Observations
ON
THE DIFFERENTIAL DIAGNOSIS AND TREATMENT OF CEREBRAL STATES CONSEQUENT UPON HEAD INJURIES.*

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THE subject of head injuries is treated, as a rule, in the textbooks of surgery rather than of medicine. It might seem, therefore, that in choosing it for our discussion we were encroaching upon surgical preserves. In practice, however, the proportion of cases of head injury which require immediate operative intervention is very small, and is limited to those in which a compound fracture calls for the obvious surgical toilet, or the rupture of a meningeal artery threatens life from cerebral compression. In so far as the latter is a cerebral state consequent upon head injury it might be included within the limits of our title, but in order that we may proceed to other and numerically more important aspects of our subject I shall propose to refer to it only in passing.

The various cranial nerve palsies which may result from fractures of the base are necessarily excluded as forming no part of a cerebral condition. Apart from the immediate surgical risks to which I have referred and the rare condition of subdural haematoma which I shall mention later, the severity of any injury to the head varies with the nature and amount of damage suffered by the brain at the moment of injury. Such damage may in itself prove fatal. When it does not there will result symptoms of cerebral disorder whose differential diagnosis and treatment may properly be considered as topics for neurological discussion. In attempting a brief description of these cerebral states I shall find it necessary to draw certain arbitrary lines of distinction.

CONCUSSION.

I shall define concussion as a condition of subtotal cessation of cerebral function following immediately upon the injury, and lasting only a few moments, with subsequent complete recovery within twenty-four hours. During the initial stage the patient is completely unconscious and in a state of flaccid paralysis. In a severe case the respiratory and cardiac functions may hardly continue. In a few minutes recovery begins; the visceral reflexes are the first to return, and vomiting is common at this stage. The other cerebral functions recover more gradually, and there may be a phase of some hours during which consciousness is clouded. Following this again there may be complaint of headache and giddiness, but at the end of twenty-four hours in an uncomplicated case of concussion recovery should be complete and permanent.

The simplest explanation of concussion is that given by Trotter. The skull being in relation to traumatic force semi-elastic is dented or compressed by the blow, its contents being momentarily squeezed dry. The loss of consciousness and paralysis are due to sudden transient cerebral anaemia. The symptoms of the recovery stage are those of a gradual return of function in physiological sequence from the medullary centres upwards. The whole clinical syndrome being due to a temporary vascular embarrassment and independent of any structural lesion, recovery is complete and permanent.

CEREBRAL CONTUSION.

Distinct from concussion, though often associated with it, is the condition of cerebral contusion. A fair idea of what is meant by this term may be obtained by anyone who will visualize the picture of cerebral damage in a case of fatal head injury. Apart from any direct laceration of the brain from compound fracture there is almost always to be seen in such a case diffuse bruising and petechial haemorrhage, often with maximal intensity at the point of contrecoup. In such a case death has probably been due to direct or indirect damage to the medulla. In patients who recover with symptoms of cerebral damage we may reasonably suppose that some lesser degree of such bruising is present.

The symptoms of cerebral contusion depend upon two factors: first, the effect upon the intracranial pressure, and secondly, the precise situation of the lesion. To take the latter first, it is clear that the presence of paralysis, loss of sensation, or altered reflexes in a case of cerebral contusion must be an accident of localization. If the lesion involves the pyramidal cells or fibres an extensor plantar response will result, and so on. The focal signs of cerebral contusion, therefore, are those of cerebral disease generally. It may, however, be remarked at once that such focal signs are rarely to be detected, possibly because it is only in the relatively slight cases of contusion that recovery is possible. The effect upon the intracranial pressure, and hence upon the intracerebral circulation, will depend upon the amount of haemorrhage and exudation.

For purposes of clinical description I propose here to distinguish between a major and a minor degree of cerebral contusion, taking as the distinguishing feature of major contusion clouding of consciousness or stupor.

The General Symptoms of Major Contusion.

The injury will almost always have been of such a nature and degree as to have caused concussion. The patient, having been completely unconscious for a few moments, partially regains his senses and passes into the state of stupor already described as a part of the clinical picture of severe concussion. Subsequently, instead of making that rapid progress towards a normal mental state which is characteristic of simple concussion, he remains stuporose, restless, and irritable. During the daytime, if left to himself, he is usually drowsy, lies curled up on his side, and resents interference. At night he is frequently noisy, hallucinated, and violent. The temperature and pulse rate, at first subnormal, are often raised.

This condition may persist for days or weeks, the tendency being towards gradual improvement, first manifested in the form of brief intervals of lucidity during the daytime, when the patient may ask where he is and for a few minutes behave and talk in a rational manner. On regaining his senses he is found to have an amnesia for the period of clouded consciousness. Such patients are often said to have been unconscious during this whole period, but it is important to distinguish between complete unconsciousness or coma and the condition of stupor or clouded consciousness which is characteristic of major contusion.

It has already been assumed that the general symptoms of cerebral contusion are due to increased intracranial pressure from capillary haemorrhage and transudation. Direct proof of this may be obtained by lumbar puncture, a manometer being employed to register the spinal fluid pressure. This is usually found to be well above the normal limit, and the fluid is often blood-stained, indicating the rupture of surface capillaries.

The effects of increased intracranial pressure upon cerebral function are well known, and there is no doubt that they are brought about by embarrassment of the intracerebral circulation. Here we have to consider three groups of blood vessels: the arteries with a high internal pressure, the capillaries with a much lower pressure, and the veins in which the pressure is lowest. It is clear, therefore, that when there is any increase of intracranial pressure, sufficient to embarrass the cerebral circulation, its first effect will be to compress and narrow the veins. Oozing from the capillaries may cause such venous compression, for the pressure in the capillaries is normally higher than that in the veins. But oozing from the capillaries cannot result in compression of the capillaries themselves—that is to say, the increased intracranial pressure due to cerebral contusion may be sufficient to embarrass the venous outflow and so cause a state of relative cerebral *anoxaemia*, but cannot reach the point of compressing the capillaries and

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causing a state of cerebral *anaemia*. The symptoms of cerebral anaemia are coma and paralysis; of cerebral anoxaemia, stupor, irritability, and confusion. These latter constitute the true clinical picture of major contusion. The development of coma or paralysis must indicate some other and more formidable source of compression, such as arterial haemorrhage or subdural haematoma.

Having regained his full senses the patient, under the terms of our definition, passes out of the category of major contusion, and his further symptoms are those of minor contusion.

The General Symptoms of Minor Contusion.

The injury may, or may not, have been such as to have caused concussion. It is possible for a glancing blow to bruise the brain, sometimes severely, without any loss of consciousness at the moment of injury.

The symptoms to be described may follow directly upon the injury, but more commonly develop after a latent interval of some hours, a day or two, or in certain cases after several weeks. Thus a patient who has been concussed may seem to have made a complete recovery from his concussion and yet later develop disabling symptoms. The three symptoms almost constantly complained of are headache, giddiness, and mental disability.

The *headache* is described in terms of pain rather than discomfort. Throbbing, shooting, splitting, are the words usually employed. At its worst it may be continuous with exacerbations. More commonly it is intermittent. If it has any fixed situation this is likely to be related to the site of the injury. One of the most characteristic features of this headache is a relation to alterations of posture. In most cases it is worse when the patient lies down. Thus it is experienced on going to bed, and may keep him awake during the early part of the night, and it is commonly present when he wakes in the morning. Often the patient will discover that one position in particular, lying with chin upward, to the right or to the left, is especially likely to cause or aggravate the headache. It may also be brought on or intensified by coughing, sneezing, and quick alterations of posture, as in stooping, or rising from the stooping posture. The other aggravating factors in order of their frequency and importance are mental stress, physical exertion, noise, bright light, a stuffy atmosphere, and thundery weather.

The *giddiness* is usually described as a general transient sense of unsteadiness. It is particularly related to sudden change of posture, so that the patient is, for instance, unable to stoop to lace his boots, or, if he does so, stoops and rises slowly and with caution. The changes from vertical to horizontal posture and vice versa occasioned by going to bed and rising are also apt to induce this symptom.

The *mental* complaints are of inability to concentrate, defective memory, indecision, loss of emotional control, and rapid fatigability of the mental processes. In severe cases this is associated with insomnia and nocturnal restlessness. There may be some clouding of consciousness at night time, the condition then approximating to that of major contusion.

The Focal Signs of Cerebral Contusion.

As has already been stated, these are rarely encountered, and are to be regarded rather as accidents of localization than as of primary clinical importance. Their occasional presence, however, provides additional proof that the symptoms which have already been described have their origin in organic cerebral damage. As a reminder the association is of all the more value when it occurs in a case of minor contusion. I shall therefore quote briefly a single example.

In June, 1924, a labourer, aged 39, presented himself with the characteristic complaints of minor contusion. The story was that six weeks previously, while he was at work, a piece of steam piping fell on to the top of his head; he lost his sense of reckoning for a second but did not fall, and saw the pipe dancing on the floor. He kept at his work and experienced no symptoms of importance until a week later, when he commenced to have severe and disabling headaches. On examination he was found to have no physical signs, with the important exception of an extensor plantar reflex on the right side. The blow, which had been of a glancing nature, had been on the left side of his head, near the vertex, and as nearly as could be judged over the upper end of the left precentral gyrus. He was treated over a period of three months and then returned to his work. At that time the right plantar response was flexor, but obtained less easily than on the left. He writes that at the present time he is well, save for occasional headaches which occur at times of mental or physical strain or in thundery weather.

Apart from objective physical signs, there are certain symptoms which must be related to focal damage, amongst which permanent mental change and epilepsy are of importance.

Permanent mental deterioration to the point of necessitating institutional care would appear to be rare. Lesser degrees of impairment are by no means uncommon, especially after a history of major contusion. Thus in a series of 80 cases of head injury severe enough to necessitate hospital treatment, 18 patients interrogated one or more years after the injury complained of memory defect. Six of these had suffered from major contusion in the terms of our definition.

Epileptic attacks may occur in the early stages of a major contusion and are usually of the Jacksonian variety. They are probably due to subarachnoid haemorrhage, and do not always portend a permanent liability to attacks. Of more serious significance are the attacks which develop after a latent interval of months or years. These are usually generalized seizures of major or minor character, and quite commonly persist. The frequency of epilepsy as a sequel of head injury is apt to be under-estimated through neglect of the latent interval. In a series of 20 cases (7 gunshot wounds, 13 civil accident) in which a family history of epilepsy could be excluded and there was a clear history of serious head injury preceding the first attack, the interval between the accident and the first attack was in 13 cases longer than two years. In 19 of the 20 cases the attacks were of a general nature. In 18 of the 20 cases in which the history of the earlier stages was adequate, the story was of a major cerebral contusion.

Cerebral abscess following a compound fracture and *chronic subdural haematoma* are two sequels of head injury which are likely to come within the view of the neurologist. Both are rare. The story of subdural haematoma is commonly that of a fall or blow upon the back or front of the head, with or without concussion. After a latent interval, usually of several weeks, the patient begins to complain of headaches and gradually develops other symptoms of increased intracranial pressure. Symptoms of mental disorder are often a prominent feature of this stage. Later stupor develops, and the final stage of coma and paralysis supervenes rather suddenly and proceeds rapidly to a fatal issue unless relieved.

Owing to the long latent interval and the trivial nature of the injury the diagnosis is sometimes missed because it has never been considered. Examination of the spinal fluid may be of value in a doubtful case, for this sometimes contains altered blood pigment and flakes of fibrin.

Finally, there is a considerable group of cases in which the disability which follows head injury is partly or entirely *neurotic*, based usually upon the problem of compensation. The symptom picture in these cases of so-called traumatic neurasthenia differs in no respect from that of any other anxiety neurosis, save that the patient's concern is chiefly with his head, and anxiety may be focused upon the question of damage to his brain.

Differential Diagnosis.

The differential diagnosis of the several conditions I have described can best be reviewed by considering the problem as it may be encountered at varying intervals after the accident.

1. *During the First Twenty-four Hours.*—If the patient has been concussed it is impossible to make any comprehensive diagnosis of his condition at this period. The state of concussion masks what lies behind it. If after complete or partial recovery of consciousness the patient sinks again into a true coma or definite paralytic signs

develop, arterial haemorrhage is almost certainly present. If recovery is progressive and the patient is apparently normal at the end of twenty-four hours, major contusion may be excluded, but the symptoms of minor contusion may supervene. The absence of concussion does not exclude the possibility of the symptoms of minor contusion or subdural haematoma developing at a later stage.

2. *After the First Twenty-four Hours.*—If at this stage there is any clouding of consciousness, something more than simple concussion has occurred. A condition of stupor and irritability which persists, or shows a tendency towards improvement, indicates the presence of major cerebral contusion. A lapse into coma or the development under observation of paralytic signs will provide evidence of an increase of intracranial pressure greater than can be accounted for by contusion alone, and should immediately arouse the suspicion either of a late arterial haemorrhage or the formation of a subdural haematoma. The patient who, at the end of twenty-four hours, has apparently recovered may yet develop symptoms of minor contusion, and the latent interval may amount to several weeks. Especially is this likely to happen if the patient has been rested completely during these weeks and returns abruptly to his ordinary way of life. I have seen one or two striking examples in cases of multiple injury in which the contusion symptoms have developed only on the patient's discharge from hospital.

The symptoms of minor contusion are as a rule unassociated with any physical signs. They may need, therefore, to be distinguished from those of an anxiety neurosis. If they have developed from those of a major contusion—that is to say, if the patient has been stuporose for more than twenty-four hours after his injury—this fact should have considerable weight in favour of an organic basis. More difficult may be these cases in which the onset has been delayed.

The symptoms of true minor contusion, however, vary so little from one case to another that any physician who takes the trouble to elicit a full history will discover for himself a series of touchstones for the truth. Of particular importance are the character of the headaches and their relation to posture. The neurotic, as a rule, will describe his headache in terms of discomfort rather than of pain; it is continuous rather than intermittent, has no relation to posture, and is aggravated only by mental stress. The association of true contusion headache with giddiness also related to posture is a valuable point.

The mental symptoms are more difficult to evaluate, especially for one who has not known the patient before. It should be a rule in such cases to inquire for a family history of mental instability and to ascertain the patient's previous biological record, with especial reference to nervous breakdowns. A patient who was sent to me for an insurance report with mental symptoms following a head injury admitted having had a similar nervous illness some years previously after he had accidentally swallowed his false teeth. Of the several physicians and surgeons who had examined him before none had elicited this important fact.

Retardation of the intellectual processes and a defective memory, especially for recent events, are valuable signs of organic cerebral damage, and would probably be discovered more often in these cases if formal tests for memory and retention were generally employed.

My impression is that the frequency of traumatic neuroses following head injury is a good deal exaggerated and that the minor mental symptoms so often encountered are mainly due to organic damage. They are, in fact, the mental symptoms of major contusion spread thin. The argument to the contrary, that such symptoms are commoner amongst workmen, is to my mind of no great weight. Mental stress is an important aggravating factor in the symptoms of true contusion, and one can hardly imagine a greater mental strain than that of a lawsuit for compensation hanging over a man who has nothing to show as evidence of his disability besides his own word.

In this connexion I would urge the importance of teaching the legal profession that the brain may be seriously damaged without any fracture of the skull, without any objective physical signs, and occasionally in the absence of any history of concussion; and, conversely, that a fractured skull is in itself no proof of cerebral damage.

It would seem even that a fracture of the skull, if not fatal, may carry with it some degree of immunity from disabling after-effects. In the series of 80 cases to which I have already referred, the presence or absence of fracture was determined by *x* rays and clinical evidence in 72. Ten of these had fractures. At the time the inquiry was made—that is to say, one or more years after the accident—not one of these 10 was completely disabled; 7 were able to do full work and the remaining 3 light work. By comparison, of 61 cases without fracture, 7 were completely disabled, 28 were able to do light work only, and 26 full work. These figures suggest that, in so far as the traumatic force is expended in fracturing the skull, there is less available for lacerating the brain.

Of all the sequels of head injury, the differential diagnosis of subdural haematoma is the most difficult. My personal experience has been of 5 cases.

In one of these the diagnosis at first sight appeared to be that of a cerebral tumour. The patient was a young man with headache, papilloedema, and an extensor plantar response on one side. There was a story of a fall on the back of the head four months previously. The presence of xanthochromia and fibrin flakes in the spinal fluid led to a correct diagnosis.

In another case, also presenting the signs of a cerebral tumour, the correct diagnosis was made only at necropsy, and no history of injury was ever obtained.

A third patient was admitted to hospital with hemiplegia under the diagnosis of cerebral thrombosis. The fact that the hemiplegia had taken several days to develop excited suspicion; a history was obtained of a fall on the back of the head three months previously with slight concussion, and this led to a correct diagnosis.

In a fourth case increasingly severe headaches in a man with frontal sinus disease led to an exploration for cerebral abscess. *Post mortem* a bilateral subdural haematoma was discovered, and the history of injury six weeks previously was obtained only after death.

The fifth case was that of a magistrate who was knocked down by a motor car, sustaining a black eye and contusions to his body and limbs. After ten days' rest he returned to his work. Subsequently it was noticed that his judgement was faulty, he became irritable, and was obsessed in a manner unlike himself about the question of compensation for his accident. He was thought to be suffering from traumatic neurasthenia. It was not until two months after the injury that he somewhat suddenly became drowsy and developed the signs of a double hemiplegia. Exploratory craniotomy revealed a bilateral subdural haematoma.

Treatment.

I shall not dwell upon the treatment of concussion further than to remark again that the indication for surgical intervention during the first twenty-four hours is a lapse into coma after a lucid interval or the development under observation of paralytic symptoms. At the end of this period, in a case of simple concussion, recovery will be complete. Minor contusion, however, may be latent at this stage. In every case of concussion, therefore, the patient or his friends should be warned of the liability to subsequent headaches, and he should be advised to return gradually to his normal mode of living. If headaches should develop he should be treated as a case of minor contusion.

In the treatment of a case of major contusion the first principle to be observed is that of complete rest, and in securing this expert nursing is essential. The patient should be disturbed and handled as little as possible. Food should be light and easily assimilable. Sedatives will often be necessary at night—paraldehyde in full doses is effective if the patient will take it; drugs of the medinal group are less satisfactory in that, given in sufficient doses to induce sleep, they sometimes tend to increase confusion on the following day. A similar objection applies to hyoscine, which may sometimes be necessary in the management of a violent or noisy patient.

There are two means by which relief of intracranial pressure may be obtained during this stage, sometimes with excellent results. One is lumbar puncture. A manometer should be used, and the fluid—usually blood-stained—

run off until the pressure is subnormal. If the procedure gives relief it may be repeated as necessary. The other measure which may be employed is the intravenous injection of hypertonic saline—50 to 100 c.cm. of a 15 per cent. solution is the dose usually given. The effect is to shrink the brain by absorption into the blood stream of its extravascular fluid contents. This effect is temporary, and the procedure may have to be repeated at intervals of two days. An alternative and simpler method of obtaining a similar result is to give a saturated solution of magnesium sulphate, 3 oz. in 6 oz. of water, by the rectum. This needs to be retained for half an hour if it is to be effective. In the later stages the treatment is the same as for minor contusion.

The symptoms of minor contusion should be treated in the first place by rest in bed. The position of choice should be decided by experiment. In most cases the patient is most comfortable when sitting propped up, and, if so, should be enabled to sleep in this position. Cases will be found, however, in which the patient will discover for himself some other position which is the optimum, and he should be encouraged to persist in it. He should be protected from bright light and noise; visitors should be excluded or strictly limited. An ordinary light diet may be given, but alcohol should be forbidden. A sufficient dose of magnesium sulphate should be given daily to secure a fluid evacuation. If the patient is at all inclined to be restless by day a bromide mixture should be given. Aspirin, 10 grains at need, may be administered for relief of headache, and chloral or medinal at night for sleeplessness. This regime should be maintained until the patient has been free from symptoms for a day or two. He should then get up for an hour or two each day and have more latitude in regard to visitors. In this way he should be permitted to return step by step to an ordinary quiet mode of living, being put back a stage should there be any tendency to relapse with increasing activity. When he is able to live in the ordinary way without symptoms he should be encouraged to subject himself to more stress by means of physical and mental exertion, in order that he may test his capacity for a fully active life. This is especially important in the case of a manual worker.

Treated by these means the majority of patients suffering from symptoms of minor contusion make complete recoveries. The outlook is not so good in cases where the early story has been that of major contusion.

I have notes of a series of 80 patients who have been under my care with symptoms of cerebral contusion and have replied to a recent inquiry as to their present state. This inquiry was limited to cases in which at least one year had elapsed since the accident. All were cases referred to me, either in hospital or private practice, on account of symptoms which had persisted despite the simpler methods of treatment. They represent, therefore, a group from which the mild and quickly recovering cases of minor contusion have been excluded.

Of these 80 patients, 18, or 22.5 per cent., stated that they had made a complete recovery.

Of 71 who were dependent for their livelihood on regular employment:

33 (46.5 per cent.) were able to return to full work.
31 (43.5 per cent.) were able to return to light work.
7 (10.0 per cent.) were totally incapacitated.

These patients may be divided into those with major and those with minor contusion.

Of 54 with minor contusion:
28 (52 per cent.) were able to return to full work.
24 (44 per cent.) were able to return to light work.
2 (4 per cent.) were totally incapacitated.

Of 17 with major contusion:
5 (29.5 per cent.) were able to return to full work.
7 (41 per cent.) were able to return to light work.
5 (29.5 per cent.) were totally incapacitated.

These figures show that in the case of a major contusion the chances of the patient being able to return to his full work are less than one in three, and there is the same chance of total incapacity.

In cases of lesser injury, there is an even chance of the patient being able to return to full work, and a very small risk of total incapacity.

For purposes of obtaining these figures, the criterion taken for a diagnosis of major contusion was that the patient should have been in a state of unconsciousness, or partial unconsciousness, for more than twenty-four hours following the injury.

In cases of persistent contusion headache unrelieved by medical treatment, surgical decompression has been advocated. I have seen this in one or two cases attended with considerable success, in others with none. The result may possibly depend upon a choice of the correct moment at which the procedure should be undertaken. I shall hope to hear more of this method of treatment from others with greater experience of it.

THE EFFECTS OF IRRADIATED ERGOSTEROL IN LARGE DOSES.

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It is established that the presence of accessory food substances, or vitamins, is essential in the perfect diet. Observations are accumulating to show that when certain substances in a food are extracted and administered to animals in amounts out of proportion to the other constituents in that food poisonous symptoms may occur.[1] This has also been said to be true for the so-called vitamins. Excess of irradiated ergosterol—for example, when administered orally to rabbits and other animals—causes sickness and pathological changes:[2 3] mice died within twenty days after the administration of 1 mg. daily; rats and rabbits died within ten days with 10 mg. daily, and guinea-pigs died within thirty-six days after the administration of 50 mg. daily, whilst hens were immune. In those animals which died the characteristic *post-mortem* findings were an atrophic spleen, and extensive calcium deposits in the arterial walls, heart muscle, stomach walls, lungs, kidneys, and intercostal muscles, associated with secondary sclerosis of greater or less severity. It is obvious that changes of this character produced in so short a time are of a different order from the well-known arterio-sclerosis that can be produced in rabbits after feeding them with cholesterol for five to six months, or with non-irradiated ergosterol for two to three months.

The difference found by these workers between the therapeutic and toxic doses is considerable and leaves a wide margin of safety. It is important, however, to remember that their observations apply only to normal animals. We are still in the dark as to how far this ratio applies to man, and how far it may be modified in sickness or in initial vitamin deficiencies. The present observations were made to determine the effects of large doses of irradiated ergosterol on rats fed with a normal diet including an ample supply of vitamins A, B, and C. They demonstrate that grossly excessive amounts interfere with calcium metabolism to the extent that all the treated rats form calcium phosphate concretions in the urinary tract.

Experiment 1.

Four litters, each of four young rats weighing about 70 grams, were divided into four groups so that each group of four consisted of a pair from each of two litters. After ten days' control observation on a bread-and-milk diet the ergosterol was given daily in addition. Group A received 2 mg. of irradiated ergosterol in 2 c.cm. of arachis oil, and their litter mates in Group B 2 c.cm. of the oil alone. Group C and Group D received 1 mg. of irradiated ergosterol in 1 c.cm. of arachis oil, and 1 c.cm. of the oil alone, respectively. The administration was oral by pipette, and was continued for forty days. All the rats remained in perfect condition.