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OPHTHALMIC INJURIES IN WAR*

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THE present war has taken on the character of trench warfare. The experience of the World War showed that on the Western Front eye injuries increased two and even three times during the period of trench warfare in comparison with the preceding period of open warfare (Darier).

Trench warfare consists mainly of artillery activity which, directed against fortifications, inflicts not only wounds through fragments of bomb, shell and shrapnel, but also by innumerable splinters of stones, cement and sand. These splinters, "indirect projectiles," accompany every explosion and, thanks to their having acquired great speed, cause injury to the globe of the eye no less dangerous than that of the shell fragments. But, according to my own observations, the most destructive agents of the visual organ are rifle and machine gun bullets which cause mainly transpiercing wounds of the head, orbit and of the eye itself.

These observations were made at the Chief Casualty Clearing Station on the Russian South-Western Front during 1914 and 1915, and from 1916 as consulting ophthalmologist to the Army

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on the same Front. I had the opportunity of observing and studying every variety of ophthalmic injury from the day of injury, and later followed cases through until the Special Medical Board finally decided whether the patients were fit or not for further service in the army. The early cases numbered 238, while 593 cases of eye injuries were treated at the hospitals in the rear and are termed "late cases." Study of late cases showed that each eye patient occupied a bed, on an average, during 46.8 days. Out of 100 wounded there were 2.25 cases of eye injuries; out of 100 head injuries, 20.4 per cent.—very similar to the figures given by Oguchi for Japanese casualties in the Russo-Japanese war. The figure of percentage relation of eye wounds to head wounds refers with certainty only to those cases which reached the Chief Casualty Clearing Station and the rear Hospitals, as the penetrating through and through gunshot wounds, eye—brain, in the great majority of cases were mortal and did not reach the Hospital.

There has been little if any change in the nature of gunshot wounds since the Great War, and so some more detailed description of the injuries incurred and their end results may be of service to medical officers in this war. The results of my clinical and statistical studies have been published in a whole series of articles in different Russian medical and ophthalmological magazines. But the aim of the present article is to point out those cases of fire-arm injuries of the visual organ, the therapy, diagnosis and prognosis of which can present difficulties to many surgeons during the first weeks of their war practice, as was experienced by myself.

Out of many similar cases two cases of cortical blindness might be mentioned, one of which was caused by a rifle bullet which pierced the occipital bone somewhat lower than the apex of the lambdoidal suture. This case was accompanied by injury to the brain tissue of this region. In the second case there was a concussion of the occipital region due to the explosion of a heavy artillery shell.

First case (Fig. 1). The patient, Trooper K.A., aged 32 years, arrived at the Chief Casualty Clearing Station 22 hours after being wounded. He stated that he felt he was wounded in the head on the previous day and lost consciousness. When he came to himself again he noticed that he did not see anything, though he felt that the lids were open. The patient coherently answered the questions put to him. Eye examination: lids, eye-ball movement and external membranes of the globe were normal. All pupillary reactions—normal; Fundus oculi—normal. Vision: R.E.=L.E.:—perception of light directed straight into the eye. In the periphery of the retina the patient had no perception of light. He complained of headache and blindness. On examining the

patient's wounds on the occipital bone it appeared that the wounds of entry and exit were almost alike in size and were located at a distance of 6 centimetres from each other on either side of the middle line in the occipital region. Brain substance was flowing out of both wounds, but there was no other pathological finding. During the first examination the patient lost consciousness several times and his pupils were fully dilated. The diagnosis was obvious: any oculist would have no difficulty in diagnosing cortical amaurosis due to wound in the occipital region, but the prognosis was established only during hospital treatment. After proper toilet of the wound and the removal of bone splinters, a sterile dressing was applied and an ice-bag was placed on the occipital region of the head. On the next morning (two days after being wounded) the patient could distinguish hand movements. Temperature normal. On the second day the vision = 0.5 in both eyes. During the dressing a small quantity of oily, viscous material was discharged from the wound. The patient vividly described the details of the battle in which he was wounded. On the fourth day his vision was 6/6. The field of vision for white, red and green colours was normal. The fundus oculi was normal. Temperature normal. On the fifth day the patient was evacuated to the rear.

The *second case* of cortical blindness was caused by concussion of the occipital region following the explosion of a heavy shell without any visible injury to the occipital bone. Trooper K.K., aged 24 years, stated coherently that 8 days previously, he was wounded in the head during a shell explosion in the trench; the trench was destroyed and he himself buried by earth. He came to himself when he was being driven in an ambulance wagon, and the first thing which he felt was that he had become blind in both eyes. He complained of severe pain in the head which, according to his words, was shot through in the region of the neck. On examining the skull on both sides of the occipital protuberance there were slight skin scratches. When palpated, the skull bones appeared to be intact. (There was no X-ray apparatus at the Station.) Besides blindness there were no other changes in the somatic and psychic spheres. During the examination of the vision the following was noticed: the pupillary reactions to direct light and the consensual reactions were very sluggish; on attempting convergence the left eye showed external deviation. Vision R.E.—light perception, L.E.—movement of hand before the eye in the nasal half of the field of vision. Ophthalmoscopic examination: the margins of the optic disc of the right and left eyes were slightly swollen, the veins of the disc somewhat widened in the left eye and even tortuous in the right eye. Treatment: rest and ice-bag on the head. On the eighth

day of the patient's stay in the hospital the improvement observed was very slight. In R.E., hyperaemia of the optic disc was more pronounced than in L.E. Vision R.E.=counting fingers from the distance of 2 metres in the temporal side of the field of vision; L.E.=2 metres also in the nasal side.

In view of urgent need to evacuate wounded, the patient was sent to Kiev with the diagnosis: Cortical amaurosis, right hemianopia and intra-cranial haemorrhage in the occipital region of the head due to concussion. The later history of the case is that five weeks afterwards the patient was found unfit for further service by the Medical Board, the cause being the right sided hemianopia and the deficient vision: viz., counting of fingers at the distance of 2 metres in the seeing part of the retina of both eyes.

These two cases may serve as examples of the fact that the prognosis regarding the degree of loss of vision resulting from injuries of the cortical visual centre should be very careful: the vision sometimes remains unimpaired when the brain substance of the visual cortex is lost; while the concussion of the occipital bone (the skull being intact) can produce an intra-cranial haemorrhage with a moderate papilloedema and also disturbances of the visual cortex resulting in hemianopia of different grades and various central and paracentral scotomata with great loss of vision.

Similar cases of cortical blindness after wounding and concussion as well as injuries of the visual path were observed at all fronts, and were described by a whole series of English, French and German surgeons. (Lister, Gordon Holmes, Hine, Jessop, Pierre Marie and Charles Chatellin, Uththoff and others.)

But at the Chief Casualty Clearing Station it is necessary to decide quickly and differentiate between injuries and concussions of the cortical visual centre on one hand and the multitudinous cases of hysterical blindness due to severe traumatic neurosis with loss of vision on the other.

The differential diagnosis between these two morbid syndromes of blindness consists in that the patients suffering from cortical blindness due to injury walk bravely supported by their comrades, talk willingly and show no signs of psychic disturbance, while "the blind" suffering from a form of a severe traumatic neurosis have a peculiar posture distinguishing them from hundreds of other wounded. These patients supported by their comrades walk heavily leaning on a stick, walk carefully as if afraid of losing their balance; the expression of their faces is gloomy, unsatisfied and as though frozen; the gaze is purposelessly fixed staring forward; the movements are slow and languid, the voice is monotonous; the answers are monosyllabic and slow. It seems

as if the patient hears the words addressed to him indistinctly, forms an answer with difficulty, stammers often and sighs. Usually in the history we found that the patient had been wounded by the explosion of a heavy shell, or had fallen on his back during the explosion. With such patients, besides well known hysterical eye symptoms (such as marked concentric contraction of the field of vision for all colours, proptosis, miosis, nystagmus and so on) may also occur diplopia and monocular polyopia, accompanied sometimes by micro-megalopsia et macropsia.

These cases were discovered by the author in the following way : when patients alighted from a hospital train, I inquired of each soldier with a bandage round his head about the condition of his sight, and invited him to count the fingers at the distance of one metre with each eye separately. Showing one finger I asked "How many fingers?" A patient with monocular diplopia or polyopia would answer slowly, as if hesitating, "two" or "many." When ordered in the dressing room, in the presence of other doctors and nurses, to take hold of the right finger, the patient would extend his arm and take the false image seen by him at the right side of the real position of the finger. Not feeling the finger in his hand the patient became disconcerted and perturbed and said confusedly, "no, there's nothing!" On endeavouring to take hold of another finger on the other side the same mistake was repeated. Then the patient, visibly agitated and perspiring all over, started moving his hand from one false image to the other, and coming across the real finger shown took hold of it and firmly gripped it, as if desiring to make sure that he had taken hold of the object seen by him. Such patients were not left at the Chief Casualty Clearing Station, but were immediately sent to hospitals in the far rear of the country.

But at the Chief Casualty Clearing Station the oculist sees chiefly gun-shot injuries of the orbit and its contents. Out of 287 cases of injuries to the eye ball it appeared that together with orbital injuries there were 163 cases of eye-ball wounds, *i.e.*, 56.4 per cent., and 124 cases without orbital injury, *i.e.*, 43.6 per cent. From these figures it follows that the orbit not only does not protect the eye-ball from destruction, but also contributes to the destruction of the integrity of the eye-ball by fragments of orbital bones.

On the Russian Front, at the beginning of the war, artillery battles did not attain such an intensity as on the Western Front. Therefore, in my statistics rifle-bullet wounds of the orbit and its contents predominate. But of the above 163 cases of injuries 109 or 66.7 per cent. were inflicted by a rifle-bullet, and 54 or 33.3 per cent. by artillery shells. It is necessary to point out that the rifle bullets give predominantly a through and through penetrating

wound of the orbit (79.8 per cent.), while the artillery shell fragments give piercing wounds of the orbit amounting to 21 per cent. of orbital injuries. The rifle bullets inflict nearly three times more through and through penetrating wounds of both orbits (19 cases), than the artillery fire (7 cases).

When diagnosing the character and extent of the orbital injury the surgeon should take into consideration that its cavity is filled with a semifluid mass—orbital fat on which the eye rests; the muscle tissues are also rich with fluid. The rifle bullet passing behind the eye-ball transmits its energy to the fluid which, thanks to its incompressibility, presents an ideal medium for the transmission of the energy conveyed. The kinetic energy of the Russian bullet at the moment of its exit from the gun-barrel was 303-402.5 kilogramme-metres. Certainly the modern fire arm agents and bullets have bigger velocity and bigger mass than before. Therefore, their destructive action must be also bigger.

The bullet having penetrated the orbit acts by its force not only along the line of its path, but develops immediately hydrodynamic forces in the fluid contents of the orbit, and these forces act in all directions perpendicular to its path. (Explosive effect of the bullet.) These forces strike also the posterior pole of the eye-ball and the same impact will be sustained by all the walls of the orbit. On applying a force of great momentum to an elastic body, in this case to the eye-ball, the latter either will change its form, *i.e.*, there will appear different ruptures of the eye-ball itself or of its internal membranes (choroid and retina) or it will change its position, *i.e.*, the eye ball will move in the direction of the action of the energy, in our cases—towards the aperture out of the orbit; which gives a clinical picture of protusion, luxation, or avulsion of the globe and orbital contents. Such cases are described below and illustrated by Figs. 2, 3, 4, 4a and 4b.

Trooper K.C. was wounded by a rifle bullet on November 28, 1915. The diagnosis was a gunshot wound of the temporal bone and left frontal bone. Ectopia of right orbital contents and counter-rupture of the sclera of the left eye. The wound of entry was 6 cm. outside from the outer margin of the ligamentum externum of the right eye-lids; the wound of exit was 2 cm. beyond the left eye-brow (Fig. 2). Out of the right palpebral fissure a formless fleshy mass covered with coagulated blood protruded; under this bloody clot stretched—like a finger of a glove turned inside out—the periorbita, attached at the orbital margins by a compact fascia periorbitalis. In other words, it was a case of traumatic autoexenteration of the orbit.

After excision of the expelled periorbita (under chloroform anaesthesia) it appeared that the external and internal walls of the

TABLE I

FIG. 1.

FIG. 2.

FIG. 3.

right orbit had been destroyed only along the path of the bullet, while the upper wall of the orbit (not touched directly by the bullet) was destroyed utterly and broken into tiny splinters which were forced in a great quantity into the periorbital tissue pushed outside. At the upper wall of the orbit there were big bone defects through which prolapsed brain tissue. The microscopic examination of the mass expelled (Fig. 3) failed to discover either the eye-ball membranes, or the optic nerve, the mass consisted only of periorbital tissue with the rest of the periorbital fat cells and other orbital tissue, and of bone fragments forced into it. In drawing 3, which shows a horizontal section of the mass, bone fragments are marked by 1; necrotic tissue—by 2; blood clot—by 3.

The process of the expulsion of the orbital contents and absence of the eye-ball may be explained in the following manner: the bullet, when passing from the right side to the left, broke the orbital pyramid at its apex and cut the optic nerve; then owing to the hydrodynamic forces (explosive action of the bullet) the globe together with the periorbita was dislocated outside into the rima palpebrarum, *i.e.*, in the direction perpendicular to the passage of the bullet. It is important to note that the upper wall of the orbit was also broken by the same explosive action of the bullet in the direction perpendicular to its path, the perpendicular force acting both upwards and downwards. Besides being pushed forward from behind by the explosive action of the bullet the periorbita was also expelled by the subsequent strong haemorrhage and turned inside out, as a glove finger turns wrong side out when being pulled off the hand; the eye-ball having no firm connection, freed from its attachment to the external eye by muscles to the Annulus Zinnii, simply rolled out of the orbital contents. For the complete understanding of this case it is necessary to add that on investigating the left eye-ball there was found in the lower inner quadrant of the sclerotic, near its corneal margin and parallel to it, an inferior rupture of the sclerotic with prolapse of the iris and ciliary body. In other words, although the wound of exit was lying in the frontal bone over the left eyebrow, "the explosive action" of the bullet spread perpendicularly to its path, pressed the eye-globe from the top downwards, wherefore by contrecoup occurred the inferior corneo-scleral rupture.

Under chloroform anaesthesia the tissues near the orbital margin were cut off by means of scissors. Bone fragments were removed from the orbit, and the orbit was filled with sterile gauze. On the second and third days after the operation the temperature rose to 38° C., but then did not rise higher than 37.2° C. On the tenth day the invalid felt so well that he walked to the Hospital train supported by one man.

TABLE II

FIG. 4.

FIG. 5.

FIG. 4a.

FIG. 4b.

Second case: W.B., aged 26 years, wounded by a rifle bullet.
Diagnosis: Gun-shot wound of temporal bone on each side, with luxation of the globe and evulsion of the optic nerve on the right side and rupture of the left globe by contrecoup (Figs. 4, 4a and 4b).

In Fig. 4 the point of entry was lying 4 cm. external to the outer corner of the right eye, that of the exit—at the external angle of the upper lid of the left eye. On examination *the right eye* appeared to be luxated outside. It was held only where the conjunctiva was fastened to the tarsus of the upper and lower lid. The cornea was not perforated but black. The left eye was decreased in its dimensions. The cornea was gray, not transparent, there was no anterior chamber, the eye-ball was soft.

An operation was performed on the right eye: under chloroform anaesthesia the conjunctiva was cut by means of scissors along the circumference one centimetre from the upper tarsal margin. The conjunctiva was densely adherent by scar tissue to the underlying tissue. When this scar tissue was being cut by means of scissors, crackling was heard due to its density. When the conjunctiva was cut away the globe fell off. The separated eye was photographed in a scale somewhat smaller than the actual size and shown in Fig. 4a. There was no optic nerve in the globe; it had been torn from it; the orbital walls were covered with the periorbital tissues, and no evident destruction of its walls was noticed. Daily bandaging, washing the wound with hydrogen peroxide, tamponing the wound were done. Three days later the wound appeared to be granulating; headaches which had been insupportable before had now diminished, consciousness which early had been dull was now clear; general well being was satisfactory. The temperature was normal all the time. The next day the patient was evacuated to the base.

Fig. 4b shows a section of the microscopic preparation magnified two and a half times. It is possible to see that the conjunctiva starting from the cornea (1, 2), covers further all the exterior part of the sclerotic which in its posterior part (3) is covered with the orbital tissues (6, 7). There is no optic nerve, it had been torn out of the globe, and in its place there remained the cavity (8), the walls of which consist of fat, cellular, and orbital tissues. The inside of the eye is filled with blood clot, the lens is luxated inside the eye-ball and lies touching the posterior pole (4b).

This case of luxatio bulbi is of great interest in that there is a true evulsion of the optic nerve, while it confirms the presence of the explosive action directed towards the posterior pole of the eye-ball, owing to which the eye was torn off the optic nerve like a cherry off its stem. The lens by contrecoup was dislocated into the vitreous close to the posterior pole. The whole cavity of the eye-ball was filled with blood.

The fact that the patient suffered from severe headaches and an impaired consciousness indicates trauma of the brain and the meninges, which rapidly improved by rest. No doubt, these disturbances were caused by the effect of explosive force on the bony walls of the orbit.

In 163 cases I observed in only 9 cases a penetrating wound of both temporal bones, *i.e.*, 5.6 per cent. They have been mentioned at the beginning of the article because a surgeon does not observe them in peace time, and because these cases give the possibility of appreciating the effects of the explosive action in a gun-shot wound causing much more extensive destruction than one can suppose on external examination.

The following table shows the various directions of orbital gun-shot injuries:—

			Per cent.
1. Injuries orbito—cranial	...	68 cases	41.7
2. „ orbito—subcranial	...	12 „	7.3
3. Bilateral temporal injuries	...	9 „	5.6
4. Orbito—facial injuries	...	74 „	45.4
		<hr/> 163 cases	<hr/> 100.0

This table illustrates how dangerous to life are the injuries of the orbit, as a cavity lying near the brain. To the orbito-cranial injuries I refer all the orbital injuries where the wound of entry or of exit, or both lie above the upper margin of the arcus zygomaticus, *i.e.*, where the cranial bones bordering on the anterior and middle cranial fossae may also become subjected to trauma. To the injuries orbito-subcranial I refer all the injuries where the bullet, having entered the orbit or destroyed its walls, breaks its way under the base of the brain, and comes out below the mastoid process, and at different heights of the back of the neck depending on the position of the head at the moment of injury. On the basis of above figures, one may come to the conclusion that in every two orbital injuries one will be accompanied by injury of the cranial bones, and, as a consequence, by trauma of the meninges and of the brain itself. Therefore, injuries in the orbit should be considered as cranio-cerebral ones, and appropriate care taken in treating and transporting such patients. A serious injury to the orbit causes most certainly such damage to the bulb of the eye that enucleation is necessary. The surgeon should very carefully separate the lacerated sclera from the underlying tissues in order not to inflict any additional trauma to the tissues and walls of the orbit which have already been injured by the bullet. Usually several days after the injury the lacerated sclera and particularly posteriorly is attached so densely to the underlying orbital tissues that, when cutting through them, a creaking sound is heard as if glass was being cut. In such cases it is better not to draw upwards by force the remains of the sclera on the optic nerve, but to cut them as short as possible, having cleaned them thoroughly from remains of the choroidal tissue.

It should be made a rule that the enucleation of the eye must be performed by an eye-surgeon, who is accustomed to preserve every millimetre of the conjunctiva for the formation of a conjunctival sac of a sufficient dimension for the future prosthesis.

The fear of sympathetic ophthalmitis setting in, has sometimes led to the hurried enucleation of the eye. This fear is groundless. There are no proved cases of its having set in before the seventh day after the wounding of the eye. This time is sufficient enough for sending the patient to an eye surgeon. Among 593 "late cases" the author saw only one case of sympathetic irritation on the twenty-sixth day after the injury. Among 238 "fresh cases" he met neither sympathetic irritation, nor sympathetic ophthalmitis.

As to the problem of the influence of injuries of the orbit and its contents on one side on the condition of the vision in the other eye, no change in the unaffected eye was observed among 137 cases of one-sided orbital injury.

The healing of orbito-cranial injuries under hospital treatment at a Chief Casualty Clearing Station was satisfactory enough. The abundant, often evil smelling suppuration decreased and soon discontinued under the influence of soaking gas tampons. The wounds granulated well. "Fresh" cases with destruction of brain and the meninges did not develop meningitis. The temperature which was high before and immediately after the operating and opening the wound wide, removing fragments of bones and enucleation of the damaged eye, abated after 3-4 days. Consciousness, which had been dulled, soon became clear again, and severe head-aches disappeared.

However, the prognosis for the general health, and even for the further life of the patient with orbito-cranial injuries should be made with great care. I have seen a fatal case of suppurating meningitis which set in 52 days after a penetrating wounding of both orbits. Previously the general health of the patient was good and he had been already ordered to appear before a final medical board for his discharge. One case of a tangential injury of the orbit from a rifle bullet was complicated by a cerebral abscess which developed on the twentieth day after the wounding. The end was fatal. Therefore orbito-cranial cases should be kept in hospital as long as possible, before the patients are sent home.

Orbito-facial injuries, *i.e.*, those where the wounds of entry and of exit lie below the upper margin of the arcus zygomaticus, in cases of oblique or penetrating wound of the external or lower wall of the orbit, are always accompanied by a major or minor injury of the eye-ball. In none of the 74 cases seen by me was consciousness affected, nor were there severe head-aches caused by trauma to the brain or the meninges. It is, therefore, possible

to conclude that the orbito-facial injuries, however extensive they may be, cause no trauma to the brain and the meninges.

Therefore, the classification of orbital injuries into the orbito-cranial and orbito-facial ones has both anatomical and clinical reasons. The former endanger the life of the patient while the latter, however terrible the appearance of the wound with the antrum of Highmore exposed, or the zygomatic process and evil smelling pus welling out, are not fatal, for the wounds heal well. Usually in oblique orbito-facial injuries the anterior hemisphere of the globe with the choroid attached is ruptured. Pieces of the choroid may partly adhere to the tissues of the orbit. In such cases enucleation or exenteration of the eye should be postponed until the suppuration from the wound stops, and then the patient should be sent to the base to a suitable hospital for an osteoplastic operation.

As to the character of wounding of the eye-ball without injury to the orbit, the wound was inflicted by artillery fire and bombs in 59 cases (47·5 per cent.), and by gun-shots in 39 cases (31·5 per cent.). The remaining cases refer to the category of casual wounds: the patient had met with a bayonet, ran against a tree branch in the night, fell or was knocked against a stone and so on. In 59 cases eye-ball injuries were accompanied by a prolapse of the iris; in 23 cases this prolapse was aggravated by traumatic cataract. In 28 cases iridocyclitis was observed; in 15 cases there was complete destruction of the eye, in 17 cases there was panophthalmitis of both eyes, which in four occurred simultaneously. Such severe injuries are also observed in peace time and they require just the usual accepted treatment, as: cutting away of the prolapsed iris, covering the wound by conjunctival flap, removing the lens, extraction of a foreign body, exact determination by means of X-rays of the location of the foreign body, applying the magnet and so on. But during the war the final results of all the perforating injuries were bad. In "fresh" cases met with by the author the eye preserved a slight vision in 15 per cent. cases. In "late" cases seen at Eye-Clinics of Kiev University the vision was preserved only in 8·2 per cent. cases. Early operation is likely to preserve the sight in twice as many cases as in late cases. The cause of such a high percentage of cases losing their sight is due to the "indirect projectiles." The tiniest splinters, on account of their enormous kinetic energy, tear through the cornea and the sclera. These splinters consist of the tiniest particles of stone, sand, cement and any kind of dirt or mud blown up by the explosion of shell or bomb. These particles are so small that after enucleation of the eye it is impossible to perceive them with the naked eye, or to palpate them in the retina and the choroid between the fingers. It is

possible that eye-shields (Cruise) would prove a partial protection against these splinters during the explosion of bombs and grenades. There were no such protective shields in the Russian army, and I have had no experience of their use. The destructiveness of these splinters may be illustrated by the following case (Fig. No. 5):

Trooper W.N. was wounded during the explosion of a heavy shell near trenches. The shell blew upwards. The patient saw that it exploded not far from him and felt immediately as if his eyes were burnt and that something had knocked against his arm. Eight days after, the patient was brought to the Chief Casualty Clearing Station. The face was covered by tiny excoriations and scratches. On the part of the *eyes*: perforated wounds and panophthalmitis. R.E.: Scleral rupture and prolapse of vitreous. L.E.: Corneal wound and suppuration. Protrusion of the globe. (Fig. 5.) Such extensive and destructive injuries to the eyes are not observed in peace time. This case is of interest also, because it shows clearly how much more complicated becomes the comparatively simple operation of enucleation under war conditions. Owing to violent pain in the left eye, it was decided to enucleate it. But on operating, the conjunctiva was separated with difficulty on account of adhesion to the sclera. All the extrinsic eye-muscles had adhered so densely to the underlying tissues that the hook for tenotomy could not be introduced, and it proved impossible to draw upwards any of them: the hook met everywhere with sclerotic connective tissue. Instead of the classic enucleation, exenteration had to be performed at first, and then the sclera was separated from the underlying tissue with great caution. The sclera was cut off from the optic nerve in such a way that a small part of sclera remained adherent to the nerve. The patient was fit enough to be evacuated after four days.

Among 238 "fresh" cases the eye was enucleated in 33 cases, *i.e.*, in 13.8 per cent., but among "late" cases consisting of 593 casualties the eye was enucleated in 218 cases, which constitutes 37.5 per cent. In other words, however strong the desire for preserving the eye in late cases was, the surgeon had to enucleate the eye three times more often than in "fresh" cases, in order to avoid the danger of sympathetic ophthalmitis.

Concussion of the globe.—However, loss of sight in war occurs not only on destruction of the exterior membranes of the globe (corneo-scleral rupture, and laceration of the bulb), but also when its exterior form is preserved intact. Such disturbance of vision is due to concussion of the eye. But the physical laws at work in both types of injuries are the same.

Although the force exerted at the point of impact may be great, it is applied to the eye-ball not at the posterior pole (the

results of which have already been mentioned above), but at some other side (upper, lower, outward) and the bony wall of the orbit prevents the dislocation of the eye-ball, as a whole. In this case dislocation of the part takes place, since dislocation of the whole is impossible. The tissues of the eye-ball are separated from each other. The tissues of the eye are stretched even until they rupture.

The limit of the stretching of any tissue is dependent on its elasticity. The more elastic the tissue, the greater is the limit of its stretching and vice versa. Daily experience teaches us that with reference to trauma the vascular system of our body is the least elastic. A momentary blow, even of moderate force applied to the skin of the arm, causing no damage to the integrity of the epidermis, will cause disturbance of the vascular system at the point of impact resulting in a subcutaneous haemorrhage of varying degree. If the blow is not so strong, however, as to cause disturbance of the integrity of the vascular system, then first spastic phenomena appear, and later paralysis of the vascular system follows. The skin grows temporarily pale and then reddens with swelling at the site of trauma. This swelling is the result of the transudation through the vascular walls; this transudate accumulates in the surrounding tissues both in its intercellular space and in the cells themselves; in other words, slight trauma to the vascular system causes that pathological condition which we call oedema.

Of the three ocular membranes—*tunica fibrosa*, *tunica vasculosa* and *tunica nervosa*—the least elastic and fragile is the *tunica vasculosa* and then the *tunica nervosa* with its own net of arteries and veins in the retina. Every kind of concussion of the eye-ball expresses itself first of all by the damage to its vascular system. It is possible to establish as a rule that the severity of concussion of the fundus oculi is in direct proportion to the disturbance of the vascular system of the two tunics: vascular and nervous. As will be shown below, the degree of cerebral concussion is determined by the extent to which the vascular system of the brain and meninges is disturbed.

The oculist has an advantage, while studying the mechanism of concussion of the eye-ball, over the physician studying that of brain. The former can observe ophthalmoscopically all the changes of the retina; whereas the changes of the "cortical retina" (*area striata*—*pars occipitalis cerebri*) are not accessible for direct observation. So also the changes in other parts of the brain causing the clinical symptoms of concussion are inaccessible to direct observation.

The ophthalmoscopic picture of a slight concussion of the retina is expressed by the aspect of a milky white cloudiness of the

retina in the posterior pole of the globe and particularly in the region of the macula lutea which is nourished by the underlying choroid.

A whole series of authors on examining the substance of this cloudiness came to the conclusion that it was the result of transudation from paralysed, dilated vessels, and the milk-white colour was due to an optical reflex. Such a white reflex may be obtained by pulverizing some transparent glass in a mortar; the powder will be seen as white while every glass particle is transparent; the cause of the apparent white colour is that among the grains of glass with their own index of refraction there is air, a substance which has another index of refraction. The two different reflexes of the two different substances give us a strong reflexion of light which we see as a milky white colour of the oedematous retina. Usually this milky white cloudiness of the retina is the result of slight trauma and disappears in 6-8 days, as soon as the blood circulation is restored. But during war, trauma is inflicted on the eyes by elements of enormous kinetic energy. A part of the vessels, both in the retina and in the choroid, is severely damaged giving haemorrhage of different degree in these membranes and into the vitreous; simultaneously, a part of the vessels is paralysed by the instantaneous blow. Ophthalmoscopically in such cases we can observe the oedema, haemorrhage and rupture of the retina (hole at the macula), and haemorrhage and rupture of the tunica vasculosa (rupture and haemorrhage of the iris, ciliary body and choroid). Groups of colloidal molecules of the transudate accumulate in the transparent tissue of the retina, and we observe various glistening white areas of the injured retina, dependent on the varying concentration and duration of its oedema. Long standing disturbances of the vascular system of the globe of the eye lead to lasting disturbances of nourishment of the tender tissue of the retina, as a result of which different degenerative changes of its epithelial elements (vacuolisation, fat-degeneration, necrosis, etc.) set in. These necrotic cells are often covered by the increased proliferation of the injured layers of pigmented epithelium of the retina and by an accumulation of connective pigment cells of the choroid after the destruction of its lamina vitrea. The fibrinous transudate organises quickly both in the choroid itself, in the retina and in the vitreous as well, and we observe connective tissue of white greyish colour along the retina and in the vitreous; in other words, we have the ophthalmoscopic picture of traumatic retinochoroiditis. As soon as the blood circulation is restored, the oedema disappears and the retina renews its visual function.

But with gun-shot concussion of the eye, as well as of the brain the disturbance of the vascular system is always extensive, and the restoration of normal circulation is delayed for a long time.

If we take into consideration that the tunica nervosa of the eye and of the cerebral hemisphere develop out of the prosencephalon, and that the tunica fibrosa (sclera) corresponds to dura mater, while the tunica vasculosa of the eye corresponds to pia mater, and that the retina and the brain have both terminal arteries of the same system then it is possible to say in advance that the essential nature of cerebral concussions will be of the same character, as concussion of the globe of the eye. The explosive action of a bullet on the cranium will correspond to what we observe in retrobulbar wounding of the orbit. As the eyeball filled with a fluid mass is enclosed in a rigid orbit, so "the sponge like brain is enclosed within a rigid skull and possesses a certain amount of independent movement and is subjected to various degrees of pressure." (Broster.)

The highly developed cerebral and intracranial vascular system will suffer first of all from any cerebral concussion which will give rise to different degrees of oedema, haemorrhage—both intra and extradural, and in different degrees to destruction of the brain substance itself. This causes a corresponding falling off of brain function. In Case I, we have seen that the oedema of the brain in the area striata led to the failure of vision. After the restoration of the blood circulation the visual function was restored. In the second case, the extensive intracranial haemorrhage which led to a long standing interference with the nourishment of the area striata, caused a lesion of the "cortical retina" with a failure of its visual function (right sided hemianopia).

The case described below illustrates the complicated injuries to the tunica vasculosa et nervosa oculi due to blast concussion. These resulted in persistent oedema of the retina, extensive haemorrhages and ruptures of both membranes with resultant degeneration of the retina and particularly of the papillomacular bundle and the optic nerve. The indirect image of the left fundus of the patient was drawn by the author 56 hours after the concussion, and then once more three days later. (Figs. 6-7.)

History of the cases.—B.V., a volunteer, aged 15 years, was bruised by the explosion of a heavy shell. He was thrown to one side and, according to his story, two troopers who were sitting close to him were killed.

The boy, well built, was in a state of a strong psychical depression, trembled all the time, and incessantly gave involuntary sighs. The speech was slow and broken, he did not answer at once, as if deaf, but the answers given were reasonable and coherent. The face was swollen and covered with multiple ecchymoses. The skin of the face was blue with ecchymoses of the lower and upper lids of both eyes.

Diagnosis: R.E.: Subconjunctival ecchymosis. Corneal

abrasions. Traumatic cataract with subluxation of the lens. Posterior synechiae. Vision: counting fingers before the eye. L.E.: Eccentric pupil. Haemorrhage and oedema of the retina, optic disc very pale. Acute pigmentation of the left fundus of the eye. R.E. could not be examined ophthalmoscopically on account of a traumatic cataract. L.E. Fig. 6 was made 56 hours after the concussion. In the lower part of the drawing extensive haemorrhages to be seen in the retina. Among the haemorrhage there are brightly glistening dots ranging in size from a big pin head to two-three mm. in diameter. Clots of blood are interspersed among milky-white areas of the oedematous retina. The vessels are greatly enlarged in the areas of oedema and partly covered by the haemorrhages. Both internal and external to the optic disc the papillo-macular bundle and the retina are of a whitish, bright steel colour. In the oedematous retina are distinguishable enlarged tortuous vessels of irregular outline and also punctate haemorrhages.

Fig. 7 was made three days after. The white glistening dots have disappeared. In the area of the haemorrhages there are seen dense patches of pigment. The papillo-macular bundle, as well as the optic disc, are still white. Vision—movement of hand at the distance of one metre from the eye. The patient does not distinguish colours: he calls red—black; green and dark-blue—sky-blue. Five days later he was evacuated.

This case is of interest in this respect that it gives us the idea of changes in the retina due to blast concussion by a heavy shell's explosion. The examination of the patient's body and face did not reveal any important injury which was caused by the fall or by a splinter from the shell.

The livid grey face is characteristic of concussion from explosion; this colour is explained by numerous subcutaneous ecchymoses caused by the sucking action in the negative phase of the blast.

The terrific fright, the trembling of all muscles of the whole body, impaired hearing, slow speech were also characteristic symptoms of blast concussion (Parsons, Grasset). Severe disturbances of the ocular vascular system caused an acute oedema of the retina, while deep destruction of the vessels of the choroid caused disturbance of nourishment in the region of the papillo-macular bundle, which led to persistent loss of visual function of the retina. The acute pigmentation of the retina was the result of the destruction of the layers of pigmented epithelium which proliferated in the inner layers of the changed retina. The rupture of the lamina vitrea of the choroid led also to proliferation of its pigmented cells in the retina.

TABLE III

FIG. 6.

FIG. 7.

The changes in the retina due to blast concussion.

Concussions of the globe of the eye owing to tangential gun-shot injuries of the upper, exterior and lower walls of the orbit gave the same ophthalmoscopic picture in "fresh" cases, as those already described as air blast injuries (Shimkin). The youth of the patients helped greatly the restoration of blood circulation in the damaged tunica vasculosa and nervosa in the majority of cases. The retina regained its transparency and gave the possibility of observing the deep ruptures of the brittle choroid which had been previously hidden by the oedematous retina (Lagrange). The ophthalmoscopic picture of similar ruptures of the choroid is well known to any oculist, as are well known also the disturbances of the anterior part of the uvea owing to the concussion of the globe (hyphaema, iridorexis, iridodialysis, subluxation and luxation of the lens, traumatic cataract, etc.) described in all textbooks on ophthalmology. But the peculiar interest of the *concussio bulbi* in war time is the severe disturbance of the vascular system of the eye to a degree far beyond what is observed in peace time.

The 1,000 lbs. bomb or shell will produce in this war even more terrible results and the destruction of the vascular system of the retina and the cortical visual centre and the brain itself will be met with still more often than in the last war.

In the World War, at the Russian South-Western front, among 100 ophthalmic injuries 77 men became blind in one eye (the right or the left), and there were 11.3 per cent. of blindness in both eyes.

The present war will give us probably an even higher percentage of traumatic blindness. Such a picture is terrible to contemplate, and we must all hope that the cause of such suffering may soon cease.

Summary

1. The author gives the results of his observations of 238 cases of eye injuries at the Chief Casualty Clearing Station and over 593 cases in base hospitals. He illustrates some of them by histories of the injuries, photos and drawings of those cases of eye injuries which are not met in peace time. He discusses difficulties in diagnosis, treatment and prognosis for the sake of those oculists who did not take part in the last World War.

2. He examines the character of the explosive action of bullets or other gun-shot missiles in wounding the orbit and stresses the enormous kinetic energy developed. He points out that the real destruction of the orbit and its contents is much more extensive than what is observed on examination of the external wound. All orbital wounds, where the missile passes over the arcus zygomaticus should be considered as cranial injuries. By these

injuries the upper wall of the orbit, meninges and the brain are wounded.

3. On the basis of numerous ophthalmoscopic and clinical observations he considers that concussion of the eye and brain is nothing but the disturbance of their vascular system. The severity of concussion is in direct proportion to this disturbance, which may result in varying degrees of degeneration of the nervous tissue of the retina and cortical visual centres.

4. Among 100 wounded there were 2.25 eye injuries and 20.4 injuries to the head. Rifle bullets gave two-thirds of all of the orbital and of the eye injuries penetrating through and through. One-third of such wounds was inflicted by artillery fire. A patient suffering from an eye-wound stayed in a hospital on an average 46.8 days.

5. The eye injuries in the war are accompanied by dense adhesions of the sclera and the destroyed choroid to the underlying tissue which greatly increases the difficulty of enucleation of the globe; therefore the author suggests that such cases of eye injuries should be sent to a centre where there is an oculist. The fear of sympathetic ophthalmitis is exaggerated: the author has seen only one case of sympathetic irritation which occurred on the twenty-sixth day after the patient had been wounded.

6. Among 100 cases of eye injuries an eye had to be enucleated in 50 cases. Among 100 cases of eye injuries and concussion 77 men lost the sight in one eye and 11.8—in both eyes. The present war threatens to produce a still greater number of blind than the last war, as in trench warfare the head, face and eyes are more often wounded than in "open warfare."

BIBLIOGRAPHY

1. CRUISE, R. R.—Protection of the Eye in Warfare. *Brit. Jl. Ophthalm.*, Vol. I, pp. 489-492, 1917.
2. DARIER.—Blessures oculaires de guerre. *Bull. de l'Acad. de Med.*, No. 15, p. 455, 1915.
3. GRASSET.—Les psychoneurosis de guerre. *Presse Méd.*, No. 14, 1915.
4. GORDON HOLMES.—(1) Disturbances of vision by cerebral lesions. *Brit. Jl. Ophthalm.*, Vol. II, pp. 352-383, 1918.
 ——— (2) Disturbances of visual orientation. *Brit. Jl. Ophthalm.*, Vol. II, pp. 449-506, 1918.
5. HINE, M. L.—Recovery of field vision in concussion injuries of the occipital cortex. *Brit. Jl. Ophthalm.*, Vol. II, pp. 12-25, 1918.
6. HOLMES and LISTER.—Disturbances of vision from cerebral lesions with special references to the cortical representation of the macula. *Brain*, June, 1916.
7. JESSOP, W. H.—On the papilloedema in gunshot injuries of the vault of the skull. *The Ophthalmoscope*, No. 12, p. 592, December, 1915.
8. KENNEDY, J. W.—Artillery. *British Encyclopaedia*, Vol. II, p. 470, 1929.
9. LISTER, SIR W.—Some concussion changes met with in military practice. *Brit. Jl. Ophthalm.*, pp. 305-318, July, 1924.

10. LAGRANGE, F.—Atlas d'ophtalmoscopie de guerre. Masson et Cie., Editeurs. Paris, 1918.
11. DE LAPERSONNE.—Indication opératoire dans les blessures de guerre orbito-oculaires. *Bull. de l'Acad. de Méd.*, No. 1, pp. 41–44, 1915.
12. MARIE PIERRE et CHARLES CHATELLIN.—Revue neurologique. Novembre-Décembre, 1915. *Bull. de l'Acad. de Méd.*, No. 24, 1915.
13. OGUCHI.—Augenverletzungen in japanischen Heere während des letzten Krieges. *Beit. z. Augenheilk.*, H. 83, 1913.
14. PARSONS.—The psychology of traumatic amblyopia following the explosion of shells. *Lancet*, April 3, 1915.
15. SHIMKIN, N. I.—(1) Injuries of visual organ in the present war. *Vestnik Ophtal.*, No. 2, February, 1916.
 — (2) Gunshot injuries of the orbit and its contents. *Vestnik Ophtal.*, No. 4–5, 1916.
 — (3) Concussions of eyes in the war. *Vestnik Ophtal.*, Nos. 6, 7, 8, 9, 1916.
 — (4) Disturbances of intra cranial visual paths and cortical visual region owing to gunshot injuries of the skull in war. *Vracheb. Gaz.*, No. 2, 1916.
 — (5) Gunshot injuries of the eye in the world war. Dissertation for the Degree of M.D. Delivered at the University of Kieff. Published at Odessa, 1917. (Ref. Book Notices, *Brit. Jl. Ophthal.*, p. 620, November, 1926.)
16. UHTHOFF, W.—(1) Ueber die Verletzungen des zentralen Sehbahnes u. des Sehzentrum bei Schädel-resp. Hinterhauptschüssen. *Ber. d. Ophtal. Gesell.*, Heidelberg, 1916.
 — (2) Handbuch d. ärztlichen Erfahrungen im Weltkriege. *Klin. Monatsbl. f. Augenheilk.*, Bd. V, pp. 303–319, 1922.

A CASE OF LUXATIO BULBI

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AMONG the many “black-out” casualties seen nowadays the following case seemed to us worthy of record because of its comparative rarity.

W. F., an A.F.S. fireman, aged 29 years, attended on October 29 at 11 p.m. with a history that he had fallen over in the dark and struck his face on something which he thought was the edge of a biscuit tin three quarters of an hour previously. He had never before had any trouble with his eyes and was not normally subject to exophthalmos. His left eyeball was dislocated anteriorly, and the lids, which were in much spasm, were almost closed behind the eye. The cornea was completely denuded of epithelium, and there was a large conjunctival tear 5 mm. posterior to the limbus from 6 o'clock to 1 o'clock on the nasal side, there was bruising of both lids, and a certain amount of subconjunctival haemorrhage, but none of the muscles, which could be clearly seen, appeared to be ruptured. The eye was almost immobile, but gave little or no pain. The pupil was small and reacted only very faintly to a bright light.