 109, or 45·2 per cent., died. Thus, of 529 gunshot wounds of the knee-joint treated in a variety of ways, generally more or less antiseptically, only 132 or 24·9 per cent. recovered. Compare with this result Reyher's 83·3 per cent. of recoveries where the aseptic principle is thoroughly and logically carried out.

I can find no statistics of the results obtained in similar injuries or operations by other methods of antiseptic treatment. We have seen in Reyher's paper the result of treatment by antiseptics.

Treatment by irrigation, unless a strong antiseptic lotion is employed, is hardly suitable for these injuries, for there are so many opportunities for retention and fermentation of discharge in the interior of a joint. Treatment by water-bath is no doubt sometimes good, but only as *keeping down* the inflammation, not as *preventing* the suppuration. The only method which prevents inflammation and suppuration is the aseptic

[1] *Deutsche militairarztliche Zeitschrift*, 1875.

method, whether it be carried out by operating subcutaneously, or by making a crust, or by the use of antiseptics in the manner recommended by Mr. Lister. The latter is, I believe, the only method by which a wound in a joint may be kept widely open for some days without the occurrence of inflammation or suppuration. In order, however, to obtain this result, it is necessary to observe the minutest precautions before detailed, and to act in the very strictest manner in accordance with the particulate theory of fermentation. It is the omission of this care which leads to the failures which are recorded as failures of the aseptic method, but which are really failures on the part of the surgeon who attempted to carry it out. Surgeons are too apt to regard the omission of details, such as the purification of hands or instruments, as 'trifling oversights,'[1] and it is by so doing that they fail to obtain the results they are led to expect, and that we have such an amount of contradictory evidence before us.

That no precaution is too minute to be attended to, is well illustrated by Mr. Lister's case of removal of loose cartilage from the knee-joint (No. 22, p. 434), which was referred to by him at the meeting of the British Medical Association at Cambridge in 1880. The case was one of loose cartilage in the knee-joint of a strong healthy man which was removed with aseptic precautions by Mr. Lister. The operation was performed on April 12, 1880, and there was no difficulty in its performance. After the cartilage had been removed, a drainage-tube was inserted into the joint, and a small dressing was applied. The same evening the discharge was so profuse that the dressing had to be changed. The discharge had no smell, and I may say that throughout the case it was entirely free from odour.

On April 13, twenty-four hours after the operation, a specimen of the discharge was taken from the drainage-tube, and after staining with methyl violet, it was found to be full of organisms. These organisms were very small, and on careful examination they were found to be of a distinctly oval form and arranged in pairs. In some parts it was very difficult to

[1] See Mr. Holmes's report of a case in which he operated for ununited fracture of the patella in the St. George's Hospital Reports for 1880.

say whether they were round or oval (see Plate V, Fig. 36). There was none of the characteristic grouping of micrococci, no threes in triangles and no pairs side by side. This was seen not to be due to their being all in pairs, for chains of several individuals were found, but nowhere the micrococcal grouping. Again, in a specimen of this pus kept moist on a slide for twenty-four hours, very long chains were found, but no masses or typical micrococcal formation. Hence, from the microscopical examination alone, I concluded that these organisms were not ordinary micrococci, and other evidence will be mentioned immediately which supports this view. They were probably bacteria or micrococci of a peculiar kind not causing *putrefactive* fermentation, but the products of whose growth were very irritating, for that is the only way of accounting for the profuse discharge from the interior of the joint.

Redness occurred around the wound, and spread a little distance up the thigh. In the meantime, the patient's temperature became high and the constitutional disturbance was considerable.

On April 15, there was still profuse discharge, now distinctly purulent, but no smell; and in the stained specimens of the discharge taken on this day, the organisms presented exactly the same characters as on the 13th.

On the 16th, a quantity of pus was pressed out of the joint; an incision was also made into the inflamed part in the thigh and a quantity of sero-purulent matter escaped. A drainage-tube was inserted into this abscess.

On April 18, the state of matters continued the same. In the stained specimens of this day's discharge, numerous organisms were seen, many of which were distinctly oval in form, but a large number were round (Fig. 37, Plate V). Two flasks of cucumber infusion were inoculated from the wound on this day, but no development occurred in them.

In spite of the incision into the thigh, the suppurative inflammation spread, and a large abscess cavity was soon formed. As the drainage of the joint was not good, an opening was made on the outer side and a drainage-tube inserted. There was distinct improvement after this. The acuteness of the process soon began to abate.

On April 22, the discharge from the drainage-tube of the abscess was found to contain organisms of the same characters, though fewer in number than formerly (Fig. 38, Plate V). On this day a flask containing *meat* infusion, and one containing *cucumber* infusion, were inoculated with discharge from this abscess, but *no development* occurred in either.

The state of matters continued with but slight improvement, and organisms were always present, though not so numerous as at first. On April 27, a flask containing *alkalised cucumber* infusion and a fresh *egg* were each inoculated with discharge from the inner side of the knee, but *no development* occurred in either. And on April 30, two eggs were inoculated with discharge from the outer side of the knee without any result.

On May 9, discharge taken from the abscess cavity showed the presence of organisms few in number but possessing the same characters as formerly. A flask of pure *vitreous humour* of a sheep and a flask of ordinary *cucumber infusion* were inoculated from the abscess cavity. *Nothing developed in either* fluid.

With regard to the ultimate result in this case, I may say that improvement now began, and healing was complete and the limb restored to a sound state, during the month of September, though there had been very little indeed to heal for a month or six weeks previously. There was a considerable degree of fibrous anchylosis. The patella was quite movable laterally, and there was a little movement between the tibia and femur, when the patient was discharged.

Now, first as to the nature of these organisms. They were certainly not ordinary micrococci, for they had not the same appearance or mode of growth, and also they did not grow in any of the various materials into which they were introduced. The micrococci of which I have spoken in a former part of this work, and, indeed, any which I have as yet come across, would have grown with great readiness in several of these fluids. This was evidently a peculiar form of organism (probably bacterium), not causing putrefaction, but nevertheless, locally of a very noxious character. Had it not been for the microscopical examination, one might have concluded that no organisms were

present and been puzzled to explain the phenomena on antiseptic principles, on the supposition that organisms were absent.

How did they get in? If the aseptic method is sufficient, as I have asserted it is, how were these organisms admitted? As we have already seen, the only organisms which usually get into aseptic wounds are micrococci. Here the organisms differed in many respects from those ordinarily found, and the ordinary forms of micrococci were absent. Hence they probably did not get in in the same way as micrococci usually do, that is, as I have previously shown, through the dressing; for the ordinary forms of micrococci are the *first* to enter, and would, I think, have been found had that been the explanation. Not only so, but these organisms must have got in at the time of, or very soon after, the operation, in order to be present in such numbers on the next day and also to account for the unusual amount of discharge on the evening of the operation.

And they did not get in through the circulation, for there also micrococci are found as a rule first, and here there was no disturbance of the general health to account for their existence.

Whence, then, did they come? Were they perhaps spontaneously generated? Truly an awkward sort of spontaneous generation for the patient! But why should the mere removal of a loose cartilage from a joint lead to the spontaneous development of organisms in it? There was no formation of a vacuum in the joint. There was no change in the physical forces. There was no introduction of cheese à la Bastian into the wound. If organisms were to develop spontaneously in the joint, why did they not do so the day before the operation rather than immediately after it? I need not pursue the many arguments against this view; for we have previously seen that in exact proportion to the care in making experiments do the facts supposed to favour spontaneous generation disappear.

Two explanations therefore remain. Either we had here to deal with some form of resisting spore, or with one which escaped the action of the carbolic acid, or there was some loophole in the method. The former supposition I am inclined to reject, for various reasons which I cannot discuss here: we

have certainly had no previous experience of bacteria resisting the means employed.

There was, however, I believe, a very distinct loop-hole in the method as practised at that time. This is alluded to at length on p. 79. I had long thought that the drainage-tube might carry into a wound dust-laden air in its interior, if the air which entered the tube on removing it from the carbolic lotion were not purified by carbolic spray. This is the explanation I offer here, viz. that the air carried into the wound by the drainage-tube was not pure air, but contained a particle or particles which gave rise to this particular form of organism. On mentioning this to Mr. Lister, he at once saw the force of the argument, and since that time he takes precautions to prevent the recurrence of a similar accident.

It is just possible that the fault lay in the fact that a very small dressing was applied at the time of the operation, and that they got in through the dressing. But then they must have got in during or very shortly after the operation, in order to produce the rapid effect which followed. And also, as I have just stated, the ordinary forms of micrococci would probably have been found in that case.

The only other explanation would be, that there was some error in the manipulations. But though, no doubt, faulty manipulation is almost the constant cause of failure in those commencing the practice of this method and in those who have practised it, when the operation is difficult and requires much thought, yet here there was a simple operation, the importance of the aseptic precautions were fully present to the mind, and I do not think that, especially in the case of Mr. Lister and his assistants, this explanation is in this instance the most probable one. Whichever explanation, however, be correct, the case is of great importanee, as confirming the views expressed before, as illustrating the necessity of excluding organisms of all kinds, and as showing the results which may follow the admission of bacteria to wounds. It is also of interest, because it shows that forms of bacteria may be present without the production of smell, and thus, because a discharge is '*sweet*,' it is not necessarily '*aseptic*.' The difficulty which was experienced in finding the organisms before the pus was

stained also warns us how careful we must be in deciding whether organisms are present or absent from wounds. Cases have been published where disastrous consequences have followed incisions into joints, but where the surgeon has asserted that the discharge was sweet and free from organisms. According to recent investigations, however (p. 253), we know that the pus of acute abscesses and from acute suppurations always contains organisms, generally micrococci; and therefore, in the published cases in which the assertion to which I have alluded has been made, it is clear that the presence of organisms has been overlooked; for if no other form was present, micrococci were sure to be there.

Various facts are known as to the removal of foreign bodies from joints without aseptic precautions. A number of these have been referred to in the historical part, and I will here content myself with quoting some figures from a paper published by M. Larrey in 1861. As we have seen in considering the History of Antiseptic Surgery, the valvular method introduced a considerable amount of security into these operations. Larrey groups the results of the direct and of the oblique, or valvular incision together, but the details are very meagre. He mentions 132 cases, of which 30 died; 7 were unsuccessful or uncertain in result; in 10 he mentions the occurrence of anchylosis; in 2 of hydrarthrosis; and in 9 of grave accidents not further specified. There are thus left 74 cases which were possibly cured with movable joints, but he expressly states that all the cases of healing in which accidents occurred are not noted, so that the number of cures is really less. Thus, only about one half of the cases recovered without the occurrence of some serious complication, yet these results, though apparently so bad, are much more favourable than those which had been obtained by several other surgeons. Larrey contrasts with these cases the results of the operation in which a bed is made outside the joint to receive the cartilage. Of these he mentions 38 cases with 19 cures, 15 failures to extract the cartilage, and 5 deaths.

Larrey's statistics express very well the opinions of the majority of surgeons on the dangers of extracting foreign bodies from joints, even when the valvular or subcutaneous

method is employed. If we search the surgical text-books we find that there is throughout a fear of such operations or injuries. Thus, Mr. Spence, in his 'Lectures on Surgery,' says,[1] 'There is no class of operations that I have a greater dread of than the apparently simple one of removing a loose cartilage.'

I have no statistics of septic cases, comparable to the aseptic ones, in which wounds of joints have been kept open for some days; but, as will be seen in the history of this subject, experience has up till recently led surgeons to the conclusion that the safety of the limb and of the patient depends on rapid healing of the wound. And yet, as all the facts quoted show, these operations, when aseptically performed, are really devoid of danger. Sir James Paget says:[2] 'I cannot doubt that operations of this kind' (referring to incisions of joints with closure of the wound), 'which, in the earlier years of my work, were done with great risk, or, with a wise fear of the risk, were left undone, may now, with antiseptic help, be done with an almost complete safety.'

[1] See leading article in *British Medical Journal*, April 1880.
[2] MacCormac's *Antiseptic Surgery*.

CHAPTER XIX.

RESULTS OF ANTISEPTIC SURGERY (*continued*).

Compound fractures. Differences between those produced accidentally and those caused by the surgeon: treatment and after-progress of each class. Tables of accidental compound fractures treated by Mr. Lister: *thigh; leg; humerus; forearm; skull; summary of results.* Tables of compound fractures produced intentionally by Mr. Lister; *femur; leg; clavicle; humerus; forearm; lower jaw.* General summary of Mr. Lister's results. Mr. Spence's results. Other operations on bones by Mr. Lister. MacEwen's osteotomies: Volkmann: Max Schede: Bardenheuer: MacCormac. Combined aseptic results. Results by other methods: Volkmann and Fraenckel: Holmes: St. Thomas's Hospital. Reyher's results in war. Open method: Krönlein. Septic methods.

I NOW pass on to a second class of cases which are often followed by most serious consequences: I refer to compound fractures occurring accidentally or made by the surgeon.

Compound fractures produced accidentally and those made by the surgeon differ from each other in various important particulars. In the first class dust is as a rule introduced into the wound before the surgeon sees the case, and, therefore, the problem is to destroy the energy of this dust. Whether such an attempt is successful or not, must of course always be a matter of doubt; and hence the results are uncertain. Then, also, the violence is often very severe and complicated with other injuries or with shock, and in this way life may be lost from causes which could not be avoided by any method of wound treatment. On the other hand, in the second class of cases the surgeon has only the ordinary aseptic problem before him, and if he is justified in other cases in looking with certainty for good results, he ought to be equally justified here. He is also independent of the other injuries and shock which so often complicate accidental compound fractures, and, therefore, the mortality ought also to be less. If we remember