EXCISION OF THE KNEE-JOINT AS A METHOD OF TREATMENT FOR SEVERE INFECTIONS.

BY

COLONEL ANDREW FULLERTON, C.M.G., A.M.S.,
M.D., M.Ch., F.R.C.S.IREL.,
CONSULTING SURGEON, BRITISH EXPEDITIONARY FORCE.

THE treatment of wounds of the knee-joint produced in warfare has received a good deal of attention of late, and much progress has been made. Colonel Gray and his followers have done much to perfect what may be called the "closed" method. Excision of septic wounds into the joint and removal of foreign bodies, if present, followed by complete suture of the synovial membrane, is now the almost universal practice among British surgeons in France. The results of drainage of the joint by tubes, as we used to see them in earlier days, were disastrous. Old traditions die hard, and officers fresh from England are still inclined to adopt the system of drainage recommended in textbooks of surgery. This is to open the suprapatellar pouch or incise on either side of the patella and insert drainage tubes in cases of infection of the joint.

Our experience has been that quite a fair proportion of distended knee-joints containing actual pus, from which micro-organisms may be grown, settle down and recover

FIG. 1.—Vertical transverse section through joint. *a*, Adductor magnus muscle; *b*, biceps muscle; *c*, inner head of gastrocnemius muscle; *d*, inner condyle of femur; *e*, external condyle of femur; *f*, joint cavity; *g*, semilunar cartilage; *h*, tendon of semimembranosus muscle; *i*, tibia; *j*, superior tibio-fibula joint; *k*, head of fibula.

movement after aspiration, aspiration and irrigation, or aspiration followed by the injection of such substances as glycerine and formalin (a few cubic centimetres of a 2 per cent. solution at least forty-eight hours old), or ether. In a certain proportion of cases, however, this line of treatment fails. The joint fills up again and again with pus, the cells of which perhaps show diminishing instead of increasing phagocytosis. Pain in the joint increases, the temperature rises, the pulse increases in frequency, and the general condition of the patient becomes such that it is obvious that something radical must be done to save his life if not his limb.

One is often asked why the old method of drainage by inserting tubes into the joint is not to be adopted; it is surely one of the canons of surgery that pus must be "let out" and an infected joint drained. For reply we point to our unfavourable experience of its results in this war. The introduction of drainage tubes favours the entrance of microbes other than the original offenders, and a mixed infection is only too certain to result. Lieutenant-Colonel Elder, who has taken a great interest in this branch of work, invited me to follow with him a series of cases of wounds of the knee-joint. In eleven cases tubes had been introduced into the joint shortly after injury and before arrival at his hospital. Three of these cases required amputation to save life, five were evacuated to England

with total disorganization of the joint and sinuses still discharging, and three gave promise of slight movement. These results are not encouraging. Similar results, or worse, have been common in the experience of other surgeons in France.

The difficulties one has to contend with in dealing with an infected knee-joint will be apparent when the anatomy of the articulation is studied. I have elsewhere¹ illustrated by drawings of sections through the joint at different levels and in several planes the various recesses, diverticula, and communications with bursae which militate against satisfactory drainage. These show conclusively, I think, that the best attempts at drainage must be inefficient. It is, in fact, impossible to drain the knee-joint. Let us consider the methods formerly adopted. Incisions were made on either side of the patella or into the suprapatellar pouch, which is in communication, as a rule, with a further extension in the form of a bursa—the suprapatellar bursa (Fig. 2). These parts appear to be the situations most requiring drainage on account of their obvious swelling and tenderness. They only receive, however, the overflow from the joint proper, which is just as tensely filled, though this is not so obvious on account of the surrounding resistant structures. The pockets between and around the cruciate ligaments in the intercondyloid fossa (Figs. 1, 2) are left undrained. These cannot be reached for dependent drainage except through the popliteal space, the posterior ligament, and a thick layer of tissue, which includes the

FIG. 2.—Vertical antero-posterior section through middle of joint. *a*, Suprapatellar bursa; *b*, semimembranosus muscle; *c*, patella; *d*, joint cavity; *e*, popliteal vein; *f*, prepatellar bursa; *g*, peroneal nerve; *h*, patellar ligament; *i*, anterior cruciate ligament; *j*, posterior cruciate ligament; *k*, bursa over tubercle of tibia; *l*, gastrocnemius muscle; *m*, popliteal artery; *n*, soleus muscle; *o*, popliteus muscle.

posterior cruciate ligament (Fig. 2). The pouches surrounding the condyles of the femur posteriorly, the interstices between the semilunar fibro-cartilages the lateral ligaments and the bones (Fig. 1), and the tube of synovial membrane which accompanies the popliteus tendon as it passes over the external semilunar cartilage and the superior tibio-fibular joint (sometimes communicating with the latter) (Fig. 4) are left undrained by lateral incisions in the anterior part of the synovial cavity. Similarly, the bursa under the inner head of the gastrocnemius, which so frequently communicates with the joint (Fig. 3), is left undisturbed. We have seen a few cases in which the suprapatellar portion, or even the whole of the anterior part of the joint, has become shut off from the main cavity. In these, no doubt, anterior drainage might be sufficient, but such cases are rare. Attempts have been made to drain the pouches behind the femoral condyles by introducing tubes through incisions in the capsule posteriorly. The latter is, however, so closely applied to the articular surfaces (Figs. 3, 4) that the tubes cannot be made to penetrate for any distance into the joint.

At any rate, the attempts made in this direction have failed. We have watched the career of patients treated by tubes placed in every conceivable corner of the joint. The results in those that have escaped with their lives

have been a stiff, swollen, painful limb, with sinuses discharging for weeks or months. We cannot believe that the final results, should the limb ultimately be saved, will compare at all favourably with those following a successful excision. Some of these joints that have healed up after a long and tedious convalescence have again lighted up after some slight movement or some attempt on the part of the surgeon to remedy deformity. This is probably due to the presence of residual septic material which lies dormant in some of the pockets referred to above.

In some quarters it has been the custom in bad cases of infection to turn back the patella, divide the lateral and cruciate ligaments, remove the semilunar fibro-cartilages and acutely flex the joint. When sepsis has been controlled—a process which may take six weeks or longer—the limb is straightened out, or a late excision is performed. The flexed position is extremely irksome for the patient, and it is difficult to arrange proper splinting to keep the parts at rest. Besides, this method fails fully to expose and drain the posterior part of the joint. The control of sepsis may take weeks to accomplish, and at the end of that time extension of the limb or excision may wake up the recently allayed infection. If excision is not done, the articular cartilages must be shed or removed if a firmly ankylosed knee is to be obtained. In addition to this, the intercondyloid and other recesses will probably be filled with granulation tissue, which must organize into badly-nourished scar tissue, in the meshes of which one may imagine imprisoned nests of infective

FIG. 3.—Vertical antero-posterior section passing through inner condyle. *a*, Semimembranosus muscle; *b*, quadriceps muscle; *c*, inner condyle of femur; *d*, tendon of semitendinosus muscle; *e*, bursa under gastrocnemius; *f*, cavity of joint; *g*, patellar ligament; *h*, internal semilunar cartilage; *i*, tibia; *j*, inner head of gastrocnemius muscle.

material ready to declare their presence on the slightest provocation.

EXCISION WITH WIDE SEPARATION.

For the past six months or so in the hospitals of the base to which I am attached as consultant I have been advocating excision of the bones with wide separation of the ends as a method of dealing with certain knee-joints in which conservative methods have failed. This procedure is carried out for the purpose of drainage, even if the bone ends have not been injured.

The operation is conducted as follows:

Lateral incisions are carried from above down, commencing two inches or more above the level of the upper border of the patella, and extending to the level of the tubercle of the tibia. These incisions are made far back so as to be on the same plane as the posterior ligament. They are joined at the level of the tubercle of the tibia by one which severs the ligamentum patellae. The flap thus included is turned back. The condyles of the femur are removed just above their cartilaginous surfaces, and a thin strip, removing the articular cartilage, is taken from the upper end of the tibia. The total length of bone removed is just under two inches. The finger explores the posterior surface of the space left, and the communication with the bursa under the inner head of the gastrocnemius (Fig. 3) is opened up or the bursa removed altogether. The popliteus

extension of the synovial membrane is cut across with the tendon, but is not further interfered with. If an attempt is made to dissect this further, the superior tibio-fibular joint may be opened and infected (Fig. 4). The open end of the sheath may be left to drain. In some of our cases the suprapatellar extension with the bursa in continuation of it (Fig. 2) has been removed. I am not sure whether this is desirable, as by doing so the fascial planes of the thigh may be opened up and infected. Further experience is required on this point. The suprapatellar pouch (Fig. 2) can be drained much better if the patella is removed, and this is always done.

The limb is placed on a Thomas's knee splint, and wide separation of the sawn ends of the bones is obtained (Fig. 5) by fixed extension in the manner suggested by Lieutenant-Colonel Robert Jones, of Liverpool, for fractured femur. A few stitches anchor the flap at the lower end, but the lateral margins are left open for drainage. Slings attached to the bars of the splint support the inferior surface of the calf and thigh, and maintain the proper alignment. The suprapatellar pouch and the cavity left between the bones may be packed around Carrel's tubes or drained in the ordinary way. Subsequent treatment is on the same lines as that of compound fracture of the femur.

The ends of the bones must not be allowed to approximate until sepsis has been completely controlled, and then very gradually.

If attention is not paid to this point, recrudescence of

FIG. 4.—Vertical antero-posterior section passing through outer condyle. *a*, Quadriceps muscle; *b*, biceps muscle; *c*, patella; *d*, peroneal nerve; *e*, femur; *f*, joint cavity; *g*, patellar ligament; *h*, external semilunar cartilage; *i*, tendon of popliteus; *j*, gastrocnemius muscle; *k*, tibia; *l*, fibula; *m*, soleus muscle; *n*, tibialis anticus muscle; *o*, anterior tibial vessels.

sepsis is very liable to occur, and the advantages of the operation will disappear. It is hoped that the thin layer of granulation tissue which forms over the ends of the bones will in time be converted into firm osseous tissue. Should firm union fail to take place, it would be a simple matter, when all the wounds have healed, and there is no longer danger of stirring up latent infection, to trim the bone ends and bring them together as in the ordinary excision of civil practice.

Advantages of Operation with Wide Separation.

Let us now consider what we have accomplished by this operation.

1. All obstacles to drainage have been removed. The pouches in the intercondyloid fossa, the extensions under the semilunar cartilages, the pouches behind the condyles, the bursa under the inner head of the gastrocnemius and the extension of the synovial membrane along the popliteus tendon have all been dealt with by one sweep (Figs. 1, 2, 3 and 4). In fact, every pocket has been removed except the suprapatellar extension, and this must be thoroughly opened up and drained.

2. We are now dealing with what is, in effect, a compound fracture with broad bony surfaces, without comminution, easily replaced in position when desired, without laceration of muscle, and with the best possible drainage.

The posterior ligament acts as a barrier against pus tracking into the popliteal space and the position of the lateral incisions allows of fluid being drained off at the lowest level of the cavity.

3. The risk of residual pockets remaining after ankylosis is reduced to a minimum.

4. It is an advantage with a stiff knee that the leg should be shorter than its fellow of the opposite side. This allows the foot to swing free of the ground in walking without the toes hitching with every step. In an ordinary case the shortening is just under two inches and part of this can be restored, if necessary, by raising the heel of the boot on the affected side. A little shortening is, as I have said, an advantage.

Objections to the Operation.

I have pointed out some of the advantages of the operation. It is necessary now to meet, on the other hand, some of the objections that have been urged against it.

1. *Shock.*—I am not satisfied that the shock of excision in capable hands is more than that of an amputation through the thigh. We have in some cases completed the operation in half an hour. No great nerves are cut, and bleeding from the soft parts is comparatively easy to control. Access to the ends of the bones for removal by the saw is facilitated by the extensive flap. If amputation is to follow, through failure of excision to control the sepsis, the risks are, of course, greater to the patient. The possibility of this increased risk is a matter for careful consideration in deciding on excision in the first instance.

2. *Oozing from the Sawed Surfaces of the Bones.*—This has occurred in two or three cases only, to my knowledge, and can, I feel certain, be controlled by packing. I have not yet dared to use aseptic wax to seal the bleeding points in the bone, for fear of damming back exudation which may be septic, but this is a method to be thought of should oozing be troublesome and confined to one or two points.

3. *Exposure of Freshly-sawn Ends of Bone to Infection.*—This is a theoretical objection which does not hold good in practice. The section is clean, the bone is not comminuted or badly bruised, and drainage is so good that retention is unlikely to occur. Osteomyelitis, starting from the cut surfaces, has not been a feature in our cases.

4. *Protracted Convalescence.*—It will be admitted at once that greater demands will be made on the patient's resources after excision than after amputation. The earlier days or weeks of his convalescence will be attended with some anxiety and trouble, and it may be six months or more before he is able to move about by himself without mechanical support. A judicial survey of all the circumstances connected with the patient's state of health, his social position, and his employment after the war, will help to guide the surgeon as to what effect the objections under this and the following heading should have upon his course of action. If he is in doubt of the ability of the patient to stand the strain of the greater demands that will undoubtedly be made on his reserve of strength by excision, he ought to amputate rather than excise. The patient, not his leg, must be given the benefit of the doubt.

5. *Stiff Knee-joint.*—The high state of perfection to which artificial limbs have been brought has given rise to the opinion in some minds that a light, comfortable, efficient, and well-shaped artificial limb, with a movable knee-joint, is preferable to a stiff leg. It must be admitted that a patient with such may pass muster as a sound man. There is, however, always the sentimental objection, and few patients, if given their choice, would choose the mechanical device, however perfect, in preference to their own leg, even with a stiff knee-joint. Artificial limbs must always remain complicated and liable to get out of order, necessitating the attention of an instrument maker who may be continents away, and unless the patient has the good fortune to possess a spare one, he may have to go without during the time his artificial limb is in the repair shop. Very few men in humble circumstances will be able to afford the luxury of a succession of highly complicated appliances, and while public funds for such

may be available during the excitement of war and for some time after, it is not unlikely that the final successor of the shapely artificial limb may be the less pretentious pin and bucket. It is wonderful how little real disability a stiff knee gives rise to after the patient gets used to it.

RESULTS.

It is too early yet to speak of the final results. We are concerned in the meantime with the problem of combating sepsis and saving life. Whether the final results will repay the trouble spent in saving the leg remains to be seen. We have done over sixty cases at this base and have only had news of the fate of a very few. The first case done on these lines was under the care of Captain McDonnell at a base hospital. The patient was wounded on March 18th, 1916, by a rifle bullet which entered posteriorly through the popliteal space on the right side, and lodged in the femur at the intercondyloid fossa. X ray showed fracture of the internal condyle. The entrance wound was septic when I saw him on the 20th. The joint was distended, tense, and painful. Pulse 88; temperature 101.4°. There was no injury to the great vessels and nerves in the popliteal space. A large flap

FIG. 5.—Skiagram showing the amount of bone removed, and the position in which the ends of the bones should be maintained until sepsis is controlled. The section of the femur is a little too oblique.

was turned up in order to examine fully the damage inflicted. The bullet was found deeply embedded in the intercondyloid notch, with some comminution at the point of impact, and a transverse fracture separated the internal condyle from the rest of the bone. The cruciate ligaments were torn, and the joint was filled with blood clot. Having regard to the obvious sepsis, the comminution of the femur, and the injury to the cruciate ligaments, we decided that the chances of the patient having a movable joint, even if he escaped a violent septic arthritis, were very slight. We discussed the question of amputation, but finally determined to try excision with wide separation of the bones for drainage. This was immediately carried out. The temperature rose to 102.4° on the evening following the operation, and fluctuated between 99° in the morning and 101° in the evening for seven days, after which it ranged from about 100° in the evening to normal in the morning for another seven days. On two occasions subsequently he had flares of temperature lasting for several days at a time. The temperature reached 104° F. on the first

CHART 1.—Comminution of femur. Excision of knee on third day after injury. A, Admission; o, operation; R, rigor.

occasion and 103° in the succeeding attack (Chart 1). The patient's general condition, however, was so good and the wounds looked so healthy that we felt sure this temperature was due to some other cause (possibly "trench fever"). We held on, therefore, with our efforts to save the leg, and the case gave no further anxiety. The ends of his bones were gradually allowed to approximate. He was evacuated to England about six weeks after his injury in excellent condition with his limb still in a Thomas's splint. Captain McDonnell heard from him five weeks later, when he reported that he was walking about with a support on his leg and his wounds entirely healed. We have operated on cases up to ten days or more after injury. It will suffice at the moment to say that the results as regards cessation of pain, subsidence of temperature, and improvement in the general condition of the patient have been encouraging. The temperature and pulse do not come down at once, as a rule. As in the case mentioned, a week or ten days or more may elapse before the evening temperature touches the normal line, but as long as the general condition of the patient remains satisfactory we are content to wait. We are, however, always ready to intervene further should untoward symptoms occur, such as rise of pulse and temperature, and before anaemia, wasting and anorexia show that the patient is finding it impossible to cope with his infection. It is well to be prepared for the gradual settling of the temperature and not to expect too much all at once.

The patient's general condition is a better guide than the swing of his temperature, provided the latter is within reasonable limits. Excision of the knee with bone injury is carried out exactly as I have described for sepsis, but it is essential to get well beyond the comminution. Several inches may be removed in the hope that the surgeon who finally has charge of the patient at home may be able to graft bone when all sepsis has ceased. This may be necessary to give the patient a limb of serviceable length. If joints with badly comminuted bone ends are seen early, before sepsis has had time to develop, it may be possible to allow the bone ends to come together at once, as in the ordinary excision of civil practice.

STATISTICS.

Statistics which deal with cases which have not been traced to their final termination must be regarded as unsatisfactory. On the other hand, it is desirable that the immediate risks and results of a major operation, such as excision of the knee, should be placed before those who may be called upon to perform these operations. As

I have stated, the ultimate results of our cases are not at present available. It may be that cases of excision which we have considered safe as regards limb and life on evacuation have subsequently belied our hopes. Time will tell. For the information of those who are not working in France it may be stated that our cases are not evacuated until sepsis has been controlled and danger to life averted. We have endeavoured to keep our excisions of the knee until the temperature has become normal and the limb is apparently safe.

In the area to which I am attached we have carried out the operation on the lines indicated in this paper in 64 cases. Twenty-two of these were operated on on or before the third day, for shattering of bone combined in all cases with septic wounds into the joint. There have been no amputations and no deaths in this series. The remaining 42 cases, all of which were septic, were operated on between the third and twenty-fifth day. Two died after the operation. One, operated on seven days after his injury, died from shock and oozing from the cut surfaces

of the bones. The second case had an incomplete excision carried out at a clearing station within twenty-four hours of his injury. When he reached the base he was doing well. His temperature shot up later, however, and the excision was completed on the twelfth day by removing more of the comminuted femur and the cartilaginous surface of the upper

end of the tibia, which had been left at the first operation. He died from septic infarcts in the lungs a few days later. Thirteen cases required amputation owing to failure of the excision to control sepsis, and of these four died. In the cases that died the excision was carried out on the tenth, twelfth (two cases), and twentieth day respectively. The last case was a boy who had already had one leg amputated, and, against our better judgement, we yielded to his demand that amputation of the remaining one should not be performed. Major West did what we considered the next best thing, but the operation failed, and a subsequent amputation, as a last resort, did not succeed in saving his life. In the other three cases pus had, at the time of the excision, begun to track in the thigh or leg, and this we now believe to be a contraindication to the operation.

It will thus appear that the total mortality was six cases out of a grand total of sixty-four. Two of these followed excision alone, and four occurred after a subsequent amputation. From a study of these statistics, incomplete as they are, one can form a fair estimate of the risks of the operation. It must be remembered that a patient who will not submit to an amputation will, even

CHART 2.—Penetrating wound of joint; no fracture; no foreign body retained. Excision of knee for increasing sepsis, oedema of leg and thigh, and rising pulse-rate, on tenth day after admission. A, Admission; E, excision of knee.

when the additional risk is explained to him, submit to an operation which gives him a fair prospect of retaining his leg, even with a stiff knee. Fifty cases reached the stage of apparent safety as regards limb and life. Most of these have been evacuated to England, and the remainder are about to be transferred. Those operated on within a few days of the dispatch of this paper are not included, as they are obviously useless for statistical purposes.

As might be expected, the results of the operation vary in the hands of different surgeons, chiefly, I think, owing to the selection of cases. One officer, for instance, reports from his hospital twelve cases, six operated on or before the third day for shattered bone, and six between the seventh and eleventh days for sepsis after failure of the closed method. There have been no deaths in this series, and no amputations while the patients have been in France. One case had amputation performed the day following his arrival in England.

If these statistics can be considered as proving anything they demonstrate first, that cases with shattering of the femoral condyles or upper end of the tibia, or both, if suitable, can be operated on by this method with practically no risk if dealt with within three days of the receipt of the injury; and secondly, that cases operated on for sepsis are likely to show good results if dealt with early, say within seven days. After this period, the prospects of saving the limb are less hopeful and the danger to life more serious.

While searching out these statistics I have seen several x-ray photographs showing the results of treatment.

Bony union appears to have occurred in some instances after a period of ten weeks or thereabouts. In some, it appears that lateral shifting of the tibia on the femur has occurred. This can be prevented by suitable measures, if recognized before union is complete. During convalescence, therefore, it would be well occasionally to ascertain the relative position of the bone ends, and rectify malposition while the bond of union is soft.

INDICATIONS.

A great deal of judgement will be required to select cases for excision. It may be stated at once that the patient's life must not be unduly risked in the attempt to secure to him what is after all a somewhat disabled limb. It is difficult on paper to give reliable indications, but I will mention a few guiding principles that have been helpful to us. The reader must understand, however, that general impressions of the patient's condition, which can only be gained by experience of a large number of cases, must be the ultimate guide. Let us take a case. A patient is brought to the base with a punctured wound

CHART 4.—Comminution of both condyles of femur and fracture of patella; large lacerated wound into joint; soft parts and bone filthy. Excision of knee on third day after injury. E, Excision; B, bronchitis.

of his knee-joint and a retained fragment of shell with or without injury to the bone. Let us assume that the wound is excised with the greatest care, the fragment removed, the joint cleansed, its contents set aside for culture, the synovial membrane accurately stitched, and the soft parts overlying either sutured up or a drain inserted down to but not into the joint. A splint is applied and the result awaited. The joint fills up again. Aspiration is performed, and micro-organisms, let us say streptococci, are found. The joint may be irrigated and again sealed, after perhaps the introduction of ether, or formalin and glycerine. Phagocytosis is perhaps found to be deficient. Again the joint fills up, and becomes hot and tense. The same procedure as before is repeated, until it becomes evident that improvement is unlikely to take place and the patient begins to show the effect of his infection in his general condition. His temperature rises

CHART 5.—Comminution of both condyles of femur and of head of tibia. Excision of knee on third day after injury. E, Excision.

and his pulse increases in frequency. Oedema of the lower part of the thigh and upper part of the leg begins to appear. Obviously something more must be done. It is at this stage that attempts to drain the joint have been made by incising freely on either side of the patella and inserting tubes here and into the suprapatellar pouch.

As I have already said, our experience of these attempts has been very unfortunate, and often, after a few days, we have been driven to the last extremity—namely, amputation—to save life. I wonder how many movable joints have been obtained by this method of drainage as adopted in this war. Of the many cases I have seen so treated in France I cannot call to mind a single satisfactory case—

that is, one that gave any promise of a freely movable efficient joint. It is to replace this system of drainage that I suggest that excision of the ends of the bones with

CHART 6.—Comminution of head of tibia; dirty wound. Excision of joint third day after injury. E, Excision of knee; S, splint changed under chloroform.

wide separation has its legitimate place. If done early, that is, as soon as it becomes evident that the closed method is doomed to failure, and before any marked oedema of the leg and thigh has set in, limbs will be saved that would otherwise inevitably require amputation. If a policy of waiting is adopted, the risks of the procedure are much increased. If the patient has a good colour, if his appetite remains good, if he is not wasting, if his pulse though rapid is of good tension, if he is cheerful and his condition as a whole fairly satisfactory, excision ought, in my opinion, to be considered, provided always that pus has not broken through the synovial membrane and tracked in the fascial planes of the thigh or leg. If, on the other hand, he is anaemic, if he has lost much flesh, if his appetite is poor, if he is restless and sleepless, if his tongue tends to be dry, if his pulse is rapid and flapping in character, and his condition as a whole gives rise to anxiety, it would be tempting Providence to do anything short of amputation.

If pus has begun to track in the thigh or leg, excision will probably fail and a subsequent amputation will very likely be required.

If the patient is struggling with other severe wounds, excision is, I think, contraindicated unless his general condition is very good indeed.

If one compares the condition of a patient who has been drained in the old way with one after excision he will, I think, be convinced that the morbidity is less after the latter operation, and that the relief of pain is more immediate and complete. We have in some cases had to amputate after excision had failed, but in these the operation had probably been done too late. It is a nice point to decide on the best time for an excision, but we are inclined lately to do it early. In other words, we give the closed method a chance for a few days. If the joint is not at the end of this time beginning to settle down, immediate excision will, I feel sure, save amputation in a fair proportion of cases. In fulminating cases amputation rather than excision will be required to save the patient's life.

It will be gathered that excision is here recommended as an alternative to drainage by the older methods, and to amputation. If the surgeon is satisfied that a less radical measure than amputation will suffice in a case in which the closed method has failed, he will be the more inclined to operate early, and the statistics of excision will improve accordingly.

The accompanying charts will give some idea of the course of the temperature after successful excision.

I am indebted to Captain McDonnell for Charts 1, 2, and 4, to Captain Whittington for Chart 3, to Captain Lock for Chart 5, to Captain Edye for Chart 6, and to Captain Palmer for Chart 7.

Adjustment of Splint.

I have been asked to add a few words on the splint and its management. All our cases have been treated with a Thomas's knee splint. The junctions between the bars and the ring ought to be so welded or brazed that no irregularity is left which might project through the

padding and cause intolerable pressure over the ischial tuberosity. The ring must be firmly padded, and should not be too wide or too thick. If too wide, it will be impossible to keep it in contact with the ischial tuberosity, from which, and not from the perineum, the bearing must be taken. Sizes from 22 to 25 inches in circumference will be found the most suitable. If too thick a ring is used, a firm bearing will be impossible to obtain. Considerable traction will be required to overcome spasm and keep the bones apart. In order to maintain this, the extension straps should be inspected daily, and any slipping or loosening adjusted. A rise of temperature or pulse will often indicate that the traction is insufficient to keep the bones far enough apart to provide free drainage between the ends. In Chart 6, the temperature did not begin to settle until comfortable adjustment and sufficient traction had been obtained. Painful spasm is an indication that either the splint is unsuitable, or has not been properly applied.

There is one other practical point. As we have been making our lateral incisions further and further back in order to secure satisfactory drainage of the cavity between the bones, it has become increasingly difficult to drain the proximal portion of the suprapatellar space, whether the

CHART 7.—Operation by "closed" method on second day after injury; shell fragment removed. No bone injury. Excision of joint six days later owing to failure of first operation. O, First operation; E, second operation, excision of knee.

synovial membrane has been removed or not. To meet this, it has been necessary in some cases to make a median incision at the extreme upper limit of the space in question and insert a tube so as to ensure that no pocketing shall take place. Sir Almroth Wright's most recent irrigating apparatus, "the Boulogne rose irrigator," which is now available, and can be obtained from the Base Medical Stores in France, might be of great service in these cases.

I desire to express my sincere thanks to the officers who have kindly placed their statistics at my disposal. I am also indebted to Professor Symington, F.R.S., and Mr. R. Hunter, of Queen's University, Belfast, for the drawings which illustrate the text, and to Captain Gamlin, R.A.M.C., for the x-ray photograph.

REFERENCE.

¹ *British Journal of Surgery*, vol. iv, No. 13, 1916.

GUNSHOT INJURIES TO THE KNEE-JOINT:

SOME SUGGESTIONS WITH REGARD TO THEIR TREATMENT.

BY

LIEUT. WILLIAM EDMOND, F.R.C.S., R.A.M.C.(T.C.),

AND

CAPTAIN WALTER WEIR GALBRAITH, M.B., Ch.B.,
R.A.M.C.(T.C.).

Of the injuries met with at base hospitals, gunshot wounds involving the knee-joint are, perhaps, the most troublesome to deal with, and there is as yet no consensus of opinion as to the most satisfactory methods of treatment. It is still held by some surgeons, of considerable experience in this class of injury, that such wounds may be roughly divided into two main groups: (a) Those which get well without interference; (b) those which are better amputated.