Preliminary Notes

ON

THE TREATMENT OF THE CRANIAL INJURIES OF WARFARE.

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[FROM THE BASE HOSPITAL, BOULOGNE-SUR-MER.]

DURING the past five months we have had the opportunity of seeing and dealing with a large number of cases of head injury at the base hospitals in France, and we now feel that our experience is sufficient to justify a preliminary communication.

Any such experience is the more important as, owing to modern methods of warfare, and especially to trench fighting, the proportion of head injuries to the total number of wounded is surprisingly large. The excellence of the British transport arrangements allows a large number of these cases to be dealt with at the base hospitals at an early date after the infliction of the wound, and many even of the severest cases now reach the base which would not survive the journey if the means of transport were less efficient. Further, the patients are rarely seriously affected by the journey, and the most important and in many cases the determining factor in the prognosis is proper early treatment before the wounds have become seriously septic.

DIAGNOSIS.

Too much importance cannot be attached to a complete examination, not merely of the local lesion, but also of the symptoms of cerebral disturbance in each case, as these are the only reliable indication of the extent and intensity of the intracranial injury. A proper appreciation of the probable nature of the damage is essential before deciding, not only whether an operation is necessary, but also what kind of operation ought to be undertaken. An examination of the optic discs, for instance, is important, as many of those cases in which there is little other evidence of increased intracranial pressure have definite optic neuritis within a few days of the infliction of the wound. The exigencies of the work at the base hospitals may not permit much delay, but an examination adequate for the proper treatment of the case does not require an unreasonable amount of time.

It must, of course, be recognized that the sum of the symptoms in many cases, and certainly in the early stages of all, is made up partly of functional disturbances (shock, diaschises) which gradually subside, often without any local treatment; and it is only by a proper consideration of this factor in the first place that the extent of the damage can be estimated, and in the second that an approximate idea of the amount of ultimate recovery can be attained.

WOUNDS OF THE DURA MATER.

Many varieties of cranial wounds are seen in warfare, but from the practical point of view the most important distinction is between those in which the dura mater is, and those in which it is not, opened. It is only on the former class that we propose to offer certain remarks here, as injuries in which this membrane remains intact are sufficiently familiar, and require treatment on the same lines as similar injuries met with in civil practice, excepting that in these injuries of warfare a septic scalp wound is almost invariably present. This circumstance naturally modifies the line of procedure, and makes incision of the dura mater so dangerous that this step must be postponed in many cases in which under aseptic conditions it would be clearly the right line of treatment.

Recognition of Extent of Injury to Brain.

The commonest type of case is that in which disintegrated brain matter is exposed or protrudes through the

wound of entry or exit, or through both; or where the missile has not entered the cranial cavity but has produced a comminuted fracture and laceration of the dura mater, by a glancing blow. It is usually found that the damage both to the skull and brain is more extensive than inspection, palpation, or even an x ray examination would indicate. This is particularly so when the wounds of entry and exit are not far apart; then there is almost invariably extensive comminution of the bone between them, and often fissures radiating far in several directions. This extensive comminution is particularly frequent when the frontal bone is involved. The problem of dealing satisfactorily with such wounds is the problem that most frequently confronts us. It is complicated by the almost invariable presence of infection in the scalp wound. In such cases the choice lies between a conservative line of treatment, which consists of cleaning up of the scalp wound, removal of fragments of bone and antiseptic dressings, and more radical measures aimed at the prevention of such complications as commonly follow the conservative line of treatment.

Frequent Need for Radical Measures.

There can be no doubt that many patients recover, or at least survive, when little is done, but the course of a considerable proportion of these cases, not only from the point of view of life, but also from that of the function of the brain, is such as to lead to the conclusion that more radical measures are often required. Mere survival of the patient—perhaps hemiplegic, aphasic, or demented—cannot be regarded as a satisfactory result, and if a more complete recovery or preservation of function can be obtained by a more thorough operation, this must be at least considered even if it were to entail an increased risk to life. In our opinion, however, this increased risk is not great, in view of the usual course of such cases when treated on more conservative lines.

Early Clinical Course.

Let us briefly consider the usual course and fate of a patient in whom the brain is exposed through a relatively small opening, whether produced by a bullet or by a timid trephining operation. These patients are usually unconscious immediately after the infliction of the wound, and are drowsy and obviously suffer from the effects of shock on regaining consciousness. A gradual improvement may be observed in the general condition and in the direction of recovery of function during the next few days, but soon some protrusion of the brain is observed, together with symptoms of progressive loss of certain functions according to the site of the injury. The patient becomes duller, apathetic, and more drowsy, or may be restless and noisy, and often complains of headache; optic neuritis frequently develops, together with other symptoms which point to a pathological increase of intracranial pressure. This naturally leads to further protrusion of brain matter which then becomes strangulated and more and more septic. Even at this stage the septic process may come to an end and the patient survive; but if so, it is often at the expense of an irremediable loss of function.

Fungus Cerebri: Pathology and Prevention.

On the other hand, the hernia or fungus cerebri often increases and entails, as we will later emphasize, destruction of portions of the brain, which were not primarily injured, and death eventually ensues. The development of a fungus cerebri is therefore the most deplorable incident, to the prevention of which our treatment must be directed.

To decide the best means of obviating this danger, and the most rational method of dealing with it when present, we must shortly consider the pathology of such a fungus as is liable to occur with injuries of the skull when these are associated with conditions that may lead to a pathological increase of the intracranial pressure, and the opening in the skull is not sufficiently large in relation thereto.

If the brain of a patient who has died with this condition soon after the infliction of the wound be examined softened disintegrated tissue is found protruding through the dural opening, the gyri of both hemispheres are flattened, and appear compressed; there is very little cerebrospinal fluid on the surface, though the ventricles may be

distended; and the whole brain may appear too large for the cranial cavity. It is noteworthy, however, that even when the disintegrated brain is very septic there may not be, and frequently is not, any general meningitis; this must be largely attributed to the adhesions that form early between the dura mater and the pia arachnoid in the neighbourhood of the injury, and often block effectively the meningealward spread of the infection. A diffuse spreading infective encephalitis is also rare.

If such a brain is more closely examined, the tissue beneath and around the hernia is found soft and is almost fluctuating to touch. Incision, however, rarely reveals an abscess or any actual collection of fluid, but only pale, oedematous, partly disorganized white matter of the centrum ovale, in which there is as a rule no evidence of active infection. This oedematous area is not sharply demarcated, but extends widely and diffusely from the base of the hernia. There may be small haemorrhages into it as well as into the hernia, but we have rarely seen a clot sufficiently large to contribute seriously to the pathological tension.

Rise of Intracranial Pressure.

It is impossible to discuss the complicated subject of pathological intracranial pressure here, but its effects when the skull is opened must be briefly described, and the causes to which it is due considered.

When the skull is opened in a person in whom the tension is normal, the dura mater rises with each arterial pulsation and falls below the level of its normal convexity between them. On palpation it can be easily indented without much pressure, and when it is opened the brain matter shows no tendency to protrude through the incision. If the intracranial pressure is raised, however, the normal pulsations of the brain may disappear, and when the dura is incised the brain matter at once protrudes through the opening, or rises to a higher level than that represented by the concave internal surface of the skull, and continues to do so, if no obstacle is offered, till sufficient tissue has been extruded to reduce the intracranial pressure.

When the opening in the dura is sufficiently large the hernia so formed may, and usually does, as after the ordinary decompression operation, consist of undamaged brain, but when it is small, or too small in relation to the intracranial pressure, the brain matter protruded through it must be stretched and torn and its blood supply is seriously interfered with. Further, the pia arachnoid is torn, the cortex is ruptured, and soft disintegrated tissue is extruded. Eventually the hernia so formed becomes strangulated and its vessels compressed at the edges of the opening, so that the whole must be permanently destroyed and functionless.

Further, the compression of the cortical vessels, particularly the large cortical veins, at the edge of the dural opening, interferes with the circulation of adjacent areas of the brain still within the skull and leads to important changes which, if long continued, entail permanent functional impairment. It also produces oedema and swelling of portions of the brain which were not originally damaged, and consequently leads to a further increase of intracranial pressure. Thus a vicious circle is established which may rapidly lead to a functional and organic destruction of large portions of the brain.

Cause and Early Symptoms of Rise of Pressure.

It is, however, necessary to account for the early rise of the intracranial pressure that produces protrusion of the brain within a short time of the injury. This occurs chiefly when the injury is sufficiently severe to produce considerable concussion, and it is then obviously due to the histological changes associated with concussion, and especially to traumatic oedema, which can raise the intracranial tension sufficiently to start a hernia.

The same changes of course occur with severe head injuries even when the dura mater is not opened. To them the headache, drowsiness, and lethargy after the recovery of consciousness are due, and a further indication of the rise of intracranial pressure may be found in the early development of a mild degree of optic neuritis, or the blurring of the inner or vertical margin of the discs with congestion of the retinal veins. This traumatic oedema and the symptoms associated with it subside within a short time if an opening of the dura mater does not permit

infection of the brain or the development of a hernia, but the headache may persist a week, ten days, or even longer. Recognition of this fact is extremely important to those under whose care the patients first come, as the persistent headache, slow pulse, and drowsiness may suggest a condition which requires relief by decompression; this is not only unnecessary, but if resorted to may entail the series of events we are now discussing, as well as the fatal spread of infection from the scalp.

Frequently, however, the protrusion of brain is not observed until some time after the infliction of the wound, or a limited trephining operation; then the swelling of the brain can be attributed either to direct local septic infection, to which the pressure of indriven fragments of the bone may contribute, or to a toxic oedema. Abscess formation in the depth of the brain is a much less common cause than might be expected, and extensive intracranial infection, or a widespread meningitis, is an early cause in only a small proportion of the cases.

Fig. 1.—Shows a strangulated necrotic fungus projecting through an opening in the dura mater. The central cortical veins which lead to the longitudinal sinus are obstructed.

Fig. 2.—An oblique sagittal section of the same hemisphere showing the strangulation of the protruding brain by the dural edge, oedematous softening beneath it, the existence of dural adhesions, and a rifle bullet behind the softened area.

Hernia and Fungus Cerebri.

We usually distinguish between a hernia cerebri and a fungus cerebri: by a fungus we mean the strangulated, disintegrated, and partly necrotic mass of brain matter which forms a cauliflower-like structure connected with the intracranial contents by a relatively narrow pedicle; while by hernia we describe the protrusion of relatively intact brain matter covered by unruptured pia mater, through an opening sufficiently large to avoid any danger of its strangulation.

TREATMENT.

CLASSIFICATION OF CASES.

Leaving aside cases of injury to the longitudinal sinus, which form a class apart, and which will be considered separately, there are three main groups to be dealt with:

1. Where there has been a glancing blow, or where the wounds of entry and exit in the scalp lie so close together as to form practically a single lesion.
2. Where the missile has entered and remains within the cranial cavity.
3. Where the missile has traversed the cranium.

I. Wounds of Entry and Exit Close Together.

This is the most common class of case seen in base hospitals. The scalp wounds are irregular, contused and lacerated, often with everted edges, usually very septic, and surrounded by a wide area of oedematous scalp. Unless urgent cerebral symptoms demand immediate relief, it is best to delay operation for two or three days, during which every effort must be made to render the wounds reasonably clean. They cannot, however, be made aseptic. We have found the following technique to give the best results.

The whole head is cleanly shaved and the scalp washed with alcohol, after which the skin for a wide area round the wound is painted with 2 per cent. spirit iodine solution. The wound, which may require opening up, is then dressed with cyanide gauze wrung out of 1 in 40 carbolic lotion, to which has been added sodium chloride to the extent of 5 per cent., and covered by a sheet of jaconet to keep it moist; this dressing must be changed two or three times a day. Treatment for a few days on these lines will diminish considerably the danger of spread of the infection after operation.

Immediate operation must often be considered when the patient remains deeply unconscious for some time after the infliction of the wound, as the unconsciousness may be due to the cerebral compression.

But to avoid unnecessary interference it is essential to establish this as the cause. Unconsciousness is a very common symptom in severe head injuries, and should be regarded only as a symptom. Further, serious intracranial pressure is unlikely within a short time of the wound, and the limited operations which may alone be possible in the surroundings, or safe to the patient, would be useless in relieving such pressure. The removal of a small depressed fragment of bone can rarely have any influence on the intracranial pressure, and if performed merely as a temporary measure, it may be followed by the development of a fungus cerebri with the attendant vicious circle above described.

Primary Operations.

As it is impossible to foretell the extent of bone removal which will be necessary, the scalp flap must be so planned as to provide for the widest craniectomy that may be required. Once the flap is turned down it is difficult, and may be impossible, to enlarge it, and as bone should not be removed up to the full extent of the flap, because the suture line must never lie over exposed brain, a small and timid skin incision may render impossible the performance of an adequate craniectomy. The flap including the wound having been turned down and any loose fragments of bone having been removed, the opening in the skull must be enlarged in all directions.

Estimation of Degree of Pressure.

The exposure of the dura so effected allows some opinion to be formed as to the degree of intracranial pressure, and this is a guide to the probable extent of the opening which must be made. If chloroform is being given the intracranial pressure is, owing to the lowering of the blood pressure caused by this drug, lower than it will be after recovery from the anaesthetic, particularly if much blood has been lost in making the scalp flap, so that a false impression of the degree of intracranial pressure may be conveyed. The size of the bony opening must be such as to allow of a sufficiently wide incision of the dura mater to afford complete relief of the existing pressure, so that in fact the extruded brain shall escape the possibility of strangulation by pressure of its periphery against the dural opening.

Further, allowance must be made for the temporary increase of tension which, from rise of blood pressure or from traumatic oedema, usually occurs during the first two or three days. If the opening is only just large enough to relieve existing pressure at the time of operation it may prove inadequate afterwards, and some interference with the cerebral circulation may occur later and be demonstrated by an increased, though perhaps temporary, functional loss.

Treatment of Lacerated Brain.

The lacerated brain is next dealt with; any fragments of bone are gently removed and bleeding vessels tied. On no account must the finger be thrust deeply and roughly

into the brain. If the intracranial pressure does not seem to be raised, a complete opening of the dura may be postponed, and may eventually be found unnecessary; these cases are amongst the most favourable.

Treatment of Scalp Wound.

When, however, it has been necessary to make a decompressive opening in the dura mater, the problem next presents itself how best to avoid placing a dirty scalp wound in contact with exposed and lacerated brain. To excise the wound and approximate its edges by suture is rarely practicable, as the want of elasticity of the scalp does not permit it, and even when this can be done it is undesirable to place such a sutured wound in contact with the brain; moreover, it is unsound practice to suture completely without drainage.

To solve this problem we have tried several methods.

Cargile Membrane.—At first we placed a sheet of "Cargile membrane" on the under surface of the flap so as to interpose a barrier between it and the brain. The material proved unsatisfactory for the purpose; it appeared to provoke a continuance or an increase of suppuration, and required removal later.

Dural Flap.—We next used a dural flap, planning the incisions in that membrane so as to be able to slide a pedicled flap over the site of the wound to cover and protect the lacerated brain, and to form a floor for the hole left after excising the edges of the scalp wound. This plan proved satisfactory for the cases in which it was found practicable, but extensive laceration of the dura by the original wound, the inelasticity of the membrane, and unsuitable positions, on account of proximity to sinuses and so on, render this method not always applicable.

Pericranial Flap.—A third method is more often available, and is very suitable for certain cases. The edges of the original scalp wound having been cleanly excised, the pericranium is detached by undercutting for a wide area around the wound; then, by suitable incisions at its periphery, one or two flaps, as the case may require, pediculated at one or both ends, can easily be fashioned and brought together with a fine catgut suture across the under surface of the scalp defect, so as to form a complete barrier between it and the brain. The scalp flap is then sutured in position, leaving ample provision for drainage; the excised original wound is left unsutured. This method, modified to the demands of individual cases, has proved very satisfactory. When there is no obvious infection of the brain the raw surface of the pericranium now forming the floor of the wound quickly granulates, whilst the smooth surface previously in contact with bone forms an admirable covering for the lacerated brain.

Drainage.

For the necessary drainage of the space beneath the flap gauze strips are most unsatisfactory, as they adhere to the brain and to the edges of the wound; whilst their capability of acting as drains at all is no less questionable here than in other parts of the body. Rubber tubing is too hard and rigid to place against the brain. We have found the satisfactory drain to be one formed of a loose roll of thin sheet rubber.

These three methods, although possessing individually certain advantages, have one drawback in common—namely, that the only drainage of the lacerated brain is along an oblique track. In order to provide more direct drainage, especially in the more septic cases, whilst at the same time shutting off the subarachnoid space, we have devised and carried out the following procedure, taking advantage of the adhesions which quickly form between the torn pia arachnoid and the edges of the dural wound. A sufficiently large bone defect to allow a free decompression having been made, the dura is incised circumferentially about a quarter of an inch from the bony edge. This incision is carried almost the whole way round, leaving a pedicle about an inch wide at some convenient spot. The brain then herniates, carrying with it the dura mater covering. The scalp wound is now excised, and the scalp flap is replaced and sutured in position. Then the intracerebral pressure pushes the dura mater outwards against the upper surface of the scalp flap, shutting off the

* Peritoneum of the ox.

subarachnoid space. The lacerated brain or fungus cerebri, as the case may be, shut off by adhesions at the edge of the original dural opening, now lies at the bottom of the excised original scalp wound, and can be dealt with according to circumstances by removal of bone fragments, irrigation, and drainage. This method can be employed in secondary operations for fungus cerebri as an alternative to the contralateral subtemporal decompression suggested elsewhere.

II. Cases in which the Missile remains within the Cavity.

We are unable as yet to say what may be the ultimate fate of a patient in whom a missile remains embedded in the brain. It would appear probable, however, that a spreading encephalitis or a localized abscess may occur, or if complete recovery were to ensue, Jacksonian attacks may supervene. It is clear that in certain situations the projectile is not accessible to legitimate surgical adventure; but in some cases it does lie in an accessible situation, and can be removed through a clean incision at some distance from its point of entry. We have safely removed such bullets from the substance of the brain on several occasions, with recovery, and we have had no unfavourable results.

III. Cases in which the Missile has Traversed the Cranium.

When the missile has traversed the cranial cavity the treatment of both entrance and exit wounds should be carried out on the same lines as indicated under (I).

SECONDARY OPERATIONS.

We have had to deal with a considerable number of cases which have already been operated upon, the operation consisting of removal of bone fragments through an enlargement of the original wound, or through a small horseshoe flap turned down over it; in many instances a trephine hole has been made close to the fracture. These incisions have usually been found sutured wholly or partly, and in almost all cases pus has been found imprisoned beneath them together with a cerebral fungus.

Increased Intracranial Pressure: Meningitis.

The problem as to whether anything further can be done for these cases is a difficult one. In some the symptoms of generalized meningitis are definite enough to contraindicate any active treatment, though patients with headache, pain and stiffness of the neck and pyrexia do not always succumb.

Unless, however, the intracranial pressure can be relieved, death will occur, or, more and more brain being destroyed in and beneath the fungus, the recovery which might ensue would be accompanied by a deplorable amount of functional loss.

Were it not for the septic condition of the wound the obvious mode of affording relief of pressure would be to enlarge the bony and dural openings, allowing temporary protrusion, but without strangulation, of a large surrounding area of brain. It sometimes happens that a local abscess is present in or beneath the fungus, or beneath the dura in close proximity with the fungating brain, but in our experience this condition is rare; certainly it is not common enough to warrant any but the most tentative exploration should its possibility be suspected.

Contra-lateral Decompression.

As the spread of infection is almost inevitable, if a local decompression is done, it occurred to us that a clean contra-lateral decompression might offer a solution of the difficulty, and this operation we have carried out on several occasions with a remarkable degree of success, even though only the worst cases were purposely selected. The wounds have healed by first intention, the optic neuritis when present has subsided, the fungus has rapidly shrunk, and the general condition of the patients has quickly and definitely improved. The results obtained by this procedure have been so promising as to encourage us in the belief that it may prove to be of value in other and perhaps less severe cases.

Lumbar Puncture.

Some relief of intracranial pressure can also be obtained by lumbar puncture; after withdrawal of even 15 c.cm. the fungus frequently begins to subside, and if repeated daily the protrusion of the brain may be controlled. There is, unfortunately, the danger that the sudden withdrawal of cerebro-spinal fluid from the neighbourhood of a septic fungus may disseminate infection and start a general septic meningitis—we have, in fact, seen this occur on more than one occasion, but this method may be safer in the early stages after the injury, and especially for the relief of headache in the concussion stage, when the dura mater is not opened, and also later when adhesions between the dura mater and pia arachnoid have formed. From our experience, however, it is not a method that can be used indiscriminately.

INJURIES OF THE SUPERIOR LONGITUDINAL SINUS.

Injuries of the superior longitudinal sinus are common, and form quite a large proportion of the cases of cranial injury. In symptomatology, course, and treatment they form a distinct group, presenting many features of considerable interest. We hope to deal fully with these cases in a future communication, but at present we are unable to offer more than a few preliminary observations.

The majority are produced by rifle bullets which just graze the vertex of the cranial vault, producing a depressed fracture. This is not necessarily in the middle line, and usually more damage is done to one side of it than to the other. In the frontal region the upper border of the falx with the sinus may be torn across without producing the clinical picture which characterizes lesions of the sinus further back, and more particularly those which implicate the parietal lacuna. This lacuna, as one of us has pointed out elsewhere, receives the main cortical veins that drain the Rolandic area, of which the post-central and precentral veins are the chief. These enter its under surface, and do not as a rule pass directly into the sinus. This lacuna extends outward on either side of the sagittal suture for a variable distance, sometimes as much as an inch and a half, and its upper or outer wall lying in contact with the bone is very thin. Hence it comes about that a small depression of bone interferes easily with the return of blood from the cortical veins into the longitudinal sinus, and leads to far-reaching effects in loss of function of the area which they drain. We have evidence to show that in the majority of cases this loss of function is not due to laceration of brain or to subdural or intracerebral haemorrhage, though these occur, but to interference with the cortical drainage and the consequent oedema. In more severe cases there may be, in addition, laceration of the dura and gross damage to the brain, but in many instances there is no such complication.

Indications for Operation.

The question of operation in these cases is most difficult, for the additional damage that may be done may leave the patient worse off than if he is left alone. A certain extent of thrombosis must be assumed to exist already, and, if progressive, this leads to an increase in the symptoms, increasing intracranial pressure from the cerebral oedema, and ultimately to death. If operation is performed, the elevation of the depressed bone may at once be followed by such free haemorrhage as to necessitate plugging, and this will almost certainly involve a complete thrombosis of the sinus, which in our experience is often fatal; on the other hand, many of these cases, if left alone, show a very decided tendency to spontaneous recovery.

We think, therefore, that such cases should be watched carefully, the scalp wound in the meantime being cleaned as thoroughly as possible. If no improvement occurs in a few days, or if symptoms of increasing intracranial pressure become manifest, and it is therefore necessary to interfere actively, the following procedure should be adopted.

A large scalp flap is reflected exposing the whole damaged area of bone and with its two limbs directed laterally so as to allow, if necessary, of their being continued downwards later for the performance of a decompressive operation. The bone is then freely removed around the depression leaving the depressed bone isolated but undisturbed.

If when this piece of bone is very gently removed haemorrhage from lacuna or sinus occurs, one is in a position to see the bleeding point clearly and to control it. The sinus should not be plugged with gauze. The haemorrhage can be arrested by applying a piece of tissue cut from the under surface of the flap, as Sir Victor Horsley originally suggested; if this is pressed gently down upon the bleeding point for a few minutes it will adhere firmly to the dura and control the bleeding effectually, but without obliterating the lacuna or sinus, as is almost certain to occur if gauze plugging is employed. This method has been found satisfactory. It encourages re-establishment of the cortical venous drainage, and leads to a diminution of such intracranial pressure as was due to oedema. Should the compression, however, persist, it may be advisable later to perform a decompressive operation, but of the effect of such a secondary operation we are not yet in a position to express an opinion.

It must not be supposed that we are recommending extensive operations in all cases, or even in a large proportion. Naturally, the indications in each individual case must be considered carefully, and the question as to what symptoms an operation may relieve or prevent must be answered before the exact nature of the contemplated operation can be determined. Indiscriminate extensive operations might well prove as discouraging in their results as indiscriminate limited trephining.

We desire to emphasize this point, as it is, of course, possible to do much harm in one case by an operation which would be wholly suitable in another.

The drawings have been kindly made by Dr. W. Crampton Gore, British Red Cross Society.

EPIDEMIC CEREBRO-SPINAL FEVER:

THE PLACE OF THE MENINGOCOCCUS IN ITS ETIOLOGY.

A BACTERIOLOGICAL STUDY.

(Preliminary Note.)

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Is the Meningococcus the Primary Infective Agent?

It is believed by many authorities that the meningococcus of Weichselbaum is the primary infective agent in the disease known as epidemic cerebro-spinal fever. And it is also believed, both in the profession and outside it, that the available evidence in support of this view is satisfactory.

Briefly the evidence is based on the following facts:

1. The frequency with which the organism can be isolated from the naso-pharynx, cerebro-spinal fluid and blood in acute cases of the disease, and from the meninges and other tissues *post mortem*.
2. Its frequent isolation from the naso-pharynx of primary and secondary contact carriers.
3. In some ascertained carriers the disease subsequently develops with typical meningococci in the cerebro-spinal fluid or elsewhere.
4. Its presence in the naso-pharynx of carriers acting as a theoretical bridge from one epidemic to the next.
5. Meningitis can be produced in monkeys after exposure of the arachnoid and injection of living cultures of the organism, or by direct inoculation into the spinal canal.
6. The injection of antisera produced by injection of cultures of the meningococcus is sometimes followed by cure.
7. Emulsions of the organism can often be agglutinated by the serum of a patient suffering from the disease.

Taken together these seven points constitute at first sight a formidable mass of proof.

Before discussing their true value it may be well briefly to enumerate the few ascertained facts which suggest that the meningococcus, as we know it in artificial culture, may not be the cause of the disease, however much it may prove to be responsible for the more or less terminal event of meningitis.

These facts are:

1. The attendants on acute cases of the disease rarely contract it, although the percentage of such acute cases harbouring the organisms in the first few days is very high.
2. For every case of the disease there are ten to fifty carriers, but of detained carriers of the meningococcus in the naso-pharynx only few develop cerebro-spinal fever.
3. Injection of cultures of the meningococcus into monkeys elsewhere than into the meninges or spinal canal does not reproduce the disease, or meningitis.
4. Agglutination reactions with serum from cerebro-spinal cases are often unsatisfactory both at 37° C. and at 55° C., both with autogenous and with heterogenous emulsions.
5. The marked instability of the organism in the laboratory, both culturally and biochemically.

These five points, whilst not disproving the reputed etiological relationship of the meningococcus to the disease, at the same time suggest that extreme care is needed in judging of the value of the positive evidence usually relied on.

A good deal of stress has been laid on the fact that cure may follow the injection into the spinal canal of Flexner or other antiserum. Against this must be set the fact that in the present epidemic Flexner's results have not been reproduced. Moreover, not a few cases, even of extreme gravity, recover without specific treatment, and we have no control observations to show the value of the injection of normal serum; and, thirdly, as suggested by Dr. W. M. Fletcher, it is conceivable that careful control observations may show that simple puncture alone may be as beneficial as injection of normal serum, or of antiserum.

The evidence afforded by antisera is, therefore, at present worth little. The evidence derived from the occurrence of a fatal meningitis in monkeys after the formidable procedure of exposing the arachnoid, followed by injection of cultures of the meningococcus, is of small value, since meningitis can be produced in monkeys by other organisms when injected in the same way, and we have no evidence that meningeal infection can produce cerebro-spinal fever, however capable it may be of setting up meningitis.

The evidence afforded by agglutinability of the organism by serum from cases of the disease must not be taken too seriously, because we now know that secondary invaders are capable of specific agglutination even in relatively high titre. And in the absence of experimental evidence to the contrary we cannot at present deny that the meningococcus may be only a secondary invader, as was suggested at a recent discussion on the subject, just as a streptococcus may be in scarlet fever.

Moreover, apart from secondary invasion, the mere presence of the meningococcus, however frequent, in acute cases of the disease, or in healthy carriers, does no more than suggest a causal relationship. In the absence of good collateral evidence, and especially of experimental reproduction of the disease in animals, the association does not prove that the meningococcus is the cause of epidemic cerebro-spinal fever. And finally, we have yet to show that the meningococcus occurs frequently in the blood in abortive cases with fever in a disease that frequently presents all the clinical features of a septicaemia. On the whole, therefore, it would appear to be unwise to make dogmatic statements that the meningococcus, as we know it, is the cause of epidemic cerebro-spinal fever, though this does not imply that the future may not provide better evidence than at present exists. The purport, in short, of this note is to show that the evidence at present available, however suggestive, is inadequate, and to plead the necessity for fresh research into the etiology of the disease.