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CRANIOCEREBRAL WAR WOUNDS

OBSERVATIONS ON DELAYED TREATMENT

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THIS REPORT is based upon the experiences which we have encountered with severe head injuries, which have been admitted directly to a General Hospital in the North African Theater of Operations, or which have reached here through the usual channels of evacuation. There have been 130 cases of fracture of the skull, of which 74 have been battle casualties, and the remainder due to accidentally incurred injury. Although the number of cases of open head wounds which have been selected as a basis for this report is admittedly small, the cases which are cited illustrate some of the problems of treating this type of injury. Several case histories will be given in detail to demonstrate the fact that treatment, however long delayed, may still be expected to yield satisfactory results. We shall confine this report to facts which we ourselves have observed, and from which we have drawn certain conclusions.

EARLY TREATMENT

The aim of treatment of head wounds, like that of wounds of other regions, is multiple: First, the prevention or eradication of infection in open wounds; second, the preservation of function, or the improvement of physiologic defects resulting from the injury; third, the restoration of anatomic structure as completely as possible. Early and thorough definitive treatment with prompt conversion of a bleeding, contaminated, potentially infected, open wound, into a dry, clean, closed wound, remains the ideal for which to strive, and the following cases illustrate this point.

Case 1.—Age 23, a prisoner of war, was shot by a rifle bullet on August 10, 1943. At a Station Hospital 45 minutes after injury, a diagnosis of compound fracture of the right parietal bone was made. Sulfanilamide powder and dry dressings were applied, and the patient was transferred here 10 hours later. After shaving the head, examination showed a wound of entry in the posterior parietal region, with the wound of exit about 6 cm. anteriorly. From the wound of exit, there oozed brain and bloody fluid. Roentgenograms showed a comminuted fracture with multiple indriven fragments (Fig. 1). There was left hemiparesis. Operation was performed 13 hours after injury. After excision of the wound of entry and exit, a partial horseshoe skin flap was reflected,

exposing comminuted depressed fracture of the upper part of the parietal bone. Bone edges were rongeuired and all loose bone was lifted out. There was a laceration of the dura, 3 cm. long by 1 cm. in width. Several fragments had penetrated to a depth of

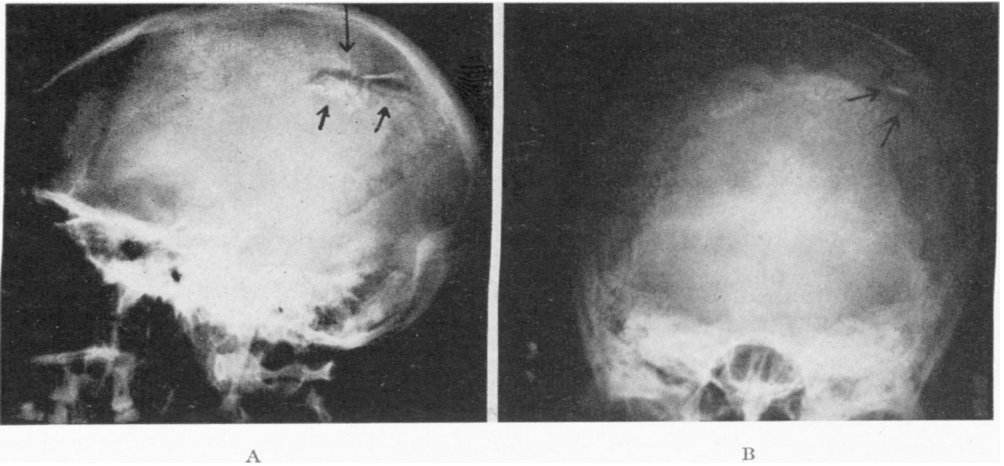


FIG. 1.—Case 1: A, Lateral, and B, anteroposterior views showing fracture of the right parietal bone, with indriven comminuted bone fragments.

2 cm. All fragments and macerated brain tissue were removed. The involved area lay chiefly in the arm center. All bleeding points were coagulated. The dura was closed with temporal fascia transplant. The rest of the wound was closed in layers with silk, without sulfonamide or drainage. The postoperative course was smooth. The wound healed *per primam*. The patient was allowed up on the 10th day. Neurologic examination showed residual left facial weakness, and weakness of the left hand with loss of fine movements. He was transferred to the Prison Section on August 28. On October 15, 1943, reexamination showed considerable improvement in skilled movements of the left hand.

Case 2.—Age 23, was not a case of gunshot wound, but the problem involved differed not at all from that found in tangential perforating wounds. On September 1, 1943, he was struck in the head by the edge of a log protruding from a rapidly moving truck. At a Station Hospital the head was shaved, and sulfanilamide crystals and dry

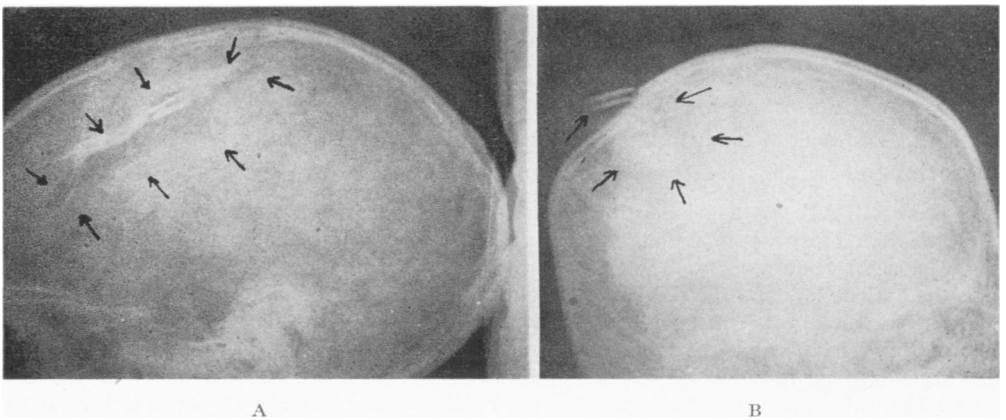


FIG. 2.—Case 2: A and B. Extensive fracture of right parietal and frontal bones, outlined by arrows, with indriven bone fragments, and elevation of one large fragment (B).

dressings were applied to the compounded right frontal wound. He was treated for shock, and transferred to this hospital 20 hours later. Examination on admission showed a ragged laceration about 10 cm. long over the right frontoparietal region, from which bone fragments and brain were protruding (Fig. 2). There was left hemiplegia and inability to rotate eyes to the left. Twenty-one hours after injury, operation was performed by Major S. P. Harbison. After excision of the skin edges, the wound was extended inferiorly and superiorly, to obtain adequate exposure. Multiple bone fragments were removed; several fragments projected deep into the brain. Macerated brain tissue was sucked out to a depth of 4 cm. Hemorrhage was controlled with coagulation and muscle stamps. The dura was closed with temporal fascia transplant. The rest of the wound was sutured in layers with silk, without sulfonamide or drainage.

The first few days after operation were stormy, with periodic episodes of increased blood pressure and restlessness. Hypertonic fluids were used to good effect, with daily normal fluid intake being restricted to 1500-2000 cc. Beginning about six days after operation, the patient's course improved steadily, and he became oriented and rational. The wound healed *per primam*. Left hemiplegia persisted, but the left leg recovered sufficiently to allow the patient to start walking on the 26th day. The defect was depressed, soft, and pulsating freely. He was sent to the Zone of Interior on October 27, 1943.

Case 3.—A French soldier, age 31, was shot by a rifle on May 16, 1943, and reached this hospital one hour after injury. There was a perforating wound of entry in the left lower frontal region; the bullet traversed tangentially, coming out through the tragus and pinna of the left ear. Bleeding was profuse from both wounds. This right-handed patient was not unconscious and had no speech disturbance, astereognosis or apraxia. Except for hyperactive knee-jerks, neurologic examination was negative. Blood transfusion was prepared, and operation was begun three hours after injury. The wound edges were excised and the entry and exit wounds were connected by incision through skin and temporal muscle down to bone. Depressed, comminuted fragments of the frontal and temporal bones were lifted out. A dural tear was enlarged and the underlying macerated brain was sucked out. Bleeding was controlled by silver clips and muscle stamps. The dura was closed, and the remainder of the wound was sutured in layers with silk without drainage and without sulfonamide. The postoperative course was satisfactory. Head and ear wounds healed *per primam*. On June 2, 1943, 16 days after operation, neurologic examination was negative, the patient was up and about, and he was discharged to the French authorities.

Case 4.—Age 30, was injured by shell fragments on February 7, 1943. He was admitted to a British General Hospital three hours later, with a severe compound fracture of the left frontal bone, and bleeding from the left nostril. Immediate operation was performed, through a frontal skin flap. Fragments of frontal bone were removed and the frontal sinus was curetted out. Through a laceration of the dura, the damaged tip of the frontal lobe, "the size of a tangerine," was sucked out. All bleeding was controlled by coagulation. The dura was closed with a fascial transplant, and a muscle tampon was placed over a defect in the cribriform plate. Sulfanilamide powder was applied extradurally and the wound was closed without drainage. The patient was allowed up on the 12th day after operation, and evacuated to the rear on the 19th day. He arrived at this hospital on March 2, 1943. The left frontal wound was well-healed, and pulsed freely. There was complete amaurosis of the left eye with primary optic atrophy. Neurologic examination was otherwise negative. The patient was perfectly well until March 12, when he developed cerebrospinal rhinorrhea. He was kept in a sitting or upright position, fluids were forced, and sulfadiazine was given prophylactically. Rhinorrhea ceased on March 18. There were no signs of infection or aerocele, and he was discharged to the Zone of Interior on March 30, 1943.

In cases of acute head injury seen early by us, tight closure without drain-

age and without local sulfonamide has been the rule. Sulfadiazine is given orally or parenterally as prophylaxis only in those cases in which infection is suspected, particularly in wounds which communicate with the nasal or accessory sinuses, *e.g.*, Case 4.

Case 4 illustrates the effectiveness of early and thorough treatment of a severe head wound complicated by penetration of the frontal sinus and cribriform plate, and loss of dura. The treatment of the subsequent cerebrospinal leak followed well-established principles. Had the leak persisted, or had an increasing arocele developed, secondary craniotomy would have been necessary.

DELAYED DÉBRIDEMENT

Patients with head wounds who may be expected to survive, tolerate transportation quite well, and delayed but thorough treatment is to be preferred to early incomplete measures. Early in the North African campaign we were faced with the necessity of doing long-delayed débridements. Since then we have found that this procedure may be expected to yield satisfactory results, although undoubtedly not as good as would ensue from more prompt definitive care. Conversely, we have been impressed with the complications that may arise if reliance is placed upon inadequate early treatment.

The establishment of any arbitrary time limit within which definitive therapy may be carried out is not necessary. Early débridement and closure should always remain our goal. However, it should be noted that, with the exception of the few cases with dangerous compression due to hemorrhage or a very large depressed fracture, hasty, urgent, inadequate surgery is not usually demanded in head wounds. Unless there is at hand a surgeon familiar with the technical aspects of the treatment of these injuries, and unless he has available sufficient equipment with which to control bleeding, plus satisfactory assistance and the facilities to care for these patients for several days after operation, it is questionable whether any radical procedure should be attempted. The desirability of having such equipment as suction, silver clips, and/or electro-surgical unit for hemostasis, cannot be over-emphasized.

In our series, there have been eight cases in which débridement with closure was done between 36 hours and four days after injury, with primary healing. Additional cases, some of whose records follow, were operated upon and closed after a much longer interval (one as late as 32 days) with surprisingly good results.

Case 5.—Age 29, was injured by a mortar shell fragment on March 24, 1943, sustaining a compound fracture of the left parieto-occipital region. On the day of injury, the wound was “débrided” at a Surgical Hospital, with removal of bone chips and copper fragment. Sulfanilamide was placed in the wound, and the galea and skin were closed in layers. The patient reached here on April 8, 1943. The left parieto-occipital wound was incompletely healed; there was one small area which communicated directly with underlying necrotic brain. There was early papilledema. The left pupil was larger than the right. Repeated visual field examinations by Capt. E. B. Alvis, revealed right homonymous hemianopsia with macular sparing on the right.

Hyperreflexia with ankle clonus was present, without pathologic toe signs. There was minimal nominal aphasia; no alexia or agraphia. Roentgenograms showed multiple indriven fragments in the occipital region (Fig. 3). On April 14, (21 days after injury) operation was performed under local anesthesia. The entire incompletely healed scalp wound was excised. There was a long narrow bone defect through which necrotic brain extruded; this was enlarged to expose the edges of lacerated dura around the periphery. Necrotic brain, old blood clots, numerous bits of hair, and multiple small fragments of bone were gently sucked out until the edges of the lesion were reached. Several pieces of bone, with accompanying hair, were found to have perforated through the wall of the ventricle, and on removing them there was a gush of ventricular fluid. All damaged brain was removed. The defect involved most of the occipital

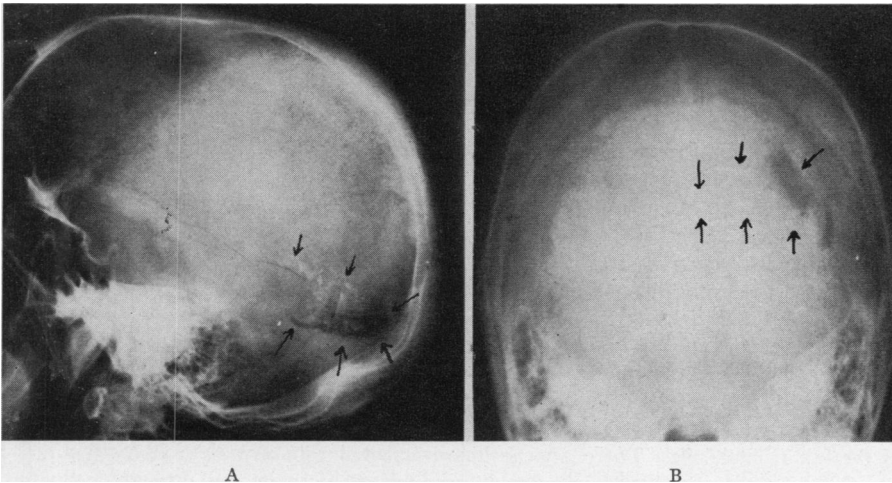


FIG. 3.—Case 5: A and B. Wound of left parieto-occipital region, with extensive destruction of occipital lobe by bone fragments (arrows) driven in to the midline. In this case, the ventricle was penetrated by loose bone and particles of hair. Delayed débridement, with tight closure, was carried out.

lobe, extending medially to the midline; inferiorly to the second temporal convolution; posteriorly only a small bit of brain tissue overlying the tentorium was uninvolved; anteriorly the defect extended to the posterior horn of the left lateral ventricle. Bleeding was controlled by hot saline packs. One large vessel near the surface was clamped and ligated with silk. After the field was dry, the defect was filled with saline. The thickened galea was split, giving an extra layer for suture, and the wound was closed without drainage.

The patient was given a course of sulfadiazine by mouth, and the postoperative course was perfectly smooth. The wound healed by first intention, and the papilledema subsided promptly. Examination after operation showed complete splitting of macular vision, but there was decrease in the blind spot on the left with some improvement in the peripheral field. All other neurologic abnormalities regressed and he was able to be up and around on the 10th day. He was discharged to the Zone of Interior on May 15, 1943.

Case 6.—Age 23, sustained a penetrating shrapnel wound of the right fronto-temporal region on March 24, 1943. "Débridement" was performed within three hours at a Treatment Station, where it was noted that brain tissue protruded from the wound. Sulfanilamide was applied and the wound was closed. At an Evacuation Hospital the next day, roentgenograms showed a metallic fragment in the *left* parietal region; this was wisely left alone. The patient reached here on March 31, 1943. The sutured wound of entry was infected and swollen. Neurologic examination was negative except

for a dilated right pupil, with ptosis and partial ophthalmoplegia. Roentgenograms showed a depressed bone fragment at the point of entry on the right, and a metallic foreign body at a depth of 5.5 cm. in the left parietal region. Because of the swollen wound and retained bone fragments, operation was performed on April 1, eight days after injury. The original wound was completely excised. Through a defect in the anterior part of the temporal muscle, a tract led down to the opening in the bone. Two pieces of bone were lifted out; beneath them lay false dura. Anteriorly unhealthy granulations and necrotic tissue were found and removed. *Sulfanilamide crystals were sprinkled in the wound outside the false dura, and closure was done in layers, using fine catgut in this case for the temporal muscle and subcutaneous tissue.

The wound healed *per primam*. The third nerve palsy cleared rapidly. On April 4, the pupils were equal and reacted well; extraocular movements were well-performed, but some weakness of the levator palpebrae remained. The patient was discharged to the Zone of Interior on April 17, 1943.

Case 7.—Age 20, was struck by aerial bomb fragments on July 6, 1943. At an Evacuation Hospital, immediate débridement was done, with removal of bone fragments and necrotic brain, with primary closure. The wound of entry in the right frontotemporal region was small. Proptosis of the right eye developed. The patient arrived here on July 17, 1943. He was manic, irritable, and uncooperative; there was no power of reasoning or judgment. The slightest stimulus sent the man into a frenzy of screams and obscenity. His behavior was thoroughly uninhibited. There was a healed 5-cm. wound in the lower right frontal region. The bulbar conjunctiva was edematous and protruded between the lids. After retraction of the conjunctiva, the cornea was found to be cloudy, and vision in the right eye was absent. The left optic disk was hazy. Neurologic examination was otherwise negative. Roentgenograms (Fig. 4, A and B) showed a bony defect in the right frontotemporal region; the roof of the right orbit was crushed, and numerous bone fragments could be seen lying in the frontal lobe as well as within the orbit. There was a metallic foreign body near the surface of the left frontal lobe. There was no improvement during a week's observation.

On July 26, 1943, 20 days after injury, bilateral craniotomy through a Souttar incision was carried out (Fig. 4 C). The original wound of entry was used as one of the openings for the right bone flap. Extradural dissection was begun anteriorly. When the orbit was reached, a large dural defect was visualized, and necrotic brain welled up into the field. This was sucked out and the dissection was carried down to the optic chiasm. Many fragments of bone were found within the necrotic tip of the frontal lobe, and the roof of the orbit was shattered back to the optic foramen. These fragments were removed, relieving pressure on the orbital capsule. The optic nerve between the foramen and chiasm was intact. After the field was dry and clean, a transplant of temporal fascia was sutured in place to close the large dural defect. On the left side, exposure of the frontal lobe revealed adhesions between cortex and dura; on the surface of the cortex there was an area of yellow discoloration, in the center of which was a thin layer of necrotic brain covering the underlying foreign body. The fragment, together with the surrounding damaged brain, was excised *en masse*. The dura was sutured, and after replacing the bone flaps the wound was closed in layers with silk. Skin sutures were removed on the second day. The wound healed *per primam*, and the postoperative course was most gratifying. Proptosis disappeared. The patient became clear, rational, and cooperative; judgment, insight, and calculation were restored. He had no recollection of his earlier behavior. On August 17, the atrophic right eye was removed by Capt. Alvis. On September 6, 1943, he was returned to the Zone of Interior, with no demonstrable neurologic abnormalities. A letter written September 23, reported him to be in excellent state.

Case 8.—Age 21, was struck a glancing blow by a shell fragment on July 12, 1943. First treatment consisted of dressing, without débridement; he received sulfadiazine by

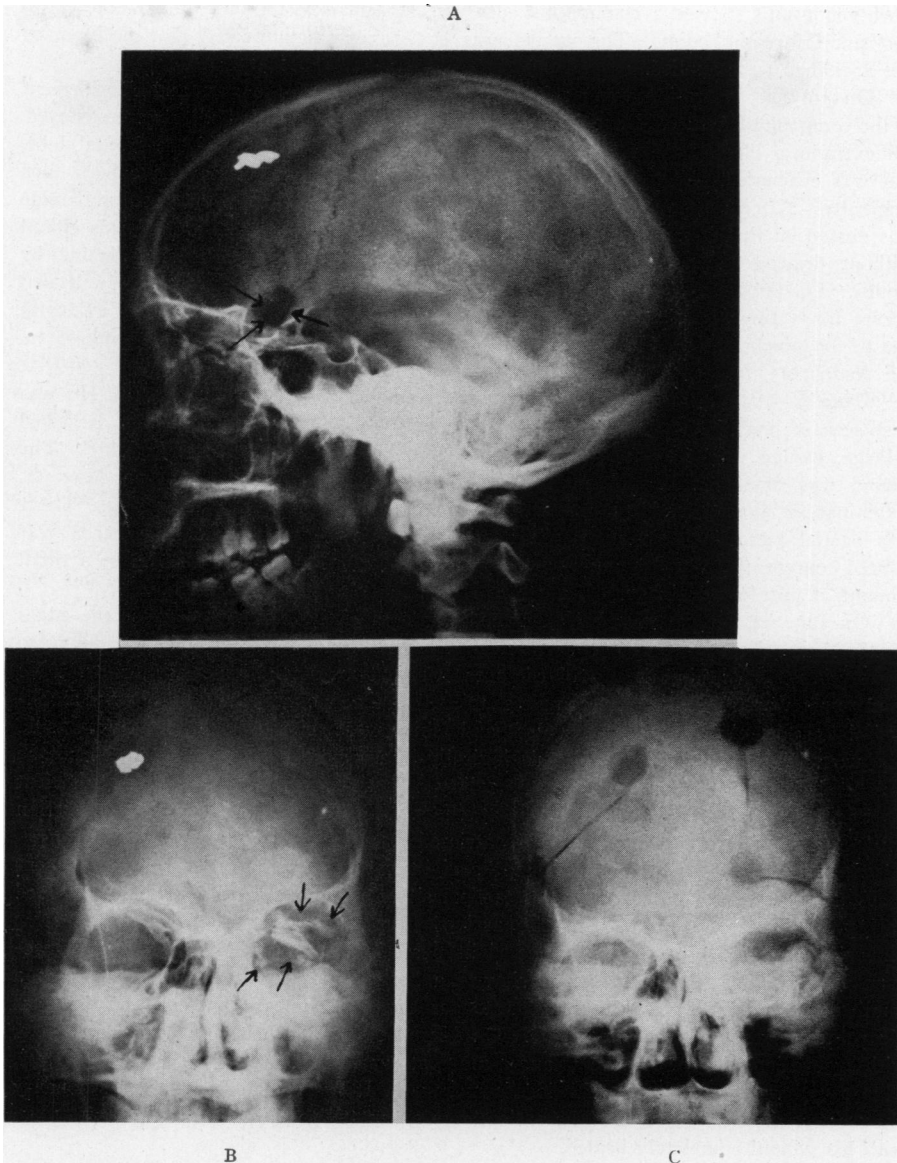


FIG. 4.—Case 7: A, lateral view, before operation, showing bone defect (wound of entry) in the inferior part of the right frontal bone. In B, postero-anterior view, roof of the right orbit is smashed and the orbit is filled with numerous bone fragments (arrow) many of which have penetrated the frontal lobe. The retained metallic foreign body is visualized in the left frontal lobe. C, postero-anterior view, after operation; the foreign body has been removed from the left frontal lobe, and the bone fragments have been removed from the right frontal lobe and orbit. (Compare with B). Outlines of the frontal bone flaps are seen.

mouth. The patient arrived here on July 26, with his original dressing in place. There was a dirty, sloughing wound of the left frontal region, about 4 cm. in diameter. Roentgenograms showed a comminuted, depressed fracture of the left frontal bone, with two small foreign bodies. The wound was so grossly contaminated that preliminary wet dressings were applied.

On July 28, operation was performed, with excision of the skin and débridement of the compound fracture. Bone fragments and the metallic foreign bodies were removed. An extradural clot, 1 cm. thick, was found over the anterior part of the frontal lobe, and was evacuated. The dura appeared to be intact, although it may have been torn originally. After repeated flushing with ether and saline, a thin layer of sulfanilamide was dusted on the dura. By means of a short releasing incision, the wound was closed without drainage. Postoperatively the patient received a course of sulfadiazine by mouth. On August 5, seven days after operation, the wound was completely healed except for a tiny area in the center which was not covered with epithelium, evidently due to too much tension. This area, about 2 Mm. long, was fully healed on August 10. On August 25, 1943, the patient was discharged to a Convalescent Hospital.

Case 9.—Age 30, a prisoner of war, was wounded about April 23, 1943. He was first seen at one of our Evacuation Hospitals on May 1, at which time was described a large, gaping wound of the left parietal region "obviously a week or so old." The wound was dusted with sulfanilamide and left open. He arrived here on May 11. Examination showed a 2-inch wound with infected cerebral hernia extruding. There was partial motor aphasia and right hemiparesis; no astereognosis. The herna was treated conservatively and became partially epithelized, but there continued to be a small amount of purulent drainage.

On June 14, the partially healed wound was completely excised to expose the edges of the bone defect. Through the defect, necrotic brain was sucked out down to intact tissue. Within the involved area were two small bone fragments. No frank pus was seen. After complete toilet of the wound, the scalp was mobilized by undermining and the galea and skin were closed in layers with silk. The wound healed *per primam*. Neurologically, there was slow improvement in speech and hemiparesis. The patient's mental agility was superb, and he was able to defeat his comrades and attendants regularly at chess. He remained in the Prison section until October 8, 1943, when he was repatriated as a walking case.

Case 10.—Age 26, was struck in the right parietal region by a bomb fragment on February 18, 1943. Because of the tactical situation, surgery could not be performed during his course of evacuation. He arrived here on March 2, 1943. Examination showed a tiny puncture wound in the right posterior parietal region, with sanguineo-purulent drainage. Roentgenograms showed a superficial metallic foreign body with a small depressed fracture. There was tenderness over an area 5 cm. in diameter. Neurologic examination was negative. On March 6, 1943, débridement was performed, with evacuation of bone fragments and a moderate amount of pus. The dura was intact. The wound was packed open with iodoform gauze. It granulated slowly, and secondary closure was done on April 8. The patient was evacuated to the rear on April 21, 1943, with his wound completely healed.

Case 11.—Age 23, received a shrapnel wound of the right parietal region on July 11, 1943. At a Provisional Surgical Hospital, the compound fracture was "débrided," and brain tissue removed. The wound was packed open with sulfanilamide powder and vaselined gauze. On July 20, he reached a Station Hospital where a firm pack was removed, revealing a cerebral fungus. There was early choked disk and left hemiparesis. The patient was operated upon by a neurosurgeon nine days after injury. After débridement, with removal of many bone fragments, sulfanilamide powder was sprinkled into the wound, and it was closed around a Dakin's tube. The wound healed promptly, and the patient was transferred to this hospital on August 9, 1943. The

CRANIOCEREBRAL WAR WOUNDS

wound was well-healed. Eye grounds were normal. Left hemiparesis was slight. The patient continued to show steady improvement and he was sent to the Zone of Interior on August 17, 1943.

Case 12.—Age 23, received penetrating wounds of the head and abdomen from a land mine explosion on August 7, 1943. He was treated for shock, and celiotomy was performed four hours later at an Evacuation Hospital; there was no visceral perforation. His condition was too precarious for further surgery, and nothing was done to the left occipitoparietal wound except dressing with sulfanilamide and vaselined gauze. He was evacuated on August 12, and arrived here on August 29. *En route*, records of three medical installations noted exudation of pus and bone fragments from the wound. On admission here, there was blurring of the left optic disk with fullness of the

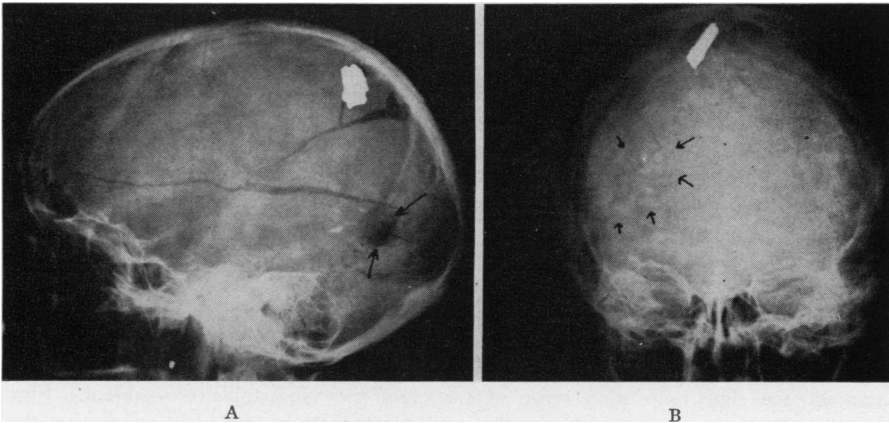


FIG. 5.—Case 12: A and B. Very extensive fracture with small wound of entry (arrow) in the left parieto-occipital region. Lines of fracture extend through the parietal to the anterior part of the frontal bone. There are two large fragments which have been elevated, and numerous smaller fragments driven deep into the occipital lobe. There is a large metallic foreign body just to the left of the midline. At operation, two pockets of pus were encountered, one around the metallic foreign body, and the other surrounding the indriven bone fragments. Treated by radical débridement and closure.

retinal vessels. There was right homonymous hemianopsia with some macular sparing. The patient was oriented, but had nominal aphasia, alexia, and agraphia. There was weakness of the extremities, with unsustained bilateral ankle and patellar clonus; and pathologic toe signs on the right. Position sense on the right was partially lost. In the left occipitoparietal region, there was a puffy, tender area, about 6 cm. in diameter, with a 2 x 3 cm. wound above the pinna of the ear. Foul, thick pus exuded through the wound. Roentgenograms showed extensive fractures of the left parietal and frontal bones; there were many bone chips driven deep into the brain beneath the defect, and a large metallic fragment in the region of the superior longitudinal sinus, just to the left of the midline (Fig. 5). While the patient was being built up generally, drainage from the wound continued. Repeated visual field examinations by Capt. Alvis, confirmed the macular sparing.

Transfusion was given preliminary to operation, which was performed on September 9, 32 days after injury. A left parieto-occipital skin-galeal flap was reflected, which included the draining entry wound near its center. Necrotic brain oozed from between multiple fractured fragments which were denuded of periosteum. The fragments were lifted out and bone edges rongeuired away until the peripheral edges of dura were exposed. Through the large dural defect, pus began to exude from the inferior as well as the superior portions of the parieto-occipital region. Surface vessels, of as yet intact areas of cortex, were coagulated and the entire lesion was uncapped. There was one large abscess in the lower part of the field. This was evacuated, and

from its depths multiple small bone fragments were removed. Another abscess lay superiorly. This was sucked out, and within its medial wall was found the metallic foreign body which was seen roentgenographically. The piece of metal touched the wall of the longitudinal sinus but had not penetrated it, and was removed. It was clear that the falx formed the medial boundary of the superior abscess. Between the two abscesses lay a mass of necrotic brain. This was removed by suction and found to extend to, but not through, the ventricle wall. Both abscess cavities and the intervening bridge of necrotic tissue were converted into a single saucer-shaped defect, 4 cm. wide, 7 cm. long, and 5 cm. deep, extending from above downward along the posterior part of the parietal lobe, with the falx medially and the petrous ridge inferiorly. Marsupialization would have been the procedure of choice on the basis of good surgical principles. However, since the approach had been made through a horseshoe-shaped incision, it was feared that a longitudinal incision through the center of the flap would jeopardize the blood supply of the anterior half. Accordingly, after toilet of the defect, the wound of entry was excised and closed, and the skin-galeal flap was sutured in layers, without local sulfonamide or drainage. It was thought that if abscess recurred, the entry wound could be reopened for drainage if necessary.

Sulfadiazine therapy was begun immediately after operation. The wound healed *per primam*. The postoperative course was uneventful and the patient was allowed up on the 10th day. The defect remained depressed and pulsated freely. Neurologically, there was slow but definite improvement. Blurring of optic disks disappeared. Visual fields showed no change. Visual acuity was 20/20 in both eyes. Nominal aphasia improved considerably. Alexia was marked but improved so that monosyllabic words could be read. There was definite acalculia. Skilled movements of the right hand were slightly less well-performed than on the left. Position sense of the arms was intact. The right lower extremity was slightly spastic with hyperactive knee jerk; no clonus or pathologic toe signs. Position sense of the right toes and ankle was absent. Fine discriminatory sense was absent over the entire right side of the body except for the head and neck; other sensation was intact. The heel-knee test was uncertain bilaterally. With the hands outstretched and eyes closed, the right arm drifted upward. The patient was able to walk well with eyes open; but with eyes closed, lack of position sense of right foot became apparent. He was discharged to the Zone of Interior on October 27, 1943.

Cases 5 (21 days), 6 (8 days), 7 (20 days), 8 (16 days), 9 (51 days), and 12 (32 days) are illustrative of what may be expected in some cases of head wounds even if they are allowed to go for a very long period of time before receiving adequate débridement, and are then subjected to radical débridement, with tight closure, without drainage. This is not to be misinterpreted as meaning that tight closure is the procedure of choice in all cases. The surgeon must apply his own judgment to each individual case. For example, in instances where there is gross infection and it is obvious that complete cleaning out of the wound cannot be accomplished, drainage is essential. The wound in Case 11 was closed around a Dakin's tube which was left for two days. In Case 10 the wound was packed open with iodoform gauze because of the extensive area of subcutaneous swelling and tenderness and the fear of spreading osteomyelitis. In this connection, it may be noted that, in our experience, spread of osteomyelitis in the skull is far less likely in battle wounds than in civilian practice where hematogenous infection occurs.

The good result in Case 5 is particularly significant in view of the long delay and the fact that the ventricle was penetrated by bone fragments and

hair. The procedure followed in Case 12 may be open to justifiable criticism. This defect presented every indication for drainage, containing as it did two pockets of pus and having discharged pus for over four weeks. The reasons for not draining have been given in the description, and through fortuitous circumstance, the case now stands as an extreme illustration of what may be accomplished with late débridement and tight closure in at least this instance.

As a rule, we have not used sulfonamide locally, even in late cases, but have given large doses parenterally and by mouth, checking blood concentrations daily. Usually, immediately after operation, the patient receives either six grams of sulfanilamide subcutaneously, or three grams of sodium sulfadiazine intravenously. The latter is repeated after four to six hours. In practically every case it has been possible to give one gram of sulfadiazine by mouth every four hours, beginning about 12 hours after operation. The six grams per day oral medication is continued for four days in the ordinary case (blood and urine being checked), after which time the dosage is decreased by two grams daily.

Emphasis should be placed upon adequate débridement. Débridement as a descriptive term is unhappily used somewhat loosely. The foregoing histories are a few that serve to illustrate the fact that incomplete débridement is usually ineffective. It is urged that, even if time is lacking, the surgeon should qualify the term débridement so that more rapid evaluation of the requirements of individual cases may be made as soon as they reach an installation where definitive surgery is available.

If débridement cannot be done adequately in early cases (and it should again be pointed out that physical facilities and equipment cannot be over-estimated) it is better simply to shave the head and apply a snug, dry sterile dressing to the wound with sulfanilamide crystals superficially, and transport the patient to the rear, fortified with sulfonamide medication by mouth.

FASCIAL TRANSPLANTS

In our acute cases we have made every effort to restore anatomic relations whenever possible, and have used fascial or periosteal transplants when necessary to close dural defects. In later cases, unless one can be absolutely certain of the completeness of the débridement, it would appear to be unwise, and we have not closed the dura in such instances. The following cases, done elsewhere, are cited: The first with successful outcome; and the other two associated with complications.

Case 13.—Age 24, was struck in the left parietal region by a fragment of enemy anti-aircraft shell on April 19, 1943. The wound was excised and metallic foreign body was removed at a Clearing Station two and one-half hours after injury. He was evacuated to a General Hospital (British) where a secondary débridement was done on April 21. A bone fragment and necrotic brain tissue were removed. A periosteal graft was used to close the dural defect and the wound was closed tightly in layers.

Recovery was uneventful. The patient arrived here on May 9, at which time neurologic examination was entirely negative, and the head wound was solidly healed. On May 15, 1943, he was sent to the Zone of Interior with the expectation of subsequent return to full combat duty.

Case 14.—Age 21, was struck in the right frontal region by enemy rifle fire on August 7, 1943. He was able to walk to an Aid Station, where his wound was dressed and he was given sulfanilamide. Due to local conditions, he did not reach a Field Hospital until August 9. Roentgenograms there revealed a right parietal fracture, with numerous foreign bodies at the site of fracture. He had a left hemiplegia, and brain tissue extruding from the wound. On August 10, three days after injury, operation was performed. After removal of macerated brain and bone fragments, the dura was

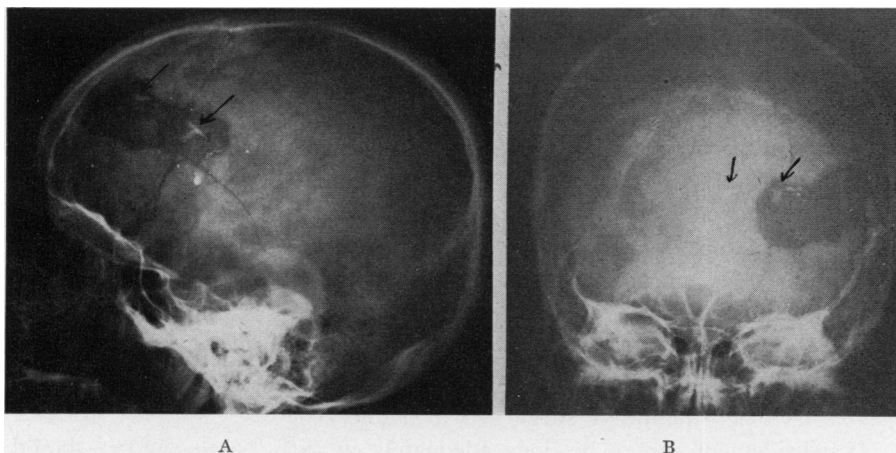


FIG. 6.—Case 14: A and B. Showing large bone defect in right frontal bone, with some deep, retained bone fragments. This patient had had a fascial dural graft three days after injury, followed by infection and development of cerebral hernia.

closed with temporal fascial graft; local sulfanilamide; closure in layers. He was removed to a General Hospital on August 16, where it was noted that the right frontoparietal wound was broken down and exuding pus. The patient was sent to a Station Hospital on August 22, and subsequently arrived here on August 29. Examination showed a dirty semilunar wound, right frontal, with granulations and pus extruding. There was left facial weakness. The right optic disk was blurred and there was cervical rigidity. Roentgenograms here showed multiple linear fractures with a 6 x 2.5 cm. defect of the right frontal bone. Bone fragments were visualized in the brain as well as some metallic fragments at the posterior aspect of the defect, just within the inner table (Fig. 6). On August 30, operation was performed. The semilunar incision, through which projected three small cerebral fungi was reopened, exposing bulging infected brain and a large piece of necrotic fascia, partially attached by multiple silk sutures. The sloughing fascia was removed together with the sutures. There were three separate points draining pus. The bulging mass of infected brain was excised with the electrocautery, exposing in the course of excision several small pockets of pus which were evacuated. Several pieces of bone were found and removed. The underlying brain was necrotic and obviously the seat of spreading infection; this was sucked out. The wound was packed open with a Mickulicz drain. He was placed on a course of sulfadiazine immediately.

Following operation, meningeal signs promptly disappeared, and the optic disks, previously blurred, became clear. The exposed brain began to granulate over, and the

skin flap became firmly attached except at the lateral margins. On one occasion it was felt that there was a communication with the ventricle which sealed over. A small point of drainage persisted. This was injected with diodrast and was found to extend down for about 2 cm., and there was evidence of osteomyelitis at the lateral bone edge. On October 15, the skin flap was reflected back, and osteomyelitic bone was rongeured away. The wound was again packed open. Sulfadiazine was given by mouth. The exposed brain became epithelized promptly and the defect was covered with solid epithelium except for a tiny area in the center which was almost healed when the patient was evacuated on November 20.

Case 15.—Age 31, was struck by mine fragments on August 3, 1943. At a Clearing Station that evening, a diagnosis of compound fracture of the left frontal bone, with herniation of the frontal lobe, was made. At operation, the defect was smoothed, hemorrhage controlled, and devitalized brain removed with bone fragments. The wound was packed with sulfanilamide and vaselined gauze. He went through a Field Hospital the next day and reached an Evacuation Hospital on August 5, when reoperation was undertaken. According to the accompanying notes a cerebral fungus was resected, requiring "left frontal lobectomy"; a large foreign body was removed. Sulfanilamide powder was placed in the wound. The dura was closed with a fascial graft from fascia lata. Sliding graft was necessary for scalp closure. He was placed on sulfadiazine and his condition was noted as satisfactory when he was evacuated on August 10. He reached here through the chain of evacuation on August 15.

There was foul discharge through the original head encasement. Neurologic examination was negative, speech was clear. On removal of the encasement, there was a pulsating puffy defect with foul purulent drainage. Skin sutures were removed, resulting in profuse discharge of pus. On retracting the skin edges there was a 5-cm. bony defect in the center of which lay a loose, sloughing fascial graft. The graft was removed together with silk sutures and the wound was packed open. The cerebral fungus responded well, and in the course of a week began to recede. Skin edges were allowed to epithelize over the periphery of the hernia and it healed completely within six weeks, except for one small area medially, which continued to drain a small amount. Roentgenograms, with diodrast, showed a small invaginated pocket. A tiny piece of retained bone fragment was lifted out and a thin rubber drain was inserted. This resulted in prompt healing. The patient was discharged to the Zone of Interior on October 27, 1943.

The persistent infection which complicated the course in Cases 14 and 15 might have been expected in the presence of retained bone fragments plus the addition of a fascial dural transplant with silk sutures in a contaminated field. They also serve to illustrate the inefficiency of incomplete débridement.

"PACKING" OF HEAD WOUNDS

Cases 11 and 15 were both subjected at first to incomplete débridement with sulfanilamide-vaselined gauze packing. We do not believe that this type of dressing is applicable to head injuries. Just as its abuse has been noted in cases of wounds of the extremities, where tight packing results in damming up of infected tissues, the packing of a penetrating head wound with vaselined gauze (if allowed to remain for long) is equally hazardous, particularly when bone fragments and foreign material have not been removed. The following case illustrates this point.

Case 16.—Age 35, received a gunshot wound of the head on February 16, 1943. On the night of the injury he was treated at a Surgical Hospital, where the "scalp wound (was) excised; fracture of skull present; depressed fragments removed; sulfanilamide-vaselined gauze; scalp sutured loosely." He was started on a course of sulfadiazine. The patient arrived here on February 24, 1943. He was confused and irrational. There was

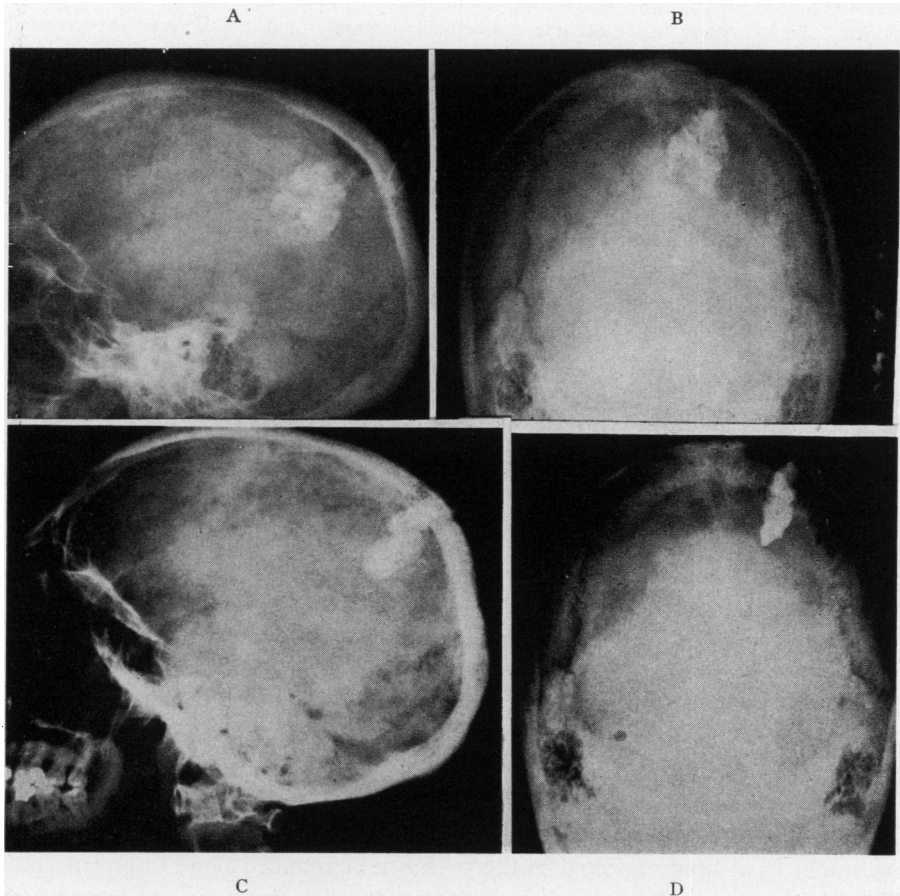


FIG. 7.—Case 16: A and B. Showing extent of abscess as outlined by radiopaque iodoform gauze drain. C and D. Comparable views, taken two weeks later; the abscess cavity has become much smaller and healing is progressing. This patient had retained bone fragments within the abscess cavity; original wound treated with vaselined pack.

early papilledema. The left shoulder girdle muscles were weak and there was drifting of the outstretched left arm. Neurologic examination was otherwise negative. The edges of the infected right parietal scalp wound were held by two silk sutures, which forcibly restrained a vaselined pack. On removal of the sutures, the pack delivered itself, and the underlying wound showed an obvious central defect through which necrotic brain oozed. Roentgenograms showed a depressed comminuted fracture of the right parietal bone with indriven bone fragments. On February 26, operation was performed. After removal of redundant brain tissue, at a depth of 1 cm. a large abscess containing 40 cc. of thick creamy pus was found and evacuated. The abscess wall was moderately thick. Several pieces of bone were found and removed from the cavity. Iodoform drains were placed in the abscess and the skin left open. Roentgenograms, with iodoform drains in place, were taken at weekly intervals, and we were

able to follow the healing process visually (Fig. 7). There was complete healing of the abscess and the skin on April 2. Neurologic examination showed almost no drifting of the left arm and only slight instability on finger-nose test. He was able to walk well. Optic nerve heads cleared promptly. He was evacuated to the Zone of Interior on April 8, 1943.

METALLIC FOREIGN BODIES

The problem of removal of metallic foreign bodies is a difficult one at times. These materials are usually not a nidus of infection, whereas retained bone fragments appear to be responsible for infection in most cases. The occurrence of an abscess around the indriven piece of metal in Case 12 demonstrates that this cannot be considered a hard and fast rule. The following case is cited to illustrate failure on our part to recognize the presence of a large lesion resulting from multiple metallic foreign bodies.

Case 17.—Age 21, was struck by enemy fire on July 12, 1943. The exact type of missile was not known. Operation aboard ship was performed within 12 hours, consisting of débridement, local sulfanilamide and closure of the left temporal wound. The patient was stuporous and had partial paralysis of the left face and leg, at least until July 16, when he reached a Station Hospital. There the temporal wound was found to be infected, and on July 22, a second débridement was done, with drainage. The patient's condition improved and he was evacuated, reaching here on August 8, 1943.

Examination showed an infected left temporal wound with a large amount of drainage. There was swelling below the mandible with trismus. Neurologic examination was entirely negative. Speech was clear. The partial left facial and leg palsy had apparently cleared up while *en route*. Roentgenograms showed a 2.5 cm. defect in the squamous portion of the left temporal bone, with two large metallic fragments at the fracture site; there were several smaller fragments intracranially beneath the coronal suture (Fig. 8 A).

During the next few days trismus became more marked. On August 12 an aneurysm of the internal maxillary artery was found and excised, resulting in relief of trismus. The left temporal wound continued to drain profusely. Neurologic examination remained negative, with normal fundi. Sulfadiazine was given right along, with maintenance of high blood concentration. It was thought that persistent drainage was due to retained foreign bodies at the fracture site.

On August 20, operation was done. The temporal wound was excised down to the anterior part of the pars squamosa. A sinus tract ran down to the bone defect. Lying in the defect were several loose bits of bone, and buried in the zygoma were several pieces of metal, dirt, and hair. All this was removed and the bone edges were rongeuired down to healthy bone. The dura was covered over with tough scar and there was no evidence of a tract through the dura, at this time. The wound was closed loosely around a Penrose drain.

Sulfadiazine was continued postoperatively. The wound continued to drain. Postoperative roentgenograms (Fig. 8 B) showed a clean temporal defect, with the previously noted small metallic fragments along the vertex. Neurologic examination was consistently negative. Eye grounds were checked repeatedly by us as well as by the ophthalmologist, and disks remained flat and clearly outlined. Visual fields were full. The patient was mentally clear. Vital signs were normal. He was allowed to get up. On September 17, he complained of general malaise and had low grade fever; neurologic examination was negative. Malaria was suspected, but no parasites were found on smear. On September 18, there was fully-developed meningitis, with temperature 104° F., rapid pulse, and stiff neck. The patient became very confused. Spinal



FIG. 8.—Case 17: A. Lateral view showing several large metallic foreign bodies (arrows) within a ragged frontotemporal defect. Numerous small foreign bodies scattered throughout the frontal lobe. B. After removal of the large metallic foreign bodies and pieces of bone in the defect. This patient developed an extensive brain abscess which was not recognized clinically.

puncture was done, pressure was 220 Mm. of water. The fluid was turbid, contained 14,000 cells per cc., of which 90 per cent were polys. No organisms were found on smear. Sulfadiazine was continued. On the morning of September 19, temperature was 99° F.; neurologic findings unchanged. At noon he suddenly lost consciousness and died of respiratory failure.

Autopsy showed a narrow tract running through the scarred dura to the temporal lobe. There was diffuse basilar meningitis. The entire left hemisphere felt soft and the gyri in the frontotemporal region were flat and yellow. On section of the brain, a large, thin-walled abscess was found which involved the frontal and temporal lobes, and extended back to the posterior horn of the left lateral ventricle, at which point it had ruptured into the ventricle.

On reviewing this case, there are several significant features. There had been two débridements before evacuation to a General Hospital. After reaching this hospital, despite the large size of the abscess, there were neither general pressure, nor localizing signs. As a matter of fact, mental and emotional instability noted on admission here had disappeared, as had the facial and lower extremity palsy which had been observed aboard the Hospital Ship. From the extent of the lesion demonstrated at autopsy, one would have expected aphasia (the patient was right-handed), visual field defect, and at least partial hemiplegia. The infection had evidently progressed with only thin walling-off despite continued sulfadiazine therapy. For our part, we were led astray by the fact that there was no demonstrable tract leading through the scarred dura at the time of exploration of the temporal wound, as well as by the prevailing opinion (which we share) that intracerebral metallic foreign bodies are not often associated with abscess. In our own experience, indriven bone fragments have most frequently been found in association with infection. The persistent discharge of pus led us to suspect, erroneously, that there might be osteomyelitis of the superior margin of the zygoma. In retrospect, despite lack of general pressure and localizing signs, the mistake we made was in not exploring intradurally with a needle. If it was felt unwise to insert a needle through the infected temporal defect, this procedure could have been done safely through a perforator opening in a clean field.

We believe that the removal of indriven bone fragments, with particles of clothing, hair, *etc.*, is of paramount importance in all cases. If a metallic foreign body is readily accessible and if its removal does not mean inflicting severe functional damage, then every effort made to effect its removal is justifiable. We do not yet know what incidence of traumatic epilepsy may be expected to occur in this war, in head wounds with retained foreign body and cortical scar. In Case 7 it was believed that removal of the foreign body (Fig. 4) which lay near the surface of the left frontal lobe was indicated at the same time that we performed delayed débridement of the right frontal lobe.

Due to the relatively short period in which wounded men remain in the Theater of Operations, we could not expect to encounter many cases of traumatic epilepsy. The following case of jacksonian seizures which came

under our care is cited as our single experience with the condition in this Theater.

Case 18.—Age 24, was struck by high explosive fragment during an air raid on June 6, 1943. He did not lose consciousness. At a General Hospital (British) two hours after injury, examination showed a small penetrating wound of the right parietal region just above the ear. He had a right peripheral facial weakness, partial flaccid paralysis of the left arm, and absent knee-jerks. Débridement, with primary suture, was performed immediately. The immediate postoperative course was uneventful, and he was transferred to a Station Hospital on June 23. The following day he had a jacksonian fit, beginning in the left hand and arm, spreading to the left leg, and then

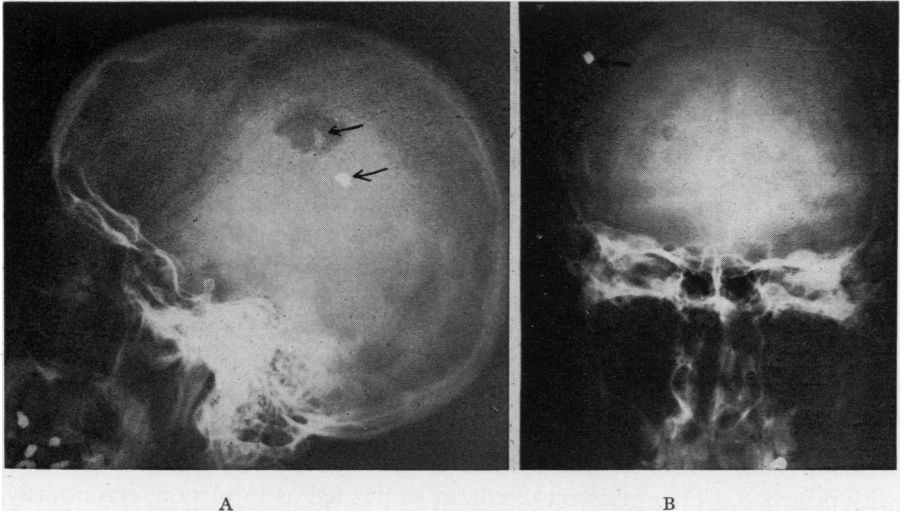


FIG. 9.—Case 18: A and B. Penetrating wound of right parietal bone with retained bone fragment and metallic foreign body. Patient had jacksonian seizures beginning in the left hand. At operation cortical scar with retained foreign body removed *en masse*.

becoming generalized. He was transferred to a General Hospital on June 25, where the wound broke open and drained a small amount of serous fluid. This healed within a few days, and the patient reached this hospital on July 21. There was a healed incision 3 cm. long in the right parietal region, with a small underlying bone defect. The only neurologic abnormalities were astereognosis, ataxia, and lack of fine movements of the left hand. Roentgenograms showed a few loose fragments of bone directly beneath the bone defect and a small metallic foreign body, 1 x 0.5 cm. apparently within the cortex (Fig. 9). The patient was right-handed.

On July 29, 1943, approximately seven weeks after injury, and one month after the wound was healed, a right parietal craniotomy was done. Through a small bone flap, the original laceration of the dura was found to be covered with tough fibrous tissue which led down through a dense scar to underlying brain. This part of the dural flap was cut out. In the position of the arm area the cortex was yellow and scarred, with the rolandic vein running along the surface. It was possible to peel this vessel away from the lesion and preserve its continuity. Superficial vessels were clipped and cut, and the entire scar with its retained foreign body was removed *en masse*. The defect was 3 cm. in diameter and 2.5 cm. deep. The wound was closed in layers with silk, using a piece of temporal fascia to close the dural defect. While undergoing anesthesia (pentothal sodium), the patient had tonic-clonic movements of the left arm and leg, but did not go on to general convulsion. On two occasions coagulation of

small vessels at the periphery of the cicatrix resulted in flexion of the left hand and arm, and rotation of the shoulder.

On the night of operation, the patient was started on luminal, grains one, three times daily. There was paresis of the left arm and face; the leg was not affected. On the first day, he was able to extend and rotate the arm and hand, and the facial weakness was disappearing. Sutures were removed on the second day, at which time there was no longer any facial weakness, and the arm was improved. The wound healed *per primam*. By the tenth postoperative day arm movements had returned and he was able to manipulate a match box with his left hand as well as before operation. He was allowed up on the 10th day, and his course continued satisfactory. Astereognosis and impairment of fine movements of the left hand were still present when the patient was returned to the Zone of Interior on September 6, 1943. In a letter dated November 1, his sole complaint was sensory impairment of the hand.

In cases in which the retained metallic foreign body is inaccessible, where it is situated in a vital area, the offending fragments should not be disturbed unless it gives rise to abscess later on. Figure 10 shows a metallic fragment

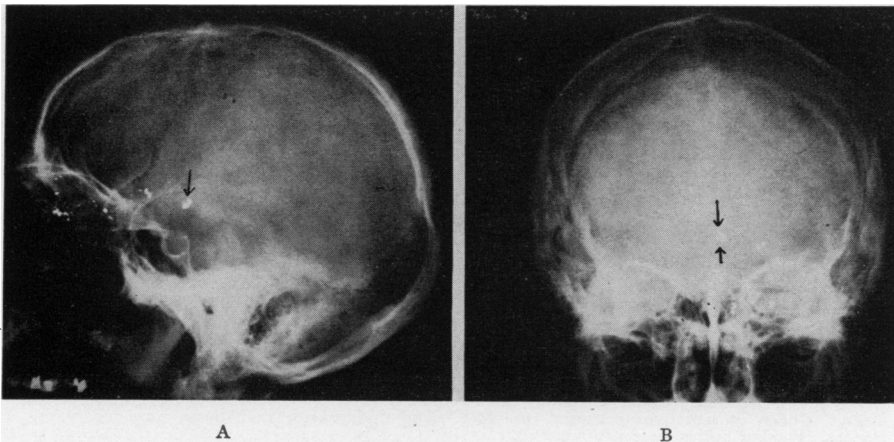


FIG. 10.—A and B. Films of a soldier with a healed penetrating wound of the right orbit. Several retained metallic foreign bodies the largest of which lies in the midline directly above the sella turcica. There had been transient polyuria and polydipsia which cleared rapidly. No attempt at removal of foreign body indicated.

which entered the right orbit of a soldier on February 27th and lodged over the sella turcica. There had been transient polydipsia and polyuria early, but neurologic examination was entirely negative, and there were no hypothalamic signs or symptoms on arrival here on March 8, 1943. Any attempt at removal of the foreign body would have been disastrous.

The following case demonstrates a problem that may arise from time to time:

Case 19.—Age 22, sustained a penetrating wound of the parieto-occipital region on March 28, 1943. There was almost total blindness immediately. On March 31, débridement was performed at an Evacuation Hospital, with removal of bone and metallic fragments from both calcarine areas, "some fragments were inaccessible." At a Station Hospital papilledema was noted on April 10, 1943. He reached here on April 12, 1943. There was a transverse occipitoparietal wound just above the region of the torcula, which was healed except for one area in the center at which point galea was not epithelized

There was bilateral papilledema. Visual acuity, bilateral, was limited to finger movements at five feet. Roentgenograms showed a defect over the midline posteriorly; there were several metallic foreign bodies including one which appeared to be within the region of the sinus (Fig. 11). We believed, with the original surgeon, that removal of the fragments should not be attempted unless absolutely necessary. Aspiration with a needle through intact lateral margin of the defect yielded a few drops of sero-sanguineous fluid; no pus. The eye grounds were checked repeatedly, and papilledema receded gradually, so that there was no measurable elevation by April 24. Visual acuity rose to 3/200 in each eye. Tangent screen examination on May 11, showed right homonymous central field defect with involvement of the maculae. The unhealed portion of the wound healed within a few days. The patient was able to be up and about and was discharged to the Zone of Interior on May 16, 1943. Had signs of pressure persisted, we would have been obliged to remove the shell fragments as a source of infection.

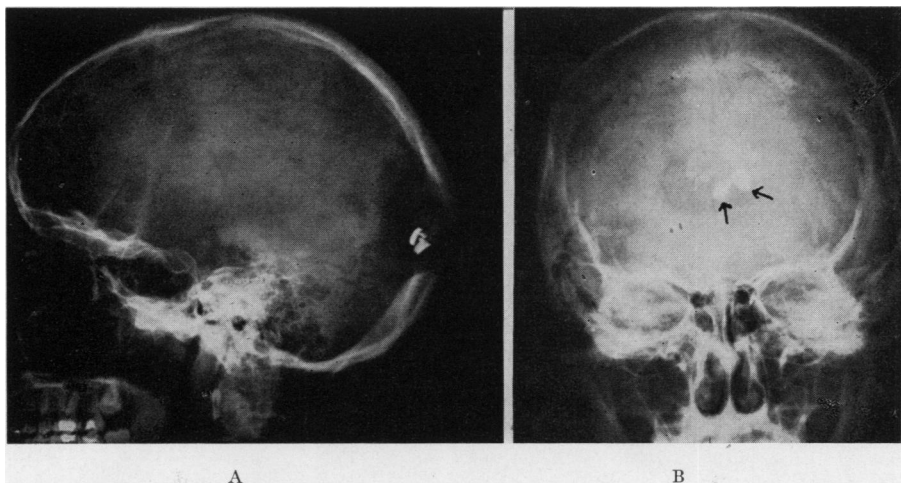


FIG. 11.—Case 19: A and B. Wound of occipital region, midline, with retained metallic foreign bodies just above the torcular Herophili. Admitted after early incomplete débridement, with choked disks. Under conservative treatment, pressure signs disappeared, and there were no signs of abscess. Foreign bodies were not removed.

Parenthetically, it might be added that an attempted removal of these foreign bodies in the forward echelon, without adequate facilities would have courted disaster.

CLOSURE OF WOUNDS

In early cases, following débridement, it has been an accepted neurosurgical practice to close the head wound tightly, without drainage. Such closure after careful toilet of the wound will almost inevitably result in primary healing, and will prevent the development of a cerebral hernia, with its long period of morbidity. At times, there has been so much loss of skin that after excision of only a narrow margin, difficulty in closure is encountered. If undermining does not result in sufficient mobilization of the scalp, one may then be forced to use releasing incisions and "sliding grafts." If this procedure is performed, sufficient relaxation must be sought to allow closure without too much tension, and the releasing incisions must be so placed as not to jeopardize the vitality of the primary wound.

We have had to resort to releasing incision in only one case, and in that

instance (Case 8) it is worth pointing out that one part, however small, of the primary wound was not fully healed until the 12th day; this was due to too much tension. The following case is presented as an instance in which laterally placed releasing incisions appeared to have jeopardized the vitality of the central wound, although local infection was probably the main factor.

Case 20.—Age 49, was hit by shell fragments on April 23, 1943, sustaining a penetrating wound of the vertex. He was taken to an Evacuation Hospital, where pre-operative examination noted "neurological essentially normal, except for semicoma." Roentgenograms showed a defect in the vertex of the skull, with a metal fragment deep in the right temporal lobe. The wound was débrided on the day of injury, exact time interval not known. The superior sagittal sinus, which ran through the wound was successfully avoided. Bone fragments were removed, but the metallic fragment was not looked for. The dura was not closed. To close the scalp, two lateral releasing incisions were made. The patient was transferred to another Evacuation Hospital on April 25, where "sensory epilepsy" was noted. At a Station Hospital on April 30, paralysis of both legs was observed. The patient arrived here on May 4, 1943.

Examination showed an area about 6 cm. in diameter directly over the vertex, which was red, hot, and swollen. There was a central tripod incision, flanked by two lateral releasing incisions, about three inches long. The three wounds were covered with pus, and the tripod had broken down, with cerebral fungus protruding. From the relative position of the anterior limbs of the tripod and the releasing incisions, it was thought that blood supply to the central wound was not adequate. The patient had terrific paroxysmal pain in both legs. The left leg was completely paralyzed; the right partially so. Both disks were blurred. The right pupil was larger than the left. There was marked incoordination and loss of fine movements in both arms, particularly the left. There were no pathologic toe signs. Sensation was definitely diminished and position sense was absent in both legs.

The head was shaved and wet dressings were applied for a few days to reduce the cellulitis. Fluid intake was limited, although sulfadiazine was given. After cellulitis had disappeared, aspiration with a needle through a clean field was done to rule out possible abscess; no pus was obtained. The bulging hernia was then treated with boric-vaselined dressings. Lumbar puncture was done twice to reduce the protruding mass. After subsidence of the cellulitis and infection, the hernia receded and epithelization began. *Pari passu* with recession of the hernia the patient's condition steadily improved. On June 6, 1943, there was complete healing of the tripod as well as the releasing incisions, and the defect was flat. Disks were normal. The patient was free of pain. Abnormal signs in the upper extremities disappeared. He was able to move all muscle groups of the lower extremities, but was not yet able to support his own weight. There was marked ataxia on heel-knee test. Absent position sense below hips, and loss of fine discriminatory sensation below the costal margin. There was no clonus or pathologic toe signs. The patient was discharged to the Zone of Interior on June 15, 1943.

In late cases, closure may be attempted if there is no massive infection, and if removal of all involved necrotic tissue and retained fragments is accomplished. This has been carried out successfully in cases cited previously. Although it was also successful in Case 12, in the presence of abscess, we realize that this was a risky procedure, and this case would have been more safely handled if drainage had been instituted.

HERNIAE CEREBRI

In a certain number of cases, cerebral hernia is bound to occur. In our series, this complication was noted in either (1) cases incompletely débrided and closed, and broken down by infection; or (2) cases which were so badly infected by the time first medical treatment was available that closure was deemed unwise; or (3) cases which were débrided but were not closed tightly.

Treatment of such herniae is conservative. If superficial infection is taken care of, recession of the hernia with epithelization usually occurs, unless there are retained bone fragments or other material which act as a focus of deep infection. In cases without retained material, we have dressed these wounds with fine mesh, vaseline- or boric ointment-impregnated gauze, after preliminary cleansing with boric acid solution or wet saline dressings. If the hernia is large, lumbar puncture is done to promote recession of the mass. Where bone fragments are retained beneath the surface, there will usually be a draining sinus through the hernia, and prompt removal of the fragments, with drainage, will save time and may prevent more serious complications. If the hernia continues to enlarge and shows no signs of recession, underlying brain abscess should be suspected, and if this is present, should be treated by uncapping the hernia and instituting drainage. It is our opinion that drainage, with removal of contained bone fragments and foreign bodies in the abscess, should be performed promptly.

The following case represents an unhappy outcome due to abscesses beneath a cerebral fungus:

Case 21.—Age 24, prisoner of war, sustained a penetrating gunshot wound of the left frontoparietal region on May 5, 1943. Available records began only after his first admission to an American Evacuation Hospital on May 11. At that time, he was aphasic and had right hemiplegia; pulse was slow; the left pupil was larger than the right. The previously sutured scalp wound was infected. Roentgenograms revealed a slight shift of the calcified pineal body to the right and downward. On May 12, the infected scalp wound was opened, with escape of pus and blood. The brain was apparently sealed over and was not disturbed. The wound was left open, with sulfanilamide and vaselined gauze. A left subtemporal decompression was then done. The patient was transferred here on May 20, 1943. Examination showed tense, subtemporal decompression. Near the vertex on the left, there was a cerebral hernia which bulged moderately. There was aphasia and right hemiplegia. On May 26, 1943, operation was performed. The edges of the old infected cruciate wound of the vertex were retracted. Redundant hernia was excised, and at depth of 4 cm., a large multiloculated left frontal lobe abscess, with retained bone fragments, was evacuated and drained with iodoform gauze. Immediately following the procedure, the subtemporal decompression became flat and remained so for a week. With iodoform drains in place, roentgenograms demonstrated apparent healing of the large abscess. Another abscess was suspected in the inferior part of the frontal lobe in the vicinity of a retained metallic foreign body. This proved to be a small one when aspirated through a perforator opening on June 8. The patient received continuous sulfadiazine therapy from May 26 until he died on June 22. Autopsy revealed complete healing of the large multiloculated abscess which was drained on May 26. Throughout the remainder of the left hemisphere, including

the occipital lobe, however, there were multiple small abscesses, with a small amount of pus in the left lateral and the third ventricles.

SUMMARY AND CONCLUSIONS

(1) The experiences in the treatment of craniocerebral wounds in a General Hospital in the North African Theater of Operations are presented.

(2) Early complete débridement of head wounds, with anatomic closure in layers, and without drainage, is the most desirable type of therapy.

(3) Satisfactory results may be achieved by thorough débridement, even when there has been a very long delay. In selected cases, delayed débridement, with tight closure, and without drainage, has been successful after as long as 32 days. The establishment of any arbitrary time limit within which definitive treatment may be given is not indicated.

(4) If facilities for definitive neurosurgical therapy are not available in the forward echelons, it is to the patient's advantage that he be transported to an area where such facilities are available, rather than be subjected to inadequate early treatment. Prior to evacuation, the scalp should be shaved and a sterile dry dressing, with sulfonamide crystals, applied.

(5) Facial transplant for repair of dural defects is hazardous in late cases.

(6) "Packing" with sulfanilamide-vaselined gauze is not applicable to the treatment of craniocerebral wounds.

(7) Retained bone fragments, with or without foreign materials, are the most common source of persistent suppuration, and their removal is almost mandatory. Metallic foreign bodies do not commonly act as a focus of infection, but may do so.

(8) Sulfonamides have been used in the treatment of this group of cases. However, as a rule, we have not used sulfonamides locally, but have given these drugs parenterally and orally.