BRAIN.

PART II, VOL. 42.

GUNSHOT WOUNDS OF THE SCALP, WITH SPECIAL REFERENCE TO THE NEUROLOGICAL SIGNS PRESENTED.

BY GEOFFREY JEFFERSON, M.S.LOND. F.R.C.S.ENG.

*Assistant Surgeon, Salford Royal Hospital, Manchester, Late Captain,
Royal Army Medical Corps.*

Surgical Specialist attached 14th General Hospital, British Expeditionary Force.

	PAGE
I.—INTRODUCTION	93
II.—MATERIAL	95
III.—THE TRAUMA	96
IV.—CHARACTER OF THE SCALP WOUNDS	96
V.—TYPE OF OPERATION PERFORMED	97
VI.—CONCUSSIONAL CHANGES.. .. .	97
VII.—GENERAL SIGNS.. .. .	98
VIII.—CEREBRAL CONTUSION	101
(a) Contusions of the Motor Cortex	102
(b) Contusions of the General Sensory Cortex	106
(c) Contusions of the Visual Cortex	107
IX.—CONTRALATERAL INJURIES	109
X.—PATHOLOGICAL ANATOMY OF CEREBRAL CONTUSION	110
XI.—SUMMARY	110
XII.—REFERENCES	112

It is common knowledge that, owing to the resilience of the cranial vault, it is possible for a severe blow to cause an injury of the underlying brain without an actual fracture of the calvarium occurring. It is granted that this injury may be sufficiently severe to manifest itself by definite and unequivocal clinical signs, but it is not sufficiently well known how common such cerebral contusion is. A scalp wound is usually regarded as a trivial thing with an unusually happy prognosis

as regards healing, even when grossly infected. Attention has, however, been too sharply focused upon the wound of the soft parts, to the exclusion of the deeper lesion so often present and so vastly more important than the other. No class of head injury better illustrates the aphorism of Hippocrates with which Percival Pott prefaces his work on the nature and consequence of wounds and contusions of the head—"Nullum capitis vulnus contemnendum." The object of the present paper is to attempt to rescue scalp wounds from the position of

FIG. 1.—Scheme of scalp wound with intracranial injury, the calvarium being intact. Bruising of bone and dura, with small extradural and cortico-meningeal hæmorrhage.

contempt which they too often occupy. It is true that the brain injury is rarely of a very serious character unless the calvarium has given way and so allowed the force to continue and to act unopposedly on the hemisphere, but deaths from scalp wounds do sometimes occur. The lesser grades of brain injury are by no means the least interesting, and below will be found evidences of injury of very varying degrees of severity.

Two factors have undoubtedly contributed to the failure to recognize intracranial upset in head injuries. In the first place the disturbance is often very slight, and in the second it wears off comparatively rapidly, frequently within a week, so that unless a neurological examination is made at once signs will be missed, and by the time these patients reach the United Kingdom all objective signs have passed away. A third factor may be added, and it is this, that the great pressure of work in France has caused most of us to confine our attention to cases more insistent in their claims, such as the penetrating wounds of the head. But that the closer investigation of scalp wounds amounts to more than a luxury, the histories set forth below will show.

The only recent references to contusion in scalp wounds are those of Adie and Wagstaffe [1] and of Harvey Cushing [2]. The former note three Jacksonian fits in 118 cases and one death (from pneumonia), the latter one death from hæmorrhage into the vermis and cerebellar fossa. Cushing, however, makes the following remark: "It is quite possible that some of the other cases in this group [scalp wounds] should not only have been trephined but should have had the dura opened as well, for eleven out of the number [i.e., 50 per cent.] showed distinct evidence of moderate intracranial damage."

In the series now to be brought forward, no less than seventeen out of fifty-four showed evidence of local contusion, and all but five a cerebral disturbance of some sort or other.

II.—MATERIAL.

The observations embodied in this paper are based upon a series of fifty-four scalp wounds under my care in the Head Service of 14 General Hospital between the months of July and November, 1918. The number of cases is admittedly very small, but they are quite unselected, some slight, some severe, and are typical of the average run of scalp wounds as seen at the base in France. A few had been operated upon before admission, but the majority were untouched. It was a general rule which admitted of no exception that all head wounds, however trivial they might appear to be, should be submitted to a rough neurological examination before operation. These remarks are the result of observations so made, often very sketchy, and jotted down under extreme pressure of work.

There can be no question but that head wounds of all degrees of severity benefit from collection into one place, where they can be kept

for a long time before being moved further, and where they can receive the benefits of standardization and continuity of treatment.

III.—THE TRAUMA.

The protective value of the steel helmet is undoubtedly great, but beneath its shelter a man may receive a blow of very considerable severity without fracture of the calvarium. This is corroborated by those cases, and several were noted, where the helmet has been deeply indented without being perforated and the patient has suffered a considerable scalp wound with underlying cerebral contusion. But for the helmet, the shell fragment would undoubtedly have penetrated the head, and the case have thus passed into a graver category.

How severe the blow on the head may be is illustrated by a man who remarked several days after he had been wounded that he "could hear the old tin hat ringing still." In one or two cases the fragment has hit the helmet with such force as to break the chin-strap. This is liable to occur with bullet wounds whose trajectory is flat, whilst shrapnel bursting above tends to drive the helmet on to the head.

Notes were kept on the nature of the injury to the steel helmet as far as could be determined. Reliance had usually to be placed on the man's own statement, as not many patients succeed in getting their helmets through to the base. In conjunction with the position and extent of the scalp wound, the injury to the "tin hat" helps one to form a clearer mental picture of the exact nature of the force which has been applied, and, in my opinion, the helmets should always have accompanied the patients on their journey right through to England.

IV.—CHARACTER OF THE SCALP WOUNDS.

The wounds of the scalp were of the usual type, with contused ragged edges. They varied from one-half to four inches in length, and were from one to two days old on admission. Owing to the vascularity of the scalp, they did well with conservative excision and suture with a rubber tissue drain. The wound extended almost invariably to the pericranium, and when this was torn it was not uncommon to see a faint bruise in the bone like a shadow beneath the external table. In none of the series now under consideration was there a fracture of outer or inner table.

V.—TYPE OF OPERATION PERFORMED.

Of the operative methods used little need be said here. Excision of the scalp wound as sparingly as was compatible with removal of all hopelessly contused and infected tissue was performed. The wound was then washed over with flavine followed by warm saline to remove the albuminate first formed, and then rinsed with flavine again. Catgut sutures were inserted in the galea, and the wound closed with interrupted silkworm-gut sutures, twisted twice but not knotted. A trephine disc was removed three times (see below). The anæsthetic of choice is undoubtedly novocain—adrenalin, with a hypodermic injection of omnopon $\frac{2}{3}$ gr., and scopolamine $\frac{1}{100}$ gr. an hour beforehand. The advantages are: a minimal loss of blood (and such loss may assume formidable proportions if plastic flaps have to be cut), and, secondly, the great comfort of having a conscious patient who can lie in the position most convenient to the surgeon unembarrassed by an anæsthetist. This is of especial value in wounds of the posterior part of the head. A great part of the art of surgery lies in making things easy for yourself (to paraphrase a remark of Charles Mayo's), and local anæsthesia makes this possible for the head in a way which must be surprising to any one not already conversant with its convenience.

The dura was not incised at operation either in this or in the depressed fracture series, as sepsis was already established, and it did not seem justifiable to incur the added risk which this step would have entailed. It may be noted that none seemed to be the worse for this conservatism.

VI.—CONCUSSIONAL CHANGES.

A large number of the cases showed generalized signs; a history of unconsciousness, complete or partial, with vomiting, nausea, headache, and exaggeration of the tendon jerks generally, so that one must define some standard for the diagnosis of contusion apart and aside from such signs. In the Rolandic lesions such signs can be traced through all grades of severity from a local increase of the tendon jerks and a few beats of ankle clonus on the side opposite the lesion, these being absent on the same side, up through slight aphasias, numbnesses and pareses, finally culminating in definite palsies and Jacksonian fits. In no type of cases can the effects of cerebral contusion in its varying gradations of severity be more beautifully traced.

It will be readily acknowledged that signs of contusion of the silent

areas of the brain, particularly of the frontal lobes, are very difficult to detect. It is not until the wound falls over a non-silent area, such as the motor or visual cortex, that one is able to say with accuracy whether or not the impact of the missile has caused a local lesion. These localizing signs have to be distinguished from the concussion and post-concussion effects which are met with in severe cranial injuries whatever their site.

VII.—GENERAL SIGNS.

The signs of intracranial disturbance common to all, whether concussion cases or locally contused cases, will be now discussed with a view to determining their frequency. Those cases in which a localized cerebral injury has occurred will then be dealt with.

It may be stated at once that only five patients out of the whole series showed no positive neurological signs at all. In ten more the only thing complained of was headache, but this was often so severe and the patients were mentally so dull for a short time that one could not doubt that the brain had received a severe shaking up. All the other cases presented additional and unmistakable signs which made the diagnosis sure.

Unconsciousness.—As regards a period of unconsciousness, one can here only rely on the man's statement, as it was always of short duration, and was gone by the time he reached a Casualty Clearing Station. To the patient, the border line between being stunned and being actually unconscious is indistinct. One quarter of them allege that they were actually unconscious for brief periods, whilst another quarter were stunned, frequently being knocked down by the impact of the missile.

Headache.—As might have been expected, headache has been more commonly present than any other symptom. Out of the fifty-four cases it was present in forty-five, definitely absent in six, and not noted in three. A note was kept as to its situation with a view to determining, if possible, some connexion between the site of the wound and that of the headache. It was "fixed," severest in the region underlying the wound, in twenty-three cases, roughly 45 per cent. As it improves, it tends to become frontal, and this was the commonest general site for headache. Frontal headache was present with wounds of the vertex, temporal, parietal and occipital regions indiscriminately.

When it occurs in occipital wounds it is difficult to be certain that it is not the result of a local trauma by *contrecoup*, and occipital and frontal headache were sometimes associated. One can only conclude that it is due to a general upset of the intracranial circulation or localized oedema the result of the trauma. It was most severe in the evening just when settling down for the night, and often appeared then when it had been absent throughout the day.

Giddiness was the next commonest sign, only being noted on gross changes of posture, and therefore later in convalescence when such active movements began to be attempted. It was never a serious factor.

Nausea and vomiting.—These two valuable positive signs of severe intracranial disturbance were, as might be expected, not frequently presented by this series of scalp wounds. Vomiting occurred in eight cases and nausea was, or had been, present in thirteen.

Tendon jerks were exaggerated in twenty cases in all, and of these eight presented increase of both arm and leg jerks. Increase of the arm jerks always portended a graver injury, and cerebral injury was always suspected when they were active.

Clonus.—True ankle and patellar clonus, continuous and regular, was never found, but a few beats, from two or three to six, occurred in seven cases. But when present on one side only, even this mild form has a value.

One or other of these general signs was present in the vast majority of the cases of this series and were the result of the force which inflicted the wound. To a certain extent their significance was merely concussion and due to the impact of the missile on the steel helmet which tended to distribute the force generally all over the head.

All cases from the Head Service were given M.R.C. form 6 and a slip as well asking them to communicate with me at the end of a month or on discharge to an auxiliary hospital. Judging from their answers it seems that a large hysterical element often developed, and many complained later of headache and sleeplessness, and weakness in limbs which had appeared to be entirely recovered before they were sent across the Channel. This is not to say that they were malingering but that they had acquired a true hysteria (see, for instance, Cases 8 and 11).

The three following records are illustrative of varying grades of concussion injuries:—

Cases 1 and 2.—Scalp wounds presenting evidence of slight general intracranial upset of a concussion type.

Private J. C. (Series No. 24). Shell wound over right parietal bone, August 27, 1918. Wound overlies Rolando. Steel helmet worn, one hole in it. Admitted No. 14 General Hospital August 28, 1918. Dirty contused wound. Never unconscious, no vomiting. Nausea ++, yesterday. Headache +, frontal. Tendon reflexes: arms normal, legs exaggerated, equal. Plantar reflex, flexor. No palsies. Mentally quite clear.

August 28, 1918.—Operation, novocain-adrenalin anaesthesia, wound completely excised, bone bare over an area 1.0 cm. diameter, uninjured. Suture with flavine gauze wick.

August 30, 1918.—Wick removed.

September 5, 1918.—Evacuated to United Kingdom, condition excellent.

Private P. J. (Series No. 48). Bullet wound over right parietal bone September 9, 1918; excised in — Casualty Clearing Station next day, no bone injury. Admitted No. 14 General Hospital September 12, 1918. Steel helmet presented one hole and a groove on the inner surface. The bullet evidently followed the curve of the helmet and escaped between the head and the brim. Never unconscious, no vomiting. Nausea +, slight, when first hit. Headache +, fixed, not severe. Tendon reflexes all normal. Plantar reflex flexor. Palsies nil. Pulse 72.

September 20, 1918. — No headache, no neurological abnormalities. Evacuated to United Kingdom.

Case 3 (Series No. 69).—Scalp wound of vertex presenting severe concussion signs.

Sergeant W. H. H. Shell wound extending from mid-line, $3\frac{1}{2}$ in. to the left transversely, 2 in. in front of Rolando above, October 31, 1918. Dressed in — Casualty Clearing Station (no notes from there). Admitted No. 14 General Hospital November 7, 1918, a week after being wounded. Patient stated that he was semiconscious for about two days in the Casualty Clearing Station, remembers being very restless. Headache ++, both temples. Says he vomited many times at first. No nausea now, clear mentally. Tendon reflexes, arms +, legs ++, equal. Ankle clonus, 6 beats both sides. Plantar reflex flexor. No palsies. X-ray, no fracture detected.

November 8, 1918. Operation, novocain-adrenalin anaesthesia, wound excised, bone had been bare at centre of wound. Wiped out with bismuth, iodoform, paraffin paste suture.

November 15, 1918. Doing well, headache, slight frontal at night.

November 18, 1918. No headache, tendon reflexes normal. Evacuated, United Kingdom.

Such, then, are the neurological findings in about 50 per cent. of scalp wounds, denoting an intracranial upset of more or less severity, but of a generalized nature. There were no definite signs of a localizing

character by which one could say that one limited area of the brain had suffered more severely than another. We must now turn to those cases in which definite signs were present to such a degree that one is justified in saying that such and such an area had suffered a local contusion. We shall see, in fact, the special signs of a local contusion lifting their heads above the general ruck of signs of the coincident concussional changes.

VIII.—CEREBRAL CONTUSION IN SCALP WOUNDS.

As has been remarked, local contusion was detected in seventeen cases of the fifty-four of this series, that is, 31·5 per cent. In thirteen the lesion was Rolandic, and in two of these there was an added sensory disorder, whilst in four the lesion was occipital with visual disturbance. It is notoriously exceedingly difficult to determine whether there has been a contusion when one is dealing with the silent areas. Visual and motor lesions are comparatively easy to recognize, but it is a different matter with the frontal lobes and some parts of the temporal and occipital areas. That contusions of the silent areas did occur, but were undetected, there can be little doubt. So that the figures given are probably too low, as they deal only with the motor and visual areas, and to a certain extent with the parietal area too. This leaves a large part of the hemispheres unaccounted for. Head's work on the sensory cortex was unpublished at the time that these observations were made, and if his discriminatory tests had been applied, no doubt some interesting facts would have been obtained. In forming a true estimate, therefore, of the frequency of cerebral contusion beneath an intact skull, one can arrive at an approximately accurate conclusion only by noting the number of cases in which the injury fell over a non-silent area, and comparing this figure with that of the number which showed a definite contusion.

The results of this analysis are as follows: of the fifty-four cases thirty-nine overlay non-silent areas, and of these seventeen showed signs of cerebral contusion. This gives a percentage of 43·6, in place of the 31·5 just noted. These figures are high, but I, personally, am inclined to believe in the higher rather than the lower. The number of cases is too small for dogmatic statements to be based on them, and it remains for future investigations on larger numbers to correct or corroborate them. It is unlikely that the accidental scalp wounds of civil practice will show anything like so high a percentage of brain injury, for the force expended in producing them cannot compare with that of the high

velocity projectile which has generally pierced a steel helmet before inflicting the wound.

To turn now to a more detailed examination of the various contusions.

(a) Contusions of the Motor Cortex (Thirteen Cases).

Contusion of the motor cortex evidenced itself by motor aphasia and by palsies of all grades of severity. It was usual for the paralysis to be limited to two organs—in fact, a complete hemiplegia was never seen. In some cases the injury was very slight, and a local increase of tendon reflexes was all that was noted (see the illustrative cases below). The face and arm suffered most, and the movements of the fingers more than those of the elbow and shoulder. In fact there was an often repeated syndrome of aphasia with palsy of the right face and hand for low left Rolandic lesions, the aphasia being omitted when the blow fell on the right side. In two cases the pre-operative neurological findings were so definite that I removed a bone disc, although the cranium was quite intact. In one an extradural clot was found, in the other nothing (see Cases 6 and 10). In a third case the findings were equally definite, but this step was not taken, and I had the mortification of seeing him develop Jacksonian fits, and when a decompression was done a clot was found and washed away with no return of epilepsy (see Case 7). Jacksonian seizures occurred in three cases in all—the one just mentioned and in two others, which had already been operated upon in casualty clearing stations before admission to No. 14 General Hospital. One of these latter was completely controlled by large doses of bromide (30 gr. every two hours continued for three days). In the second recourse had to be had to lumbar puncture, and after this there was no return of convulsions. The Jacksonian fits seen in some of these head wounds, not only in scalp wounds but in depressed fractures as well, though we are not at present concerned with these last, are often of a very severe and protracted nature. In Case 9 there was hardly any interval between the second and third fit, and the twitchings continued until he was anæsthetized. In Case 7 the fit lasted for thirty-five minutes. These cases call to mind the four cases presented before the Moscow Neurological Society by Kozhevnikov under the title of “A special form of cortical epilepsy,” or partial continued epilepsy. By this he meant continuous twitchings, which rose into a definite convulsion and faded again into local contractions, rising again to a convulsion, and so on without ceasing. A very pretty case was

recently recorded by Pollosson and Collet [8]. In their case there was no injury to the calvarium, but they found an extradural clot on trephining. The character of the Jacksonian fits noted in my own cases seem to be stepping-stones on the way to a full-tide Kozhevnikov's syndrome.

The following six cases are illustrative of contusions of the motor cortex, and include motor aphasia and facial palsy, paralysis of face and hand (two cases), and three cases in which the hand was affected in excess of anything else. They include the three Jacksonian cases.

Case 4.—Scalp wound over lower part of left motor cortex. Slight facial palsy and motor aphasia. Cranium intact. Recovered.

Lance-Corporal T. C. (Series No. 35). Machine-gun bullet wound, September 1, 1918, 4 in. long, over left parietal bone, crosses Rolando low down. Steel helmet worn, two holes found in it. Scalp wound excised in — Casualty Clearing Station, no bone damage. Admitted to No. 14 General Hospital September 12, 1918. Clean healed scalp wound. Headache +, "fixed," occasional. Vomit —. Nausea + at times. Unconscious —, stunned +. Grips normal, equal. Tendon jerks +, clonus three beats right, nil left. Plantar reflex, flexor. Has slight right facial palsy, tongue tip deviates to right, with mild grade of motor aphasia. Was X-rayed in Casualty Clearing Station, report no fracture. Re-X-rayed here, no fracture detected.

October 24, 1918. Evacuated to United Kingdom, slight evening headache only.

October 16, 1918. Heard from, has severe headache, gets up, but then has acute pains in the head.

Case 5.—Scalp wound over lower part of motor area; cranium intact. Paresis right arm. Recovered.

Private H. T. (Series No. 38). Shell wound over left parietal, 2 in. long, October 14, 1918. Wound lies across lower end of Rolando; excised in — Casualty Clearing Station same day. Admitted No. 14 General Hospital October 17, 1918. Clean sutured wound. Vomit —, nausea + at first. Walked 200 yards to aid post after being hit. Unconscious —, stunned +. When first hit right arm became numb immediately, could not do anything with it. Legs were weak, had to be helped along. On admission hand was much better, but finger movements were clumsy; shoulder and elbow normal. Slight left facial palsy, tongue tip deviates to left. No aphasia. Tendon jerks normal. Pulse 80.

October 24, 1918. Greatly improved. Palsies recovering rapidly. Tendon jerks normal. No headache.

The next case presents an injury of the motor cortex with an associated lesion of the post-central gyrus. A better example of anæsthesia of cortical origin will be found in Case 10 (*vide infra*).

Case 6.—Scalp wound over left motor and sensory cortex. Palsy right side of face and partial anæsthesia of hand of cortical origin. Cranium intact. Trephined; extradural clot discovered. Recovery.

Lance-Corporal C. F. (Series No. 62). Rifle-bullet wound over left parietal bone September 3, 1918. Wound crosses middle of Rolando. Two clean holes drilled in steel helmet. Admitted No. 14 General Hospital, September 4, 1918. Was unconscious for a few seconds when hit, and about ten minutes afterwards felt numbness in right hand which then hung loosely at his side. Headache +, frontal; vomited twice in — Casualty Clearing Station. Nausea now, slight. Right hand numb, grip very weak; slight palsy right side of face. Tendon jerks, right side +, left normal. Radiograph, metal dust in scalp; no fracture.

September 4, 1918. Operation: Wound excised, no fracture found. In view of pre-operative neurological findings, a bone disc was removed and an extradural clot $1\frac{1}{2}$ in. in diameter discovered. Sponged away with hot saline, flavine wash. Dura not opened. Wound closed in layers with flavine cigarette drain.

September 8, 1918. Right hand improved, wound slightly septic. Bacteriologically staphylococci and long streptococcus.

September 29, 1918. Right hand still more improved, still slightly weaker than left. Face and leg normal. Subjective numbness of second, third and fourth fingers and distal half of corresponding portion of palm. Clinically appreciates cotton wool touch, pin pricks, &c., normally. Tendon jerks slightly exaggerated on both sides equally. Evening headache, slight; no giddiness. Wound healed save for two small spots.

September 30, 1918. Evacuated.

Case 7.—Scalp wound over right motor area. Cranium intact. Jacksonian epilepsy. Trephined, extradural clot. Recovery.

Private T. P. (Series No. 15). Bullet wound over right parietal bone, 4 in. long, crosses lower end of Rolando, August 27, 1918. Two holes in steel helmet 6 in. apart. Admitted No. 14 General Hospital, August 29, 1918. Unconscious for a few minutes after being hit. Headache ++, low frontal. Vomit 0, nausea +, palsy —; weakness left side of face; left hand grip weak; finger movements retained but slow, subjectively hand is numb and stiff. Elbow and shoulder practically unaffected. Hand was all right when first hit, but became weaker as he walked to aid post. Leg normal. No aphasia. All tendon jerks exaggerated, ++. Plantar reflexes strongly flexor. Pulse 60. Mentally clear; slightly drowsy. X-ray, no fracture detected.

August 29, 1918. Operation: Novocain-adrenalin anæsthesia. Wound excised *en masse*, bone bared, slight bruising in diploe, no fracture. Closed with flavine cigarette drain.

August 31, 1918. Neurologically no improvement.

September 1, 1918. At 6 p.m. patient had a severe Jacksonian seizure

lasting thirty-five minutes. Whole of left side of body involved, but especially face and hand. Operation: Novocain-adrenalin. Wound re-opened, 1-inch bone disc removed, extradural clot found some 6 mm. thick. Bone nibbled away leaving an oval defect 3 in. long. Clot sponged away. Wound closed with flavine cigarette drain. After operation patient had the common post-epileptic paralysis of left arm.

September 2, 1918. Arm recovering; Todd's paralysis passing off. Elbow and shoulder movements normal.

September 9, 1918. No further fits; hand now quite recovered, fine movements can be executed firmly and rapidly, but not yet quite normal. Subjectively, hand is still a little numb. Face recovered.

September 17, 1918. Hand is now normal. Face, arm and leg normal. No headache, giddiness or nausea. Tendon jerks slightly exaggerated. General condition excellent. Pulse runs 64, 72, 66, 64; temperature 98° F.

October 13, 1918. Seen in England. Up and about; no headache, no giddiness; arm and face normal.

Case 8.—Scalp wound over left parietal field. Cranium intact. Paresis right arm. Jacksonian fit. Recovered.

Lance-Corporal J. G. (Series No. 59). Shrapnel wound over left parietal bone 2 in. from mid-line and post-Rolandic, September 2, 1918. Wound overlies middle of left parietal field. Half-inch hole in steel helmet, missile came directly from above. Complications: flesh wounds of right arm and thigh. No vomit, no nausea. Hand and arm felt numb after wounding. Unconscious —, stunned +, headache +. Scalp wound excised in — Casualty Clearing Station, September 3, 1918, together with thigh and arm wounds; no fracture of skull. (Admitted No. 14 General Hospital, September 4, 1918.) Wounds clean. On September 8, 1918, patient had a brief Jacksonian fit limited to right arm. Post-epileptic Todd's paralysis of right hand and arm; face and leg normal. Pulse 68. Put on 360 gr. of bromide every twenty-four hours.

September 11, 1918. No further fits. Bromide stopped.

September 13, 1918. Hand and whole arm still weak; has a wound on the right arm which interferes with movement and makes it difficult to judge the exact weakness due to the cerebral injury. Fingers a little clumsy at rapid co-ordinated movements, but grip becoming strong.

September 23, 1918. No further fits; hand recovered. Evacuated.

October 23, 1918. Heard from; still has headache; says the strength has not returned to his arm (hysterical relapse).

In this case there were very slight evidences of underlying cerebral injury and the Jacksonian fit came as a surprise. As it was not repeated and seemed to be held in control by the large doses of bromide given, lumbar puncture was not performed.

Case 9.—Scalp wound over right motor area. Cranium intact. Three Jacksonian fits. Lumbar puncture twice. Recovery.

Private W. H. (Series No. 80). Shrapnel wound over right parietal bone, 4 in. aside from mid-line running forwards from a level 1 in. aboveinion for $3\frac{1}{2}$ inches. Wound just reaches motor cortex at its anterior end. September 18, 1918. One hole in steel helmet behind; missile escaped between brim and head, tearing the scalp. Wound excised in — Casualty Clearing Station; no bone injury, September 19, 1918. Admitted No. 14 General Hospital September 21, 1918. Was unconscious first half-hour, then walked over two kilometres. No headache; no vomiting; nausea at first +. Slight weakness of left hand, tendon jerks +, equal. No aphasia. Slightly drowsy. Pulse 48.

September 26, 1918.—Patient has had one Jacksonian fit during the past night and two this morning. The last fit was very severe, and of long duration (forty minutes), controlled finally with chloroform. Was very stertorous. Pulse 60, 56, 52. Lumbar puncture under novocain: 40 c.c. clear cerebrospinal fluid withdrawn, under high tension. Bromide, 360 gr. in twenty-four hours.

September 27, 1918.—Better; no further fits. Headache, frontal, ++.

September 28, 1918.—Still drowsy, but no fits; moves left arm but it is weak. Lumbar puncture: 15 c.c. clear cerebrospinal fluid withdrawn; tension still higher than normal, but less than before.

September 29, 1918.—All headache gone; less drowsy. Bromide stopped.

October 14, 1918.—Is now quite normal. Hand grip strong; no headache. Pulse runs 68, 70, 84, 80, 90.

In this case the impact of the missile was evidently greatest at the anterior end of the wound, where it reached the motor cortex, as its main part lay over the parietal field. There was no notable sensory upset.

(b) Contusions of the General Sensory Cortex.

There was one case which was particularly interesting. In the first place it is an example of the manner in which the effects of a cerebral contusion may rapidly wear off, leaving a residuum of greater chronicity, for after being hit he was hemiplegic for a time, but the leg very rapidly recovered. In the second place it shares, with Case 6, already described, the distinction of presenting very definite sensory changes, which persisted long after the palsy had recovered. It is therefore better as an example of contusion of the sensory field than of the motor area. These two cases should be considered together. The clinical picture of the second was this:—

Case 10.—Scalp wound over left motor cortex and sensory defect. Cranium intact. Transient hemiplegia with persistent sensory defect. Trephined. No extradural clot discovered. Recovered.

Private H. W. (Series No. 60). Sniper's bullet wound over left parietal

bone, 5 in. above and 1 in. behind external auditory meatus, runs across Rolando on to pre-central gyrus.

August 29, 1918.—Admitted No. 14th General Hospital, August 30, 1918. Unconscious —, stunned +. Headache ++, "fixed." Vomit —, nausea —. When hit, temporarily lost the use of right arm and leg. Lay in a shell hole for six or seven hours, and whilst lying there power returned to leg. This happened within about half an hour. At dusk, walked about a mile to dressing station. On admission to No. 14 General Hospital hand was still quite numb, especially along the ulnar border of forearm and hand. Right hand grip was weak but not feeble; finger movements clumsy. No facial palsy; no aphasia. Tendon jerks normal; plantar reflex, flexor. Radiograph, no fracture.

August 30, 1918.—Operation under novocain and adrenalin. Wound excised; no bony injury found. In view of neurological findings, 1 in. bone disc removed. No fracture of inner table, no extradural hæmorrhage. Brain pulsating freely. Closed with flavine cigarette drain.

September 1, 1918.—Wick removed. Leg quite normal. Inner three fingers of left hand and ulnar border of arm slightly improved, but still numb. Feels cotton wool touch and pin-prick. Grip now strong.

September 7, 1918.—Numbness improved but still present; is a subjective numbness; cannot describe it properly; muscles do not feel supple enough.

September 20, 1918.—Grip now very strong; can write, but faint subjective numbness remains. Clinical tests for anæsthesia (wool, pin-prick, deep pressure) normal. Headache +, high frontal. Cranial defect is strong, concave, pulsates visibly. Tendon jerks arms absent, legs normal, ankle clonus two beats both sides.

September 22, 1918.—Evacuated.

Both this case and Case 6 presented a numbness of the ulnar portions of the hand, involving the inner three fingers. They are good examples of pseudo-radicular anæsthesia of cortical origin, and in the latter stages both exhibited what Head has called "introspective" anæsthesia. Unfortunately, rough tests only were made, but no doubt the joint sense and power of fine discrimination would have been found defective at first, had they been tested.

(c) *Injuries of the Visual Cortex. (Four cases.)*

Four examples of visual defect from cortical contusion occurred amongst these cases. The area striata occupies a comparatively sheltered position, less exposed to superficial trauma than the motor area and that for common sensibility. So that, unless there is a direct injury over the occipital pole, vision is not likely to suffer, and if the trauma is a direct one, the cranium will probably be fractured, and

such cases are not being described in this series. It may be noted, however, that in my depressed fracture series, fifty-one in number, visual upset occurred in six out of nine possibles. Certainly the visual cortex is no less susceptible to trauma than the other cortical projection areas, and my first impression was that it is more so.

The concussion changes clear up rapidly; thus two had normal visual fields and normal acuity within a week (one in six days, one in seven), whilst only one had a persistent scotoma, lower quadrantic, when evacuated nineteen days after the injury. In this last case, the affected visual field had recovered to a very appreciable extent in that time.

In Case 11 outlined below, the trauma fell over both occipital poles and in his case acuity was greatly depressed without noteworthy interference with the peripheral field. A central scotoma was present at first, but it cleared up and at the end of seven days vision was normal and he could read the newspaper comfortably. When the blow falls to one side of the mid-line of the occiput, no doubt the *falx cerebri* exerts an influence in limiting the concussion change to the near pole of the hemisphere only.

Hine has considered these concussion changes in detail, and gives charts showing the progressive diminution of the scotoma as the contusional effects pass away.

Case 11.—Scalp wound over left occipital lobe. Cranium intact. Severe contusion visual cortex. Lumbar puncture. Recovery.

Private J. W. (Series No. 8). Aeroplane bomb wound left occiput, almost in mid-line frominion forward for 5 in., August 13, 1918. Sutured in — Casualty Clearing Station. No bone injury. Admitted No. 14 General Hospital August 14, 1918. Unconscious for some hours after wounding. Headache ++, fixed. Drowsy. Tendon jerks exaggerated, equal. No vomiting. Vision: Sees a white mist only; can just see people as shadows if they are between him and the window.

August 18, 1918.—Vision improving daily; can see across the ward; counts fingers correctly. Sees people to-day, but acuity depressed, for their faces are blurred. Visual fields equal and not contracted; small central scotoma.

Lumbar puncture: 20 c.c. of cerebrospinal fluid withdrawn; clear; tension normal.

August 22, 1918.—Visual fields normal; can read to-day; vision seems to have recovered completely.

October 10, 1918.—Heard from; says eyesight is bad; has severe headache and cannot sleep: "sorry to say my eyesight has improved very little"; probably a hysterical relapse.

Case 12.—Scalp wound over left occipital lobe. Cranium intact. Hemianopsia in right field of vision. Recovered.

Private C. N. (Series No. 73). Shell wound of scalp, 3 in. above inion and $1\frac{1}{2}$ in. to left of mid-line, November 4, 1918. Wound overlies left occipital lobe. Excised widely in — Casualty Clearing Station; no bone injury. Admitted No. 14 General Hospital November 7, 1918. Widely open excised scalp wound running from mid-line 3 in. laterally. Needs a plastic operation to close wound as edges cannot be approximated. Never unconscious; no vomiting. Headache +, occasional, "fixed." Tendon reflexes exaggerated on right side; arms +; legs ++; left side normal. Pulse 56. Vision: Complete hemianopsia up to fixation point in right field of vision.

November 8, 1918.—Operation, novocain-adrenalin anæsthesia. Cushing's "Isle of Man incision" for plastic flaps. Flavine wash. Suture with flavine cigarette drain. Bone uninjured.

November 9, 1918.—Vomited once early this morning.

November 11, 1918.—Drain removed. Very dull mentally. Pulse has run 48, 56, 60, 50, 56, 56.

November 14, 1918.—Still drowsy; lumbar puncture performed; 25 c.c. clear cerebrospinal fluid withdrawn. Tension +.

November 16, 1918.—Much better and brighter.

November 23, 1918.—No headache. Tendon reflexes normal, but ankle clonus two beats, both. Vision improved; residual scotoma in right inferior quadrant slightly invading superior. Can read easily.

IX.—CONTRALATERAL CEREBRAL CONTUSION.

Evidences of contralateral cerebral contusion were noted in four cases, in all of which the motor cortex was the sufferer. In these cases there was increase of the tendon reflexes on the same side as the scalp wound, but the brain lesion was never so severe as to cause more than a numbness and slight weakness of the hand at the most, a declared palsy was never seen. A slight contralateral meningo-cortical hæmorrhage was probably present, as the disability rapidly wore off. The following is an example, and represents the mildest form which local brain contusion can take. The signs are definite enough to leave little doubt as to the actual condition present.

Case 13.—Scalp wound over right parietal eminence. Cranium intact. Contralateral injury left motor area. Recovery.

Lance-Corporal A. M. (Series No. 63). Shell wound right parietal eminence, November 4, 1918. Admitted No. 14 General Hospital November 6, 1918. Wound is small and superficial. Never unconscious. Headache +, left parietal. No vomiting nor nausea. No palsies. Tendon reflexes, arms normal, legs ++, inclined to be clonic, right more than left. Ankle clonus four to five beats right, nil left. Pulse 64.

November 12, 1918.—Pulse 48. No headache. Right side tendon jerks (i.e., same side as head wound) more active than left; clonus six beats right side. Pulse running 64, 60, 50, 68, 48. Evacuated, United Kingdom.

November 13, 1918.—Heard from. Very well; slight giddiness only.

This was evidently an injury of the left parietal cortex by *contre-coup*, and presents evidences of a very slight contralateral injury in the form of increased tendon reflexes without a sign of paralysis.

X.—PATHOLOGICAL ANATOMY OF CEREBRAL CONTUSION.

As all of these scalp wounds recovered, one cannot say from experience exactly what the lesion was, but presumably it took the form of a slight meningo-cortical hæmorrhage. This could rarely have been large for two reasons: in the first place the palsies rapidly cleared up, which they could not have done had the cortical hæmorrhage been of any magnitude, and in the second place the cerebrospinal fluid was clear and untinged in those cases where it was withdrawn, and was not even yellow from old hæmoglobin staining, a discoloration one not infrequently finds after severe head injury. The only observations known to me which illustrate the pathological changes underlying a simple increase of tendon-reflexes and ankle clonus of cortical origin, arise out of the very interesting series of contralateral contusions associated with penetrating head wounds published by Duperié [3]. He found, at post-mortem, patches of meningo-cortical hæmorrhage in twelve cases and severer injuries in six more. No doubt a disorganization of brain substance or a severe intracranial hæmorrhage is the pathology underlying those deaths which rarely occur in scalp wounds pure and simple (Cushing, *loc. cit.*) and may occur in lesser cases. Sometimes the disturbance may amount to no more than a local œdema, or even a commotion without gross pathological change. A continuous slight cortical stimulus, which becomes subliminal under certain ill-defined circumstances of fatigue and of changes in the circulation, seems to be the cause of Kozhevnikov's syndrome.

XI.—SUMMARY.

An analysis of the neurological symptoms and signs presented by a series of fifty-four scalp wounds treated at the base in France shows how frequently such signs are present. In only five were no such evidences found. Two types of cases must be distinguished, those in

which the changes are concussion and general, and those in which signs of a definite local cerebral contusion make themselves apparent. Seventeen cases of localized cerebral contusion were found in this series (31.5 per cent.), but reasons are adduced in the text for this figure being too low. Something over 40 per cent. is probably more accurate. This is a large number and the present series is too small to render dogmatic assertion permissible. But there is no doubt whatever that the neurological signs of underlying cerebral mischief in scalp wounds have been greatly neglected in the past; the eye has seen only the wound of the scalp and the mind has travelled no farther. In the majority of cases the symptoms are of a transient character and are not often very apparent (save in the case of Jacksonian seizures). Further the patients rarely associate the numbed or weak hand and the contracted visual field with the head wound and do not mention the subject spontaneously.

In none of these series was there any injury to the skull, yet there were eleven definite local contusions of the motor cortex, four of the visual, and two more in which a motor lesion was associated with a sensory disturbance of the hand. Three presented Jacksonian seizures, and three were trephined on the neurological evidence; in two, an extradural clot was found; in one, nothing abnormal. There were signs of contralateral injury by *contrecoup* in four cases.

This is sufficient to show that scalp wounds offer a definite field for neurological investigation, though scalp wounds in civil practice will probably not be so fertile a field for exploration, as the force which produces them is usually less than that of a high-velocity projectile.

There is a moral to be drawn from the above findings with respect to the assessment of pensions. It must be remembered that whilst the wound of the hairy scalp may have been in itself a trivial thing, many men may have suffered a cerebral injury of no little moment, and this must be given adequate consideration in the medical boarding of such subjects.

In conclusion, I must tender my thanks to several people: to Colonel Webb-Johnson, C.B., D.S.O., for collecting the head patients together for me and for arranging special facilities for working up the cases for publication; to Colonel Gordon Holmes, C.M.G., for his help and advice on the clinical side, and to Colonel R. J. C. Thompson, C.M.G., D.S.O., the officer commanding No. 14 General Hospital, for permission to publish these cases. Nor can I close without thanking Major C.

Mackenzie, O.B.E., and Captains R. S. Dobbin, O.B.E., and R. F. Young, M.C., who have kindly operated upon some of these patients for me.

XII.—REFERENCES.

- [1] ADIE, F., and WAGSTAFFE, W. W. "656 Cases of Gunshot Wounds of the Head," Medical Research Com. Statistical Reports, 1918, vol. i, p. 17.
 - [2] CUSHING, HARVEY. "A Study of a Series of Wounds involving the Brain and its Enveloping Structures," *Brit. Journ. Surg.*, 1918, vol. v, p. 565.
 - [3] DUPÉRIÉ. "Recherches sur les symptômes homolatéraux dans les perforations du crâne et de l'encéphale par les projectiles de guerre," *Rev. Neurolog.*, 1916, vol. xxix, p. 616.
 - [4] HEAD, HENRY. "Sensation and the Cerebral Cortex," *Brain*, 1918, vol. xli, p. 57.
 - [5] HINE, M. L. "Recovery of Fields of Vision in Concussional Injuries of the Occipital Cortex," *Brit. Journ. Ophthalmol.*, 1918, vol. ii, p. 12.
 - [6] HOLMES, GORDON, and LISTER. "Disturbances of Vision from Cerebral Lesions with Special Reference to the Cortical Representation of the Macula," *Brain*, 1916, vol. xxxix, p. 31.
 - [7] KOZHEVNIKOV. "A Special Form of Cortical Epilepsy," see *Neurolog. Centralbl.*, 1895, vol. xiv, S. 47.
 - [8] POLLOSSON, A., and COLLET, F. S. "Epilepsie partielle continue d'origine traumatique, trépanation, guérison," *Rev. Neurolog.*, 1915, vol. xxviii, p. 291.
-