

in that region. In a very large number of cases we simply find indefinite signs of cerebral disturbance without any localizing symptoms, either of fracture or injury to the brain. In these cases it is my habit to do an exploratory trephining, and a very large proportion of them are found to be those which most definitely require operation.

In the dim light afforded by these facts I lay down the following rules: Given positive signs of intracranial disturbance following an accident which might well cause such a condition, but without definite signs of fracture, I should explore. Given a case in which there is probable evidence of fracture, and a probability of interference with the brain, I should operate.

I have never seen fatal or serious results follow trephining by skilful hands, even when two or three openings in the skull were made, and I have seen many lives saved by exploratory operations in this very large class of doubtful head injuries.

### INDICATIONS FOR OPERATION IN HEAD INJURIES.<sup>1</sup>

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PREVIOUS to the introduction of antiseptic surgery, and indeed until within the last twenty years, the only conditions which were generally believed to call for operative interference in head injuries were compound depressed or compound comminuted fractures of the cranium.

With the general use of antiseptics and, later, asepsis, the comparative safety of operations was immensely increased, and it became natural to inquire whether operations could not be undertaken with benefit in other forms of head injury.

The general interest taken in the later eighties and early nineties in brain surgery, and the greater frequency of operations on the brain, drew attention to the fact, which was contrary to the preconceived views of the time, that under aseptic conditions the meninges and the brain could be incised, punctured and manipulated with comparative impunity. I shall never forget how, in one of the earliest cerebral operations in which I was professionally interested, I saw one of our best-known surgeons plunge a bistoury into the optic thalamus, and the mental relief when no symptoms whatever followed.

The comparative safety of simple incisions of the brain being proved, there was still much discussion in regard to the dangers of interference with the meninges, and many physicians and surgeons were convinced of the serious results likely to follow upon an incision or a laceration of the meninges. In consequence of this opinion many operations were only partially performed, the meninges being left intact after the trephining, and the results being thus impaired. The question of the safety of incision of the meninges, and

whether such procedure increases the severity of the operation and endangers the recovery of the patient, has now in my opinion been definitely settled. Aseptic incision of the meninges is not in itself dangerous or even very serious. It is imperative in many cases of brain injury if the full benefit of the operation is to be obtained.

What are, in the present state of our knowledge, the indications for operation in head injuries? Opinions differ somewhat in this matter. Some surgeons go so far as to advocate operation in all cases of fracture of the cranium, and in many cases of prolonged unconsciousness following injury to the head. Others are more conservative, and would advise operation only in those cases where it is obviously and imperatively demanded.

In answer to this question I shall consider the more common signs and symptoms of head injury in detail, and discuss the value of each by itself and in combination with others.

#### FRACTURE OF THE CRANIUM.

I. How far is fracture of the cranium in itself an indication for operation? This depends on the character of the fracture, on its position and on the age of the patient. I will speak only of fractures of the *adult* cranium.

*Compound depressed and compound comminuted fractures* should be operated upon in practically all cases. (This, of course, presupposes, as we do throughout this paper, the presence of suitable conditions for operating and asepsis.) All punctured or perforating fractures come under this class. I believe that in all bullet wounds of the skull from the outside, that is, not through the mouth, nose or ears, or through the base of the skull, where there would be excessive difficulty in reaching the opening, the bone around the bullet wound should be trephined, not for the sake of finding the bullet, but simply for the purpose of cleansing the wound, as far as may be, and allowing no secretions to collect about the meninges or between them and the bone. In compound fractures of the cranium where there is no depression and where only a single fissure is found it is safer to operate (trephine) even though there be no other symptoms.

*Simple fractures.*—What shall we do in cases of simple fracture without symptoms? This is the class of cases about which opinions differ most strongly. I believe that on the whole it is wiser and better in these cases to be conservative and not to operate, but the patient should be kept under careful observation and operation be undertaken at once if any indication presents itself. Investigations on the results of simple fracture of the cranium show that only in rare cases are they serious, or such as could have been relieved by operation. I wish here to emphasize certain facts. Intracranial complications may arise with any severe head injury. Deep cerebral hemorrhages, single or multiple, may exist. We may have single hemorrhages situated in the basal ganglia or in other inaccessible parts of the brain,

<sup>1</sup> Read before The Massachusetts Medical Society June 10 and 11, 1902.

or we may have numerous minute or microscopic hemorrhages scattered throughout the brain substance. Neither of these conditions are operable, and their symptoms and results are not to be confused with those of simple fracture. Again, in all cases of severe blow upon the head, and probably in practically all cases of fracture of the skull, there is more or less contusion of the brain. This is apt to be on the opposite side from the direct blow. It is probably often the cause of certain disquieting symptoms, and its presence must not be forgotten.

The later conditions resultant from the fracture itself in cases of simple fracture of the cranium are not usually marked. If in any given case epilepsy should occur after an injury producing simple fracture of an ordinary character, an exploratory trephining should be resorted to at once after the first attack, but such condition is rare (or absent) in cases of simple fracture without concomitant symptoms of pain, unconsciousness or fever.

#### LOSS OF CONSCIOUSNESS.

II. The value of loss of consciousness as an indication for operation in head injuries varies somewhat in accordance with the degree to which it exists and, above all, with its duration. We find in these cases all shades, from that in which the patient is but momentarily dazed to deep stupor lasting for days or weeks. The severer grades are often accompanied by extreme restlessness and sometimes by delirium. These conditions will be considered later.

In the first place, the absence of any marked degree of unconsciousness does not contra-indicate operation. Such a condition may exist with very extensive cranial injury. I recall a laboring man who was struck in the head with a pickaxe, in a town about seventy miles away, early one morning. He had no loss of consciousness. He took the train to Boston that day, arriving here in the evening, waited and got his dinner and then walked to the hospital about half-past eight in the evening. On examination a most extensive comminuted fracture, involving about half of one side of the vertex, was found.

Secondly: The degree of unconsciousness does not in itself determine the necessity of operation. In many hospital cases the cause of the loss of consciousness is not uncomplicated. Alcohol plays an important part, and the influence of this factor must be eliminated. It is well known that a blow on the head of a person addicted to, or under the influence of alcohol, will induce symptoms due to the alcohol which would not have been apparent without such exciting cause. I need hardly mention the occurrence of delirium tremens after injury as an example of this. This affection is usually too apparent to be overlooked. An injury to the head in an alcoholic person, or one under the influence of alcohol, often produces a result which neither the alcohol nor the injury alone would produce. The effects of the alcohol, previously latent, suddenly reveal themselves,

taking advantage of the lessened power of cerebral resistance, and the loss of consciousness is deepened—an alcoholic stupor is added to what might be called the simple or uncomplicated condition due to fracture. Such a patient shows a greater degree of unconsciousness than would naturally occur in a patient free from alcohol who had suffered a like injury, and the unconsciousness in alcoholic cases seems to last longer than in the average non-alcoholic patient. Whether this is a fact can only be determined by considering large numbers of cases, because, as before stated, the degree of unconsciousness is *not* proportionate to the severity of the cranial injury.

Alcohol taken in excess previous to the injury (and this excess need not be such as to be apparent) not only tends to increase the degree of unconsciousness, but may also produce delirium. The low, muttering delirium so often seen in older men after a head injury, is usually due to this and may last for days or weeks. To this also is due the temporary delirium and peculiar actions in certain cases which occur at various times in the day, the patient being quite natural in the intervals.

Though the degree of unconsciousness is not proportionate to the severity of the cranial injury, the duration of the unconsciousness is so to a certain degree. I am convinced that in all cases of uncomplicated head injury in adults, where alcohol and other brain lesions, such as paralytic dementia, can be excluded, in which the patient remains unconscious for over twenty-four hours, operation should on this ground alone be seriously considered. Such a condition points to serious intracranial injury—very possibly a large epidural clot.

Cases occasionally occur in which without intervention the patients remain unconscious for two weeks or more. Experience seems to show that the results would be better were these patients trephined early, and that even a late trephining is advisable. It is scarcely necessary to say that renal and all other complications must be excluded.

Delirium in these cases, if not accompanied by restlessness and fever, and if not due to alcoholism, is exceedingly suggestive of chronic renal disease. When accompanied by restlessness and a high temperature, exploratory operation may be considered. Under these conditions, however, we are rarely without more positive indications to guide us. If delirium, fever and restlessness without other symptoms are found after head injury, the indications for operation are not positive.

*Temperature.*—When there is a marked rise of temperature shortly after a head injury, and especially when the temperature continues to increase, the prognosis is more or less serious. If not due to complications of other organs it suggests serious injury to the brain and a grave prognosis. It is to be considered in this light rather than as an indication for operation. It is not a contra-indication except so far as it indicates that operation is not likely to remedy the

trouble completely, and that a condition not to be relieved by operation, exists. Subnormal temperature after head injury is frequently due to shock. When not due to shock a subnormal temperature is not in itself a contra-indication to operation. Subnormal temperature without unconsciousness or other symptoms is of no definite importance.

Shock being eliminated, a long-continued subnormal temperature in an unconscious patient suggests edema of the brain without severe injury or laceration of the brain tissue. If this edema is not due to alcoholism, paralytic dementia or renal disease, operation should be considered twenty-four hours after the accident.

*Pain.*—Acute, severe pain is always a symptom deserving serious consideration in head injuries. In connection with other symptoms it may serve as an indication for operation. In any case where there is severe pain in the head lasting over twenty-four hours, operation is to be considered and a most careful examination made for other symptoms. I can recall at the present moment a case in which a patient was brought to consultation solely on account of persistent severe headache following an accident in which he was thrown out of his wagon. There was no unconsciousness, no fever, no delirium. The patient was able to use his limbs, and except for his headache might have been considered to be in normal condition. The only definite sign found was a dilatation of one pupil. It was in this case determined to operate, and an extensive fracture of the cranium was found.

On the other hand, we must be on our guard against functional pain dependent on the general temperament of the patient, rather than on local conditions. A person of neurotic tendency may have severe pain in the head following head injury due in large part to his nervous condition, or aggravated in consequence thereof. In these cases operation is not indicated by the existence of pain. The diagnosis between the forms of pain must be made from the general condition of the patient.

We now come to the more striking symptoms of brain *irritation* and *inhibition*, which are often also of value as suggesting or determining the position of the injury.

#### CONVULSIONS.

Convulsions may be tonic or clonic, and in either case general (diffuse) or localized. (In the adult, tonic convulsions unaccompanied by clonic are not common in the early periods after head injury.) General tonic convulsions are rare. They would suggest either some complicating affection or possibly an injury in the region of the posterior fossa or of the medulla. Localized tonic convulsions when they occur are apt to alternate with clonic convulsions of the same region, and suggest an irritation of the corresponding intracranial regions.

*General clonic convulsions.*—These are almost always due to some special condition of the

patient or some complication. When they exist epilepsy is to be suspected. Epilepsy itself may be the determining cause of the injury, or the shock of the injury may bring on an epileptic seizure. The possibility of its existence can never be neglected in a case where the previous history is not fully known, and where convulsions of this character exist. In these cases the convulsions are accompanied by unconsciousness.

When general convulsions occur while the patient is conscious or semiconscious, especially if of the female sex, hysteria or functional trouble must be considered, and this must be eliminated. General clonic convulsions may possibly be caused by alcoholic conditions alone, but I consider this doubtful. They may be due to uremia, which must always be considered before operation is undertaken.

Clonic localized convulsions are important both as determining the advisability of operation in many cases and the place of the lesion. They are not, however, an absolutely certain sign, either of the position of the most serious intracranial injury or of the necessity of immediate operation, but are only suggestive. The most common form of localized convulsions is the hemiplegic when they involve the muscles of the limbs, and often those of the face on one side—the side opposite the brain lesion. When definitely localized in one limb, or in one portion of a limb, their significance as showing the exact localization in the brain is greater than when larger areas are involved. Thus, convulsions localized in a thumb, or in certain fingers, or the forearm, would have a great localizing value; but, unfortunately, these closely localized convulsions in the limbs rarely occur. I do not, on the other hand, attach much significance to the affection of certain muscles in the face. The facial muscles seem to be readily affected in many cases. The ocular muscles often show the first signs of the commencing convulsions, whether hemiplegic or general.

It is rare that a special small series of muscles is alone affected throughout a convulsive attack. Many attacks begin with convulsive movements of a few muscles, then of more, and finally nearly all the muscles are affected. Formerly, we attached considerable importance to the determination of the group or groups of muscles first affected in these cases, and this should always be noted, but experience has shown that the importance of this symptom has probably been overestimated. We find that in several successive attacks different groups may be involved first. We find that the gross lesions involve or affect many centres and apparently the most sensitive, and not necessarily those most affected are first involved.

Convulsions are of great diagnostic importance in determining the side of the lesion, that is, which half of the brain or its membranes is affected. For closer localization they are apt to be deceptive. This is the rule. There are, however, certain exceptions or limitations thereto;

(1) They may also be produced in edema of the brain in alcoholic patients in cases where at autopsy no gross lesion whatever (except edema) is found; (2) the side of the brain so affected as to cause convulsions may not be the side of the fracture or of the greatest apparent gross injury. They may be produced by the *contrecoup*.

Hence, when the other symptoms are sufficiently decisive, the evidence of the locality of the injury given by convulsions is to be neglected. For example, if the convulsions, as is sometimes the case, are on the same side as a compound depressed fracture, operate over the fracture. It may not be advisable to operate on the other side at all.

#### PARALYSIS.

Under this heading we include not only all forms of total paralysis, but also the cases of partial paralysis or marked weakness of muscles.

Inequality of the pupils is always important. This may, of course, be natural to the individual; it may be due to local eye lesions, cataract, etc.; it may be due to syphilis or to other cause existing before the injury. These causes must receive due consideration. If, however, we decide that the evidence is in favor of the condition being due to the injury, we have a symptom of great value in the determination of the situation of the lesion. Unilateral dilatation shows injury on the side of the dilated pupil and often occurs with fracture of the base on that side. Taken in connection with unconsciousness, this sign, in my opinion, is sufficient to justify operation.

Unilateral myosis, or contraction of the pupil, is much rarer. It would suggest—if not due to some cause unconnected with the injury, as would be most probable—an irritation of the brain on the same side.

Paralysis of the external ocular muscles naturally points to fracture of the base on the same side as the muscles affected. Paralysis of the external rectus is due to injury of the sixth nerve. Paralysis of the internal rectus to that of the third. Paralysis of the fourth nerve is practically not distinguishable in the cases seen immediately after the injury. Paralysis of both sixth nerves suggests fracture of the base on both sides and very serious injury. I will merely mention that great care must be taken not to consider a previous strabismus as due to the injury.

Paralysis of the face alone may be due to injury of the seventh nerve when all three branches of the nerve are involved, or to a central lesion when only the lower branches are affected, and the wrinkling of the forehead continues essentially normal. When the lesion involves the nerve it is on the same side as the paralysis. When it involves the brain it is on the opposite side. Nuclear paralyzes are so rare that they may be neglected. It is quite possible that the seventh nerve may be injured through the ear.

The most striking form of paralysis, undoubtedly, is hemiplegia. This term is here used to denote paralysis of both limbs on the same side

of the body. This points to a lesion on the opposite side of the brain. It may be associated with paralysis of the face on the same side as the hemiplegia, which suggests a more extensive lesion than the affection of the limbs. It may be associated with paralysis of the face on the opposite side, but much more rarely. This is only mentioned to state that when it occurs it may be due to a lesion on the opposite side from the hemiplegia, involving the seventh nerve, and that this is more probable than a hemorrhage in the pons. A hemiplegia may be associated with paralysis of many other muscles, especially the external ocular muscles, but we cannot enter into consideration of these combinations here, as it would lengthen this paper unduly.

The significance of hemiplegia as an indication for operation is great. It might at once be said that when it occurs in adults as direct result of the cerebral injury operation should always be performed unless some special contra-indication exists. This is true whenever the hemiplegia results directly from the injury itself. But, unfortunately, we have a considerable number of cases in which the hemiplegia is not the immediate direct result of the injury, but is caused by the cerebral edema which follows, and this condition is specially common in the alcoholic. It is not always easy to distinguish in the unconscious patient the hemiplegia due to an alcoholic edema from that caused by a direct lesion. In my opinion one point is of special value in this connection. The paralysis in edema is rarely or never total; it is almost always a weakness or decided weakness, while some power of voluntary motion still remains. Operate, therefore, in all cases of hemiplegia in adults not due to alcoholic or uremic edema. Operate, as a rule, in doubtful cases, because even in edema the opening of the meninges undoubtedly tends to benefit the patient, but in such cases be prepared not to find a clot or a fracture, or other visible lesion.

Aphasia, when organic, suggests brain injury or pressure. It usually occurs in connection with unconsciousness or some form of paralysis, more especially hemiplegia.

I shall not consider now the question of operation in the head injuries of children, except to say that with them we should be much more conservative. Children recover without serious results from lesions which would produce much more severe after-effects in adults. The brain apparently adapts itself to a certain amount of localized pressure. Hemiplegias do not have the same serious significance.

#### SUMMARY.

(1) Operate in all cases of compound depressed and compound comminuted fracture of the cranium. It is usually advisable to operate on any compound fracture.

(2) Simple fracture of the cranium without symptoms does not as a rule demand operation.

(3) Absence of unconsciousness does not contra-indicate operation. The degree of uncon-

sciousness is not in all cases proportionate to the severity of the injury.

(4) The duration of unconsciousness is important, and when it lasts more than twenty-four hours,—no other cause than the injury being present,—operation should be considered.

(5) Marked rise of temperature after uncomplicated head injury suggests serious injury to the brain. It is not necessarily an indication for operation. A subnormal temperature without other symptoms has no special significance. When accompanied by unconsciousness and lasting twenty-four hours or more it suggests edema of the brain or intracranial hemorrhage.

(6) Severe pain in the head continuing for some time after a head injury, if organic, indicates operation. Pain in the head following injury may, however, be functional and due to general nervous conditions.

(7) Convulsions, when clonic and diffuse, suggest epilepsy or other complication. When localized they are of value as indicating the side of the brain on which the lesion producing them is situated. Taken in connection with other symptoms their presence usually favors operation.

(8) The presence of paralysis of the limbs in adults, if marked, usually indicates immediate operation. Partial hemiplegias and paralysis of the limbs may occur in edema of the brain following injuries.

(9) The above statements refer to adults only. In children paralyzes are more apt to pass away and the indication for operation is not so decided.

### GUNSHOT WOUNDS OF THE HEAD AND CRANIUM.<sup>1</sup>

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THE introduction of steel-armored projectiles of reduced calibre for the military rifle of the civilized nations has modified the subject of gunshot wounds in nearly all the tissues, the head included. The experimenters, with this new high-velocity bullet that does not deform on impact, noticed in the beginning that the amount of destruction conferred by it at close range was very great, and that this destruction was generally proportional to the velocity and the resistance encountered on impact. When these conditions of velocity and resistance obtained, the destruction took the character of what is often designated as explosive effects. These so-called explosive effects were especially noted in fluid or semifluid tissues enclosed in rigid walls, of which the brain and skull are the most typical examples. Such a lesion is usually characterized by a wound of entrance corresponding in size to the calibre of the projectile inflicting it, and a wound of exit varying in diameter from one to several inches. The channel track between the exit and entrance wounds is much lacerated and marked by the

presence of bony sand and spiculae of bone varying in size from one-fourth to one-half inch. The latter are usually found to have been driven into the tissues not only in the line of flight of the projectile, but at right angles to it, as if an internal force had exerted itself in all directions. Many theories have been advanced to explain explosive effects, but it is now pretty generally attributed to the transmission of the energy of the projectile to the particles of bone and other tissues that become detached and then act as secondary projectiles.

In the middle and remote ranges where the remaining energy has become very much less, the destructive effects in wounds of the head by the new bullet are very much less than those inflicted by the old large leaden bullet that was so apt to deform on impact. The illustrations accompanying the paper afford typical examples in support of this statement.

Gunshot wounds of the head are usually divided into flesh wounds and fractures. The latter are necessarily very fatal. In the Civil War the fatality among all head wounds that reached the hospitals was 28.93%. The fatality of the same class under similar conditions in the Spanish-American War was about the same, 26.09%. The figures concerning the relative number of the two are shown in the following table.<sup>2</sup>

	Seat and character of injury.	No. of cases.	Percentage.	Per cent. of all wounds.	Recoveries.	Deaths.	Undetermined results.	Per cent. of fatality.	
	Head:								
Civil War .....	Flesh wounds.	7,739	64	3.14	4,9	6,573	2,676	2,480	28.93
	Fractures.	4,350	36	1.76					
Spanish-American War.....	Flesh wounds.	40	56	2.74	4.86	42	18	2	26.09
	Fractures.	31	44	2.12					

The figures illustrate the frequency of glancing shots with the slow-velocity leaden bullet of the Civil War as compared to their infrequency with the high-velocity steel-jacketed bullet in use at present. The latter as a rule travels in a straight line from the point of impact, being seldom deflected from its course by resistant bone. The relative increase in the number of fractures from the use of the modern military rifle augments the fatality in head wounds, so that the humane features attributed to this weapon already referred to, do not apply to wounds of this region. These results were foretold by the experimenters before the opportunity to observe the effects of the new arm in the actual conditions in war had presented themselves. Stevenson,<sup>3</sup> writing in 1897 upon the proportion of flesh to fractured wounds of the skull, states as follows: "In future wars the proportion will be very different. Omitting indirect and grazing hits, almost every bullet which hits

<sup>2</sup> Extract from Borden's Military Surgery, Prize Essay, Proceedings Association Military Surgery, 1900.

<sup>3</sup> Wounds in War, W. F. Stevenson, Colonel-Surgeon, British Army.

<sup>1</sup> Read before The Massachusetts Medical Society, June 10, 1902.