

union and a complete restoration of power. This has been done in a number of cases with perfect success, and I may refer to Eschenburg's thesis, published in 1877, for the history of these attempts and their results. I may quote two passages from this thesis which shew a striking contrast between the results of septic and aseptic surgery. The first is taken from Ravoth, who says: 'Selbstverständlich wird man die Sehnennaht vermeiden, wenn keine Hautwunde gleichzeitig vorhanden ist.' On the other hand, Küster writes as follows: 'Es ist nun eines der Hauptverdienste der antiseptischen Wundbehandlung dass sie den Kreis unserer operativen Indicationen wesentlich erweitert hat, dass sie dem Chirurgen mit ruhigem Gewissen und ohne die mindeste Besorgniss an eine Anzahl von Operationen zu gehen erlaubt, welche sonst entweder gar nicht, oder nur unter ganz besonders günstigen Bedingungen unternommen werden durften.' And among these operations are those of stitching ruptured tendons.

This is only one example of the numerous applications to which a method can be put which renders operations practically subcutaneous. Look also at all the operations for ununited and badly united fractures, and for deformities of bones, operations to aid the reduction of dislocations, more especially when of old standing, radical cure of hernia, and so on. These instances are so numerous and varied that I cannot detail them here, but, in the practice of the operating surgeon, cases are constantly occurring in which the advantages gained by means of the aseptic method are of the greatest importance.

While the scope of the operating surgeon is so much increased by the aseptic method, the cause of conservative surgery is also greatly advanced. I have at p. 442 shewn that in cases of disease of joints a cure may be obtained in a large proportion of instances, without resorting to any further operative procedure than the free incision of the diseased articulations. By this treatment not only is the limb retained without any shortening, but also there is frequently a considerable amount of movement in the articulation, a result of the greatest importance to the patient. In the treatment of compound fractures, also, there is much less necessity than formerly for amputation, either primary or secondary. This is hardly a

point which can be treated by statistics, but my own experience—and it is the same as that of others who have practised careful aseptic treatment, and a careful perusal of the cases in Chapter XIX. will demonstrate it—is, that the necessity for these mutilations is very much less than when other methods are employed. A limb must be very badly injured indeed before it is necessary to perform primary amputation: it must not be merely that a joint is opened, or that the bone is extensively comminuted or the soft parts badly lacerated: the questions really are, whether the part beyond will retain its vitality, whether if it does so it will be useful, and whether there is a fair probability of purifying the wound. If the last is probable the chance of recovery should be given, and if afterwards it is found that purification is not successful, and if otherwise the injury is one which, without aseptic management, would demand primary amputation, the operation can be performed in two or three days after the injury—as soon, in fact, as it becomes evident that aseptic treatment is impossible.<sup>1</sup> Again, where primary amputation is necessary it need not be performed above the injured parts, but, with the view of getting a longer limb, where that would be an advantage, bruised and even lacerated parts may be included in the stump; for inflammation will not occur in the flaps, and hence the sloughing which would otherwise take place is avoided. I have myself seen limbs amputated in the practice of septic or semi-antiseptic surgeons which I know could have been easily saved by aseptic management; and I have, on the other hand, known the surprise of surgeons when amputation has been performed through the bruised parts in order to get a longer stump or to save an important joint, and their expectation that the injured parts

<sup>1</sup> This statement may seem contrary to the well-known facts as to the dangers of secondary amputations, but here the case is different; for under ordinary circumstances the question of secondary amputation does not arise till it is found that there is danger to the patient if conservative treatment is persisted in. Here, however, I do not advise that one should wait till the patient is in a dangerous state; I merely say that attempts may be made to save limbs which would otherwise be certainly amputated, and that if it is found that fermentation has not been avoided, then the limb ought, in the majority of these severe cases, to be amputated as soon as it is evident that the attempt to purify the wound has failed, without waiting for the appearance of any constitutional symptoms.

would slough 'when inflammation came on.' But fortunately inflammation is not likely to come on if the wound has been properly treated.

I need not discuss this matter further. If one remembers that an incision, supposing it can be made aseptically, provided also that the wound is kept at rest and otherwise properly treated, is not followed by any local reaction nor by constitutional disturbance, one can readily realise how many little operations of convenience may be performed with benefit and increased usefulness to the patient. It may be argued against such operations of convenience that man is fallible, and that a failure of the method might prove a serious matter to the patient. This is to a certain extent true, but the chances of failure in experienced hands in any given case are very small indeed. The performance of such operations by those just learning the method cannot be too much discouraged. It is too much the fashion nowadays to begin aseptic work with some of these daring procedures, such as opening joints; but such operations, however simple they appear, ought not to be lightly undertaken; indeed they ought not to be attempted till one has had extensive experience in the aseptic treatment of wounds, and more especially of chronic abscesses.<sup>1</sup>

Experience is needed in aseptic work just as in every other department of surgery. Why does the student devote so much of his time to learning anatomy and to acquiring manual dexterity in the use of the knife? Simply in order that he may be able to operate with safety to the patient. Take the operation of ligature of an artery or lithotomy or any other great operation in surgery. When performed by an experienced surgeon it seems very simple and easy of performance, but the young operator finds that many difficulties have to be overcome and many little arts acquired before it can be done in the same way as by the experienced surgeon. One would never dream of allowing a man who had never handled a knife

<sup>1</sup> Surgeons are too apt, even without having had any experience of the aseptic method, at once to introduce modifications which generally are illogical and hurtful. Volkmann (*Lancet*, August 13, 1881) makes the following true remark on this point: 'Most of the unfavourable judgments,' says he, 'passed on this method are due to the fact that surgeons who have not yet learnt to experiment *with it* have already made *it the subject* of their experiments.'

before to commence with one of these operations on the living human body. It is just the same with aseptic surgery. For its proper practice are required a scientific training, and more especially, a training in experimental work with its consequent acquirement of patience and dexterity. Let the beginner commence its practice in simple wounds where but little harm will result from his failures, or, better still, let him try some experiments on fluids contained in flasks. Then, just as the operator feels his way to more serious operations, so the surgeon operating aseptically extends the application of his method; and just as the experienced operator may proceed with confidence to operations which in the hand of an inexperienced man would be very doubtful procedures, so the surgeon practising Listerism may with confidence in its protection perform operations which would otherwise be unjustifiable, such as many of the operations of convenience of which we have been speaking. He has then chiefly to consider whether the advantage to be derived from the operation is worth the inconveniences attending its performance. Of course if one has to deal with a large number of cases one cannot say that *all* of them will do well: in some one or other the experiment may fail. Where there is a large number of cases or a continuous run of successes the surgeon may become less particular than in any special case which he has determined to keep right, and an accident might occur. But we may fairly put the matter in this way: given any *single* case, say of incision into a joint, the surgeon may reckon with certainty that in *that particular instance* no harm will result from the operation. When, therefore, the surgeon undertakes one of these serious operations he should realise the dangers which are run and the means of avoiding them, and should devote his most careful attention to the case in question throughout the duration of the treatment. If this is done it is right to undertake such operations if their performance can increase the usefulness of the patient.

I have said that operations performed aseptically, where the wounds remain aseptic and where they are properly treated otherwise, are not followed by any local or constitutional disturbance, and I must now say a few words on this point. And

first with regard to the local progress of a wound treated aseptically.

Where the wound is treated aseptically by the method formerly described (where the drainage is efficient, where the stitches are not too tight, and where there is no other local cause of irritation, such as movement), no inflammation occurs; there is no swelling nor redness of the edges, as is so frequently the case in wounds treated otherwise. The skin around the wound remains as pale and as lax as it was when stitched up at the time of the operation; there is no evidence of reaction. Thus it comes that such wounds are quite painless, and their edges may be pressed and handled without occasioning the patient any uneasiness. Hence even after the most extensive operations the patient remains free from pain; indeed, the operation being performed under an anæsthetic, and there being no inflammation afterwards, the whole treatment from beginning to end is unattended by any suffering. Patients constantly express their astonishment that the pain which they perhaps most dreaded is absent; and this astonishment is the greater if the patient has been previously operated on and treated by the older methods.

Then, as the result of this absence of inflammation, the scar is linear and soon becomes hardly apparent. One or two surgeons have stated that the scars after wounds treated aseptically were conspicuous, and that therefore the method was unsuitable for wounds on exposed parts. This statement must, however, rest on some mistake—either protective has not been used or some other error has been committed; for my own experience, which is now very extensive, is, that an inconspicuous and linear scar is one of the most striking results of the treatment.

But not only is there absence of inflammation along the cut edges of the skin, it is also absent from the deeper parts of the wound. Thus there is no suppuration even where the deep structures are not absolutely in contact. The discharge from the drainage tube is purely serous and rapidly diminishes in amount so as to render the drain unnecessary in a very short time.

The importance of this absence of inflammation in the

deeper parts of the wound has been well shewn by the advantages gained by the application of the method to experiments on the lower animals. This is perhaps best illustrated by the experiments recently performed by Professor Gerald Yeo on the brains of monkeys.

In Dr. Ferrier's former experiments on the brains of monkeys for the purpose of investigating the function of the various parts of the brain, no attempt was made to keep the animals alive after the operation, because, as the result of experience, encephalitis was looked on as a certain consequence. The attempts which were made failed owing to the occurrence of encephalitis, with the exception, I think, of one animal which lived for some time. It was therefore deemed useless to attempt to preserve the animals, for the after effects of the injury done at the time of the operation were so complicated by the effects of the inflammation which succeeded, that results of any value could only be obtained from observations made at the time of the operation.

Lately, however (1878-80), Gerald Yeo has performed a number of these operations with aseptic precautions, and the results were extremely striking, and yielded very definite and valuable information. Twenty-six operations were done. In the first case great difficulty was found in retaining the dressings in position, and this animal tore off the dressings. It died in a short time of encephalitis, and was the only one out of the twenty-six in which inflammation occurred. Afterwards a very convenient and satisfactory mode of fixing the dressings was devised, and this accident did not happen again. In the other twenty-five cases no inflammation whatever occurred, as was confirmed on post-mortem examination of the animals which died shortly after the operation, or which were killed after a sufficient length of time had elapsed. As no inflammation occurred, the symptoms which were manifest after the operation were due to the lesion caused at the time, and thus valuable and definite facts were elicited. The gain to physiological observation indicated by these experiments cannot be over-estimated.

Of the twenty-six cases operated on seven died, the remainder surviving the operation permanently, without ever

presenting any symptoms except such as were due to the cerebral lesion. Of the seven deaths, one—the first case, in which the animal tore off his dressings—died of encephalitis; two died soon after the operation, one from chloroform and one from shock; one died six days after the operation from cerebral hemorrhage, and here there was no trace of inflammation; three died apparently from the intense cold of winter, one of these surviving the operation for thirteen days without a trace of inflammation. The wounds always healed by first intention, and the dressings were dispensed with in about a week.

As a result of this absence of inflammation in the deeper parts the scar does not become adherent but remains movable. This is of greatest importance after amputations where so much inconvenience is often caused by the adhesion of the scar to the divided end of the bone.

This absence of inflammation is also well seen after opening bursæ or hydroceles. Of late it has become very much the fashion in Germany to treat hydrocele by making an incision into the sac aseptically, stitching the tunica vaginalis to the skin by means of catgut, and inserting a drainage tube. No inflammation follows this procedure; the discharge becomes very slight, the drainage tube is removed in a day or two, the wound heals, and the hydrocele is cured. (The violent inflammation which follows incisions into hydroceles without aseptic precautions is well known.) Similar results are obtained in cases of bursitis, more especially of bursitis in connection with the sheaths of tendons. Incisions may be made into these, the fluid and solid material evacuated, and a drainage tube inserted, without fear of bad result, and with ultimate cure of the disease without any adhesion of tendons or other accidents which commonly follow such attempts.

In cases treated aseptically the wound heals as a rule much more rapidly than when it is treated otherwise; for where the edges can be brought into contact, healing by first intention is the rule, and even where there is a space left, this becomes filled up with blood clot which rapidly undergoes organisation.

The organisation of the blood clot is one of the most marked features in aseptic treatment. That blood clot may become

organised under certain circumstances is no new fact in medicine or surgery. We all know what happens in subcutaneous injuries. Blood clot and lymph are thrown out, they are gradually removed by absorption, or their place is taken to some extent by new tissue. In a simple fracture blood clot and lymph are present between the ends of the fractured bone. The effused material gradually disappears, and its place is taken by new tissue which ultimately ossifies. So after tenotomy; the space between the ends of the divided tendon is filled up with blood clot and lymph, and these become organised, and thus union again occurs. I need not bring forward other examples to show that blood clot in the living body, when protected by the skin, is gradually removed and its place taken by new tissue. In an open wound not treated aseptically the blood clot generally putrefies, and, as a result, breaks down, liquefies, and is washed away with the discharges; the surface of the wound granulates, and thus healing takes place. Where, however, a wound is aseptic, and where it is protected from other sources of irritation, such as the action of the antiseptic employed, the blood clot in it undergoes the same changes as it would under the skin, for the aseptic method renders wounds practically subcutaneous. Thus it does not break down but remains, filling up the wound with a solid brown mass; no granulations are seen, nothing but this brownish solid material. After some days, if this clot be scratched, it will be found to bleed, implying that new vessels have been formed in it, and on lifting up the edge of the clot a broad margin of cicatrix will often be found. If the clot is left undisturbed it frequently happens that after a time a superficial layer of toughish brownish material (old blood clot) may be peeled off and a complete scar found underneath. In some cases organisation occurs in the clot up to the level of the skin, and cicatrization spreads for some distance under the superficial unorganised layer, and then by-and-by the remaining central portion granulates, and we have a small superficial granulating sore which rapidly heals. The occurrence of granulation may in this case, I think, be due to the entrance of micrococci, which as we have seen sometimes occurs at a late period of the case. If there is much movement of the wound, or if no protective

be employed, this organisation may also be imperfectly or not at all observed. The organisation of blood clot has been demonstrated by several writers, and therefore I need not describe it minutely. The process essentially consists in this: young cells (whether white blood corpuscles or derived from the connective tissue, or both, is not yet determined) pass into the blood clot and gradually form fibrous tissue and vessels, which become connected with already existing ones, according to the various well-known methods of vascular formation. This process gradually extends to the surface till, after some days, as I have said, the blood clot bleeds when scratched. When organisation has sufficiently advanced, the epidermis spreads from the edge. The original blood clot takes no active part whatever in this process: it forms a mould in which the young cells develop, and is gradually either used up as pabulum for these cells, or removed by absorption. Here, just as when subcutaneous, the original blood clot disappears, and its place is filled by young tissue which developed *in* it not *from* it.

Sloughs are served in the same way. When a part under the skin dies, as is frequently the case where infarcts occur, it does not necessarily separate, it is gradually removed by absorption and its place is taken by new tissue. In the same way a slough of the skin if kept aseptic, and not imbued with carbolic acid or otherwise rendered irritating, does not separate but goes through the same process as the blood clot. The ordinary process of separation of sloughs is the occurrence of inflammation at the line of junction of the living with the dead tissue owing to the irritating character of the latter. (The slough causes inflammation because it is undergoing decomposition, for the products of decomposition are irritating.) But if the slough is not chemically irritating it does not cause this inflammation; it does not irritate the living parts around. Then the young cells pass into it as into the blood clot, and the whole process is exactly the same. Thus in lacerated wounds, if rendered aseptic and kept free from the irritation of the antiseptic employed, suppuration and sloughing do not occur: the raw surfaces and the interstices between the torn pieces of tissue become filled up with blood clot, the process of organisation just described goes on, and the whole

or the greater part of such a wound may heal without the occurrence of granulation, suppuration, or sloughing. A similar process has been observed in dead bone kept aseptic and not loose: the granulations gradually encroach upon it, and it soon entirely disappears by absorption.

The same process occurs in catgut introduced into a wound, whether for the purpose of ligaturing vessels or as a drain. The young cells gradually infiltrate the catgut from without inwards,<sup>1</sup> develop into fibrous tissue, remove the original catgut, and take its place. The ordinary process of separation of a silk or hempen ligature is, that fermentation occurs in the discharge which has soaked into it; the ligature thus irritates the walls of the vessel on each side of it; these granulate, and then suppuration takes place at the point of contact of the dead part included in the loop of the ligature with the living tissue. When suppuration has occurred all round on both sides the ligature is loose and may be pulled away. Secondary hemorrhage results when the portion of the vascular wall which has undergone degeneration into granulation tissue as a consequence of this process is not strong enough to resist the blood pressure. If, however, a hempen ligature be applied around a vessel and the wound be kept aseptic, the ligature remains chemically unirritating and may never separate at all. I have seen this well illustrated in a case of amputation where the surgeon operated aseptically, but tied the vessels with hempen ligature and left the ends hanging out: the ligatures would not separate but had to be broken short inside the wound. If now catgut be employed it is a material which is rapidly removed by the young cells which, as I have previously said, infiltrate it, and its place, as a ring round the vessel, is taken by this young tissue, which rapidly becomes organised and replaced by a ring of newly formed fibrous tissue. Thus where a catgut ligature is employed there is no ulceration of the

<sup>1</sup> The great advantage of the new catgut prepared with chromic acid is that the cells have a great difficulty in penetrating it, and therefore only erode its surface, and thus a stitch which has been left in the wound for some days, though narrower where it has been in the tissues, is still firm and free from cellular infiltration. With catgut prepared by the older method cells infiltrate it in a few days. With unprepared catgut the cell infiltration and the absorption of the thread is a very rapid process.