coats of the vessel, but after a time a ring of newly formed fibrous tissue will be found in the situation of the original ring of catgut. For these reasons also the risk of secondary hemorrhage is reduced to a minimum.

The facts with regard to the organisation of the catgut ligature were described by Mr. Lister in his first publication on the subject as long ago as 1869,[1] and as some of his statements have been misunderstood I may quote what he says. It has been supposed by some that he held that the dead blood clot and that the dead catgut became revivified in the tissues. Such an idea is of course utterly absurd and was never entertained nor expressed by Mr. Lister. Indeed, he speaks as follows as regards the blood clot, and applies his remarks to catgut: 'Thus the dead, but nutritious mass, had served as a *mould* for the formation of new tissue, the growing elements of which had *replaced* the materials absorbed, so as to constitute a living solid of the same form.' Mr. Lister tied the carotid artery of a calf in two places with a ligature of catgut (in one place with two ligatures), and a month later he killed the calf and examined the parts. He says: 'The two pieces of catgut which had been tied round the vessel at the distal part had become, as it were, fused together into a single fleshy band, inseparably blended with the external coat of the artery. The knots were nowhere discoverable, and the only indication of the end which had been left long at the time of the operation was the presence of a black speck' (the original material contained dark mineral impurities) 'here and there upon a delicate thread of cellular tissue in connection with the vessel. The cardiac ligature was in like manner continuous in structure with the arterial wall. The short ends had disappeared; but the massive knot was represented by a soft smooth lump, which appeared at first entirely homogenous, except that it was speckled with dark particles as before referred to. On section, however, I discovered in the interior of the mass, and lying close to the wall of the artery, a small residual portion of the original knot, of comparatively firm consistence, and with the threefold twisted character of the cord plainly visible. It was quite distinct from the living tissue, so that it could be readily picked

[1] *Lancet*, April 3, 1869.

out from its bed with a pair of needles.' Here almost all the original catgut had been removed, but it had served as a mould for the development of new tissue which had taken its place, and which retained the form of the mould in which it had grown. Mr. Lister describes the microscopical appearances as follows: 'A bit of the residue of the peritoneal thread, having been teazed out with needles in a drop of water, presented, like a fresh piece of peritoneum, the wavy bundles of parallel fibres characteristic of perfectly developed fibrous tissue. Adhering to the surface of the remnant of the ligature was some soft opaque material, readily washed off with water, consisting of corpuscles of different forms, most of them caudate or fibro-plastic, but some spherical, though not resembling those of pus; and here and there fragments of the original peritoneal tissue, affected more or less with interstitial cell-development. At a short distance from the remains of the old thread, the fleshy material which had been formed at its expense proved to be a most beautiful example of fibro-plastic structure, the coarse fibres which mainly constituted it being composed of very large elongated cells, often containing several nuclei, and presenting in their course branchings and thickenings of various forms. Here and there were some fibres more perfectly formed, and also cells of a more rudimentary character. Again, the band which had resulted from the organisation of the two fine threads of catgut, which, from the smallness of their bulk, had no doubt vanished early, having had longer time to perfect its structure, was a comparatively well developed form of fibrous tissue, consisting of coarse fibres rather than of elongated cells, being thus intermediate between the merely fibro-plastic material of more recent growth and the completed texture of the original thread.'

A number of writers have described the changes which blood clot and portions of dead tissue undergo in the process of organisation. One of the most interesting and thorough investigations on this subject has been made by Dr. H. Tillmanns of Leipzig.[1] Tillmanns took portions of the liver, kidney, spleen,

[1] Experimentelle und anatomische Untersuchungen über Wunden der Leber und Niere. Ein Beitrag zur Lehre von der antiseptischen Wundheilung. Virchow's *Archiv*. Bd. 78, 1879.

and lungs of rabbits, and hardened them in absolute alcohol for one to three weeks or longer. Pieces of these hardened dead tissues were then introduced with aseptic precautions into the peritoneal cavity of rabbits (in each case several pieces were used); after some days the animals were killed and the state of matters investigated. Twenty animals were experimented on, and into their peritoneal cavities about 100 portions of tissue were introduced. The animals did not appear the worse for the operation; the temperature remained normal, and they seemed well. Of these twenty animals only two died, both of acute peritonitis: in one case an error was committed in the treatment, the stitches were removed too early, and the intestines protruded: in the other case the animal was suffering before the operation from chronic peritonitis which afterwards became acute. When the animals were killed early, in a day or two after the operation, the masses of tissue were found to be adherent to some part of the peritoneum, and sometimes two pieces of tissue were attached to one another. Where fourteen days or more were allowed to elapse, the portions of tissue were found firmly adherent and much diminished in size, evidently undergoing absorption; in some places there was only a thick layer of new material containing a pulpy mass in its interior. In one animal into whose abdominal cavity a whole kidney had been introduced, and which was allowed to live for forty-seven days, the kidney had entirely disappeared; the only thing noticeable was that at one part of the omentum there was a thickish tough spot, where probably the absorbed kidney had been attached. On investigating the process microscopically the following were briefly the appearances found: After twenty-four hours the mass of tissue is, as I have just said, adherent to the peritoneum and surrounded by a layer of soft new material—lymph. Any defects which existed in the margin of the specimen are filled up with this soft mass. This new material when examined is found to be composed of countless numbers of cells, which Tillmanns holds to be white blood corpuscles. If two pieces of dead tissue lie close to each other, they become adherent to each other by means of this material. If these tissues are examined at a later period, say forty-eight or seventy-two hours after their introduction,

these cells are found to have increased in number and to be no longer confined to the outside of the organ, but to have penetrated into it where possible, forming, as Tillmanns puts it, streets and pathways of cells through the tissue. Thus, for example, in the case of the liver these cells penetrate in the first instance along the streaks of connective tissue which lie between the lobules, entering first those channels which are largest but gradually spreading along the smaller ones. At this time the cells have already begun to develop to higher tissue, and not merely round cells, but also elongated spindle-shaped cells undergoing further development, are found. Fig. 39, Plate V., represents this: to the right is seen the old liver cells, and to the left the new cells which have penetrated along the interlobular connective tissue; at the upper part these cells have already become spindle-shaped. This process gradually goes on, the young cells penetrate more and more among the dead materials, which gradually disappear by absorption, their place being taken by this young tissue which has come from without. This tissue rapidly undergoes further development into fibrous tissue, vessels, &c., according to the well-known processes (see fig. 40, Plate V.). The contraction of this young connective tissue and the further changes which it undergoes lead to the disappearance of the original mass and the formation of a cicatrix at its site, which also, as time goes on, tends to dwindle and disappear.

Thus the replacement of blood clot, sloughs, and other dead tissues, in the living body by new material—their organisation, as it is commonly called—is no longer a fact resting on clinical experience alone, but is a process which has been traced step by step under the microscope. What at first sight seems remarkable, what is certainly something new, is, that this process occurs in an open wound. But when the whole facts are carefully considered, it will be seen that this fact is only one which might have been expected, and that it is quite in accordance with well-known facts in pathology.

While there is this absence of local disturbance in wounds treated aseptically, the constitutional state of the patient remains good; in fact, if he has not lost much blood during the

operation, or if the operation has not caused shock, he is, on recovery from the effects of the chloroform, practically as well as before. His appetite is perfect, and I may say here that after operations performed aseptically there is no reduction of diet even for a few days; an hospital patient remains on full diet, and a private patient may have anything he fancies provided it is wholesome, and the more nutritious the food the better. Indeed, after the opening of a psoas abscess, or after an operation which rids the patient of some depressing disease, such as a carious joint, the appetite which was previously very imperfect returns in a few days, and hunger becomes the

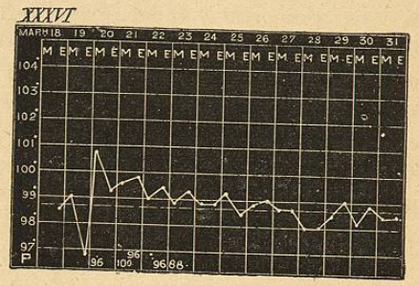

FIG. 80.—TEMPERATURE CHART.

Temperature chart from a case of MacEwen's operation for double genu valgum (Case 69, p. 488).

patient's chief trouble. At the same time there is no fever, as so frequently occurs after operations treated otherwise. I do not propose to discuss here the subject of temperature after operations; to do so would require much space, and our knowledge of the origin and regulation of temperature changes in the living body is as yet so imperfect that we could not come to any definite conclusions. I shall therefore content myself with referring to the following facts.

After an operation performed aseptically, and in which there is no cause of elevation of temperature, such as tension, the temperature remains normal; or if the operation has been at all extensive, the following changes are observed, of which Chart XXXVI., fig. 78 (Case 69, p. 488), is a very good example. In this case both femora were divided, *i.e.* a compound fracture of each femur was made, on the same day: the temperature previous to the operation was 99° F.: on the evening of the

operation it had fallen to 96·8°: on the following morning it was 100·6°, and then it again rapidly fell to the normal, being on the same evening 99·3°. As a rule the temperature after operations performed aseptically resembles this example: the temperature is below the normal on the evening of the operation, it then rises to or above 100°, reaching its highest point on the following morning or evening, and then rapidly falls to the normal line again. In some cases before reaching the normal it fluctuates for a day or two between 99° and 100°, but this fluctuation is not within the range of fever temperature but within the normal range.[1] It is very seldom that the pulse rises in equal proportion, indeed it generally remains normal.

This normal[2] temperature may be disturbed for various reasons, but especially when tension and retention of secretions occur. The elevation of temperature which follows imperfect drainage is often very marked. Among the cases narrated in detail there is no good example of elevation of temperature from tension: I may therefore quote the following instance. A little boy had an unreduced dislocation backwards of the bones of the forearm of six weeks' standing. On December 9, 1876, Mr. Lister cut down on each side of the joint, opened it, and succeeded, after detaching the muscles from the condyles of the humerus, in reducing the dislocation. The parts were very tense after reduction, and the primary rise of temperature reached 101° on the day following the operation, and remained at that level for thirty-six hours; it then fell rapidly as usual. On December 14th Mr. Lister moved the joint for the first time. That evening there was profuse hemorrhage, which ceased on removing the dressing. A fresh dressing was applied, but the hemorrhage went on into the limb, which was next day very much swollen and distended with blood. The temperature rose rapidly and continuously till it reached 104·4°. On December 16th incisions were made into the arm to evacuate the blood

[1] It has been pointed out by Wunderlich that after disturbance of the temperature the curve often fluctuates for a day or two before regaining the normal.

[2] Mere elevation of temperature without other symptoms cannot be called fever. Fever is indicated by a combination of symptoms, and an elevated temperature is only one, though the most striking, feature of the febrile state.

clots; on the following day the temperature began to fall, and on the morning of the 18th was 100·8°. After some oscillations about this height it rapidly fell to normal. Here in the first instance, coinciding with tension of the parts after the operation, the primary rise reached 101°, and did not fall at once, but remained for some hours at that height. Then it fell; but the parts became greatly distended with blood, there was great tension, and coincidently with this the temperature rose rapidly and to a considerable height, and again fell when the tension was got rid of. The pulse at the same time increased in rapidity, being on one occasion 144.

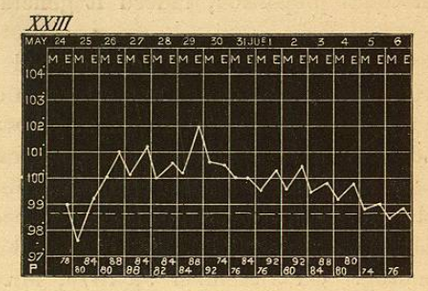

FIG. 81.—TEMPERATURE FROM A CASE OF COMPOUND FRACTURE, IN WHICH THERE WAS GREAT DIFFICULTY IN RETAINING THE FRAGMENTS IN POSITION (CASE 27, P. 472).

Why it is that the accumulation of discharges and the consequent tension should be accompanied by rise of temperature, often very rapid and high, is a very debateable question, and one which can hardly as yet receive an answer. At first the impression was, that this rise of temperature was due simply to the effects of the tension on the nervous system; that it was, in fact, a nervous phenomenon. There can be no doubt that several instances of elevation of temperature in children and hysterical women after operation are in some way or other reflex phenomena. Thus in a child the presence of a tight stitch may be accompanied by a rise of temperature, which subsides as soon as the offending cause is removed. Probably this is the reason for the rise of temperature in Case 27, p. 472 (see fig. 79). In this case great difficulty was experienced in keeping the upper fragment in position and there was therefore

constant disturbance of the parts. At the same time, it must be observed that the pulse rate had not increased in rapidity in proportion, and the patient did not feel out of sorts; with the exception of the elevated temperature there was no other symptom of fever. Here there was no fermentation in the wound and no retention of discharges, and therefore it seems probable that it was a nervous phenomenon. On the other hand, there are cases in which there may be great tension, as after subcutaneous bruises, or local disturbance of the parts as in some forms of joint disease, without an elevation of temperature at all corresponding to that which occurs when the discharges of wounds are retained. And also, the weight of evidence derived from experiments on animals seems to go against the view, that mere disturbance of the nerves of a part is a frequent or probable cause of the marked elevation of temperature which sometimes occurs in cases where there is retention of discharge. Indeed, according to Wunderlich,[1] the application of external irritants has the effect of lowering the general temperature rather than of raising it, and the same author states that Heidenhain has found that irritation of sensory nerves constantly and suddenly lowers the temperature, except after division of the medulla oblongata from the spinal cord or when fever is present. On the other hand, it has been demonstrated that the products of inflammation (the serum of pus, &c.), when introduced into a healthy animal, cause a rapid rise of temperature, which soon passes off if no further injections are made.[2] It is thus quite possible, that when discharges are retained by the blocking of a drainage tube or for any other reason, the fever which follows is due, at least in part, to absorption into the circulation of the retained materials. (In most cases of elevation of temperature from tension the pulse is

[1] *On Temperature in Disease.*

[2] That the products of inflammation should cause fever is not surprising. For, in inflammation, not only do liquor sanguinus and corpuscles pass out of the blood-vessels, but the tissue cells, which are constantly taking material from the blood and altering its constitution—in fact acting as ferments—are, I think there can be no doubt, stimulated to increased activity; their function is also probably perverted, and the changes which they produce in the nutritive materials with which they are supplied may be different from those which occur in health, and may lead to the formation of substances which, when absorbed into the circulation, cause fever.

correspondingly quick, and the patient feels ill—in fact, he has fever. On the contrary, where it is a merely nervous phenomenon, I think, though perhaps I may be hasty in this conclusion, that the pulse does not increase in rapidity to a corresponding degree.) This is, to my mind, the most probable explanation of the high temperature which occurs after ovariotomy in Mr. Thornton's practice.[1] Mr. Thornton does not drain the peritoneal cavity, but stitches it closely up. The consequence is, that the fluid effused from the divided pedicle or from other injured parts is absorbed by the peritoneum, and although Mr. Thornton's wounds are aseptic, yet he has fever in many cases. This fever, however, is not fatal, for as the pedicle heals the discharge diminishes and the temperature falls. Here tension cannot be at work; and further, surgeons who drain the peritoneal cavity, and who at the same time treat their cases thoroughly aseptically, do not meet with this high temperature. Which of these two is the cause of the elevated temperature in tension, or whether both may not play a part, are questions which cannot as yet be definitively settled.

Though tension is the most important cause of elevation of temperature in aseptic cases, there are other minor causes, such as retention of fæces, the occurrence of menstruation, &c.

What the meaning of the transitory rise of temperature after aseptic operations is, it would be difficult to say. In some cases no doubt, where much blood has been lost, it is merely the rise which normally occurs in these circumstances. It seems to be established in the case of the lower animals, that after blood-letting, though the temperature may fall in the first instance, it generally rises to a considerably higher level than that at which it stood before the blood was taken. Similar facts have been observed after blood-letting in man. This rise of temperature after loss of blood is probably the explanation of the curve in Case 16, p. 430 (see fig. 80). Here the ankle joint of a hæmophilious child was opened and hemorrhage occurred from the cut surface on various occasions during the following three days; there was no fermentation of the discharge and no tension. Nevertheless loss of blood cannot always be the cause, for what we may call the 'aseptic curve' occurs in

[1] *Medico-Chirurgical Transactions*, 1881.

cases where little or no blood is lost. In aseptic cases it is probably a nervous phenomenon, more especially as the pulse rate in no way corresponds. I cannot discuss this matter further, as much space would be required, and we do not yet know enough about the origin and regulation of the temperature of the body. One fact is, however, apparent, that besides the ordinarily recognised elevations of temperature after operations *there is a transitory elevation which occurs soon after the operation and as an immediate result of it*, and which can be readily recognised when all other disturbing causes are excluded. I have not met with any instance of the high temperature which Volkmann has after a large proportion of his operations, and which he has termed 'aseptic fever,' and I do not understand it at all.

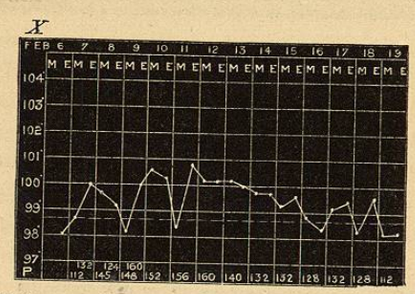

FIG. 82.—TEMPERATURE CHART FROM A CASE WHERE THE ANKLE JOINT WAS INCISED IN A HÆMOPHILIOUS PATIENT, AND WHERE HEMORRHAGE RECURRED SEVERAL TIMES (CASE 16, P. 430).

If one compares the temperature in cases which are treated aseptically with that of those which are not, the contrast will be found to be very marked. I do not of course by any means intend to say, that the temperature is always high after operations which are not treated aseptically; far from it. Many wounds not treated aseptically heal by first intention, and in these there is, of course, no elevation of temperature or merely the 'aseptic curve.' Further, in many wounds in which fermentation of the discharges occurs the discharge is drained off and but little can be absorbed; and in other cases the wounds are small, or the conditions for absorption are not favourable. In these instances there will often be no marked elevation of temperature. But in a great number of severe

operations treated by the ordinary methods of cleanliness, as described at p. 542, there is marked elevation of temperature—traumatic fever—and in some cases this passes into a septicæmic or pyæmic temperature. Look at the temperature chart of Case 22, p. 434 (see fig. 81), and contrast it with that of Case

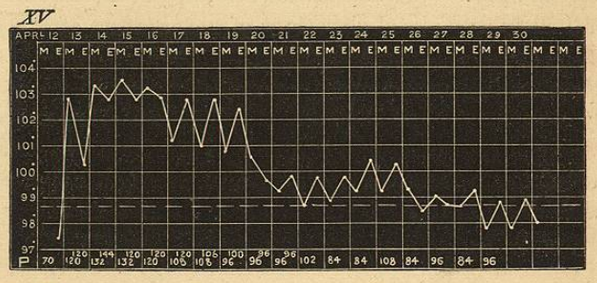

FIG. 83.—TEMPERATURE CHART FROM THE CASE OF REMOVAL OF LOOSE CARTILAGE FROM THE KNEE-JOINT IN WHICH FERMENTATION OCCURRED (SEE CASE 22, P. 434).

15, p. 430 (see fig. 82). In the former case we have a small operation performed on a joint, but fermentation occurred in that joint. As a result we have a severe attack of fever. (Here it is interesting to note that there was no *putrefactive*

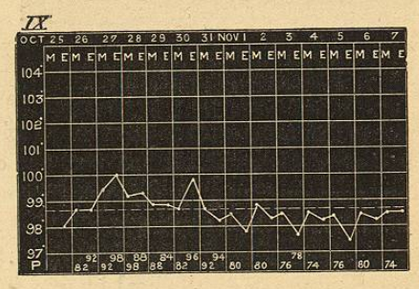

FIG. 84.—TEMPERATURE CHART FROM A CASE OF OPERATION FOR RECENT FRACTURE OF THE PATELLA (CASE 15, P. 430).

fermentation.) In the latter case we have an operation of greater severity, but the causes of fermentation were excluded, and there is a correspondingly normal temperature. The difference between aseptic and septic temperatures is also often very marked after serious injuries or operations such as compound fractures. Contrast the temperatures in the cases of compound fracture. In eight cases of compound fracture produced accidentally putrefaction occurred. In four of these (Cases 14, 17, 20, 29) it is stated that the temperature ranged for several days after the injury between 100° and 103° or even higher. In one case (No. 4), though there is no statement as to the temperature, there can be no doubt, from the description of the case, that it was high. The temperature charts of three cases are given here, and in two of them (Cases 12, 26) it will be seen that traumatic fever was present, while in only one (No. 40) was there a normal temperature. In one case (No. 58), in which putrefaction occurred after operation, amputation was performed chiefly because the temperature was rising rapidly; and in another, of which the chart is given (Case 68, Chart 35), there is little doubt but that some form of organism got in, and here also we have a high temperature. Contrast these with the highest temperatures in cases of compound fracture produced by the surgeon and treated aseptically. The difference is so marked that I need not dwell on it.[1]

If we contrast the local and constitutional course of wounds which are not kept aseptic with the foregoing description of aseptic wounds, we see a very marked difference.

Look at the cases treated with antiseptics but not aseptically in the foregoing tables. In one case of wound of joint (No. 3) putrefaction was not avoided, and the case therefore became, as I have previously pointed out, one treated with antiseptics but not aseptically. Here fever and inflammation set in, and threatened to be so serious in their results that it was considered advisable to amputate. In one case of operation on a healthy joint (No. 22) the wound was not kept aseptic, and thus the case became one treated with antiseptics but not aseptically. (It was dressed throughout with the ordinary gauze dressing,

[1] With regard to the temperature charts published in this work, I wish to state that they have not been in any way selected; I publish all the temperature charts which I have been able to obtain. Till 1877 temperature charts were not in use in Mr. Lister's wards; the temperatures were noted on a card, and it was seldom that the clerk took the trouble to copy them into the books, unless, indeed, the case was a serious one, and the temperature high. Hence the average of the temperatures in the charts is probably higher than it ought to be.