DIAGNOSIS AND TREATMENT OF FRACTURES OF THE SKULL.

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There are few surgical conditions which require the nicety of judgment in their management as do fractures of the skull. In writing on the subject John Abernathy in 1811 says "The difficulties connected with this part of surgery are sufficiently proved by this circumstance, that notwithstanding it has at all times excited the attention of surgeons of the greatest talents and possessing the most extensive field of observation, much difference of opinion still subsists, and the practice to be followed in particular cases yet remains a matter of dispute." This statement applies with almost equal force today. The essentials in treating skull fractures are, first the observation of various clinical manifestations of the condition, secondly their proper interpretation and thirdly the correlation of these manifestations with treatment. We realize that each case of skull fracture is best treated individually and that to apply "routine" treatment is to court disaster in many cases; but it is our aim here to bring out as far as possible the relation between various clinical aspects and therapeusis. With these ideas in mind we present a study of 223 cases of fracture of the skull which represent the cases admitted to the Cincinnati General Hospital in 1922 and 1923, all of which with few exceptions have been personally observed and treated.

The procedure followed in this Clinic is to observe the patient for varying periods of time before any operative interference is offered, unless he presents a compound fracture, a depressed fracture or signs and symptoms of an extradural hemorrhage, in which event he is operated on immediately provided his condition permits it. During this observation period various studies are made which form the basis for his subsequent management. These consist of a general physical and neurological examination, a record of pulse and respiration every 20 minutes, frequent temperature observations, an X-ray of skull, and a spinal puncture with a record of the pressure.

To our minds the most important phase of the treatment is this observation period when one recognizes and interprets correctly the changing train of signs and symptoms and on them bases his subsequent procedures. Under observation the cases

resolve themselves into grpups, i. e. (1) those whose injuries are incompatible with life and who rapidly die; (2) those who show only mild degree of injury and who never present alarming symptoms; and (3) those who stand between groups (1) and (2), whose outcome is problematical and whose management is both difficult and fascinating.

Age:	Between	1	and	10	yrs.	of age,	41	cases -	mortality	14.6%.
	"	11	"	20	"	" "	29	" -	"	13.7%.
	"	21	"	30	"	" "	31	" -	"	32%.
	"	31	"	40	"	" "	36	" -	"	38.9%.
	"	41	"	50	"	" "	29	" -	"	58.6%.
	"	51	"	60	"	" "	25	" -	"	44%.
	"	61	"	70	"	" "	21	" -	"	42.8%.
	"	71	"	80	"	" "	6	" -	"	66%.

These figures corroborate those of other observers as to the more favorable prognosis in children as compared to adults. This is due to several factors such as greater elasticity of bones, lack of fusion of suture lines, lack of adherence of

It is less often necessary to resort to decompressions in children, and one finds fewer cases with depressed fractures. It is interesting to note that the greater number of cases occurring in any one decade is found in the first. It is to be expected that after the age of 50 the mortality is increasingly high.

SEX AND RACE. There were in the series 183 males (mortality 35.5%) and 40 females (mortality 37.5%). 186 (mortality 38.2%) were in the white race and 37 (mortality 24.3%) in the colored. There is little of significance in the sex or race as such; since the severity of the injury is the most potent factor.

TYPE OF FRACTURE. Here one finds a marked variation in the mortality and there is much of prognostic value in the type of fracture. The most innocuous fractures are the simple ones of the vault, whereas, the most serious are the ones involving the base.

Number of simple fractures of the vault, 59 - mortality 13.5%.
" " " " " " base, 33 - mortality 42.4%.
" " " or depressed fractures of the vault and base, 107 - mortality 47.6%.
" " compound fractures of the vault, 8 - mortality 12.5%.
" " compound, comminuted depressed fractures, 16 - mortality 37.5%.

Mixter in 1917 reported 301 cases of fracture base of skull with a total

mortality of 54.1% (but of only 36.5% in that part of the series from 1911-17). He, however, eliminated the cases with severe associated injuries of those which died within 2 hours, whereas, our series indludes all cases. Ransohoff in 1910, reporting on 190 cases of fracture of the base of skull, shows a mortality of 65%, and quotes Cushing as having a mortality of 80% before he began to do decompressions. Phelps reports 570 cases of fracture of base with mortality of 54.5%, and 213 cases of fracture of vault with 28.6%. Crandon and Wilson show 530 cases of fracture of base with 41% mortality. The compound fractures of the vault do extremely well with immediate operation. They rarely show marked signs of pressure as they tend to decompress themselves through their wounds before operation. The compound, comminuted depressed fractures with extensive cortical laceration and associated basilar injuries are of most grave prognosis. The simple depressed fractures of the vault offer a good prognosis and are best treated by immediate elevation of the fragments.

MODE OF INJURY. One hundred and eleven of the 233 cases were caused by automobiles, i. e. about one-half of all our cases; and of the 80 cases in the series that died 52% were due to the automobile. This emphasizes first the importance of the automobile as a factor in producing skull fractures and, secondly, the seriousness of the injuries thus sustained. The injuries caused by the automobile are usually very extensive ones and are so often associated with fractures of other bones, stove-in chests or intra-abdominal injury that the prognosis is apt to be poor. One particularly fatal form of injury as noted by us are those cases which receive a very forcible blow on the point of the jaw with a fracture of the jaw and a fracture from indirect violence to the base of the skull. Of these we have had 6 cases all of which died within a few hours.

STATE OF CONSCIOUSNESS. Much stress was laid on the state of consciousness as of value in prognosis and as a guide in treatment by early writers, such as Hippocrates, Pare, Quesnay, Potts and Abernathy. Of our cases 47 were fully conscious on admission and of these 3 died - a mortality of 6.3%. Sixty-six were semi-conscious, of whom 5 died - a mortality of 5%. As against these two classes of cases was that in which the patients were unconscious on admission and remained so for a varying period of time, of

whom there were 107 with a mortality of 66.3%. Phelps reports that of cases of fracture of the skull with unconsciousness 318 died, of 76 practically conscious 30 died, of 289 who were conscious 80 died. In Ransohoff's cases of fracture of base 95% showed some change in state of consciousness, of 98 cases in deep coma 70% died, of the conscious cases only 3 died. The state of consciousness influences us greatly in the treatment. If consciousnesss is retained at the same level, we are inclined to wait longer before decompressing (even if the pulse is slow but regular and respirations are quite slow but not varying in depth) than we would be in an unconscious patient with the same degree of slowing of the pulse and respiration. A steadily increasing state of consciousness we feel to be a good omen even if some of the other findings are not so encouraging; whereas, a deepening state of unconsciousness causes us considerable alarm and demands urgently relief of pressure. The classical picture of an immediate loss of consciousness, followed by a clear interval, which is in turn followed by a second loss of consciousness, calls for an immediate operation which nearly always discloses an extradural hemorrhage. To recapitulate, a persistent deep coma means serious intracranial damage and grave prognosis (66% mortality in our cases), retention of consciousness is quite favorable, a returning consciousness even in the presence of unfavorable symptoms is most encouraging, but a deepening coma is indicative that the case is progressing unfavorably and measures for relief of pressure should be instituted.

TEMPERATURE. Patients having normal temperature or above normal on admission, 82 with 17% mortality. Patients having sub-normal temporature on admission, 138 with mortality 45%. Patients presenting a sub-normal temperature on admission are those with the most severe injuries and associated shock for which reasons the mortality is especially high. In the individual case the temperature on admission means little, unless it is extremely high or unduly low, in either event offering a poor prognosis. On the other hand, the course that the temperature takes later on does have a definite meaning. Cases with a steadily mounting temperature reaching 104^{0} - 106^{0} rarely recover for this is associated so often with deep coma, Cheyne-Stokes respiration, cyanosis and weak, rapid pulse and with them means that the stage of cerebral

decompensation has been reached. In cases where the temperature remains subnormal the danger from shock is of paramount importance. In favorable cases the temperature rises promptly after shock subsides but does not usually go higher than 102 falling by recessions a degree or so a day. The onset of meningitis is usually indicated by a sudden rise of several degrees. Brain abscess is associated with normal or subnormal temperature. We do not believe a decompression advisable in a patient whose temperature is 102 and steadily mounting. Wilensky has called attention to the prevalence of fever in skull fractures and attempts to explain it in one of three ways, i. e. (1) upset of the heat center, (2) meningitis or (3) the escape of cerebro-spinal fluid through tears in the pia which in the presence of a bacteriaemia gives a temporary mild meningitis. Courtney states that the temperature stands supreme in scale of importance among the valuable prognostic and diagnostic signs. He feels that contusions of the brain are associated with temperature arpund 102 and if the case is progressing favorably it falls gradually, but if unfavorably, it mounts steadily; lacerationsof the brain give an immediate upward trend with infrequent and slight recessions. Nichols states that the temperature is low in simple edema but high with lacerations of the brain. Phelps feels that with a primary temporature of 102 or a subsequent one of 105 there are no recoveries.

THE PULSE. Much information of value may be derived from the pulse. On admission the pulse has significance only if it is very slow 30-40 or very fast 120-160. Rates between these convey little of immediate prognostic or diagnostic value. It is what happens to the pulse later that is of significance. Our records show 82 cases admitted with a pulse of 90 or over with a mortality of 39%; 83 cases with a pulse of 70-80 with a mortality of 31%, and 54 with a pulse of 70 or below with a mortality of 37%. A steadily diminishing pulse rate means a steadily increasing intracranial pressure and indicates that the pressure must immediately be relieved. In addition to the actual slowing of the pulse, one notes a slight irregularity in the cases who are bordering on decompensation. This is apt to be an irregularity in rate first - thus, if one holds the pulse a full minute or two he will count it 50 for one quarter and say 90 for the next. When this is noted we feel that unless urgent steps are taken for the relief of pressure the case will soon pass over into that place where therapy will be of

no avail. When a pulse that is steadily rising goes over 120 we feel that operative interference is not indicated. On the other hand, a slowly increasing pulse rate that does not go over 90 or 100 is a good omen. One too often sees a pulse going from 50 per minute to 140 in a very short space of time and if this occurs the prognosis is absolutely bad. The most important features of the pulse in skull fractures are (1) that a steadily slowing rate or the same slow rate associated with a slight irregularity calls for relief of pressure, (2) a weak, rapid pulse is of poor prognosis and contra-indicates operation. No definite lower limit to the pulse rate can be set when operation is indicated but one must consider the other aspects of the case in conjunction with the pulse. A case with a consistent pulse of 50 or below usually comes to operation. A comparison of both radial pulses was not done regularly so we are not prepared to comment on the asymmetry of the pulses on the 2 sides as described by Phelps, and which he ascribes to an interference with the correlation of the sympathetic and central nervous systems.

BLOOD PRESSURE. Unfortunately, our observations on this phenomenon are not accurate or sufficient enough to justify any report. From the literature it seems conceded the blood pressure changes are not consistently enough to be uniformly of much value as a sign on which prognosis may be based.

RESPIRATION. Number of cases with respiration over 12, 192 with 33% mortality.
" " " " " " 12 or less, 16 with 43% mort.
" " " " " Cheyne-Stokes, 59 with 80% mortality.

(Note: Death over-laps in these cases, i. e. one death may be counted under 2 headings.)

If when one first sees a case it presents Cheyne-Stokes respiration, the prognosis is utterly bad, or if this type of respiration appears later in the course of the disease the hope of recovery is slight. In either event we feel that little will be accomplished by operative interference. We are particularly careful to pay the closest attention to the respiration combined with rapid, weak pulse and coma. Slowing means increasing pressure, (2) frank Cheyne-Stokes respiration combined with rapid, weak pulse and coma contra-indicate operation, (3) slight early irregularity in depth of respiration is most important as a positive sign of impending decompensation. It is necessary to watch the respirations for several minutes with a good view of chest and abdomen in order to

appreciate the first appearance of irregularity. We have noted in several cases a peculiar sigh interspersed at intervals in otherwise regular respiration and have come to regard this as a particularly ill omen.

BLEEDING. Number of patients bleeding from nose or mouth, 59, mortality 47%.
" " " " " ear, 84, mortality 50%.
" " " not bleeding, 80, mortality 12.5%.

Phelps states that of 285 of his cases that bled from the ear 119 died, and of 90 that bled from nose or mouth, 51 died. Crandon and Wilson report 395 cases with bleeding from ear, nose or mouth with 181 deaths; they advise against irrigation of ears or nose. Ransohoff emphasizes the seriousness of bleeding from nose as in 19 of such cases only 4 recovered. Bleeding ears, nose or mouth mean usually more extensive injury to the base of the skull and a resultingly high mortality. At this point we would like to emphasize the importance of caring properly for a bleeding ear or nose. Negligence in this precaution is sure to lead to a certain number of cases of meningitis. Cleanliness and avoidance of introducing fluid into the ear or nose are the essentials. We are in the habit of cleansing the external ear or nares with gauze moistened in peroxide not irrigating and applying a large sterile dressing to the ear. This is changed as often as necessary. Under this regime we have had only 2 cases of meningitis which is a bit lower than one finds in other series published. Thus, Mixter reports 8 cases in a series of 301; Wilensky 4 in 75, LeCount 39 in 504, Phelps no cases in 2000, Ransohoff 4 in 190. We have seen brain substance in the external auditory canal in 3 cases, two of whom promptly died and one recovered without operation but was mentally deficient when last heard from. Phelps reports 3 similar cases with the same result.

EXAMINATION OF THE FUNDUS. This we have not found to be particularly useful as an aid in diagnosis, except in the later stages of the disease when one suspects pachymeningitis hemorrhagica or other causes of long continued pressure. In the acute stages the fundi rarely, in our experience, give any information other than what one can glean from other sources. Kearney reports constant findings of blurring

of disc edges with some edema, Wilensky agrees with this, but other observers fail to corroborate; thus, Cohen in 75 cases never saw a choked disc or doubts if they occur, though he finds frequently a fulness of the vessels and slight blurring of the disc edges, Jackson does not feel that the fundi show much change early and does not rely on them.

PUPILS. Cases with pupil dilated on side of lesion in skull, 48, mortality 52%.
" " " " " " opposite lesion, 20, mortality 95%.
" " no pupillary change, 155, mortality 23%.

The pupillary changes we feel are rather good indications of the amount of intracranial damage. An extreme amount is associated often with fixed dilated pupils and here the mortality is frightfully high, in our series 100%. This seems universally true, thus, Cohen calls attention to the poor prognosis associated with fixed dilated pupils, Nichols advises against operation when they are present, Crandon and Wilson show 131 deaths in 142 cases, Ransohoff 42 cases with 41 deaths. The dilated pupil is most often on the side of the injury for there the damage is severe, so much so, as to cause 52% mortality in our series; when, however, the pupil on the opposite side is dilated we are inclined to feel that the contre-coup damage is more severe than that on the side of the injury and that the sum total of the injury is such that an extremely poor prognosis is offered. When a pupil which was large on admission comes down to normal size the prognosis is apt to be favorable; but when a pupil which was equal to its mate on admission later becomes dilated we feel that the intra-cranial damage is progressing and become suspicious of an extra or intra-dural hemorrhage. Walton feels that the pupillary changes are due to injury to the celio-spinal tract. Phelps states that a single dilated pupil was found in 11 out of 30 cases of extra-dural hemorrhage, both pupils were dilated in 7 cases, normal in 3, and contracted in 5; and quotes Hutchinson as saying that a single dilated pupil meant an extra-dural hemorrhage in middle fossa on the same side. Crandon and Wilson show that in 155 cases with unequal pupils 90 died; Holman (A.M.A. 84, 18, 1333) emphasizes the value of unilateral dilatation as a localizing sign and cautions as to transitory character.

CONVULSIONS. Cases presenting focal convulsions, 7.)
" " general " , 2.) (mortality 66%.

Convulsive seizures ordinarily mean extensive cortical damage rather than extra-dural hemorrhage for in the latter case one more frequently finds paralysis rather than an irritative lesion. When a focal convulsion is repeated two or three times over an interval of an hour or so we are in the habit of operating as much for the possibility of correcting damage which may later lead to epilepsy as for immediate results. We do not believe that one focal attack particularly in children calls for operative interference, as we have two cases who recovered spontaneously.

PARALYSIS. In our opinion a definite, persistent, paralysis or weakness of an extremity in a patient with a skull fracture is an absolute indication for operation. A hemiplegia, if one can rule out an apopletic stroke and coincident skull fracture, is an urgent indication for operation for it is so frequently associated with extra-dural hemorrhage. Facial paralysis is most often due to injury to the nerve in the canal and scarcely falls in the same category as paralysis of an extremity. In our series 25 patients presented evidence of paralysis with a mortality of 48%. We have not encountered a case of longitudinal sinus syndrome of Holmes and Sargent.

REFLEXES. Not many cases in this series show changes in the reflexes. About all one learns of value as to reflexes is that absent reflexes are of very grave prognosis, any real change in reflexes means more damage within the cranium and more serious prognosis than if the reflexes were unchanged. Our records show normal reflexes in 183 cases with a mortality of 28.4%, absent in 17 with 100% mortality, increased on side of lesion 10 with 50% mortality, increased on side opposite lesion 13 with a mortality of 46%. The impression gained from the literature is that changes in reflexes are apt to be transitory and are of little value both in prognosis and indication for operative interference.

SPINAL PUNCTURE. Reports as to the use of lumbar puncture in the treatment of fractures of the skull begin to appear in the literature about 1905. From that

time until about 1922 most of the advocates were among the French and Italians. Jackson in 1922 strongly advocated its use and seems to have stimulated interest in it as a diagnostic and therapeutic agent. Until 3 years ago we had been fearful of performing spinal puncture on patients with skull fractures on account of the supposed damage of medullary jamming into the foramen magnum. We have been using it as a routine measure in the series of cases herewith presented and now feel that not only is it not dangerous but is frequently of real value either therapeutically or from a diagnostic viewpoint. One hundred and seventy-eight of our patients had one or more lumbar punctures and of this number only one showed ill effects attributable to the puncture. This occurred in a patient who later was found to have a large extra-dural hemorrhage. The ill effects manifested were a focal convulsion becoming generalized, weak, rapid pulse, irregular respiration and coma. He rallied, however, and was later operated on. More will be said later of the use of lumbar puncture in extra-dural hemorrhage. In doing a puncture one should proceed cautiously, allowing the fluid to escape very slowly and allow the patient to get quiet before making a reading of the pressure. Our readings are made with a vertical manometer graduated in centimeters of water, taking 5-10 cm. as normal. We do not feel that any reading is absolutely correct in that it gives the exact amount of intracranial pressure, but that one can arrive at fairly definite conclusions even though there is some degree of error. In our opinion spinal puncture cannot be used alone as a means of relieving intracranial pressure in every case, but must be combined with a decompression in the higher degrees of sustained pressure. It seems of undoubted value as a means of lowering the intracranial tension and I feel sure that due to its use we are doing fewer decompressions than formerly. We are in the habit of performing punctures as frequently as indicated and withdraw the fluid until the pressure is normal. Not all cases admitted with skull fractures receive punctures; those who are only mildly affected by their injuries and show no evidence of pressure by sign or symptom are not punctured; compound fractures are not punctured for fear of producing a meningitis; patients with marked bleeding from the ear, especially if cerebro-spinal fluid escapes at the same time, are not punctured, unless it is urgently required, for the same reason; obvious extradural hemorrhage

cases are never punctured. Viewed from the standpoint of spinal puncture one can arbitrarily group cases as follows:

1. Cases with definite evidence of skull fracture but a normal pressure, and no alarming symptoms. Here the fluid is pinkish or clear. One puncture suffices. If the pressure is normal, no fluid is withdrawn.

2. Cases with evidence of increased intracranial tension of severe or moderate degree and on whom puncture shows a high pressure (20-30 cm.). Following one or more punctures the signs of pressure diminish and succeeding punctures show a falling pressure. The fluid here is apt to be quite bloody. Punctures are done at intervals until pressure is normal or the signs no longer are alarming. It is in this class that the puncture finds its greatest therapeutic usefulness and obviates many decompressive operations.

3. Cases with marked evidence of intracranial tension and a high pressure on the initial puncture. Subsequent punctures show either no drop in pressure or a rising pressure. Here the puncture is of little value therapeutically as it accomplishes no lasting reduction in the tension but it is of much value as an indicator for some other means of relief of pressure. This is the class of case we treat by decompression.

4. Cases with evidence of high intracranial tension and high initial pressure in the spinal manometer, the subsequent taps reveal a low pressure but the severity of the symptoms do not abate. Here the symptoms seem to be due to the injury to the brain itself rather than to pressure on it. Decompressions seem of no avail, for when the dura is exposed no undue tension is found and the patients succumb.

5. Cases with marked evidence of pressure with a spinal fluid clear, of small amount, and under high pressure. Here we strongly suspect an extradural hemorrhage, are apt not to withdraw any fluid but watch the patient more closely and on finding localizing signs or signs of increasing pressure we decompress rather than take the risk of a spinal tap.

Our views on spinal punctures are summarized as follows:

1. It is not dangerous if properly used.
2. As a therapeutic measure it is of value in selected cases.
3. It may be used to advantage as an indicator of the intracranial pressure and on this, subsequent therapy may be directed.
4. With clear fluid under high pressure we strongly suspect an extradural hemorrhage.

Hollbrook uses lumbar puncture as a diagnostic means of determining early increased intracranial pressure and as a therapeutic measure. Fay states its use to be dangerous, Grant uses it as does Jackson. Sachs is opposed to its use, having seen two deaths attributable to it. Wilensky in 1919 says lumbar puncture is of no value clinically or therapeutically and in 1921 (Surg. Clin. N. A.) states that "lumbar puncture has not given complete satisfaction as a therapeutic measure." Nichols (Surg. Clin. N. A.) says "high pressure of spinal fluid as shown by manometer readings is of greater value than high blood pressure as an indication for operation." Ransohoff in 1910 predicted that lumbar punctures would be used more widely in fractures of the base.

Other statistics on lumbar puncture are as follows:

Number of patients receiving punctures on admission 178 with mortality 38%.

" " " not punctured on admission 45 with mortality 20%.

Bloody fluid obtained in 168 cases with mortality 73%.

Clear fluid obtained in 12 cases with mortality 8.3%.

Character of fluid not reported 2 cases.

Initial pressure of fluid	1-10 cm.	18	mortality 44.4%.
" " "	1-20 cm.	59	" 18.6%.
" " "	20-30 cm.	49	" 46%.
" " "	30-40 cm.	41	" 63.4%.
Not recorded		11	

Amount of fluid withdrawn at initial puncture:

1-10 cc.	14 cases	mortality 57.1%.
10-30 cc.	83 "	" 32%.
30-50 cc.	46 "	" 50%.
50-70 cc.	15 "	" 20%.
75-100 cc.	5 "	" 66.6%.
Not recorded	14 "	

Cases with increasing pressure	26	died 14.
" " decreasing "	29	" 7.

Apparently bloody fluid is associated with a higher grade of intracranial damage and a necessarily higher mortality. It is interesting to speculate as to why pressure as low as 1-10 cm. should be associated with such a high mortality as 44%. This could conceivably be due to a filling of the foramen magnum by an edematous brain stem or blood clot and a consequent lack of free communication between intracranial and intraspinal chambers; or to a leakage of cerebro-spinal fluid through fracture lines. Naturally the higher pressures are associated with higher mortality. There seems to be no gross relation between the amount of fluid obtained and the mortality!

The field of usefulness of spinal puncture may well be extended to the post-operative period also. It has been of much help in this respect and we feel that several of our cases have survived after operation due to its employment. The pressure as shown by the degree of bulging, lack of pulsation of the decompression is surely temporarily relieved following the puncture. If one assumes that some of the late effects of skull fracture, such as headache, photophobia, mental changes, etc., are due to a continued increased intracranial pressure, it would seem rational to continue the punctures during a patient's convalescence until the pressure is found to be normal. Only recently have we insisted on this and it will be instructive to follow these cases comparing them as far as possible to those on whom it was not done.

We have frequently been struck by the large amount of fluid one obtains on spinal puncture in some cases of skull fracture. In six of our cases 75-100 cc. were withdrawn on the initial puncture, in 15 cases 50-75 cc., in 46 cases 30-50 cc. Subsequent punctures continue to yield large amounts until within 24 hours one may withdraw as much as 600 cc. of fluid. Whether this is an increased production, a decreased absorption or not true cerebro-spinal fluid, we have as yet found no good method of determining.

EXTRADURAL HEMORRHAGE. Of our 223 we have only 9 cases of proven extradural hemorrhage, one of which was disclosed at autopsy in a patient who was not operated on. Six recovered and 3 died. Moody reports 100 cases of extradural hemorrhage in 908 cases of skull fracture, and states that 63 were not diagnosed clinically; that 37 cases were subjected to operation and of these 26 died. Phelps (Ann. Surg. XLIV) reports 34 cases found in a series of 200 fractures of the skull. One should always be on the alert for this type of case for an early diagnosis and operation give the patient his only chance. The history is most important if obtainable, a hemiplegia is strongly suggestive, and a clear fluid under high pressure should serve to put one on his guard at once. Many observers lay much stress on a single dilated pupil as an excellent sign of extradural hemorrhage on the side of the dilated pupil; we have found this to be quite true. Peairs emphasizes the point that extradural hemorrhage is accompanied many times by irritative phenomena rather than by paralysis - this has not been true in our series, where we have seen paralysis nearly every time.

OPERATION. Operations on the skull for fractures have been done for centuries - the procedure of trephining being among the oldest of operations. From this through various phases of evolution has come our present day subtemporal decompression. The first trephinings were done on account of the fracture and without regard for any secondary effect on the brain itself - if a fracture could be demonstrated a trephining was done. This mistaken idea of the pathology accounting for the signs or symptoms held until about 1800, since when most observers mention at the beginning of their writings that "it is not the operation which needs alteration but the results on the brain."

The rationale of this procedure seemed to be (1) that a great many of the cases developed abscesses beneath the skull at the site of fracture, and the early trephining was a prophylactic measure; (2) that extradural hemorrhages could be evacuated. More than one opening was made if found necessary, the openings being made at the site of fracture. It was considered very dangerous to open the dura, aand this was rarely done. The opening of dura was later advised if it bulged through the bone defect, thus for the first time a true decompression was offered, the procedures prior to this not really affecting the intradural contents at all. The dura was closed if possible, thus doing away with the decompressive effects. Warren[25] in 1890 adviseddraining the sub-dural space in fracture of the base through a trephine opening with a gauze wick. Finally, Cushing in 1908 devised the present subtemporal decompression.

Ever since operations have been described there has been much discussion and dispute as to their usefulness, the indications for them and the type of operation that should be done. Apparently the profession has grouped itself into 3 classes on these questions, one group advising operation on nearly all cases, another advising against operation, and a third believing in operation for selected cases. At different periods various ones of these groups hold (HAVE HELD) the field; at present the pendulum seems to be swinging towards conservatism, operating rarely but relying on lumbar punctures, various salt solutions, etc., for the relief of the increased intracranial pressure.

The subtemporal decompression as described by Cushing is used in this Clinic. Care is taken to extend the cranial defect well down to the base of the skull; we are in the habit of closing the temporal muscle but not the temporal fascia as we feel this allows more room for the bulging brain. Fine black silk is used throughout the closure. A rubber tissue drain is inserted down to the base, to act as a continuous avenue of escape for the cerebro-spinal fluid. It is removed in 48 hours. Since using the spinal puncture during the post-operative course of our cases we have only resorted to a bilateral decompression once. The depressed fractures are operated on immediately, simple elevation through a trephine hole adjacent to the depression being the method of choice. Many of these fractures cannot be elevated as simply as this

and it becomes necessary to rongeur away portions of the depressed fragments in order to effect a satisfactory elevation. If the dura is uninjured it is not opened, if lacerated it is opened wider, and inspection made of the cortex, and the dura closed. If there are signs of pressure a sub-temporal decompression is combined with the elevation. The compound fractures are handled by a meticulous debridement of the soft tissues, removal of loose bone fragments, debridement of the lacerated cortex and suture of the pia if possible. If there is much loss of dura so that its closure is impractical a transplant of fascia lata is done from the thigh. The wound is closed completely without drainage. All cases have healed per primam save one in which a superficial skin infection developed. The operation is combined with a subtemporal decompression if necessary. This type of case so often decompresses itself through the open wound that one rarely sees the manifestations of increased intracranial pressure associated with them. The extensive oesteoplastic flap operation such as one uses for exploratory craniotomies is to our minds not the operation of choice in these acute cases; for it is time consuming and many of these patients do not tolerate loss of blood or prolonged anaesthesia. Frequently we have encountered depressed fractures in old patients who have injuries to the chest and these are easily operated on under local anaesthesia. The cases which were subjected to operation were the most serious ones in the series and a few were done early in the series in cases which in view of an increased experience would probably now be treated in other ways. Fifty-six cases were operated on as follows:

1. Debridement of extensive scalp wounds in cases with linear fractures and no pressure symptoms, 3 cases with no mortality.
2. Elevation of depressed fractures, 11 cases with 9% mortality.
3. Elevation of depressed fractures combined with subtemporal decompression, 7 cases with 28.5% mortality.
4. Subtemporal decompressions in 35 cases with 45.7% mortality.

There were two infections in the series, both in compound fractures but both superficial and of no real consequence.

MORTALITY. The total mortality for the entire series which includes all cases of skull fracture irrespective of other associated injuries, length of time they survived, etc. Phelps reports a general mortality of 46.6% in 793 cases, Bealey 53% in 1000 cases, Harris and Nissen 51.3% in 330 cases, Brown 29.8% in 100 cases, Wilensky 31% in 75 cases. The analysis of the deaths shows that 14 died in 1 hour or less after admission, 24 died in 1-3 hours, 5 died in from 3-6 hours, 9 died in 6-12 hours, 5 died in 12 hours - 1 day, 11 died in 1-2 days, 7 from 2-4 days, 5 from 4-7 days. Four cases died of pneumonia, one from cardiac dilatation. Thus we find that of the 80 deaths 52 occurred in the first 12 hours. These 52 represent that group of cases referred to previously as those who rapidly die in spite of all therapeutic measures. This leaves 171 cases grouped under "those that rapidly recover" and "those whose outcome is problematical." In these two groups the mortality is 16.3%. In 22 of the 80 deaths there were other severe associated injuries, such as stove-in chests, compound fractures, etc.

COMPLICATIONS. Of the early complications following skull fracture only three are found in our series, i. e. one case of meningitis; one of persistent facial palsy, and one slight wound infection following operation for compound depressed fracture of vault. We have not seen sinus thrombosis, arterio-venous aneurysm, mastoiditis, brain abscess, aerocele, etc.

TREATMENT. As noted previously therpay was directed at first to the fracture itself but later and now is directed to the results of the injury to the brain, i. e. to repairing damage and the brain or relieving the increased intracranial pressure. This may be done by decompression, by spinal punctures, by concentrated salt solutions or by combinations of the three. Remarks as to thorapy have been interspersed with the foregoing paragraphs and they may be summarized as follows:

1. Depressed fractures or compound fractures, and cases suspected of extradural hemorrhage are operated on immediately.

2. All cases except the very mild ones and compound ones are subjected to lumbar punctures and are carefully observed for variations in pulse, respiration,

temperature, state of consciousness and neurological signs. If, in spite of the lumbar punctures the pressure is found to be increasing or to remain stationarily high a sub-temporal decompression is performed at an early date. Those cases which respond to lumbar puncture are treated by that means.

3. The punctures are done until the pressure is found to be normal and to remain so.

The most important phase of the treatment is the period of observation when one views the changing train of events, weighs the importance of each, directs the therapy accordingly.