TREATMENT OF GUNSHOT FRACTURES OF THE LIMBS

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General Considerations

The experience gained during eighteen months of the present war has revealed the advantages and disadvantages of the various methods of treatment for gunshot fractures of the limbs. From these preliminary data the results of therapy can be assessed, and general rules can be laid down for the treatment of these fractures, both in the field and at base hospitals.

The methods used are based on three main therapeutic factors: wide surgical excision of the wound; adequate local and general use of sulphonamides; prolonged fixation in plaster. These principles are indisputable, and surgical excision should not be replaced by chemical sterilization or the introduction of packing. In addition the application of dry sulphonamide powders is immeasurably better than the use of other antiseptics or repeated irrigations, and allows adequate splinting with plaster, which is essential for complete immobilization of the limb. This immobilization is of paramount importance in the case of gunshot fractures, especially of the femur, not only for procuring adequate union of the fracture and healing of the wound but for the survival of the limb and even the patient. Not only is immobilization in plaster the most important factor in the treatment but it is most suitable for the transport of the patient over long distances.

Immobilization by extension has undeniable merit. Its great advantage is its application to almost any case of fracture or dislocation, and by it satisfactory reduction can be obtained even after delay in therapy; but even in the treatment of closed fractures such procedures are impossible when the patient has to be moved repeatedly from one place to another. The amount of time and trouble expended in the autumn months of 1941 on moving patients to and from air-raid shelters was enormous and the effectiveness of treatment was greatly impaired. In addition in times of stress it is difficult, if not impossible, to use methods of extension at advanced casualty stations, and by the time such patients have reached a base hospital union is so complete that correction by traction is no longer possible. Moreover, with infected fractures it is difficult to secure adequate rest for the patient, and the healing of the wound and fracture is impaired by repeated dressings and movement in bed. This not only retards recovery but jeopardizes the final result, and the more rapidly healing occurs in both soft tissue and bone the greater preservation of function there will be. On the other hand, the slower the resolution of the infection the more scar tissue there will be, and final function will be less, particularly in the case of the knee-joint.

We do not consider it possible to procure adequate immobilization of the bone fragments and soft parts with hinged splints and other forms of apparatus; in fact, these defects are present to a greater degree with such apparatus than with skeletal extension, since they cannot be fitted securely enough and are apt to become displaced. Plaster-of-Paris bandages are applied direct to the skin and immobilize the whole limb, thus securing maximum rest and allowing easy transport; the nursing is thereby simplified and the work of the surgeons lightened.

Plaster Fixation

There are, however, some important defects and drawbacks in this method of treatment, and we would point out its limitations for general application. The three main drawbacks are: (1) the defective position of the bone fragments may not easily be seen and serious shortening of the limb may result; (2) contractions and stiffness of the joints may occur; (3) sepsis may progress unnoticed. I shall consider each of these drawbacks separately.

Shortening of Limb.—Should an unreduced fracture with serious displacement and shortening occur, it is not the fault of the method but of the surgeon who allowed this to happen during application of the plaster. In cases of gunshot fractures displacement of the fragments and shortening are as a rule slight, and good alignment is usually possible in any part of the limb after the excision of the wound. This, however, does not apply to fractures close to joints, in particular the knee-joint. In most cases a good position is obtained by manual reduction before the plaster-of-Paris is applied, but 20 to 25% of gunshot fractures of the femur show considerable deformity which cannot be eliminated in this way; in such cases a light extension apparatus with a screw extension is required.

The application of plaster-of-Paris necessitates a certain skill, and the successful use of an extension apparatus requires a knowledge of orthopaedic surgery, though not more than the use of weight extension.

There are still some cases in which one cannot avoid anterior displacement, and sometimes in order to avoid shortening it is necessary to insert a pin as well as using plaster. Such a method of forced extension and plaster in combination (as used by Winnett Orr) sometimes admits of correction of deformity even up to periods of three to six weeks after the injury. Even in such cases fixation in plaster has many advantages over skeletal traction by weights, as in the latter the amount of weight required is enormous and the length of time in bed much prolonged; in addition evacuation from one hospital to another is facilitated. Consequently the first alleged defect does not in fact exist.

Contracture and Stiffness of Joints.—The statement that plaster fixation causes contracture and stiffness of joints is wrong; immobilization by this means causes harm neither to joint surfaces nor to the healing process; the real cause of the contracture is scarring in the muscles as a result of injury and infection, and the adhesion of damaged muscles to the site of fracture and callus. In injuries to the femur the wound is generally in the quadriceps femoris, and this explains the frequency of extensor contracture of the knee-joint. All along, the quadriceps lies close to the bone, but the flexors are further away from the femur and thus are less often involved, consequently flexor contracture is less common.

I would also mention that gunshot wounds of the leg are treated in the same way. An extensor contracture of the knee-joint never occurs although immobilization may last for months, and this method of fixation cannot be blamed for the impaired function of the knee-joint, but indeed seems to be the best means of treating both the fracture and the muscle injury, and securing the least amount of deformity.

Suppuration beneath Plaster.—The most serious disadvantage alleged against plaster fixation is the impossibility of seeing the extent of suppuration under it. This, it is suggested, gives rise to the risk of neglecting appropriate treatment for the sepsis at any given time. Such fears are groundless in many respects; the degree of infection may be judged by the general disturbance, both subjective and objective, as well as by direct observation of the wound, and frequent dressings following wound examination

are harmful. Moreover, plaster bandages have proved themselves to be very absorbent. A great drawback is the odour, which is a small factor when it is compared with the advantages this method affords.

Procedure in Plaster Fixation

Anyone, in fact, who uses this method for gunshot fractures will never wish to return to any other. The condition of the wound and the granulation tissue which develops under the plaster are remarkable. I will not now endeavour to explain the wonderful reparative power of the tissues under such treatment, but will merely point out that no other method produces such rapid sterilization of wounds, granulation of cavities, and rapid epithelization. It should be emphasized, however, that the plaster must only be put on after wide excision of the wound and removal of all dead and damaged tissue. If this is not done, whatever the method of treatment used fatal infection may occur; but, even under adverse conditions when such treatment is impossible, no other method has given results as good as immobilization in plaster. In this method all surgical procedures preparatory to fixation must be suitable for the application of plaster over them. The extent of the operative procedures varies according to the time of the operation after the initial injury—that is, in relation to the degree and spread of infection.

Early Cases.—If operation is performed early and the wound is not yet clinically infected—that is, on an average within six to eight hours—the procedure is confined to the removal of all large foreign bodies and blood-clot, and a thorough excision of all devitalized tissue. Bone fragments need much care, and only loose fragments should be removed. Bone still adherent to the periosteum or to muscle must be preserved. In such cases this operative procedure allows of relative sterilization of the cavity. Excision of the surrounding muscles should be sparing and only such muscular tissue be removed as is in danger of necrosis. After the excision no stitches should be used either in skin or in muscle, and the wound must be freely opened throughout to allow of free drainage of exudate. Hence there is no great need for accessory drainage through undamaged tissues. Next the whole cavity must be liberally filled with a sulphonamide powder, carefully ensuring that no part is missed. The limb is then encased in plaster over the open wound, no dressing being applied, and the healing of the wound should proceed without gross infection.

Cases in Later Stages.—In gunshot fractures of the thigh which are brought to operation at a later stage there will be found various degrees of infection. Some cases, though 24 to 36 hours may have elapsed from the time of trauma, are afebrile, show little clinical evidence of infection, and the discharge from the wound is not grossly purulent and has no smell. Other cases show purulent discharge, though the general condition of the patient is good and the infection appears localized. Both these types of case, if it be found at operation that the process of suppuration has not spread far beyond the wound, can be treated in the same way as the first group.

Suppurative Cases.—The third main group consists of cases which show gross infection spreading far beyond the wound itself. Under such conditions a wide excision to allow free access to the site of the fracture is absolutely necessary so that drainage is free. Lateral drainage may be needed in some cases if the wounds do not easily permit dependent drainage. The operation is designed to produce a funnel-shaped cavity with the summit at the site of fracture and the wide base on the surface of the thigh, and this should be established for both entrance and exit sites of the wound.

(I should here emphasize the preparatory cleansing of the wound with water and soap, which is widely used by English and American surgeons. We consider that adequate use of soap and water around and in the wound is of the greatest importance, and I will describe its use in detail at a later stage.)

This third group of cases consists of patients with severe suppuration at the site of fracture and spreading infection beyond the damaged area. They arrive for operation from the fifth to the fifteenth day after the fracture, showing not only local suppuration but severe signs of toxæmia. Until quite recently it was doubtful whether such cases should be treated by wide excision of all necrotic material or whether it was advisable to leave the wound completely

alone. After many operations it was found possible to put the limbs in plaster and treat them in the same way as the previous groups, and there is now no question as to the right course. The technique of wide excision down to the site of fracture as previously described is of extreme importance, as is adequate use of a sulphonamide powder, both locally and by mouth. In such conditions immobilization in plaster is irreplaceable by any other means of fixation. In the present war, experience has shown that the majority of gunshot fractures have arrived for treatment when infection is far advanced. It has therefore been a matter of great importance to evolve this technique and to make available our present knowledge to all doctors dealing with Service cases.

Pre-operative Treatment

When the men first arrive at the hospital their general condition must receive attention. Many have had long journeys over bad roads; they are often physically exhausted, worn out by pain, and suffering from exposure to cold. They frequently show marked signs of shock and haemorrhage. Many have not slept for several days and nights, and some are starving. Immediately on their arrival, therefore, general treatment must be started. The application of warmth is of great importance, and this factor is often not sufficiently appreciated: operation may have to be postponed for several hours, during which time they are warmed and their shock is treated. Hot drinks such as sweetened tea, spirits by mouth, and the application of hot-water bottles and warm woollen or fur blankets often improve their condition enormously, and special resuscitation departments should be established in all base hospitals. Such departments have proved of inestimable value in the preparation of the patients for adequate surgical treatment. Blood transfusion or the infusion of glucose or saline solutions may be required in a large number of cases, especially in conditions in which the blood pressure is much lowered, and after considerable blood loss.

Anaesthesia

The problem of anaesthesia must be considered in detail. It would be ideal if anaesthesia could be induced immediately after injury—that is, before first aid is applied—and continued during transit to hospital. There is no doubt that the administration of morphine, 10 mg., before first aid, and again before removal to hospital, would considerably ease the patient's discomfort and lessen the inevitable shock. This administration of morphine may again be necessary before surgical procedures are undertaken; but, if conditions permit, it is advisable to treat the shock and to undertake measures such as radiography and nursing procedures before starting any operative procedure. The operation will need complete surgical anaesthesia, and this will have to be maintained during the application of the plaster while the patient is on an extension apparatus or an orthopaedic table. For the latter morphine may suffice. The time available and the order in which these procedures are undertaken will determine the mode of administration of morphine and the dosage. Thus, if time allows, subcutaneous morphine given a quarter of an hour before will suffice, but if anaesthesia is required urgently the intravenous injection of 1.5 to 2 c.cm. of a 1% solution of morphine, or, better, the Kirschner mixture (morphine hydrochloride 0.25 g., scopolamine hydrochloride 0.025 g., narcotine hydrochloride 1.25 g., ephedrine hydrochloride 0.25 g., and 0.75% sodium chloride 100 c.cm.) will give considerable analgesia and even sleep. If the operation requires the administration of a general anaesthetic this preliminary medication will aid in the induction and reduce the amount of general anaesthetic required, and, moreover, will lengthen the anaesthesia so as to allow ample time for subsequent drying of the plaster.

Local anaesthesia in cases of gunshot fractures of the thigh has a very limited application. There is no doubt that the injection of local anaesthetic into the fracture site and surrounding haematoma is of great value if it can be used, but in the conditions under discussion it is sometimes very difficult to ascertain the exact site of the fracture without prolonged and careful examination, which is often impossible, and certainly undesirable. Secondly, with open fractures it is difficult to maintain the solution of local anaesthetic at the local site. In a few cases of closed fracture it may be of some use. Local anaesthesia for the excision of a wound is open to serious

objections. The injection at the local site is difficult, and in consequence it is often impossible to ensure anaesthesia. It is also often impossible to determine beforehand how extensive the excision will have to be, and so during the operation there may be constant delays while fresh areas are anaesthetized in order to complete the operation successfully. Moreover, the infiltration of the local anaesthetic conceals the natural appearance of the muscles and makes it difficult to determine how much muscle tissue has been damaged by the injury and in consequence how much muscle should be excised. We consider, therefore, that the use of local anaesthesia not only impedes the operative procedure but, in open fractures, restricts the accuracy with which one can assess the extent of the damage and infection in the tissues. There is yet another consideration. The patient after operation is in an uncomfortable position for a considerable time while the plasters are setting, whether he be on some form of extension apparatus or on an orthopaedic table, and this position is exceedingly irksome and tiring, particularly to patients who are exhausted even before the operation is begun. Under these conditions the surgeon may be tempted to allow the removal of the patient before the plaster is firm; this would entail considerable risk of spoiling the plaster, and the whole process might have to be repeated from the beginning. It may often prove that, even after local anaesthesia, general anaesthesia would be required during this stage and the benefit of the former lost. Finally, local anaesthesia for such complicated operations is time-consuming, and under conditions of war it is unfair to delay so long, as many other operations of equal urgency may thereby be postponed, with grave risk to the waiting patients.

Ether, with preliminary administration of morphine, provides an excellent and simple method of anaesthesia and allows complete freedom for the operator, both in the extent of the operation and in the time required. There is, of course, no reason why local block in large nerve-trunks with novocain should not be employed in addition if thought necessary. Ether should not, however, be used if the patient is suffering from bronchitis, which is not infrequent during the autumn months. It is also necessary to take adequate precautions in case of fire.

Evipan intravenously is an excellent anaesthetic, but for prolonged use the services of a skilled anaesthetist are required. This is overcome to some extent by the use of a 2% solution instead of 10%; it can be given up to 200 c.cm. by subcutaneous injection. It is useful to bear this in mind if general anaesthesia is required during an operation begun with a local anaesthetic.

None of the previous methods offers such advantages or secures such adequate relaxation as spinal anaesthesia. This allows the most satisfactory conditions for reduction of the fracture, and adequate time for examination of the tissues and excision of the wounds and for the application and drying of the plaster. The great drawback of this method is the fall in blood pressure induced. This makes it unsuitable for patients suffering from shock and also for many others who have had considerable haemorrhage, and, since in the cases under discussion one or both of these conditions are often present, this method, although very satisfactory when used, may not be possible. Spinal anaesthesia is therefore of limited value in the early stages at casualty clearing stations, where shock and haemorrhage occur with such frequency. However, during the last 18 months experience has shown that many gunshot fractures of the thigh arrive in hospital at a late stage, and, although there is often considerable infection in the wound, with signs of toxæmia, the initial shock has been overcome and the blood pressure is stable. Such patients are suitable for spinal anaesthesia. In fact, in many the condition definitely improves after induction of spinal anaesthesia, and the main difficulty encountered is the movement of the patient in preparation for the lumbar puncture. Great care must be taken in the movement of patients with fractures high up in the thigh, but we find it is possible to move them in most cases. In the last 300 fractures of the thigh which passed through our clinic we were able to use this form of anaesthesia in all cases, and I have had no difficulty with it even in front-line hospitals. 1 c.cm. of 1% nupercaine (percaïne) and the Soviet preparation sovkaïn are excellent preparations. The anaesthesia takes place within a few minutes and lasts for three to four hours. This

allows the patient to be moved on to the extension apparatus without pain and also admits of adequate fixation or extension of the limb painlessly. After fixation in the extension apparatus the patient is washed with soap and water, and in the same position such operative procedures as are necessary are performed; following this, the plaster is applied. During the whole procedure the anaesthesia remains and there is no complaint of discomfort from the patient, and adequate time is available for the hardening of the plaster. If neither nupercaine nor sovkaïn be available, novocain, tropacocaine, or stovaine may be used instead in doses of 1.5 to 2 c.cm., but the anaesthesia will be of shorter duration. With the use of any of these spinal anaesthetics it may be necessary to inject subcutaneously 1 c.cm. of 5% ephedrine if an undue fall of blood pressure occurs.

During the last 43 years spinal anaesthesia has varied greatly in popularity. There is no doubt that the successful application of this method calls for considerable skill and experience, particularly if high anaesthesia is required; but lumbar puncture in the usual situation between the 2nd and 3rd or 3rd and 4th lumbar vertebrae, and the injection of the anaesthetic mixed with 1 to 2 c.cm. of cerebrospinal fluid, are adequate in these conditions and the patient placed again in the horizontal position. Although, therefore, spinal anaesthesia is considered inapplicable in cases with shock or following recent haemorrhage, it is of immense value during the treatment of open fractures of the thigh once shock has been relieved, even if there is well-marked infection of the wound.

Position of Patient and Cleaning of Wound

The patient should not be removed from the stretcher until anaesthesia has been induced. He should then be placed immediately on to the extension apparatus, and extension applied to both legs, with a narrow support under the sacrum. This position allows adequate access to all parts of both limbs. The first procedure is thorough washing of the skin not only of the operation field but of the whole limb. The entire area should be washed thoroughly with soap and water; any shorter method, such as painting the skin with alcoholic solution of iodine, is grossly inadequate. Some difficulties may be met with during this procedure. A fresh fracture needs much care during the cleansing, and the presence of other wounds on the limb requires special attention. We do not think it adequate to use soap and water on gauze or cotton-wool; the whole area should be scrubbed with a soft brush. By means of this the cleaning is done better and much more expeditiously. It is often advisable to protect wounded surfaces during this cleansing procedure. In suitable situations this can be done by packing with dry sterilized gauze, but in many cases it is advisable to close the wound temporarily with Michel's clips. This permits of more rapid cleansing of the skin surfaces. With skilled assistance washing can be completed in from 5 to 10 minutes, and this time includes shaving the limb if necessary. The limb is then washed with water and dried with a towel or with gauze and alcohol, and the whole operation field is painted over with iodine, the limb being isolated by means of sterile towels and any temporary stitches or clips removed. There are a few sites of injury which cannot be approached with the patient in the same position—mainly cases with wounds in the buttock and perineum. Such patients should be operated on first in the prone position, and only after completion of the operation there should they be transferred to the extension apparatus for the rest of the examination and treatment. We have, however, found that in many cases these apparently inaccessible sites are easily accessible with an operation table that admits of lateral inclination of the table itself. This has been found possible by fixing the extension apparatus to the operating table. We have designed a simple wooden stand which can be given a lateral inclination of 35 degrees. We have also designed a new model of a portable apparatus with a screw extension for both legs. These two designs form a good orthopaedic table for all the operative procedures on this type of injury.

Treatment of Recent Open Fractures of the Thigh

Even in extensive wounds with gunshot fractures of the thigh operative procedures which can be done within the first 8 to 12 hours must have as their purpose complete and thorough mechanical cleansing so that the whole wound and site of

fracture should be made sterile. To achieve this all foreign bodies must be carefully removed from the wound and a diligent search made for even the smallest fragments that may have penetrated the surrounding tissues. All damaged tissue must be removed and all blood clots, so far as is possible, taken out. This may entail a wide excision of the tissues and the removal of bone fragments. The only bone fragments which should be left are those still adherent to their periosteum. One should then take great care to ensure haemostasis. Finally, the cavity which is left should be of adequate size and situation to allow easy escape for the discharge of exudation into it.

Operative Technique of Recent Fractures

The excision of fresh wounds should be done under aseptic conditions and the operation should be carried out with strict precautions; there should be available a double set of instruments and gloves, so that a fresh set may be ready for use during the clean part of the operation when the infected tissue has been removed. The question of the excision, or otherwise, of various tissues in the wound depends on their naked-eye appearance. The light available must therefore be adequate and access to the deeper parts of the wound must be wide, so that this visual examination can be effectively made.

The approach to the fracture must then be decided. In the majority of cases adequate inspection and the provision of free dependent drainage can be procured through the wound sites. If this is not easily obtained the fracture should be explored and drained through an additional incision in a suitable area.

In cases of established infection quite small excisions of the wound may have to content the surgeon, because it may be necessary to establish lateral drainage quite apart from the main direction of the wounded surfaces; but with recent wounds this is not the case. In these circumstances there is no need for the preparation for drainage through the wound, and wide excision can be performed with impunity. There may, however, arise the question of lateral access to the fracture in order to allow adequate inspection of the tissues. If the wound cannot be extended owing to the proximity of important structures, then even with recent injuries it may be necessary to explore from another direction; such exploration should always be made from the lateral aspect of the limb. This should only be done in cases of strict necessity. In addition we believe that fresh wounds should not be stitched either in the muscles or in the skin. It is assumed that adequate treatment at this stage will prevent infection in the wound, and we need not discuss here the question of treatment of sepsis.

The amount of tissue removed depends on surgical experience and requires expert judgment. First the skin wound is fully excised; this is performed in such a way that the skin surrounding the wound can be dissected intact. From one end of the excision the skin is then dissected off with a scalpel and the subcutaneous tissues inspected; all damaged subcutaneous tissue is excised with the skin. The deeper layers of tissue are removed along with the deep fascia. Extensive removal of deep fascia is often necessary to permit adequate inspection of the muscles underneath. The opening in this deep fascia should be elliptic, with its long axis in the long axis of the skin incision, and its length only slightly less than the length of the skin incision and with the deeper-wounded structures in the centre. The incision in the deep fascia is made with a scalpel, through which the tips of Cooper's scissors are introduced; by means of incision with these scissors a wide opening in the fascia can be made and the muscle brought into view, and the wounds in the muscle can now be inspected.

When the skin and infected superficial and deep fascia have been removed the dirtiest stage of the operation is completed; fresh instruments and gloves should be used and adequate haemostasis must be secured in the freshly cut surfaces. Then all damaged and injured muscle tissue must be excised and wide access to the fracture allowed. All loose fragments and blood-clot are removed, and care must be taken to ensure that suitable drainage from the fracture site is possible through this aperture, making the wound, so far as practicable, cone-shaped, with its summit at the site of fracture and its base lateral or posterior in the limb. Sometimes this is difficult owing to the direction of the wound, but in most cases with an entrance-

and-exit wound one or other of the wound tracks can be chosen for dependent drainage. Thus, with the wide excision of skin, wide aperture in the aponeurosis, and the excision of adequate muscle tissue, not only is infection removed but adequate drainage is established. During the excision the muscle contracts, and therefore this is best performed with scissors, which tend to hold it as they cut through, whereas the use of the scalpel is made difficult by the retraction of the muscles as they are cut.

In deep cavities it is often difficult to distinguish the edges of wounded muscle the torn ends of which have retracted in all directions. In these circumstances the wound cavity must be stretched widely open and the main direction of destruction in muscle defined. The surgeon can then see more clearly which muscles are involved and whether their ends have retracted. If this be done systematically, from the more superficial muscles down to the most deeply situated, adequate inspection becomes possible and the surgeon can remove not only destroyed muscle but muscle that may not survive owing to bruising or disturbance of blood supply. Normal muscle tissue can be recognized by the following characteristics: First, a normal colour; muscle which is dying has a dull colour, has lost its gloss, and is becoming bluish in appearance, the colour change resembling the difference between arterial and venous blood. Secondly, fresh blood exudes from the surface of a fresh incision into normal muscle, showing that the blood supply is intact. Thirdly, when the muscle fibres are cut they contract if their nerve supply remains intact. On these three signs it can be decided whether the muscle is sufficiently devitalized to be removed or not. While adequate excision is essential we must remember that all tissue, particularly muscle tissue, must be preserved if at all possible, as muscles cannot regenerate, although the remaining tissue may hypertrophy. Although this point should be emphasized it must not prejudice the principles of the excision of doubtful tissue and adequate drainage. Thus it would be better to remove a part of some muscle than to endeavour to preserve necrotic tissue, and it is better to make large drainage apertures through healthy tissue for the removal of blood-clot and damaged tissue than to risk leaving such at the bottom of an undrained cavity. There are, however, some limitations to the extent of the excision of tissue. It is unjustifiable to expose extensive areas of either large blood vessels or nerve trunks, owing to the grave subsequent risk of haemorrhage or nerve complication. It is therefore necessary sometimes to preserve some damaged tissue in the vicinity of such structures. If these structures intersect the wound cavity an endeavour is made to clean the cavity around them, and then to protect them with a muscle-covering produced with two or three fine catgut sutures over them.

Bone fragments present another problem. We have already made it clear that any loose fragments must be removed and a careful search made to ensure that none are left behind; but that fragments of periosteum must in no circumstances be removed, though they may need to be replaced and the sharp edges may have to be rounded so long as the periosteum connexion is not damaged.

It is very difficult to give any definite indications with regard to the removal of fragments of bone with a dubious connexion to soft tissue. One should be careful to remove doubtful fragments so long as the amount removed does not prejudice bony union in the fracture. Provided that the rest of the operation has been done properly, it is unusual for an occasional necrotic fragment to produce a worse result than the formation of a sequestrum, which can be removed later. If, however, it be found impossible to perform adequate excision of the soft tissue, then it is imperative that all doubtful fragments should be removed and that great care should then be taken to leave undisturbed even the smallest portions of periosteum.

This procedure completes the operation. After this, haemostasis must be secured, and must be complete. Even the smallest bleeding vessel should be ligatured with fine catgut. The whole wound should be powdered with sulphanilamide or, better still, with a mixture of sulphanilamide and sulphathiazole. The wound should not be sutured. The plaster is now applied as previously described without any dressing or padding under it.

Operative Procedures in Late Cases of Gunshot Fractures of the Thigh

In this group of cases there are various types. Some do not show evidence of infection, but are assumed to be infected because of the long delay between injury and treatment. Such cases can often be treated as were those in the previous group. There are others in which wound infection is apparent but is confined to the local area. Such a series also includes patients who have had an excision at an earlier stage and have been left with packing in the wound. For patients with local infection the treatment as previously described may be possible still; but if the infection is more widespread, then treatment must be different. The operation in this case is designed not for wide excision but for adequate inspection and cleansing of the site of fracture and the securing of adequate drainage from the wound cavity. In this connexion the situation of the wound is of great importance. Thus wounds on the outer side or on the posterior surface of the limb frequently permit of adequate dependent drainage, whereas wounds on the interior or anterior surface of the limb are often quite unsuitable not only for drainage but even for adequate inspection of the damaged tissue. Thus it is sometimes necessary to explore through an incision on the outer side of the limb and to establish drainage from the same direction. In these cases I would like once again to emphasize how important is the mechanical cleansing of the wound cavities and the surrounding tissue with soap and water, and how essential it is that the procedure previously described for cleansing the tissues should be undertaken in every case. The water must be sterile—boiled if necessary. The best soap to use is liquid green soap; ordinary soap, however, can be used in 0.25% carbolic, and such a solution, if made under unsuitable conditions, should be sterilized by boiling. All parts of the wound should be washed, including the actual site of fracture; and plenty of water should be used, so that mechanical removal of foreign bodies will take place at the same time. At the actual site of fracture the bone fragments must be washed very carefully, taking precautions against tearing any fragments of the periosteum. After long-continued cleansing in this way the whole wound is irrigated and washed carefully with normal saline. The wound is now re-examined and all the pockets and wound surfaces are irrigated with normal saline until they appear clean and the saline from the wound itself runs clear. As an example, in a splinter fracture with laceration the washing of the wound surfaces and the surrounding tissue should be continued for 10 to 15 minutes, and something like 5 litres of solution will be required for irrigation. This last procedure is not only valuable for the cleansing of the wound but makes the operation simpler and the recognition of damaged tissue easier.

It has been stated that these procedures are unsuitable because of the time involved for use in the front line. We would say that the additional use of the surgeons' time is adequately justified by the results, and in addition the actual operative procedure is rendered much quicker by the improved conditions. Another objection is the large quantity of sterile water, liquid soap, and salt solution required; and it is true that sometimes, with a large influx of such patients, this may present a serious problem. By adequate preparation beforehand such problems of supply can be overcome—on occasion sea-water has been used instead of saline with very good results; and all the difficulties and trouble are adequately compensated for by the improved condition of the patients. We believe that the application of this method is most valuable even in cases of gross infection; although it is obvious that one cannot sterilize gross infection by this means, it will wash out much foreign material, which will aid in the operative procedures, and remove the accumulation of pus and exudate. Indeed, in such cases it is often much more important, as only by so doing can one proceed to distinguish macroscopically between damaged and undamaged tissue. We do not mean to suggest that it is impossible to carry out the operation without this washing, but we maintain that it is made very much easier. We also feel that it is advisable after the operation to carry out irrigation again with saline before the application of sulphanilamide powder, to make sure that no tissue has been left which should have been removed. If additional incisions

have proved necessary for drainage, irrigation should be carried out through such an aperture as well. If the sides of the wound are gently wiped with soft gauze under the stream of saline it is surprising how much tissue and blood-clot are washed away which would normally be left in the wound cavity as necrotic material.

Operative Procedures for Severely Infected Wounds

In the previous world war the problem of gross sepsis in wounds was not solved, and even up to the end of that conflict most surgeons refrained from active surgical intervention in the presence of severe infection. Such wounds, and particularly gunshot fractures, are now being operated upon even after a long delay, and are treated in the same manner as we have described with recent ones. It appears that it is less dangerous to treat them in this way than to leave necrotic material in the wound to separate naturally. It was feared at first that damage to the defensive barrier which had been formed against infection would cause an increase of both the local sepsis and the general toxæmia. There is no doubt that the operative procedures described will remove this defensive area in many places and damage it in others, and will certainly introduce a large fresh wounded area where the struggle between the body defences and the bacterial infection will proceed; the operation will also often result in an increase in the toxæmia: all these things do in fact take place, but the increase in the general reaction has not proved serious, and the local condition has not deteriorated as might have been expected. The mechanical cleansing of the wound and the removal of dead tissue improve the defences of the body and the condition of the wound itself; and the surgical cleansing of the wound must be carried out most thoroughly—that is, on the completion of the operation all necrotic and infected tissue should have been removed. It would be ideal if all the excisions with the scalpel and scissors were made through undamaged tissue; this is rarely achieved in grossly infected wounds, particularly in the thigh, as in such cases the anatomical difficulties often render it impossible and the removal of fascial layers and large areas of muscle would make too great a sacrifice to warrant such a procedure. Under these conditions one must secure adequate drainage for the sepsis which cannot be removed surgically. We conclude that operative procedures can be undertaken with great advantage in cases of gunshot fracture of the thigh with gross sepsis. Excision of all infected or necrotic tissue should be undertaken if possible, adequate drainage must be established in either case, and sulphonamide preparations should be used both locally and orally; and, finally, complete immobilization of the limb should be procured by means of closed plaster.

We think that drainage is so important that details of the procedure are worthy of mention. There are three basic requirements: (1) incision and approach to the site of fracture from the lateral aspect of the thigh through the vastus lateralis muscle; (2) funnel-like excision of this muscle with the apex at the seat of the fracture; (3) suturing, if necessary, of the skin edges to the deep fascia.

I have previously suggested that the lateral aspect of the thigh is the site of election for the approach to the fracture, as it allows of adequate drainage, there are no large structures which impede one's approach, and it can be used throughout the length of the thigh from the trochanter to the external malleolus of the femur; only in cases of approach to the head or neck of the femur would it be necessary to extend the incision into the gluteal muscles. Only in exceptional circumstances, with wide destruction in the lower third of the femur, would the biceps femoris need to be incised. If the actual wound, either of exit or entrance, is on the lateral or the posterior aspect of the limb, it may be suitable for use as drainage without further incision. If the wound is not in this situation, then drainage must always be done from the lateral aspect. During the lateral approach great care should be taken at the actual site of the fracture, but drainage from the fracture site must be adequate, and small exposures are to be deprecated. This large exposure has the additional advantage of permitting adequate inspection. Muscle layers, however, adjoining the bone fragments must be carefully preserved at both ends, as the blood supply to the periosteum mostly passes through this site. Muscle must therefore never be

detached from the periosteum or from the ends of the fractured bone, and excision of muscle at this site must always be minimal. It is perhaps advisable at this stage to emphasize again that no periosteum should be removed; and even if some doubtful bone fragments insecurely attached to periosteum are taken away, the small, even minute, fragments of periosteum should be retained.

The object of suturing skin edges to deep fascia is to prevent premature closing of the wound cavity with consequent pocketing. The skin edges are sutured to suitable deep fascia, or often to muscle, by means of two or three catgut sutures on each side of the wound cavity. The elastic pull of the skin then tends to retract the deep muscle layer and thus prevent occlusion of the cavity deep in the limb. This suturing should not be undertaken until the wound has been amply treated with sulphanilamide powder. It is essential to prevent any infection under the skin flaps, and this is also guarded against by the use of catgut, which will absorb rapidly and enable the skin edges to retract later. This usually occurs in 7 to 12 days, during which time the success of the operation is being decided. This procedure also seems to reduce the depth of the wound and the depression of the scar afterwards.

Conclusions

I have described the aims and technique of the operations undertaken for gunshot fracture of the femur at various times after occurrence of the injury and with varied degrees of infection. It has been shown that when operation is undertaken within a short time the procedure is strictly confined to the removal of foreign material and damaged or devitalized tissue. In such cases additional drainage is seldom required, but the wounds should not be sutured. In treatment undertaken at a later time after the injury the method of choice is wide excision of infected and necrotic tissue and great care in mechanical cleansing, followed by free drainage.

I have concluded that adequate excision of muscle, so as to produce a funnel-shaped aperture for drainage, is of great importance. Adverse criticism has been expressed of this point of view. It is stated that this unnecessarily wide excision would cause an increase not only in the extent of muscle contracture but in the loss of power in the limb as a whole, and that it would increase the devitalization of the bone fragments with the risk of non-union of the fracture. I have never suggested that the excision should be excessively wide, and have pointed out the dangers of the removal of muscles with arteries traversing them; in consequence I have advocated the lateral approach through the vastus lateralis. In 350 cases of such fractures with gross sepsis upon which I operated I have not had one single case of non-union of the fracture. In addition, owing to the use of incision through the vastus lateralis and the technique of suturing the skin to the deep tissue, we have not seen defective movement of the limb as an after-result which can be attributed to post-operative defect in muscles.

I would like to remind readers that the first task in modern warfare in the treatment of a wounded man is to prevent the loss of the man's life and limb by infection. We believe that this is mainly achieved in the case of gunshot injuries of the thigh by the operative procedures described, prolonged immobilization in plaster, and the use of local and oral sulphonamide preparations. We admit that the procedures described are often tedious and time-consuming, and we have been told that such treatment cannot be used when the number of patients is large. We believe, however, that the methods described are irreplaceable by any other method of therapy, and by their means 95% of our patients with these injuries have their lives and limbs saved. Other methods, and splinting, though useful for transport, are unsuitable for immobilization treatment over any length of time and cannot replace the use of plaster. Inadequate excision and temporary splintings could only be justified under conditions of great stress, to enable the patient to be transported from the front line to hospital; we do not think that any considerations of time should weigh when the patient's life and the ultimate fate of the limb are at stake.

In view of the criticism that these procedures are prohibitively time-consuming I would like, in conclusion, to give an average estimate of the times which the various procedures take under our conditions.

The patient is put on the orthopaedic table, a spinal anaesthetic is given, the extension apparatus is applied, and the limbs are thoroughly washed. This work is mainly undertaken by orderlies, and the time required is approximately half an hour. The surgeon is helped by one assistant or an experienced sister, and there is a nurse attending to the instruments. If the knee-joint requires opening and the wound has to be dealt with as described, the whole procedure would take approximately 24 to 25 minutes. If the wound involves the femur above the great trochanter, and particularly into the hip-joint, the procedure will take from 40 to 45 minutes. If, however, the fracture is in any part of the diaphysis of the femur the work is easily completed in half an hour; thus the average length of this part of the operation is 30 minutes. The third part of the procedure—that is, the application of the plaster—is performed by trained nurses, usually two with a third preparing the bandages. The application of plaster, including a hip spica, takes 20 to 25 minutes, and 10 minutes is required for additional drying before the patient is moved. Thus three tables allow of a continuous flow of wounded. Each of these stages averages about 30 minutes, and each patient therefore requires one and a half hours; but one patient is dealt with each half-hour, and during a 16-hour working day, with one hour for dinner, it is possible to attend to some 25 to 35 wounded men. This is the maximum figure, but has been easily attainable under such a system. The team consists of 9 people, who work on three tables; there is only one skilled surgeon in the team, and usually three experienced nurses; the rest are orderlies. In order that the work shall proceed continuously it is necessary to have another experienced doctor available for the sorting of the wounded as they arrive, directing them for radiography or for other purposes as may be required, and also choosing the next patient for operation. This same doctor could administer the spinal anaesthetics. This team is sufficient to deal with a large influx of wounded men, since there are about 30 cases of femur fracture to 400 or 500 total wounded as a rule. Thus all the femur fractures among 1,500 wounded men could be treated in 3 days. Admittedly it is unwise to wait till the third day, but under conditions of stress this can be done successfully if the patient has been given sulphanilamide powder by mouth and locally. We have found that in these conditions the proportion of dangerous infection is not higher than 2%. Up to 2% of cases may show secondary haemorrhage, but in not more than 10% of such cases is the haemorrhage likely to be dangerous. We consider, therefore, that 90% at least can be evacuated in excellent condition, and the majority of these patients will have their wounds healed and the fracture consolidated before the first plaster needs renewal.

SOME THERAPEUTIC FALLACIES

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A few years ago one of us had occasion to give a clinical lecture in a London hospital to a number of general practitioners. In it he happened to question the value of certain generally accepted forms of therapy, to be hotly attacked by a section of his hearers on the score that he was taking away their "treatment." It was in vain he protested that if this could be proved to be valueless it should be discarded. They were not to be pacified. Shortly afterwards he had a similar experience in the Provinces. This paper owes its origin to these two incidents. It is not to be expected that all our conclusions will be accepted by all our readers. If they succeed in evoking a critical spirit—now, alas! sadly lacking—in regard to present-day methods of treatment, we shall be content.

Essential Hypertension

The number of men and women in middle and late middle life who "suffer" from this condition is enormous. The number who are living full and vigorous lives in blissful ignorance of the fact that their blood pressures are abnormally high is immeasurably greater. Of those in the first category few would have any symptoms referable to the condition if they had not been informed by their doctors that they were its victims.