HEAD INJURIES IN WAR.

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Scientific progress brings forth new methods of destruction: such are envisaged in the nature of injuries sustained from present-day instruments of warfare, featured in particular in the injuries resultant on aerial bombardment.

The incidence of head injuries in war shows a preponderance over other parts of the body; due, no doubt, to its exposed position. The head is relatively unprotected in trench warfare, more prone to blows from falling masonry, and ever exposed in the constant vigilance over enemy activities. Yet the head must not be allowed to overshadow the existence of coincident damage of other regions.

Appreciation of this high incidence of cranial injuries indicates the necessity of properly trained surgical teams. Obviously the number of available trained neurological surgeons is deficient, so that the major proportion of cases must fall to the hands of general surgeons, in the initial stages at least. Nevertheless any surgeon well acquainted with the demands of traumatic surgery should be capable of dealing with a large proportion of head wounds, as any differences of technique are related to peculiarities of structure rather than variations in method. The possible association of an intracranial injury with intact integument must not be overlooked. A differentiation is to be drawn between the terms "wound" and "injury": whereas the former regularly allows of visual orientation of the extent of the damage, the latter may exhibit objective phenomena only to those with specialised training. It will be apparent, therefore, that all head injuries should be seen by a neuro-surgeon as soon as possible for an accurate estimate and record to be made, thus enabling changes for the better or worse to be recognised in the later stages of treatment. One of the biggest differences in war is a maintenance in continuity of treatment for early intervention and subsequent care fall to the lot of a succession of surgeons. Delayed surgical intervention is not so disastrous with head cases as it is apt to be with abdominal wounds or injuries involving extensive muscle destruction; there is, however, an optimum period during which the risk of attendant infection is limited. Eight to ten hours after injury seems to be a moderately reasonable period, based on war experiences.

Classification of Injuries.

The classification of head injuries has led to lists enumerating and multiplying possible fields likely to be affected, whereas reference to the tissue strata implicated in any given case deals adequately with any desiderata. This means that discussion referred to scalp, skull, and intracranial contents as entities and when affected by combined injuries will exhaust all likely forms of injury.

The most horrible wounds are those produced by explosive missiles, wherein laceration is paramount. Naturally a large proportion of such injuries are so destructive as to negative the chance of even immediate survival. Of those who do not succumb from disruption of vital parts some will die from hæmorrhage or spreading œdema. Lacerated wounds are not prone to hæmorrhage unless large vascular sinuses are affected. Strangely enough sinus injuries are frequently localised, disturbances of cerebral function resulting from vascular obstruction rather than direct brain injury.

Scalp wounds.

Scalp wounds are to be found in all degrees of severity differing from superficial wounds of other parts only in virtue of its highly developed blood supply. The superabundant blood supply means greater viability, the scalp runs less risk of sloughing, and allows of conservative excisions. The wide distribution of the sub-aponeurotic space bears mention as a warning and reminder of the distribution of effusion therein, also the special needs when drainage of the space proves necessary.

Wounds involving the bone bear importance relative to apposing structures: in other words whether, or not, the scalp is affected to produce a compound fracture; or some intracranial vessel, causing hæmorrhage.

Fractures of the skull.

Simple fractures become serious by damaging vessels the courses of which are traversed. This is the common cause of rupture of the middle meningeal artery.

Compound fractures bear import in the resultant exposure to infection, especially if the dura mater is lacerated. An intact dura is an impenetrable bar to infection, but tearing of this structure opens the path to supervening meningitis or cerebral abscess. The dura mater is firmly attached to the base of the skull, hence it is nearly always torn in basal fractures. Here again is additional risk for the fracture is liable to be compound into the nose, one of the accessory sinuses, or the ear.

Depressed fractures when compound do not present any difficulty in the decision of whether or not to operate, for all compound fractures must be explored. With simple depressed fractures the problem is a different one: such cases are to be subjected to operation when overlying the motor area, or other regions which predispose the patient to the chance of a deferred epilepsy. This means that unless an area of subjacent cortex is of a "silent" physiological nature operation is best carried out.

Foreign bodies.

Much importance is attached to the question of possible retention of foreign bodies, but in reference to foreign bodies it must not be forgotten that projectiles represent the least harmful form, more noxious materials in the forms of portions of clothing, or pieces of masonry may become embedded. Various forms of *débris* act as foreign bodies, also portions of bone dislocated from the cranial vault. Metal pieces from missiles are in fact sterile, but other substances convey many types of organisms.

Cerebro-spinal fluid fistula.

Basal fractures may be responsible for the formation of Cerebro-Spinal Fistula should the basal sub-arachnoid spaces or the ventricular system become involved. Such fistulous communications produce an ever present risk of meningitis.

Complications and Sequelæ.

The immediate complications of any wound, whether of the head or any other region of the body are those of hæmorrhage, shock, œdema, and infection.

Hæmorrhage.

Hæmorrhage, as a rule, is not very liable to occur in lacerated and contused wounds unless large venous sinuses are implicated, but may take place from injuries produced by fragmented glass or other sharp substances. As already

mentioned, intracranial hæmorrhage may occur in the absence of external wounds: in the event of this failing to be recognised a fatal termination will ensue. The possibility of the occurrence of such a hæmorrhage may be suggested when, in a patient showing gradual deterioration, a radiograph demonstrates a fracture traversing the course of the middle meningeal vessels, though the extra-dural hæmatoma thus produced gives rise to a classical syndrome which should be readily recognised. Middle meningeal hæmorrhage usually comes on within twenty-four to forty-eight hours after receipt of injury, following a "lucid interval," during which the patient has recovered from the initial effects of the causative blow.

Subdural Hæmorrhage is another type of bleeding, due to laceration of veins running between the venous sinuses and the cortex. The hæmatoma produced within this space does not draw attention to its formation for days, weeks, or even months after injury. It is manifest by symptoms and signs of increasing intracranial tension, frequently without evidence on which to base localisation or even lateralisation. The patient is apt to present mental retardation, headache and a variable stupor, with the presence, perhaps, of papilloedema. In something like 30—40 per cent. of such cases the lesion is situated bilaterally. It is not essential for the blow that gives rise to this lesion to be of any intensity, in fact it may be of so limited a nature that it is not mentioned in the history. Very meagre clinical evidence may be all that can be found: depression of the abdominal reflexes, or perhaps an extensor plantar response. As lateralising evidence may be equivocal, or false to the extent of being found on the same side as the hæmatoma, and also in view of possible bilateral distribution, it is wise in suspected cases to explore both sides of the head.

Shock.

Shock is consequent on many factors amongst which one finds damage to large surface areas, and also injuries implicating muscular tissues. As these tissues do not play large parts in head wounds one may find in this a possible explanation for the fact that shock does not accept much significance in the general reaction to head injury as in injuries of other parts of the body. Still, should surgical shock be marked, measures must be undertaken to combat it before any surgical intervention is carried out.

Cerebral œdema.

Cerebral Œdema is a constant problem in dealing with head injuries or with the every-day conduct of neuro-surgical activities. Every head case develops some degree of œdema though the intensity is not always of clinical significance. In its more vicious forms the effusion sets up venous obstruction with adverse reaction in still further accentuation of the process, the cycle thus proceeds to fatal termination. Œdema is intensified in the presence of infection, both taking part in the formation of the cerebral fungus of compound wounds involving the brain.

Sepsis.

Infection is the chief concern of all wounds for contamination is ever present, and the only sound method of dealing with it is by removal of damaged tissues. The maximal time that any wound may await surgical intervention depends on several factors: the nature and site, the presence, or otherwise, of foreign bodies, the types of contaminating organisms, and the general resistance of the patient. Our fighting forces represent man-power in whom the general physical state is at its best, but the problem of general soundness of health is a very different matter when those civilians injured by aerial bombs are to be reviewed. The most important types of organisms against which combat is designed are the pyogenic cocci,

the tetanus bacillus, and the organisms of gas-gangrene. The complications of spreading infection met in the various tissue planes are those of: Cellulitis, Osteomyelitis, Meningitis and Cerebral Abscess.

Cellulitis of the scalp and osteomyelitis of the cranial vault exhibit signs corresponding with similar states in other regions of the body, therefore no detailed reference need be made. The general reactions to these forms of infection are apt to be profound.

FIG. 1.

FIG. 2.

Chronic Abscesses excised. Both were consequent on old war wounds. Removed twenty years after receipt of injury. Both patients made good recovery.

Meningitis.

Of all the complications Meningitis is that of most serious import. Manifest by headache, increased temperature, possibly vomiting, stiffness of the neck, and a positive Kernig's sign. It is the consequence of penetrating wounds, especially if traversing the nasal cavity, nasal sinuses, or the middle ear. When meningitis develops in a case of compound fracture it is usually of early onset, for the meninges soon become adherent thus sealing off the tissue spaces in the lepto-meninges. Cerebro-spinal fistula is certain to lead to meningitis if closure of the fistula is not effected, hence cases of Cerebro-spinal Rhinorrhœa must be subjected to early surgical intervention.

Cerebral abscess.

Should infection penetrate the brain but fail to induce meningitis, predominantly in the presence of retained foreign bodies, there emerges the probability of abscess formation. (See Figs. 1 & 2.) The passage of time does not eliminate this risk, for chronic abscesses continue to appear to date as results of injuries sustained in the last war. Abscess formation is indicated by extension of local signs, but is heralded mainly by signs of increasing intracranial pressure, in disturbances of mental alertness, headache, vomiting and papilloedema. Epileptiform convulsions of general, or local Jacksonian type, may occur. Involvement of the occipital cortex, or of the optic radiations will produce defects of the visual fields and left hemispherical lesions will be responsible for varied aphasic defects. Cerebral abscess does not produce a febrile reaction as usually found with abscesses in other sites; often, in fact, the temperature is sub-normal. Elevation of temperature in a case of brain abscess means that meningeal infection is commencing, or that the ventricular system is being encroached upon. When an abscess forms under a craniotomy opening meningitis from surface spread of infection is not so likely: apart from the sealing of the leptomeninges, the oedema of the tissues causes protrusion through the bony defect, acting more or less as a plug. Cerebral abscess carries with it a high mortality from spreading oedema, implication of the ventricular system with resultant diffuse meningitis, or by its tumour-like action in raising intracranial tension.

Epilepsy.

Epileptiform convulsions are frequent sequelæ and security from their institution cannot be assured even after a number of years. Their occurrence may take place early in the post-traumatic story, when they are incited by vascular reactions, meningitis, or intracranial hæmorrhage. Early onset is associated with better prognosis as regards chances of dispersal. Delayed epilepsy may arise from scarring, the formation of arachnoidal or porencephalic cysts, also from the development of an abscess. Frequently in exploring old cases of head injury because of epileptic manifestations one finds gross cortical destruction, the tissues being replaced by a peculiar network or cobweb-like formation, the interstices of which are filled with fluid probably due to seepage of cerebro-spinal fluid. These diffuse meshwork replacements often extend to communicate with the ventricular system.

The indiscriminate carrying out of decompressive operations would appear to be responsible, in certain cases, for the instigation of epilepsy, as for other unpleasant sequelæ such as persistent headache.

Arterio-venous fistula.

Arterio-venous fistula is a much less frequent sequel to head injury. In the event of fistula formation of this type, the patient is likely to complain of an audible bruit of pulsatile character synchronising with the heart-beat. The patient, however, may not be conscious of the bruit, although it is audible to the observer in

auscultation of the head. Fistulæ between the internal carotid and the cavernous sinus produce defects of ocular movement together with proptosis and disruption of trigeminal sensation. The proptosis is sometimes pulsatile, and may be associated with the distension of venous channels in and around the eye.

Radiographic Examination.

Radiographic investigation should be made as soon as possible in order that the presence of all radio-opaque foreign bodies shall be recognised, and to determine the nature and extent of possible bony injuries. Certain depressed fractures will be recognised and the bearing of fractures with regard to nasal sinuses envisaged only by X-rays. The relationship of fractures and vascular channels will be visualised. The presence of air within the skull will prove the compound nature of the injury, and indicate also that the nasal sinuses are involved.

Ventriculography and encephalography.

In the investigation of the delayed sequelæ radiology plays a most important part, but more complicated radiological enquiry will be demanded. Stereoscopic exposures can further the utilisation of the X-ray. More important findings, as in the localisation of cerebral abscess or investigation of traumatic epilepsy, demand replacement of the cerebro-spinal fluid by air, or other contrast media in order that the ventricular system may be visualised. By replacing the fluid in the subarachnoid spaces and the ventricles with air, distension, displacement, and distortion of these pathways assures accuracy of location and of the dimensions of pathological defects.

Arteriography.

Radio-opaque substances can be injected into the carotid artery for visualisation of the cerebral circulation. By registering defects of filling and distortion of the vessels it is possible to localise damage or pathological changes in the nature of vascular fistulæ and aneurisms. Some investigators have applied this method of arteriography to head injuries in general for diagnosing hæmatomata, and localising other lesions, but the writer considers this unjustifiable. Thorotrast, which is the medium in common use, is a radio-active substance which is one objection to its employment. It is now off the market owing to the war.

Additional advance has been made in radiological technique by the introduction of the Tomograph. By the use of this machine it is practicable to determine the relative positions of certain structures in terms of the three dimensions. Thus it allows the situations of foreign bodies to be localised with accuracy of measurement, also it enables individual anatomical structures to be portrayed whilst eliminating blurring from overcasting shadows, e.g., sella turcica, spinal articulations, odontoid process.

Pathological Examinations.

Blood.

Blood examinations assist from the earliest stages of injury, first of all with regard to transfusion. Proper grouping must be determined, and cell counts together with hæmoglobin estimates will aid clinical judgment in dealing with blood loss. Later there is the reaction to infection and determination of abscess formation, when blood counts can prove of aid in treatment and prognosis; here, however,

the blood count does not appear to bear the significance that can be placed on it in disease of other parts. Blood sedimentation rate may aid the estimation of general progress, particularly in the reaction to infection.

Cerebro-spinal fluid.

Examinations of the cerebro-spinal fluid are of much value. In carrying out lumbar punctures it should be a universal practice to employ the manometer, for not only are pressure readings of valuable import but there is added safety in the control of fluid escape.

Cerebro-spinal fluid pressure.

Pressure readings are of value in dealing with oedema, hæmorrhage, and all other causes of increase in intracranial pressure. Nevertheless one should realise that pressure alterations within the skull are not conducted evenly throughout the cerebro-spinal fluid pathways; this is seen chiefly when obturation takes place into the hiatus tentorii with cutting off of communication between the supra and infra tentorial segments of the cranial cavity, thereby inducing differences of pressure between that of the supratentorial region and that of the posterior fossa and the spinal canal.

Cerebro-spinal fluid examination.

Macroscopic examination of the cerebro-spinal fluid may show variations of colour in a yellowish discoloration from disintegration of blood, or bloody contamination in active bleeding. Chemical analysis helps in detection and quantitative estimations of protein, chlorides and sugar. The protein content will be increased by hæmorrhage, meningitis, or abscess formation. Sugar and chloride contents will be deficient in meningitis. Cell counts will vary with infective processes to aid diagnosis and prognosis. Examination for organisms may isolate specific infections. With regard to the colloidal gold curve, it is of interest that in wounds with retained foreign bodies, and occasionally without, the curve frequently shows a mild paretic deviation. What the significance of this change is, has not been determined, though it suggests that the old gunshot wound involved the subarachnoid space.

The indication for lumbar puncture must be given very careful consideration, yet it accepts considerable value in both investigation and treatment. When the question of threatening meningitis has to be deliberated in the presence of a compound injury there is a risk that taking off cerebro-spinal fluid may aspirate organisms into the cerebro-spinal fluid pathways, this problem occurs, too, when a cerebro-spinal fluid fistula is present. The investigation of the complications of closed wounds will indicate lumbar puncture, but in the presence of increased intracranial pressure steps should be taken to prevent undue escape of fluid.

Prognosis.

With the closed injuries and superficial injuries the prognosis does not differ greatly from that of civil injuries, but a high proportion of the wounds involve laceration of the dura. In cases reported by Jefferson of head wounds in the last war something like 50 per cent. of the wounds involved the dura, and in these cases the mortality reached the neighbourhood of 38 per cent.

Treatment.

All head cases should be carefully observed, the pulse rate, blood pressure, respiratory rate and rhythm, and state of consciousness being registered at regular frequent intervals. The surrounding atmosphere should be maintained quiet and subdued in order to avoid ill influences from external stimulation, and dimming of light is advisable. Watch must be kept for the onset of convulsive movement and the possibility of oncoming paralysis. Should a shocked state preclude active intervention this must be attended to, with the whole body maintained in a horizontal posture; but on improvement, the head will be better raised above the body level in order to assist venous return therefrom and to reduce oedema. With an unconscious patient the bladder must not be forgotten, retention must be watched and given the necessary attention.

Alterations in pulse rate and blood pressure give good indication of progress. A slowing pulse with rising pressure will put one on guard as to the possibility of increasing intracranial tension, until such time that vaso-motor failure approaches when rapidity and irregularity will supervene. So with the respiratory rhythm which slows and then adopts a periodic rhythm (Cheyne-Stokes) as failure encroaches. The state of consciousness is of even greater importance, for increasing stupor is of poor import even though the pulse appears satisfactory. The fluid loss and intake should be observed so that dehydration does not occur, but it is important to gauge carefully the intake, for this will aid the control of oedema. In the early stages the intake should be limited to about thirty ounces of fluid per day.

Constant care of the skin over pressure points is essential; this demands regular attention two-hourly.

Treatment of the Injury.

In order to maintain a head in a state of hygiene it is important that in all head injuries the hair is removed completely by shaving. Prior to receiving surgical attention, any hæmorrhage should be controlled and a mild antiseptic dressing applied pending transfer to a suitable centre.

Generally speaking the treatment of lacerated wounds is that of excision; this may well be applied to the scalp, but to that structure alone is complete excision available, and then with its peculiarly abundant blood supply there is not the same risk of sloughing and infection liable in other regions. Wherever possible the aim of surgery should be to convert an open wound into a closed one, provided that healing by first intention is likely, though delayed primary suture may be wise in some cases. As far as the skull is concerned all loose fragments of bone should be removed, though exception to this may sometimes be made in respect of the orbital margin. When the dura mater is included in the laceration small tags may have to be excised, but more than this is unwise for if gaping is allowed, or the overlying wound breaks down, fungation of the brain may result. In considering the brain it is obvious that excision would be impracticable, yet disintegrated tissue must be cleared away and foreign bodies extracted, if reasonably approachable. Disintegrated cortex can be removed best by suction, where an automatic sucker is available this will prove ideal, in other circumstances aspiration can be made by means of a syringe and catheter.

FIG. 3.

Some of the methods employed in closing wounds of the scalp.

Interrupted lines = proposed additional incisions.

Crossed lines = sutured wound.

The above is employed in association with extensive stripping of the scalp.

Prevention of infection is effected mainly by early operation involving careful débridement of the wound together with removal of all devitalised tissue, followed, whenever feasible, by closure.

Apart from direct surgical intervention what other means are in service for preventing or controlling sepsis? Careful attention to the wound in the first place, after cleanliness by shaving the scalp, by means of antiseptic dressings. Antiseptics have their own adherents, but are used to a great extent on fashionable indications. Most of the antiseptics gaining favour have greater deodorant qualities, though hypochlorites have a particular vogue (Eusol, Dakin's Solution, Azochloramide). The introduction of powdered sulphonamide preparations into the wound has been recommended. In efforts at controlling infection by general

medication hexamine may be administered by mouth in large doses, in an alkaline medium, as it is excreted into the cerebro-spinal fluid. More recently introduced drugs of the sulphonamide group have astounding actions in certain infections (streptococcus, pneumococcus, meningococcus) and promise much in dealing with meningeal infections. Of such preparations M. & B. 693 seems to be particularly effective. The nauseating property of these drugs is disadvantageous and may limit absorption, so that if rapid action is desired intravenous administration is advisable. (It must not be forgotten that sulphur-containing substances should not be given to patients taking these drugs).

FIG. 4.

Actual Chart of patient with meningitis from a cerebral abscess showing the effect of M. & B. 693. The patient made a good recovery.

As far as prophylaxis against tetanus and gas gangrene is concerned, the usual measures will be adopted in the administration of appropriate anti-sera.

Cerebral oedema forms in every case of head injury though the degree varies considerably. A large number of patients respond satisfactorily to simple measures: calomel (gr. ii-iii) on the second night, supplemented by salines the following morning, and saline each morning thereafter. (Sulphate containing salines should be avoided if sulphonamides are given.) Should this prove inadequate, dehydration by enemata of magnesium sulphate (mag. sulph. 3 oz. to 6 oz. water) or glycerine will frequently prove effective. Still more active dehydration may, at times, be imperative, then hypertonic solutions of sodium chloride (30 per cent.), glucose (50 per cent.), sucrose (50 per cent.), may be administered intravenously, in amounts of 50—100 c.cs. Concentrated human serum may be given intravenously in the treatment of shock and for purposes of dehydration in cerebral oedema, but this method is still somewhat experimental. Use of intravenous injections is an emergency method; it may be applied to patients in whom gradual deterioration suggests the possibilities of hæmorrhage or oedema yet clinical impressions fail to differentiate the two processes. In the event of the above measures proving futile operative intervention may become necessary when appropriate decompression should be carried out.

Control of hæmorrhage depends on the source: that from the scalp by ligature or suture, from the bone by applying Horsley's wax, from large venous channels by the application of fresh muscle grafts, and from the cortex by silver clips or fine ligatures. Diathermy is a very useful method of controlling hæmorrhage from small vessels but should be used sparingly in the presence of potential infection.

Should intracranial hæmorrhage be suspect exploration will be necessary. If the hæmorrhage is thought to arise from the middle meningeal vessel, then that structure should be exposed and the torn ends controlled, or the main trunk obliterated at the foramen spinosum. With subdural hæmorrhage it is important that both sides of the head should be explored, any hæmatoma being evacuated and drained. In the event of drainage proving unsatisfactory, enucleation of the sac will be indicated.

Epileptiform convulsions of early onset will necessitate operative intervention only if thought to be due to hæmorrhage. Prevention of epilepsy is most important, as far as possible, and this demands that any wound involving arachnoid over a sensitive zone must be met by adequate operative treatment followed by a prolonged course of sedatives. This means that simple fractures and depressed fractures must be carefully X-rayed in order to see whether splinters of bone are displaced inwards, or not. When wounds are being explored and found to be associated with an intact dura, the matter of opening the dura has to be debated: indications for opening are found in the presence of clinical signs of localised intracranial damage, and blue discoloration underlying the dura due to hæmorrhage. Delayed epilepsy demands surgical intervention in the presence of Jacksonian types of attack, and when investigation of general attacks produces evidence of local abnormality. (Perhaps attention should be drawn to the term "Jacksonian Epilepsy," for this has been used loosely for old war cases in describing any case of Traumatic Epilepsy, when, in fact, the term should denote only those forms of convulsion indicative of a local focus of origin.)

References to particular drugs have been made already but a few further comments are indicated in the matter of dealing with the patient's general reactions. For general sedative purposes chloral, bromides, chloretone, and pheno-barbitone will prove adequate, but these will by no means be enough to control undue restlessness. Opiates are contra-indicated, yet they are not to be withheld completely should the other substances prove ineffective and the patient's state such that the drug is likely to do less harm than uncontrolled noisiness and restlessness. Such circumstances must be met by giving small doses of morphine, omnopon, or codeine. In the presence of poor circulatory return or with respiratory depression injections of coramine subcutaneously, or intravenously, may help.

Retention of urine must be avoided. Before resorting to catheterisation injections of Choryl or similar substances should be given a trial.

The bowels are to be kept regular in action, so that undue straining does not occur, as, in view of the possible vascular damage, it is quite possible that hæmorrhage may be started.

Patients with fractures compound into the nose must be warned not to blow the nose.

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