Observations

ON

GUNSHOT WOUNDS OF THE HEAD.

BY

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IN view of publications on this subject which have appeared in the medical press from time to time since the beginning of the war, it seems desirable to define the principles and practice followed, almost without exception, by the surgeons at work in the military hospitals in R—. These principles may be enunciated shortly as follows: We believe

That infected gunshot wounds of the skull and brain require more careful consideration and prompt attention than similar wounds of any other part;

That we can combat and prevent sepsis best by early and complete operations;

That we can prevent permanent disability in most cases by systematically removing foreign material or displaced bone from the surface or substance of the brain whenever these are accessible to legitimate surgery;

And further, that, by these precautions, the immediate results in the saving of life and more rapid restoration of function, when that is possible, are better than those obtained by more conservative procedures.

All experience has shown that the brain, sooner or later, resents the presence of any abnormality in its immediate coverings or in its substance. It is true that some small lesions of the skull or small foreign bodies in the brain have caused apparently no trouble to the patient, even after years have passed, but others, seemingly equally insignificant, have caused intolerable inconvenience, due to late effects on the brain, which removal of the exciting cause has not succeeded in relieving. This is more true, of course, in cases of actual lesion of the brain. It is rather sad to think of the number of men injured in the head during the South African war who afterwards became a burden to the State owing to derangements of the brain, and it must be remembered that the maiming effects of sepsis in that campaign were not apparent to anything like the same extent as in this one.

It has always been the aim of military surgeons to remove or ameliorate the physical defects produced by missiles. Removal of displaced bone, of foreign bodies, of blood clot, or of any substance which might interfere with rapid and smooth healing of the brain has been considered to be of the utmost importance no less than the combating of sepsis. We have discovered in this campaign no valid reason to depart from this line of thought. The immediate effects of sepsis, both in increasing the severity of the focal lesion and in causing diffuse inflammation of the brain and its coverings, have been impressed on our minds with dreadful force. The power of the brain to accommodate itself to extraordinary conditions, or, one might say, the power of one part of the brain to disregard even excessive injury of another part so that what is left "carries on" in a marvellous way, has also been very striking. But who can foretell that, later on, such cases are to be free, as never before, of sequelae which experience has shown to be so frequently inevitable?

Because of that experience and because no one can foresee how soon trouble will arise, it is surely right that we should do all in our power to prevent probable trouble. It is a matter of the greatest importance to establish the best method of preventing or eradicating sepsis, which is such a hindrance both to rapid healing and to successful attack on physical defects in the skull or in the brain. One is not justified in formulating rules which are based on results of operations performed at a period in the war when methods of dealing successfully and rapidly with infected wounds were not properly appreciated. It has been found that septic wounds of the scalp and skull are particularly easy to deal with when compared with others in that they can usually be completely excised, and the scalp sutured without danger. One might almost say that this procedure, in the hands of those who have mastered

the necessary technique, has robbed operation of its danger and has enabled surgeons to obtain results which compare favourably with those of equal magnitude in civil practice under ordinary aseptic conditions. These remarks do not apply, of course, to cases in which sepsis has already obtained a firm hold in the lacerated brain. The problems connected with such cases are much more difficult. Apparently success is then dependent chiefly on the provision of suitable drainage—a very easy thing to say!

Fragments of bone, when driven into the brain, are not usually septic at first, but tend to become infected fairly rapidly. Jagged pieces of shell almost invariably carry infection along with them. If large pieces lodge in the brain, results are very bad. Very small pieces, on the other hand, may not cause any trouble, but even they have been found sometimes surrounded by large abscesses.

While it is evident that the thorough removal of physical defects is desirable at as early a date as possible, there are objections to this, of which the most important is that patients do not travel well until at least a week or ten days after operation. During a period of active fighting they cannot be kept at the front, and therefore it would appear best that all except the most serious cases should be sent at once to the bases, so that they may arrive before sepsis has got a firm hold. At the front nothing should be done to the wound further than to remove any visible foreign material, to antisepticize the surrounding scalp, and to apply a suitable dressing. To judge from experience in Rouen, it would seem advisable that, if any operation has to be done at the front, it should be a complete one. Second operations appear to entail a greater risk, taken all over, in these cases than a complete primary one. The average case arrives at the clearing stations really in a less septic condition—although the wounds may be superficially badly soiled—than they do at a base, and results should on that account be more favourable.

The following remarks have, of course, no reference to very severe wounds caused by large pieces of shell, in which such an extensive part of skull and brain is blown away or where a rifle bullet causes such explosive intracranial effects that the patient does not survive more than a few hours.

We have seen many patients who on admission have been suffering from complete hemiplegia, and whose symptoms have cleared up in such a marvellous and rapid way after operation that only a negligible amount of paresis has persisted. On the other hand, we have seen cases who showed few or no symptoms, but who later developed serious complications and died rapidly, in spite of operation. It appears, therefore, that one ought not to pay too much attention to focal symptomatology as a guide to treatment, or even, in many cases, to prognosis.

We have seen many cases with extensive superficial injuries with little or no damage to the brain, and, on the other hand, many cases in which an insignificant looking wound of the scalp and skull was associated with most extensive injury to the brain. Whilst large, lacerated wounds are usually most septic and suppuration in the brain apt to be severe, yet we have seen cases of trivial and comparatively clean-cut wounds of the scalp to be associated with extensive fracture, and, after a few days, with such acute suppuration in the brain that only immediate operation saved the patient's life. The size or condition of the wound, therefore, is no indication of how the case will behave.

One is told that oedema of the brain, and shock or concussion accompanying a serious injury, are such that operation at an early stage is dangerous. Yet we hear of many patients who are brought into clearing stations in practically a moribund condition who, after immediate operation, in a few hours have so far recovered that they are able to speak intelligently and take food. Their injuries heal up perfectly well afterwards. It would thus appear that oedema and so-called shock are no bar to success. Indeed, it is likely that both oedema and shock will pass off more quickly when the physical defects are remedied—all the sooner the more thoroughly this is done. In wounds of other parts, oedema and tension due to interference with the circulation are relieved very rapidly by incision, removal of foreign material, and drainage. How much more must relief of the circulation be called for in a closed box like the skull! In serious cases delay does not, therefore, seem advisable.

In passing, one may be permitted to draw attention to the value of local anaesthesia for many of the cases. The solution need be injected only into the scalp tissues and pericranium. The skull, dura, and brain will thereafter be found to be insensitive. If adrenalin is mixed with the solution, bleeding from the scalp is reduced to a minimum.

After consideration of all these facts we are driven, in deciding upon a course of action, to pay more attention to the probable mechanical effects of the injury and the potentialities for infection rather than to worry much over the presence or absence of definite symptoms. The lesion is a traumatic one, the possibility of sepsis is great, and things should not be left to chance or until the development of some particular symptom. One must risk misinterpretation when one says such things. One does not wish in the slightest to depreciate the value of clinical investigation. Timely and effective operation does not interfere with that. There is no doubt that the lesions one has to deal with are chiefly mechanical and microbic, and must be treated by mechanical and antimicrobial remedies. If the mechanical disabilities are not relieved, the complicating infection has potentialities greater and more serious than in wounds of other parts.

Minor Operations.

Excision and suture of scalp wounds are said by some to be unnecessary. Such a judgement depends on the point of view. These excisions, while they do no harm when proper technique is employed, make the patient fit for duty again in a much shorter time; they establish a diagnosis of fracture in most cases with absolute certainty; there is no doubt that thereby they occasionally save life, they certainly prevent troublesome sequelae; they save time and trouble on the part of the attendants, and they save expense in dressings. (The original mastic and gauze dressing may be left until the wound is healed.) Captain J. E. H. Roberts, recording 207 cases of excision of scalp wounds, states that only in 8 did failure to obtain healing by first intention occur. One wound gave way completely. In the others, slight gaping, sloughing, or stitch suppuration occurred.

Reasons for Opening Apparently Unwounded Dura.

It has been shown repeatedly during this war that a pronounced depressed fracture of the inner table, although the dura may not be lacerated, is accompanied by a localized, usually more or less cone-shaped, bruising or pulping of the underlying brain. The base of the cone corresponds roughly to the area of comminution of the inner table. Owing to its elasticity the inner table must always be depressed considerably before it fractures, and the sudden localized blow on the brain causes the pulping. The amount of depression necessary to cause fracture varies in different parts of the skull. Such injury to the inner table and brain may exist without a trace of injury to the external table. In very rare cases intracerebral haemorrhage, sufficient to cause severe pressure symptoms, may occur.

The pulped area—a mixture of useless brain matter and blood—is an immediate source of irritation to the surrounding brain, because it is virtually a foreign body. In the process of healing a great part of it is replaced by “fibrous” tissue—a scar—which forms a remote source of irritation. The pulped mass is liable to become infected and to form a localized abscess or to lead to spreading encephalitis or meningitis, especially if the wound superficial to it is not rendered aseptic at an early date.

In cases where the force has been so great that the dura has also been ruptured, although pieces of bone have not penetrated, a definite pulped track, extending even for a couple of inches into the brain, may be found. This, when explored by the finger, resembles closely the track made in the brain by a foreign body. This shows the necessity for using *x* rays before operation to reveal whether or not a metallic foreign body is present. Operation should not, however, be unduly delayed in order to have this done. If the foreign body is beyond the reach of the finger, it is usually beyond the reach of legitimate surgery. By fitting together the fragments of the inner table one can often ascertain, with fair accuracy, whether any fragments of bone have been forced into the brain.

The mass of disintegrated brain matter and blood, whether on the surface or in the depth of the brain, interferes with the local circulation, and by this alone causes irritation similar to a solid foreign body. After its removal from either situation, pulsation usually returns at once.

Such lesions may be accompanied by persistent headache, focal epilepsy or paralysis, or even “optic neuritis.” Their presence can usually be recognized, after the dura has been sufficiently exposed, in that the dura is somewhat discoloured, the brain does not pulsate freely, and the area feels doughy instead of elastic or springy.

When the dura is opened, the pulped material wells out like grease from a collapsible tube. Pulsation returns very quickly. If healthy brain matter is forced out, this indicates excessive intracranial pressure, and lumbar puncture or a decompression operation should be done at once. A small drainage tube, down to the hole in the dura, may be left in the wound for twenty-four hours. The dura is usually opened by a small crucial incision made by plunging the knife in for half an inch or so, at right angles to the surface of the brain. It is sometimes necessary to help out the pulped material by inserting a small forceps and carefully opening the blades.

Symptoms are usually relieved within a very short time. This relief is often most striking when the dura is opened at a second operation, the first (removal of depressed bone) having failed to relieve the symptoms.

In the hospitals the dura has been opened deliberately on more than fifty occasions, without fatality. The effect has been immediately and uniformly beneficial. In four cases in which the operators thought that the procedure was inadvisable, death occurred from abscess of the brain, spreading encephalitis or meningitis.

Operations where Wounds of the Blood Sinuses are Present.

These are done as a matter of course, because it is thought advisable to remove depressed fragments of bone—

(a) Which cause obstruction to the return of blood from any part of the brain, and

(b) Which may be, or may become, soiled, and cause septic thrombosis. It seems all the more desirable to remove such fragments if they actually penetrate the wounded sinus. The operation is, *per se*, not a dangerous one if proper technique is employed. For example, fourteen cases from the recent fighting were operated on. Only one died, and he had severe laceration of both cerebral hemispheres, besides the wound in the longitudinal sinus.

DRAINAGE OF THE BRAIN.

It is difficult to formulate any hard and fast rules about drainage of the brain. On the whole, it is probably best not to drain unless one is forced to do so. The presence in the brain of definite pus, of infected blood clot, of inaccessible, definitely infected foreign bodies, or of profuse oozing from a seriously lacerated area are the chief indications for it. If when operating some days after receipt of the wound it is found that pus is absent from a track which foreign bodies have made, it is usually unnecessary to drain. In some cases one may feel, however, that it is safer to insert a short drain for twenty-four hours or so. When aseptic foreign bodies, such as bone fragments, have been extracted, or when an area or track of pulped brain matter has been evacuated in which no penetration of foreign bodies has occurred, it is unnecessary to drain the cavity in the brain, but a $\frac{1}{4}$ in. rubber tube should always be inserted, from the angle of the wound, “down to but not into” the opening in the dura, for twenty-four hours. If pus, “smelly” blood-clot, clothing, hair, or a jagged large piece of metal is evacuated from the depth, a drain should always be inserted into the track, and it should be brought straight out through an unsutured part of the excised wound. Bacteriological examination of what is removed should always be made, even though actual pus is absent. If streptococci are found drainage should be maintained until the organisms disappear or become very few in number. If streptococci are absent it is fairly safe to be guided, as to time for removal of drains, by clinical signs alone.

It should be remembered that foreign bodies, especially flat pieces of bone, compress the brain in front of them; therefore, although they may be found at a depth of, say, $1\frac{1}{2}$ to 2 in., it is not necessary to push a drain in to that

depth. The distal end of the track will, after extraction of the foreign body, be found to have approached considerably nearer the surface of the brain. If one attempts in such a case to push a stiff drain in for a couple of inches, there is great likelihood that the lateral ventricle will be perforated by it. One should, immediately before inserting the drain, gently explore the track with the finger, and push the drain in only so far that it will not quite reach the extremity of the track.

As a rule, the drain should be shortened slightly every day or every second day unless pus continues to discharge from the depth in fair quantity. It should be borne in mind that a drain, especially a rigid one, acts like any other foreign body, and may stimulate pus formation, besides providing a channel for possible entrance of fresh infection. All drains should on this account be removed as early as possible.

Rigid drains are harmful to the brain, especially those with holes cut in them. The intracranial pressure may force normal brain through the holes or end of the tube. The constant friction of the pulsating brain against the hard foreign body must have a bad effect. The most satisfactory drain, on the whole, seems to be a piece of jaconet, batiste, or similar substance, folded concertina-wise, with small pieces of salt tablet embedded in its folds. As the salt dissolves it exerts a "hypertonic" effect on the surrounding inflamed brain. In certain cases, where the pus is particularly thick or profuse, or where streptococcal infection is present, it may be advisable to insert in addition one or two narrow tubes. Salt or "eusol" solution, of strength suitable to the infection, may be injected repeatedly, a few drops at a time, along the tube.

One must be careful, when inserting a drain, that damage is not done to the healthy brain lining the track. One must therefore note the direction of the track very carefully.

Points Constantly to be Kept in Mind.

1. There may be multiple injuries, therefore always have the whole scalp shaved.

2. The force causing the injury is usually very circumscribed, and its effects are therefore likely to be localized to the immediate neighbourhood of the part which has been struck. Injury by *contre-coup* has rarely to be considered.

3. Such localized forces, if they have been great enough to cause depressed fracture of the inner table, result, practically always, in definite injury to the brain, which asserts itself by immediate or remote cerebral disability. This may occur in pronounced form, although the dura is uninjured; in rare cases it has occurred even when no fracture of the external table has been seen. One need not refer to cases of immediate disability. Some interesting examples of remote disability have turned up already even in France. We have seen a good many cases now of men who were wounded early in the war, and whose wounds were considered so insignificant at the time that the patients were not even sent down the line. Later they were invalided on account of symptoms caused by the physical defect of the skull—to wit, depressed fracture of the inner table—which, of course, was treated without more delay.

4. Experience has shown that a properly conducted, complete operation, while it cannot undo the already existing damage to the skull or brain, facilitates repair, gives better immediate results, and tends to prevent troublesome sequelae more surely than an incomplete one.

5. Death is due, practically in all cases, to the effect of sepsis on the damaged brain. In any case sepsis will increase the amount of damage to the brain. The local injury, when thus complicated, is likely to "interfere with intellect or set up permanent paralysis." Apart from that, sepsis may cause necrosis of bone and thus prolong convalescence.

6. As our efforts will therefore be nullified in large measure unless sepsis is overcome, all operations must be preceded by removal of the sepsis from the area to be dealt with. Excision of the infected parts is the most rapid and certain way of doing this. It is only in very rare cases that this is not feasible. If it is not, the patient has probably very little chance of pulling through. The wound of the scalp and pericranium must be removed *en masse*. The fractured bone must be nibbled or trephined away. Proper technique is essential to success.

It must be pointed out that to excise the wound after turning down a flap is merely courting disaster. The brain cannot be dealt with so vigorously, but removal of pulped useless material and of foreign bodies will allow it to combat more successfully any infection. "Healthy brain substance possesses considerable power of limiting microbic invasion," but one cannot say that pulped brain or brain with foreign bodies embedded in it is healthy! As already indicated, in the majority of cases in which bone fragments alone are forced into the brain, the track leading down to them is not infected at first, but it rapidly becomes so.

7. Foreign bodies in the brain act deleteriously in four ways: (a) By their direct effect on the delicate pulsating brain tissue. (b) By favouring the development of sepsis. It is practically an everyday occurrence during a "rush" to find suppuration around pieces of bone lying at the end of a track in the brain. (c) By interfering, in rather an obscure way, with the circulation of the brain. A mass of pulped brain matter acts in the same way. It is very common to find that the brain, when exposed at operation, does not pulsate, or does so only to a slight extent, until the fragments of bone or disintegrated matter are removed from the depth, when it begins to pulsate freely. A normal circulation is essential to satisfactory recovery. (d) By causing, when they become encapsuled, a localized connective tissue mass which may act as deleteriously as a tumour. If recovery of function is possible, removal of foreign bodies will procure this more certainly, more rapidly, and probably more completely than is otherwise feasible—a great improvement is frequently noted within twenty-four hours. If carefully done, further damage to the brain is not appreciable. In only one case have I seen any immediate increase of paralysis follow—when an unusually large piece of bone had to be removed from a suppurating track. One will likely do less harm to the brain in removing a foreign body through an already existing track than by cutting a way through a mass of fibrous tissue, or, worse still, healthy brain, as has to be done when the operation is postponed till the scalp has again become intact.

8. It is highly desirable to try to prevent the formation of cicatricial tissue whether on or in the brain, even though in the latter case it may resemble neuroglia. Such scar tissue acts as an irritant chiefly by preventing normal movement of the brain, by interfering with the circulation, and, in many cases, by causing pain. The nature of the injury, the amount of sepsis, the presence or absence of foreign bodies, and the treatment employed have much to do with the amount formed. Unsuitable drains, especially when kept in for a long time, stimulate its formation. The trephine opening should be covered completely with healthy scalp. It is dangerous to replace any of the fragments of bone because they are likely to be infected. The scalp wound, after excision, can usually be accurately sutured over the opening—in some cases it may be necessary to perform a plastic operation, by sliding flaps. This is greatly preferable to merely covering the exposed brain by a flap of muscle, pericranium or aponeurosis. Such a flap, if exposed at the bottom of a wound, is apt to necrose. In any case, the amount of cicatricial tissue and of permanent adhesion is greater in a wound which heals by granulation than in one which heals by first intention. It is true that Nature has a marvellous capacity for remedying defects—even by making a new dura. The greater the amount of abnormality, however, with which she has to cope, the greater will be her difficulty in imitating the *status quo ante*. Therefore we should help her in every way possible. When this help is given efficiently, the wound responds by healing *per primam*. The surgeons who have kept statistics will support the statement that, in patients who recover, at least 90 per cent. of the wounds behave in this desirable way.

TREATMENT.

Objects.

The objects of our treatment can now be shortly summed up.

1. To prevent or remove infection, thereby preventing further destruction of tissue.
2. To establish diagnosis in some cases of doubt.
3. To remove all sources of irritation to the brain; if this can be done without causing further serious

damage to it. One cannot undo the initial surface wound or cerebral lesion, but one can try to procure a condition which will allow healing to occur more rapidly, more normally, and with less permanent impairment of function.

4. In any case to procure rapid healing of the superficial parts, provided that the brain is safe.

We may be charged with being too zealous in operating on head injuries. I cannot remember death occurring after any operation which was not one of urgency. We have regretted that we have not operated or operated sooner on some patients who have done badly. In all injuries we claim that operation furnishes an additional and usually accurate means of diagnosing the extent of the lesion. In minor injuries it has done no harm so far as can be ascertained, and it renders the patient fit to return to duty at a much earlier period than would otherwise be the case.

We believe that it is better to send a patient home with a healed scalp and healthy skull, inside which are the fewest possible potentialities for future brain trouble, than that he should go with the prospect of a later operation on an area which is obscured by many abnormalities. If it can be shown that this is done with as great safety as attends more conservative methods, our procedure is more than justified.

Sepsis and the exigencies of war will always make the proportion of failures a relatively high one. Unless these military exigencies will permit of "head" cases being retained near the front for operation and for a fairly long after-treatment, it is not likely that mortality and loss of function will be reduced to any great extent. It is difficult to see how better arrangements can be made, or, indeed, how any important improvement can be introduced in the methods for disposal of all classes of wounded which already exist.

The Routine of Treatment.

The following description of routine treatment carried out in hospitals varies only slightly from that given in a small set of leaflets issued in April, 1915.

On admission of the patient his scalp should be shaved, the wound thoroughly examined (the use of a probe is deprecated), two skiagrams taken in planes at right angles to each other, and an exhaustive neurological examination made. If the whole scalp is not shaved, other wounds, sometimes more important than the most noticeable one, may be overlooked. An aperient should be given and the administration of urotropine (15 to 20 grains every three or four hours) begun. If the brain is injured it is well, for future guidance, to make a bacteriological examination of the discharge. If brain matter is exposed or exuding from the wound, operation should be carried out as soon as possible. In most other cases, in absence of urgent symptoms, there need be no great haste, but in no case should operation be postponed for longer than a couple of days.

Excision of Wounds.

The majority of wounds of the scalp should be excised, and the bone beneath carefully examined. If no further interference is made, the wounds can be sutured, usually without drainage. It may be necessary sometimes to slide flaps in order to make up for defects in the scalp.

Depressed Fracture.

Every case in which depressed fracture of the skull is suspected should be explored without undue delay, whether sepsis is present or not. Delay—waiting for surface wounds to clean—too frequently leads to dangerous intracranial developments. If the edge of the wound is much inflamed and infiltrated, treatment with hypertonic saline applications usually makes it fit for excision in twenty-four to forty-eight hours. In most cases it is possible so to excise the wounds in both scalp and bone that an aseptic field of operation is left. If sepsis has already penetrated to the depth of the brain, the sooner operation is done the better. It is rarely necessary to turn down large flaps.

The injury comes under one of the following varieties:

1. Cases without Definite External Signs of Depressed Fracture.

Because fracture with displacement of the inner table or some other subcranial lesion may be present it is important that operation should be carried out.

(a) When the entrance and exit wounds are separated so far by a bridge of scalp that the line joining them traverses the bone, or if the patient has been stunned at the time of injury, the presumption is that the bone has been damaged. Such wounds and the track between them, as well as single gaping wounds of the scalp, should be excised *en masse*, including the pericranium. Injury, even mere bruising, of the periosteum usually means that the bone has suffered. If focal loss of function (even although evanescent), persistent headache or giddiness, or other more definite signs of cerebral compression are present, especially if optic neuritis coexists, trephining should be done, even in the absence of definite laceration of the periosteum.

(b) If fracture of the outer table without depression is found, or even if the bone is merely bruised, a small trephine opening should be made and the inner table examined. Depressed fracture of the inner table may exist without any cerebral symptoms, and only the very best skiagrams will show such a fracture.

Operation in such cases is practically without danger.

2. Fracture with Depression, but without Injury to the Dura Mater.

The fractured and depressed bone must be removed by means of properly devised bone gouge forceps if possible, otherwise a small bone disc must be trephined at one side of the fracture before using the forceps. It is better to work with a small forceps and nibble the bone away in tiny pieces than to use a large powerful forceps, which may cause extensive fissure fracture. It is not necessary in such cases to trim the edge of the opening in the bone. It seems likely that bone is thrown out more readily from an untrimmed margin, so that the opening may become greatly reduced in size. If the dura is apparently normal and the brain pulsates well, the operation can then be completed by suture of the scalp, with or without drainage. If, however, the dura is muddy-looking; if there is loss of pulsation and circumscribed loss of elasticity, especially if focal symptoms have been present after the wound was received, the dura should be opened. This is usually best done by a small crucial incision, made by stabbing a scalpel in at right angles to the dura. Disintegrated brain and blood clot are squeezed out by the *vis a tergo*. If the pulped material does not come out quite readily, it may be helped out by inserting a small artery forceps and opening the blades so as to dilate the hole in the dura. Only the useless matter will exude unless the intracranial pressure is high, in which case lumbar puncture, or possibly even a large decompression operation, is indicated.

3. Injury of Dura without Foreign Body or Sepsis.

Fracture with injury to dura mater, when no foreign body is present, and the wound in the brain probably aseptic. After excision, *en masse* as before, the scalp wound may be enlarged in any desired direction. It is very rarely necessary to turn down a flap. The bone around the fracture is cleared. A "trephine" opening is rarely required. The spicules are removed and the skull cut away carefully with forceps to an extent varying with the injury to the dura. A clear margin (one-third of an inch) of uninjured dura should be exposed. Ragged edges of dura should be excised. If a "track" exists in the brain, this should be carefully explored, by the finger if possible, and any collection of pulped brain tissue allowed to escape. A piece of aponeurosis may be drawn across the opening in the dura, and the operation completed by suturing the scalp wound. A drain of folded jaconet or small rubber tubing should reach from the opening in the dura through one end of the wound. It should be removed after twenty-four hours. If sepsis asserts itself, the wound should be freely opened up at once.

4. Injury to the Dura complicated by a Foreign Body in the Brain and by Sepsis.

The position of the foreign body is previously localized by *x* rays. At the operation (as in para. 3), the track through the brain matter can usually be explored by the index finger. It may be necessary to enlarge the wound in the dura slightly. The foreign body having been located, a suitable flat or slightly curved scoop is passed along the finger under the foreign body, which is then pressed against the point of the finger, and all three are carefully

and gently withdrawn. The greatest delicacy of touch is required during this procedure. The finger, in a flexible manner, must follow the previously formed track, and must not break through uninjured brain substance. Any stiffness of the finger must be avoided. The use of a forceps is apt to increase the damage to the brain.

If the operation is done within a day or two of the reception of the wound a drain should be inserted along the track. If it is performed at a later stage and no sepsis is apparent to the eye, one need not insert a drain deeply unless considerable oozing has been caused by the extracranial of the foreign body.

If definite sepsis is present drains should be inserted leading straight out through the wound. In the worst cases the scalp wound should not be sutured till all danger has passed.

The exploration for foreign bodies by the finger at the primary operation is justified by the following considerations: (1) A track through brain substance is already present; (2) only very rarely is further injury to the brain caused by the procedure; (3) the frequency with which an abscess develops, should the foreign body be left in the brain; (4) if the wounds are large, sepsis has almost certainly penetrated along with, or following, the foreign bodies, and, as has been said, the sooner they are dealt with the better.

As already indicated, foreign bodies imbedded in the brain, by their direct influence and by their interference with the cerebral circulation, may produce symptoms of focal irritation and of compression or increased intracranial tension. If their removal does not immediately relieve these, and especially if hernia cerebri is threatened, lumbar puncture should be resorted to. If this fails to relieve the intracranial tension, subtemporal decompression may give relief, but has on the whole proved an unsatisfactory operation under these septic conditions.

5. Fracture with Injury to one of the Blood Sinuses.

Operation in such cases may be difficult on account of the alarming haemorrhage which may occur during exposure of the sinus. It should not, therefore, be undertaken by an inexperienced operator. The size of the superficial wound of the scalp or skull gives no indication of the extent to which the sinus may be injured. The results of such operations have been very favourable. Three of the procedures recommended for control of such haemorrhage have practically been given up—namely, lateral application of suture or forceps, plugging with gauze, and ligature. Plugging and ligature especially must be avoided behind the entrance of the parietal lacunae or cerebral veins. It has been found that practically all cases which survive the immediate effects of the injury are amenable to treatment by the application, under light pressure, of a piece of aponeurosis cut from the edge of the scalp wound or from the fascia lata of the thigh. The procedure is known as the "postage stamp" operation.

After free exposure of the hole in the sinus, haemorrhage therefrom being controlled by light gauze pressure, the "stamp" should be cut and spread on the palmar surface of the point of the operator's gloved index finger or on a small swab covered with batiste or rubber tissue. The perforation is then blocked by a finger of the other hand. All blood clot is carefully wiped away, the controlling finger is removed and the "stamp" applied rapidly over the perforation. Fairly firm equable pressure is kept up for a few minutes, when the graft will have adhered to the wall of the sinus. A hole, measuring $\frac{3}{4}$ in. by $\frac{1}{4}$ in., has been closed successfully in this way, and, judging by the ease with which this was done, it should be possible to close even larger ones. The graft should always be covered by scalp at the end of the operation. In these cases it is practically always possible to suture the scalp wound completely, a small soft drain being inserted close to but not on to the graft, and withdrawn in a day or so.

Lumbar Puncture.

Lumbar puncture has frequently been found to give relief in cases of local circulatory disturbance after operation—evidenced, for example, by persistent headache, recurring focal muscular spasms, or slight hernia cerebri. The amount of cerebro-spinal fluid withdrawn varies with the pressure of the fluid. It is rarely necessary to remove

more than 25 c.cm. or thereby. Usually the withdrawal of a much less quantity suffices. The process may be repeated several times if thought advisable.

Certain cases of large fungus cerebri have been cured by this procedure. If fungus is present, however, while it is to be regarded as a symptom of increased intracranial tension, it must be remembered that this is frequently due to the presence of foreign bodies or abscess in the brain or to more diffuse encephalitis or meningitis, and suitable remedies must be used for these conditions. If meningitis is present or if the fungus is fairly recent, rapid removal of cerebro-spinal fluid may allow infection to spread. The wound should always be exposed for inspection when lumbar puncture is done, because this may cause the herniated brain to sink back to a considerable depth, and protective adhesions may be torn. If lumbar puncture fails to alleviate the condition, a contralateral decompression operation may be tried.

Spirit dressing is usually employed for such cases. Picric acid ($\frac{1}{2}$ to 1 per cent.) or some astringent preparation may, with benefit, be added when discharge is free.

In most cases of hernia cerebri it will be found that posture has a marked effect, the protrusion being lessened when the patient is propped up in the "Fowler position."

It is not advisable to make lumbar puncture in the early stages after a wound of the brain has been caused, unless the dura is intact, or until the exact local conditions have been revealed by operation.

Operation.

The operation necessary in the majority of head injuries arriving at the base is a comparatively simple one. If preceded by infiltration of the scalp with local anaesthetic and adrenalin, haemorrhage and shock are obviated to a very great extent, and the operation made even more simple. The dangerous haemorrhage which may occur from large flap incisions is entirely prevented by this infiltration of the incision area with adrenalin solution, and, if some local anaesthetic has been added, the amount of general anaesthetic required is negligible.

All serious cases should be kept at the base hospitals for three weeks after operation, and even longer if one is not quite satisfied with their condition.

RESULTS.

The records of 135 cases admitted to R—from the fighting in the end of September, 1915, and those otherwise available at the moment from three of the hospitals (257 cases) show a total of 392 cases trephined with 58 deaths—a mortality-rate of 14.8 per cent. Cases are included in this list in which the patient's condition was so bad that mere cleaning of the wound alone was possible. Whenever bone, even superficial fragments, is removed, the operation is classified as "trephining." None of the cases died in which the lacerated brain was found free from visible pus. Recovery occurred in most of the cases in which the track was definitely septic and in many in which quite extensive abscess had formed, but it was very rare in cases in which large fungus cerebri had developed.

If 12 "hopeless" cases, which died within forty-eight hours of admission, are excluded from the September, 1915, series, the mortality-rate is only 9 per cent.

REFERENCE.

¹ Treatment of Gunshot Wounds by Excision and Primary Suture, BRITISH MEDICAL JOURNAL, August 28th, 1915, p. 317.

The American National Association for the Study and Prevention of Tuberculosis reports (we learn from the *Journal of the American Medical Association*) that during 1915 more than £4,500,000 was spent in fighting tuberculosis. This is an increase of £3,500,000, as compared with the expenditure in the campaign against the disease ten years ago. From the care of tuberculous patients, which was at first its sole function, the work of the association has grown until last year more than £200,000 was spent on organization and education; an equal amount in examining, advising, and treating patients; more than £70,000 in teaching and treating tuberculous children, and nearly £150,000 in the care of tuberculous lunatics and criminals. The bulk of the money spent in the campaign was expended on sanatoriums and hospitals. These, numbering nearly 600, cost £3,850,000.