its success will in the end depend upon the constant watchfulness and personal care of the surgeon, which is, of course, a hard saying when there is great pressure on the hospital staff.

II. *Excision of the Joint.*

This operation has not been much in favour at the hospitals in Rouen; at some it has not been resorted to at all, but I have collected forty-two cases. Of these, eight were followed by amputation, and the deaths, either with or without amputation, were thirteen. I do not regard this as a fair picture of what may be obtained by excision. In some cases I am satisfied that excision was resorted to at too late a stage, in the hope of escaping from the disagreeable alternative of amputation—a hope which was frustrated later on, amputation then being performed in patients who were ill able to withstand a further severe traumatism. If we are to consider excision at all it must not be as an alternative to amputation; there is a case to excise and there is a case to amputate, and these must not be confused. One of the really difficult tasks which a surgeon has to undertake if he adopts excision is to select suitable cases.

Some of the results recently reported of early excision tempt one to adopt that line of treatment, but it will be well to remember before doing so what our own experience has taught us, that a large number of such early cases recover under conservative treatment, and with useful joint function in some instances. Another point which makes one hesitate is the lack of knowledge of the final utility of the excised limb. One method suggested in a recent paper involved a wide separation of the divided bones of about two inches, and the bone ends being maintained apart until all sepsis had disappeared. From the experience of excision of the knee in civil practice failure of bony union is under these conditions likely to occur, and the union by fibrous tissue may be very unstable. Firm union after excision has always appeared to me to depend mainly on early and accurate approximation of the sectioned bones. If bony union fails, further operative measures, by freshening of bony surfaces or by bone grafting, may yet succeed, but even if they do they involve for the patient the anxiety of a further operation, a rather prolonged convalescence, and possibly further shortening of an already short limb. Conviction as to the value of excision of the knee will only arrive when we know the final results obtained. To sum up this question of excision, if we excise very early we may get immediate satisfactory results, but we do not know what the final results will be, and we shall be excising joints which in a considerable number of cases may recover under conservative treatment, some with useful movement. If we excise in a later period we encounter a considerable death-rate, a high amputation rate, and uncertainty as to the final utility of the limb in the remaining cases.

III. *Amputation.*

The third course available when the primary conservative operation fails is amputation. I have heard amputation deliberately advocated as the correct immediate treatment if there is good proof that the sepsis has not been controlled by the primary intervention, mainly on the ground that our chief business is the saving of the patient's life, and that early amputation would be attended by a very low rate of mortality.

No one would dispute that early amputation would have a low death-rate, but such a course is repugnant to the patient and to the surgeon, and many limbs would be sacrificed which are now saved. Even though the knee be ankylosed or the limb shortened considerably, there is no comparison between the disability of the man with an artificial leg and that of one who retains his own, rigid though it be. For the sake of the individual whose earning capacity and whose enjoyment of the amenities of life will be seriously diminished, as well as for the sake of the State, we must spare the limb when we dare. But the onus falls on us of deciding in each individual case that we have pursued conservatism as far as is reasonably safe. All the convictions as to the advantage of a damaged limb over an artificial one, all the sentiment which makes amputation so repugnant must be kept firmly in hand. It is a sad epitaph for any patient that his surgeon, out of too kind consideration, deferred amputation until it was too late to save the patient's life. If we are perfectly frank with ourselves, few of us will be able to say that we have not erred in this direction. Reference to the figures will show that amputation followed in 13 cases after failure of excision or arthrectomy, and in 151 other cases not so treated; the total number of amputations was 164, or 19.4 per cent. The percentage of amputations has varied considerably at the different hospitals. The total mortality from all cases has been 72; the percentage is 8.5.

1.	Total cases of injury to knee operated on	845
2.	With bone injury	438
3.	Without bone injury	407
4.	Wound excised and closed	322
5.	Cases under (4) requiring further operation	82=25.5%
6.	Wound excised and packed	336
7.	Cases under (6) requiring further operation	128=38.4%
8.	Excision of knee	42
9.	Arthrectomy, partial or complete ...	15
10.	Excisions or arthrectomies amputated ...	13=22.8%
11.	Deaths after excision or arthrectomy ...	13=22.8%
12.	Amputation without excision	151
13.	Deaths under class 12	49=32.4%
14.	Total amputations	164=19.4%
15.	Total mortality	72= 8.5%

NOTE.—One hospital with a large number of cases was unable to separate the cases under items 4 and 6.

EARLY TREATMENT OF GUNSHOT WOUNDS OF THE KNEE-JOINT.*

BY

TEMPORARY COLONEL H. M. W. GRAY, C.B., A.M.S.

THE splendid results which many of you are achieving make one wish that all knee cases requiring operation could be treated in casualty clearing stations, but during a push this is out of the question, so that a selection must be made of all cases likely to be able to travel to the base without serious risk.

Before going further, I desire to say that in no other class of cases is technique and judgement in early treatment reflected so much in the results obtained. The surgeon who exhibits the greatest care in technique, especially when removing foreign bodies and infected tissue, whether of the soft parts or of the bone, gets the best results. So good are these that, recently, several cases which, in the earlier part of the war, would have been submitted to primary amputation, on account of the extent of the damage to bone, have been sent down the line with every likelihood of having not only a useful limb, but a useful movable joint also. Conservative operations on gunshot wounds of the knee-joint, however, in order to be successful, demand such care that I think they should be handed unreservedly to the surgeon in the unit who has demonstrated special skill in their performance. I venture to lay special stress on this, because many really good surgeons fail to appreciate even what is essential in totally excising the soiled wound in such cases. To this cause I attribute most of the failures.

All wounds of the knee-joint should be splinted by the field ambulance units. This is most important, because movement may aggravate infection already present, or introduce infection where none existed, and in both ways prevent successful conservative treatment.

Excision of Wound.

The ultimate object of treatment of these cases is to secure mobility of the joint. Our primary object in the casualty clearing station must, therefore, be to secure asepsis. The surest and quickest way of doing this is to excise completely, if possible *en masse*, all tissue which is definitely or probably infected. This having been done, the wound remaining can be treated on aseptic principles. This, of course, entails the exclusion of all instruments, gloves, towels, etc., which may have come in contact with infected parts. A large percentage of these wounds are sutured, and heal by first intention. A suitable plastic operation may have to be done. In most cases it is advisable to provide drainage "down to but not into" the joint cavity or bone fragments.

*Paper read at a meeting of medical officers of an army in the field.

Although, in many cases, the wounds cannot be closed, yet it is usually possible to suture the synovial membrane of the front of the joint, especially if the suprapatellar pouch is loosened from its upper and anterior connexions by finger or curved scissors, and pulled down. This point is of very great importance.

Fixation.

Fixation of the joint is essential to success in all but the simplest wounds. We have found that the best method of ensuring this is to put up the limb in a "Thomas splint outfit," just as in cases of fracture of the femur, with the exception that the extension strips are applied with the object merely of keeping the Thomas splint in position. No traction is necessary. If a back splint only is used, it must reach from the *tuber ischii to the ankle.* Shorter splints are worse than useless. The splint can be prevented from slipping by fixing each end to the skin with strips of sticking plaster. The upper strip should not encircle the limb.

Foreign Bodies.

Removal of a foreign body, lodged within or near the joint and not visible or palpable from the surface, should *never* be attempted without *x*-ray localization when that is available. Otherwise, probably more harm than good will be done by interference. If *x* rays are not available, these cases should be transferred without delay to a unit which is provided with an installation. Of course, if the foreign body can be seen or felt, or if synovitis is already very marked, the sooner operation is done the better.

Selection of Cases.

During severe fighting the selection of cases for operation at a casualty clearing station seems to me to depend chiefly on the size and position of the wounds, especially of entrance wounds; on the size and character of the missile, especially if lodgement has occurred, and on whether it is visible or palpable; on the size of the wound in the synovial membrane, and on whether it communicates freely with the surface wound, so that infection will occur easily; on the amount and character of comminution of bone; on the presence or absence of injury to large vessels; on whether intra-articular tension is present or absent; and, finally, on whether definite sepsis has developed or not.

Cases for Transfer to Base.

Hence, if the wound of entrance is small, especially if due to an undistorted rifle bullet, if there is no external evidence of a foreign body, if there is no comminution of bone or injury to large vessels, if there is not painful tension, and if there is no inflammation, the patient may be sent on to the base, after thorough disinfection of the skin, suitable dressing of the superficial wounds and fixation of the limb, the knee being slightly flexed, in a splint of proper length. There is no need to use the "Thomas outfit" except in serious cases, but those in which penetration of the synovial cavity is even merely suspected should be fixed in a splint.

It may be noted here that an "open" wound of the back of the joint is usually less serious than a similar one on the anterior aspect, possibly because, in the latter, sepsis is more likely to gain access during transport.

Cases for Retention at Casualty Clearing Stations.

If the superficial wound is large—even, for example, like that caused by a shrapnel ball, and especially if it communicates freely with the synovial cavity—if there is a visible or palpable foreign body which has opened the joint, if there is much comminution of bone, if there is a haematoma in the popliteal space or haemorrhage from a wound there, if there is undoubted inflammation, the case should be kept at the casualty clearing station.

On admission, the limb should be dressed, fixed in a suitable splint, and, if *x*-ray localization is required, the patient should be sent to the radiologist, who should take two skiagrams, one antero-posterior (toes pointing straight forward) and one lateral, on the same plate if possible. This method is probably the quickest and best in the circumstances. The patient is then sent to the pre-operation ward. The splint should not be removed till the patient has been anaesthetized. The strapping of the splint permits examination of the wound without moving the knee.

Operative Treatment.

I think it will be simplest, in dealing with operative treatment, to discuss the worst cases first.

Amputation.—If the injury has implicated the main vessels so that the foot is already cold and dead, amputation should be done—just above the knee if the wound is likely to remain fairly clean, and through the knee if sepsis is present and the condyles are undamaged. In the latter class of cases reamputation is frequently necessary, and when the condyles are left it can be done so as to provide the longest possible thigh stump. If, as sometimes happens, one or other popliteal nerve is shot away so extensively that it cannot be sutured later on, and if the bones are much soiled as well as comminuted, the probability is that primary amputation is the best course. If sepsis is well established in presence of much comminution, especially if there be gas gangrene, and the patient in low condition from haemorrhage or toxic absorption, amputation must be done.

Resection.—If, in less severe cases, the opposing ends of the long bones are so comminuted that smooth articular surfaces are not available, it is probably best to do primary resection in the way recommended by Colonel Fullerton.

Conservative Treatment of Fracture Cases.—If large fragments have resulted from the injury, if the patient has been got early and is in good condition, and if one is fairly sure of getting away infective material, the case should be given a chance.

Removal of Patella.—As a general rule, if the patella alone has been shattered, as happens fairly frequently, the fragments should be removed.

If possible, the synovial cavity should be closed, except for a small drainage opening, by suturing the lateral edges and aponeuroses, possibly after undercutting the synovial membrane on each side, or by loosening the suprapatellar pouch as already described. If this cannot be done, a "salt pack" should be used in the way described later. The same procedure should be carried out if concomitant injury to other bones is not extensive. It is wonderful how the infection tends to remain limited to the anterior part of the joint if the limb is thoroughly immobilized—*plus* a flat pad in the popliteal space.

In considering the question of amputation, these points are of great importance: the possibility of removing or neutralizing infective material successfully, the amount and kind of comminution, the concomitant injury to vessels or nerves, and the condition of the patient.

Conservative Treatment.

When conservative measures are decided upon, the following are the most important operative details:

1. Determination of the track which leads to the depth. The knee may have been bent when the patient was wounded, so that when the limb is straight the track is distorted. Excision of the track is best made when the knee is held in the same position as when injured.

2. Thorough disinfection of skin and track. The whole of the skin *around* the knee, and for at least six inches above and below, should be shaved and disinfected. For final disinfection I prefer picric acid (3 to 5 per cent.) in spirit. The external wound and track are disinfected (*a*) if not very large, by the actual cautery, or (*b*) by rubbing thoroughly every part with 10 per cent. iodine or picric acid in spirit. The strong solution has the effect of drying the tissues.

3. Careful and complete excision of external wound and track, including the edges of the wound in the synovial membrane, if possible in one piece. Incision, using a sharp scalpel, must be made quite clear of the deep as well as clear of the superficial wound. Pockets must not be cut into. Clipping infected tissue away piecemeal courts disaster. As the blades of the scissors are closed, infective material from their proximal parts is forced along to the distal. The least little bit of infected tissue left behind may prevent success.

4. Provision of ample access to foreign bodies or comminuted surfaces in the joint. Blind groping with the finger is to be avoided, because the foreign body or infective material is thus frequently pushed beyond easy reach, and further struggles in attempts at removal end in disaster. Incisions must be chosen, therefore, which give easiest access, and they must be free enough, even to the extent of dividing the ligamentum patellae and turning up a flap, etc.,

to enable one to *see* the foreign body, and obtain plenty of room for manipulation of instruments. If complete excision of the infected wound has been made under proper technique, one should be able to get first intention after suturing, however large the wounds may be.

5. Careful removal, under direct vision whenever feasible, of all foreign material, whether free in the joint or embedded in the articular surfaces. If the latter, the bone surrounding the foreign body must be carefully chiselled or gouged away, *en masse* if possible. The joint cavity is then flushed out with 5 per cent. saline, flavine solution, etc.

6. Closure of the wound in layers, using fine catgut for the synovial membrane. Drainage tubing should not project into the joint. Of course, if tubes are required for the introduction of fluid, as in the Carrel-Dakin method, they should be carried to the deepest recesses of the joint, or inserted through a fresh incision. They should be removed as soon as possible.

7. If the wound in the synovial membrane cannot be closed, a small "salt pack," separate from any other which may be required for the rest of the wound, should be inserted firmly "down to but not into" the joint, and should be left until it is absolutely loose. A small tube may be placed in the centre of the pack, reaching to the synovial membrane, and it may be removed in a couple of days. If attempts are made to pull the pack away, adhesions shutting off the main cavity of the joint are likely to be broken down, and infection is then liable to occur.

8. Tendinous or ligamentous structures exposed during operation should be covered by skin and subcutaneous tissue, otherwise they are very apt to slough, and this postpones closure of the wound, and therefore prolongs convalescence.

9. If there is much effusion into or from the joint, of whatever nature, or if raw surfaces, whether of bone or soft tissue, are left in the joint, at the end of operation, a tube should always be inserted "down to but not into" the synovial cavity. Pressure of effusion—that is, tension—must be avoided at all costs, because it interferes with healthy circulation in and absorption by the synovial membrane, and these are essential to successful combating of any infection which may have been overlooked.

10. The injection of ether, formalin-glycerin, or hypertonic (5 per cent.) saline solution into closed joints, is of doubtful value. They are all irritants. Success is claimed for all three, although their actions are different. The common factor in their application is preliminary aspiration of the joint. This removal of tension is possibly the explanation of their apparently beneficial action. It is possible, however, that the injection of or washing out by a non-poisonous, non-irritating antiseptic like flavine, whose antiseptic action is enhanced by mixture of the substance with body fluids, may be of great value in many cases.

11. The paramount importance of obtaining *x*-ray skiagrams has already been indicated.

Haemarthrosis with Small External Wound.

I should like to discuss just one other type of injury, that which produces haemarthrosis in presence of small through-and-through wounds, and where only slight damage to soft tissues or bone is present. If the effusion cannot be aspirated, owing to the fact that firm clotting has occurred, I believe that best results will be obtained by deliberately opening the joint, by free incision on one or both sides, washing out the clot with sterile salt or flavine solution, and stitching up again without drainage. If the wounds are very small, one need do no more than sterilize them superficially. Such a blood clot, after a few days, forms excellent pabulum for the growth of organisms, and, even though it does not become infected, it is often the cause of much distress and disability in later stages, owing to formation of intra-articular adhesions. Officers at base hospitals in France appreciate the disastrous results of insidious infection in such cases. Hospitals in England have beds occupied unnecessarily long, even by non-infected cases, because, owing to the adhesions, they require skilled massage and so forth. Arthrotomy in this type must not be undertaken lightly. Technique must be perfect, else dreadful disaster is incurred.

Retention of Cases after Operation.

Operated cases should be retained for at least twenty-four to forty-eight hours. Firm compression under a very thick layer of cotton-wool and fixation in the "Thomas outfit" should be employed. I believe that a pad of wool in the popliteal space, tapering to each end, tends to prevent suppuration tracking from the back of the joint. If the joint looks quiet at the end of twenty-four to forty-eight hours, and the general condition is good, the case may be evacuated.

While the "ham" splint of the outfit is best for transport and for cases in which the wounds are in front of the joint, yet if there is a large wound on the posterior aspect, the thigh and leg should be suspended on separate slings of perforated zinc, well padded and covered with jaconet, so that access to the wound is provided without running risk of moving the joint.

Gentle passive movement, to a few degrees at first, should be begun as soon as one is certain that the parts are healing aseptically.

Sepsis.

If sepsis develops, all wounds should be opened up freely, possibly bilateral openings should be made, and the synovial cavity treated by intermittent flushing with Dakin's solution, or, which may prove to be better, with flavine solution. If improvement does not occur within twenty-four to forty-eight hours, a transverse or flap incision should be made, followed by resection, as Colonel Fullerton has advised, or, after free division of the lateral and cruciate ligaments, by packing and fixing the joint in flexion in Hepburn's aluminium splint. If the articular surfaces of the bones have been injured, the former method is preferable.

In conclusion, I would urge again the importance of rigid technique, and the necessity for thorough and complete operation. Half measures are worse than useless. "All or nothing" is a sound watchword. If the fulfilment of these principles is not possible, far rather fix their limbs properly, and send all patients on for treatment at the base.

RESULTS OF SIXTY CONSECUTIVE CASES OF WOUNDS OF THE KNEE-JOINT.

BY

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IN the eighteen months from July 1st, 1915, to December 31st, 1916, I have received into my wards sixty cases of penetrating wounds of the knee-joint in an unoperated condition. The greater part of these were from the Verdun fighting in 1916. I exclude from analysis cases which had been opened and drained at a clearing hospital, and also a certain number which got well with no further treatment than immobilization, and in which actual penetration of the joint was not certain. Apart from these exceptions, I have included all penetrating wounds of the knee which I have treated since the opening of the hospital. They were, as a rule, received in from twenty-four to forty-eight hours of being wounded.

Classification.

The cases naturally fall into the following classes:

A. No bony injury, and no projectile included.
B. No bony injury, but projectile included.
C. Bony injury, no projectile included.
D. Bony injury, with inclusion of projectile.
E. Bony injury of the lower limb of such gravity that involvement of the joint is only of secondary importance, no functional result being possible. Here the saving of life and, if possible, of the limb as well, is the only consideration.

As regards the probable final result, the presence or absence of a bony injury is the chief deciding factor. In classes A and B, given an aseptic result, which should be obtainable if the wound is a recent one, a good movable knee is nearly always to be hoped for. In classes C and D the result will vary from complete mobility to complete stiffness, according to the nature of the bony injury—again