THE PLATING OF GUNSHOT FRACTURES.

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DURING nine months' experience of large numbers of cases in French base hospitals almost every advocated method of treatment has been given a trial, and of these the method with which this article is concerned has given the best ultimate results. It would be a mistake to say that it was immeasurably superior to all others, for there can be little doubt that every surgeon gets the best results from the method to which he has devoted most time and thought; at the same time, a method which has given good results in some hands may be confidently expected to give good results in others, for there is nothing novel or special about it. Indeed it is so ordinary as to be scarcely worthy of record, yet I have not seen it used in any French military hospital that I have visited, nor heard of its use in many English ones.

Considering the subject from a purely theoretical standpoint, there are two main factors to be dealt with: First, there is the anatomical or mechanical injury; secondly, the infective or inflammatory injury. The ideal treatment would be one which enabled us to deal with each of these separate factors as we wish without interfering in the slightest degree with the treatment of the other.

The importance of obtaining an anatomical result as perfect as possible need not be emphasized. Modern surgery has already appreciated the far-reaching effects of even minor defects in anatomical reconstruction, and how closely the functional result depends upon the anatomical. This relationship is especially marked in the case of fractures, and in the compound comminuted fractures so common in gunshot injuries the great difficulty is to obtain a good anatomical result. The two main unfractured portions of the bone are separated by an interval of 2 or 3 inches, in which there is more or less comminution. In some cases pieces of bone are missing, and in others some of the intervening small fragments die, so that there is actual loss of bony substance. The most perfect anatomical results can only be obtained in such cases if the interval or gap is maintained from the first at its original length, for the consolidation which eventually occurs is frequently very imperfect, and secondary operations to increase the rigidity of the bone are needed. Such secondary operations will only lead to disappointments unless the main fragments have been maintained meanwhile in perfect relative position.

Given, then, some method of assuring a good anatomical result, the second part of the problem—namely, the infection—must be dealt with according to the best accepted methods, whatever they may be. Any method, therefore, of splinting the bone which interferes at all with the practice of the numerous methods of dealing with sepsis, or renders difficult the adoption of those accessory treatments such as massage, so important to good functional results, must be considered imperfect. When it is remembered that among the methods of combating sepsis must be included the Bier's bandage, the antiseptic bath, the drip bath, and others necessitating freedom of the limb, the disadvantage of any method of external splinting becomes apparent; add to this the inconvenience of dressing and nursing when assistance is not so abundant as in peace time, and it will be seen that external splints are by no means perfect. In fact, from the theoretical point of view, the internal splint would appear to be the better; but it must next be considered whether it complies with the other essentials—namely, that it assures perfect anatomical result, and does not interfere in any way with the infective process.

As far as anatomical reconstruction goes, it is possible in the majority of cases to obtain a considerable degree of perfection with a plate; but the problem as to whether its application would not increase the damage by opening up further channels for infection, both in the soft tissues and in the bones (chiefly through screw holes), was one which at first caused a good deal of anxiety. A wide experience,

however, has proved that the fresh infection of soft tissues is negligible in view of the already extensive damage, and that fresh infection of the bone does not occur to any extent worthy of consideration. Indeed, in some cases, chiefly of the smaller bones, a previously septic wound has healed completely over a plate. Such results were unexpected, and may possibly be due to the healthy condition of the tissues previous to the injury, for the screw-holes must frequently open up the medulla beyond the primary limitation of the sepsis, and yet necrosis, except of more or less detached fragments, does not occur. Following logically upon these considerations comes the question whether the plates tend to loosen in the presence of sepsis, and, if so, how quickly such loosening occurs. It has already been mentioned that in some cases complete healing actually occurs over a plate; in the larger number of cases, however, the plates do tend to loosen, although not to the extent that *a priori* reasoning would lead one to expect. This loosening does not occur to a degree sufficient to affect the function of the plate until the fragments have become more or less fixed in position (three or four weeks), and even then it still acts as a most efficient method of extension. Appearing to have little effect upon the septic process, the plates may often be left in position for considerably longer periods, frequently becoming consolidated again.

The chief objections, therefore, to the use of internal splints are rather of theoretical than practical interest; and the ease with which the dressing can be manipulated, and massage, etc., applied to the neighbouring joints and soft tissues, can be attained with few other methods of splinting. In view of recent writings upon the sterilization of these wounds soon after they are inflicted, it must be mentioned that in nearly all the shell wounds seen here twenty-four to forty-eight hours after infliction the infection had already got into the tissues, so that it was impossible to adopt any method of immediate sterilization with success.

Practical Difficulties Met With.

Owing to the comminution the plates on the average have to be longer than those used for clean fractures, in order to get a hold of solid bone, and this increased length sometimes makes their application a matter of difficulty, considering the surrounding sepsis and the inadvisability of opening up fresh channels. On the other hand, in many cases, the increased drainage so obtained is advantageous. In other cases the comminution extends over such a length of bone as to render it impossible to apply a plate. In one or two such cases, where the extent of the comminution was not well shown on the radiograph, the attempt at plating had to be abandoned. These cases are always very serious, and usually give poor results, whatever method of splinting is adopted. Occasionally, too, in cases with much comminution, the hold of the plate on the bone has not been good, and it has been found advisable to apply an external divided splint in addition. For this purpose a divided plaster, having a soft iron connecting piece bent to form a handle for manipulating the limb, has been found most convenient. Even in such cases the application of an internal splint has much to commend it, for it takes the place of an extension (often difficult to apply satisfactorily in compound fractures, especially those of the more distal parts of a limb), and by preventing "sagging" of the fragments makes the use of a wide gap in the plaster practicable, and so facilitates thorough and frequent dressing.

Date and Method of Operating.

The actual plating operation is not usually undertaken for four or five days after admission, which time is spent in clearing up the acute sepsis and having radiographs taken. It is essential to have good radiographs in two planes at right angles, for without them it is impossible to reconstruct the exact position of the bones, the amount of comminution, and the shape of the main ends. Unless a very clear picture of the condition of the bone is held in mind, it will be impossible to judge the best position for the plate. To combat the sepsis no routine method has been used, each case has been treated according to the indications. Of the methods more recently advocated, ether has been used with apparent benefit in many cases; an antiseptic dusting powder composed of benzoic acid 25 grams, salol 5 grams, quinine 25 grams, and magnesium carbonate 25 grams, has

also proved of use in very dirty cases after a preliminary cleaning under an anaesthetic. This powder would appear to possess the additional advantage of being slightly analgesic. Hypertonic saline solutions, both with and without corresponding vaccine treatments, have also been used, but apparently, once the sepsis has been limited, the application of a Bier's bandage, or if possible of a suction cup, is more efficient in causing a flow of lymph; it has been constantly used in the treatment of these cases. Sun-baths have been freely used, and injections of colloid gold (so highly commended by the French) were tried in many cases. In the first two there appeared to be marked improvement, but further use showed that these were probably cases of coincidence, for the average results were not equal to those obtained by the use of antiseptics vaccines.

By the energetic pursuit of these methods the sepsis can be considerably reduced after a few days, and at this period the plating is undertaken. The incision, if one is necessary, is designed, failing anatomical contraindications, so that the plate can be applied to the most satisfactory position on the bone. In many cases the original wound only need be enlarged, but, while opening up as little fresh tissue as possible, it is essential to get good exposure and at the same time to have a thought for the future drainage of the wound. The fragments are now replaced as far as possible so as to restore the continuity of the bone. Such fragments as must obviously die are removed, all others being retained. Where several large pieces are completely missing the gap so caused in the bone is carefully maintained and the plate applied to bridge it over. While this preliminary arrangement is being made, the surrounding structures are carefully examined for injury. It is surprising how frequently injuries are discovered and can be remedied; for instance, in two cases of plating of the humerus the musculo-spiral nerve was found in such a position that it must later certainly have been involved in callus; it was freed and buried in muscle, so preventing the development of pressure symptoms. Many other such cases involving nerves, tendons, muscles, and even vessels, could be instanced. The ends of the main fragments are now exposed, and the periosteum being disturbed as little as possible the plate is applied. The most useful type of plate for comminuted fractures is one having two screw-holes fairly close together at each end, and one or two intermediate ones. This enables one to get a firm hold of the main fragments and also to screw some intervening small fragments into position; not only does this increase the general rigidity, but partially separated fragments often join up again.

The screws in the main fragments should not be placed too close to the fractured end. After drilling the holes we have made it a practice to carbolyze them before inserting the screw, although whether this has had any appreciable effect in preventing fresh infection of the medulla there is no definite evidence. Where a fresh incision has been made it can usually be sewn up completely unless needed for drainage. The drainage, however obtained, must be good, and free access for the purposes of dressing maintained. In some cases the wounds are best left absolutely open for the first few days, and partial closure undertaken later. Deep sutures are generally not needed, and ligatures only in few cases; fishing-gut sutures are used for the skin. The application of a tourniquet has rarely been necessary, but where assistance is not easily obtained the use of spinal anaesthesia will be found of advantage, since it releases

one pair of hands.

The limb is now quite rigid, and for the following three or four weeks the attention will be devoted to dealing with the sepsis.

There is usually a rise of temperature for the

Average temperature chart of six consecutive cases for the first week after plating operations. O, Operation.

first few days, but this is not excessive, as the accompanying average chart, constructed from six consecutive cases, shows.

There is now no restriction; the limb may be treated

almost as one without a fracture, early movements and massage being carried out with ease. At the end of a month the position of things has become fixed, and the plate, if it is much loosened, may be removed. If possible, however, it is retained, and particularly in cases with a gap, for it effectually prevents shortening. At this period, also, one can see what portions of bone will live, and the rest may be removed. The suppuration diminishes almost

Fig. 1.—Showing bismuth paste filling the cavity following on sequestrectomy.

to nothing, although frequently after several more weeks it will be found that there is a sequestrum more or less embedded in a cavity, either of bone or of fibrous tissue; this can easily be extracted and an attempt made to close the wound by any of the recognized methods. The use of bone chips does not appear to be very satisfactory, and usually two or three injections of Beck's bismuth paste have given better results. Before the use of the paste the cavity is sterilized as far as possible by swabbing with pure carbolic, followed by the use of iodoform paste for a few days. Skin grafting has also been freely applied to assist in the rapid closure of the wounds.

Before Grafting.

In many instances this is all that is required, but, on

the other hand, a large number of cases remain in which the bone ends are separated by a length of intervening fibrous tissue (sometimes even 3 or 4 inches). In others, with much loss of bone, the separate fragments are connected by thin fibrous tissue, which renders them useless as supporting structures. Such cases can, of course, be fitted with an external support, but the results obtained by bone grafting are such as to render the patient free from this inconvenience. Grafting cannot be undertaken until absolute asepsis can be guaranteed, and that means complete closure of the wound. As explained above, this takes in the earliest cases about three months, and in others as much as six months, so that the secondary operation must be long delayed.

The nature and size of the graft depends entirely upon the use to which it is to be put. A portion of a rib or a strip of the tibia are easiest to obtain, but in many cases the graft can be cut from the same bone, so saving a fresh incision. In this way gaps may be bridged over and fragments consolidated. The grafts invariably "take," but the process is slower than when done on fresh cases, owing

Fig. 2.—Humerus after removal of plate, showing sequestrum. The position of sinus has been marked.

probably to the surrounding fibrosis, which must limit the blood supply. Grafts are best held in position by screws, bone pegs being difficult to cut without special apparatus, but in some cases such rigid fixation is unnecessary. Central grafts placed into the medulla are less suitable in these cases than lateral grafts having larger areas of contact with the bone. In cases of fracture of both bones of a leg, a portion of the fibula split in half forms an excellent graft for the tibia. After a week, when the wound is healed, massage and movements are continued. In three to five weeks the patient may get about in a removable poroplastic or preferably celluloid splint. It is wise to continue the use of this for some time. Emphasis must be laid on the fact that graftings do not require any special set of instruments for their performance, although these render the operation easier. They can be easily performed in any temporary theatre where asepsis can be guaranteed, and which possesses a Hey's or small laminectomy saw.

The short reports which follow are given, not as records, but merely to indicate the type of case in which this method has been applied.

CASE I.—Compound Comminuted Fracture of Tibia and Fibula.

Soldat, 50me Régiment d'Infanterie. Wound of left leg by shrapnel bullet, causing a compound fracture of the tibia and fibula, with extensive comminution over nearly 3 in. There was a large jagged exit wound obviously caused by splinters of bone, for the bullet remained lodged behind the tibia. Upon the day after admission the wound was cleaned up and the bullet removed. Radiographs in two planes were taken, and the sepsis considerably diminished by drip baths of mild antiseptics with dressings of hypertonic saline. Five days later the wound was enlarged, and a plate was applied to the inner aspect of the tibia maintaining the original length between the main fragments; several loose fragments were retained and screwed roughly into position. At this operation the posterior tibial artery was found to be exposed and was buried in muscle. Following this, the limb was placed in a bath of hypertonic saline for some time every day, and movements of the neighbouring joints were commenced.

Within a week secondary haemorrhage from the posterior tibial occurred, and was dealt with in the usual way. At a third operation six weeks later the plate was removed, together with several small pieces of dead bone; some of the larger fragments had consolidated. The leg was now in good position without shortening, and suppuration had almost ceased. Within three weeks the wound had healed except for a sinus leading to a small sequestrum. This was removed, the cavity being sterilized with pure carbolic and iodoform paste; three days afterwards injections of bismuth were started, first using the soft paste and later the harder one. The cavity very quickly closed. The radiograph now showed that those of the intervening fragments which had lived had formed a complete bony bridge between the main fragments, and grafting was therefore unnecessary.

Fig. 3.—Case II, six weeks after operation; showing the graft becoming ossified on to the main fragments. The gap, being an oblique one, does not show well in a single radiograph.

Fig. 4.—Case II; showing wound of exit and line of incision for grafting. The latter has been outlined to make it visible.

CASE II.—Compound Comminuted Fracture of Tibia.

Soldat, 18me Régiment d'Infanterie. The first portion of this man's history closely resembles that of the previous case. The wound of exit was on the inner side of the leg, about $2\frac{1}{2}$ inches

above the ankle-joint. When healing had eventually occurred there was an oblique gap of about $1\frac{1}{2}$ inches in the bone, and the lower fragments with the foot moved in a somewhat flail-like fashion upon the upper. At the grafting operation a long curved incision was made to expose a considerable length of the anterior border of the tibia. Two strips, about half an inch thick, were cut, one from the upper and one from the lower fragment, the former being about twice the length of the latter. These were now interchanged, so that the long strip formed a bony bridge across the gap between the fragments. It was held in position by screws. A radiograph taken six weeks afterwards shows that the graft is becoming ossified on to the fragments. At present, three months after the grafting, the man is able to walk on the leg without any external support although as a matter of precaution he is made to wear a light case.

CASE III.—Compound Comminuted Fracture of Humerus.

Soldat, 112me Régiment d'Infanterie. Shell wound of the

left arm causing compound fracture of the humerus with considerable comminution. Upon admission there was great displacement, the dressing was exceedingly difficult and painful, and it was found impossible to keep the bones in good position between the dressings. At the plating operation the musculo-spiral nerve was discovered lying between the bony fragments. It was protected by muscle. After the plating operation the pain rapidly diminished, dressings

Fig. 5.—Case III; showing humerus plated and drainage tube in position.

were carried out with the greatest of ease, and the limb could be freely moved without fear of disturbing the fragments. Massage and faradism were applied to the forearm immediately, but no signs of musculo-spiral paralysis developed. A week after the operation the patient was walking about with his arm simply supported in a sling. In this case also there was so little loss of bone that grafting was not required.

CASE IV.—Compound Comminuted Fracture of Radius and Ulna.

Sous-Officier, Chasseurs Alpine.

Shell wound of forearm; both bones fractured, the ulna being very little comminuted, but the radius very extensively so with a large portion of the bone missing. The ulna was plated through a fresh incision, the wound healing over the plate. A large raw area over the radius was eventually skin grafted, and when healing had finally occurred the gap was filled by a strip of tibia.

Fig. 6.—Case III, within a short period of operation; showing arm solely supported by sling.

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THE Hon. Sir Henry Normand MacLaurin, LL.D., M.D., aged 79, of Sydney, N.S.W., formerly a surgeon in the Royal Navy, afterwards President of the Board of Health of New South Wales, later successively Vice-Chancellor and Chancellor of the University of Sydney, left estate valued at £75,148.