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PENETRATING WOUNDS OF THE ORBIT

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APART from war periods, penetrating wounds of the orbit are not very common. Cases of interest are found, however, scattered throughout the literature. I have recently seen three cases which are, I think, worthy of record.

Case 1.—A girl, aged 9 years, was admitted to hospital with meningeal symptoms. Two days previously she had been in an accident. While riding her bicycle she had come into contact with a farm cart and had sustained a small wound to the outer side of the right eye. It appeared that the right side of her head had struck the cart and the force of the blow had been sufficient to knock her off her bicycle. She did not lose consciousness and, after the bleeding had stopped, she was able to walk home.

On the following day she was very quiet and did not play, preferring to lie down. She gradually became more and more sleepy and, during that night, she had periods of mild delirium, alternating with periods of sleepy irritability.

On admission the child was very lethargic; she lay on her side in a flexed posture. The position was similar to that seen in early stages of meningitis. She strongly resented any attempt at examination and either could not, or would not, answer questions. The temperature was 101°F., with a slightly increased pulse and normal respiration. The region of the right eye was considerably

swollen and the lids were tense and red. A satisfactory examination could not be made, as attempts to open the lids were resisted. As far as could be seen the eye was pushed forward and inwards, while external rotation appeared to be absent. It was not possible to obtain a view of the fundus.

The condition was one of acute orbital infection with symptoms suggesting involvement of the cavernous sinus. I was inclined to think that there had been a penetration of the orbit and, as the globe was displaced, the possibility of a retained foreign body occurred to me. Further careful enquiry from the mother, who had actually seen the accident, did not throw any light on the matter, as she was emphatic in stating that the child's head had only struck the flat side of the cart.

Under a general anaesthetic a more detailed examination was possible. The wound to the outer side of the external canthus led down into the orbit, along the side of the outer bony wall. A probe was passed deeply into the tissues and, towards the apex of the orbit, a hard resistance was felt. On enlarging the wound, and following the track along the outer side of the globe, a tightly-wedged foreign body was found. The wound and track had to be enlarged considerably before it was possible to remove the foreign body, as it had passed back almost to the origin of the external rectus. After cleaning the cavity the enlarged portion of the wound was sutured and a tube drain inserted.

The foreign body proved to be a piece of ornamental beading, such as is seen on the side of some carts. It was 18mm. in length and 9mm. at its base, the general shape being triangular. The child made an uninterrupted recovery; on discharge the vision was full and there was only very slight restriction of outward movement of the globe. I have recently heard from the child's parents, who say that the eye is normal in appearance and that she appears to have perfect sight.

Case 2.—A boy, aged 6 years, was brought to hospital with a sinus discharging at the inner end of the left upper lid. The history given by the mother was that five weeks previously, the child was stooping to pick a flower, when he felt something prick him above the eye. At the time there was only a small punctured wound, with practically no bleeding, but a few days later a small abscess developed in the region of the wound. Local application of heat "brought this to a head" and since that time the wound had discharged.

On admission to hospital there was a dirty granulating sinus, just above the internal canthus, surrounded by a considerable amount of chronic inflammatory reaction. The globe was pushed down and out, with a marked degree of proptosis. Movement was limited up and in. The fundus was normal and the vision full.

The external appearance was suggestive of trouble arising from infection of the frontal sinus, but a nasal examination showed nothing abnormal. X-ray examination was negative and probing did not yield any definite result.

The wound was treated on general surgical principles for a few days, when a small splinter of wood was seen extruding from the granulating sinus. This, together with several smaller pieces, was removed, and on enlarging the wound, a piece of stick, an inch and a half long, was discovered. After its removal the wound healed, but owing to the long period of local inflammation, there was considerable scarring in the region of the trochlea. As a result there was some restriction in upward and inward movement of the globe; some degree of this was present when the child was last seen. Owing to difficulty in transport, the mother cannot bring the child for observation, but in answer to my enquiry she writes that, apart from slight fulness, the eye looks normal.

Case 3.—This patient, a girl, aged 19 years, was sent to hospital by her doctor on account of some loss of sight in the right eye. Nine days previously, while riding her bicycle, she had fallen into a thorn hedge and had sustained a small wound at the inner end of the upper lid, just below the brow. This was stitched by her doctor, who reported that there did not appear to be any damage to the eye itself. On the following day the lids were enormously swollen from extravasation of blood; this had gradually subsided.

When I first saw her, there was some residual swelling of the upper lid, with absorbing ecchymoses, and a small scar could be seen just below the eyebrow. The swelling of the upper lid was somewhat exaggerated by a paresis of the levator.

The globe was pushed forwards and slightly rotated outwards; on gentle pressure of the eye backwards, a definite resistance was felt within the orbit. There was an almost complete internal and external ophthalmoplegia in the distribution of the third nerve. Central vision was reduced to a bare 6/60, and there was considerable contraction of the upper visual field. The fundus was normal and an X-ray examination gave a negative result.

Treatment, consisting of rest and the administration of potassium iodide—to promote absorption—was instituted and within a week definite improvement was noted. Within two months the pupil reactions were normal and full movement of the globe was possible; the vision had improved to 6/18. When I last saw her, some four months after the accident, she could see 6/9 part, but there was some contraction of the upper field and the disc was definitely paler than normal. I have not been able to get any further report on her present condition.

Greig¹ divided penetrating wounds of the orbit into traversing and non-traversing, and made a comprehensive survey of the former, tabulating the intracranial damage arising from such injuries under the headings of directions of penetration. In this paper I shall only discuss non-traversing wounds, and, in addition, exclude all war or similar injuries.

It is surprising that so many of the accidents which cause penetration are of a simple nature. In my second case the child was bending to pick a flower and must have driven the thin piece of stick into his orbit. As a result of the simplicity of many of the accidents patients often fail to recognize the severity of the condition. External bleeding in penetrations is usually slight and little heed is taken of the occurrence until suppuration or other complications appear. Even the presence of a foreign body in the orbit is often unrecognized, not only by the patient but often by the doctor, and subsequently cases are seen where the wound has been stitched over a buried body.

The ends of objects penetrating into the orbit are sometimes broken off and retained, while flying pieces of metal, wood, stone, etc., may gain entry through a lacerated wound. A list of foreign bodies removed from the orbit is remarkable. Knife blades, umbrella handles, iron hat pegs, wire, ferrules, pencils, nails, broken wood, and pipe stems have all been reported.

In many cases even large foreign bodies have remained in the orbit for considerable periods. Carter² quotes, from Zander and Geissler, a case of Nelaton's where part of an ivory umbrella handle, 4cm. x 15mm., was removed from an orbit three years after the original wound. Although not actually a non-traversing injury, the case recorded by Horstius (*vide* Mackenzie)³ eclipses all others for the length of time during which a foreign body was retained. A boy was struck in the region of the orbit with an arrow in August of 1594, and the tip of the arrow was not recovered on removal of the shaft. Thirty years later, while sneezing, the man expelled the tip from his nostril. There had been no symptoms during those 30 years.

It is surprising that the globe escapes in so many of these accidents. Being relatively free it is usually pushed aside, and the wound often lies between it and the orbital walls. As the direction of most accidents is from below upwards, the majority of wounds (Würdemann states 75 per cent.)⁴ are found above and to the inner side of the eye. Greig¹ suggested that the unconscious throwing back of the head, at the time of injury, would give most wounds an upward direction. The majority of foreign bodies usually penetrate deeply.

Although primary healing is the rule in simple, clean wounds, yet complications, especially in cases where foreign bodies are

retained, are many and can be most severe. Orbital cellulitis, sinus thrombosis, meningitis, and tetanus may follow an infection of the wound, while the contents of the orbit may be affected by direct injury, infection or repair. Fracture of the thin roof of the orbit is a serious injury often resulting in a fatal issue.

Haemorrhage into the orbit is one of the commonest complications. In simple wounds the bleeding produces a moderate amount of proptosis, but where considerable laceration has taken place, the eye may be forced forward by the pressure of haemorrhage to an extent determined by the limit of stretching of the extrinsic muscles. So great may be the exophthalmos that the lids sometimes fail to cover the globe.

Protrusion of the globe associated with infiltration of blood into the lids and under the conjunctiva have long been considered as evidence of a fracture of the base of the skull involving the orbital walls. It must be remembered, however, that large haemorrhages into the orbit can take place as a result of injury without fracture, and also that fracture can occur without orbital haemorrhage. It is reasonably safe to suspect a fracture whenever the exophthalmos is very severe.

I believe that the complete loss of sight, in cases of extreme proptosis following haemorrhage, is analagous to that which is occasionally seen in orbital cellulitis. It is most probably due to pressure on the nerve, bleeding into the nerve sheath and interruption of its blood supply. In my third case there was considerable interference with vision. I think there can be no doubt that this was caused by the increased pressure behind the globe from haemorrhage. I have seen a case of very severe orbital haemorrhage with extreme proptosis, following an operation for chronic ethmoiditis, where the sight was completely lost and later optic atrophy supervened.

Absorption of blood in the orbit is very slow. The reason usually given is that the orbital fat is poorly supplied with blood vessels; but Wolff⁵ has drawn attention to another aspect of this question. He points out that, when the eye is pushed forward to the limit of elasticity of the extrinsic muscles, the orbit, or the space within the muscle cone, can be regarded as a closed space. Any haemorrhage or inflammation, in such a space, with its associated oedema would cause venous obstruction and later increased transudate. Thus the normal dilatation of the capillaries could not take place and absorption would be delayed.

Delay in absorption of blood in the orbit favours the production of blood cysts, while if infection takes place, either from a foreign body or from nearby sinuses, an orbital abscess may develop rapidly.

A list of detailed injuries to the eye itself is somewhat beyond

the scope of this paper, but mention must be made of injuries involving the globe as a whole. Displacements of the eye have, for convenience, been described as luxation, meaning displacement outside the lids; avulsion, separation of the eyeball from the body; and dislocation, displacement of the eye into a cavity bounding the orbit.

Dislocation of the eye is always due to a severe accident. Several cases have been recorded, the commonest position being displacement downwards into the antrum. Luxation and avulsion usually result from accidents due to large blunt objects, cows' horns, large door keys, etc., where the force applied acts in two ways, *viz.*, protrusion from pressure behind and at the sides, with some traction either forwards or sideways.

Enophthalmos, following trauma, is rare. A considerable amount of discussion has taken place concerning the aetiology of the condition. Absorption of the orbital fat, displacement of the pulley of the superior oblique, lesions of the sympathetic nerve, lesions of the fifth nerve, together with mechanical causes dealing with enlargement of the orbital cavity have all been suggested. Perhaps the last mentioned, associated with laceration of the ligaments and fascia affords the most likely explanation.

An interesting case was reported by Ulrich,⁶ where the eye was affected as a whole. This report dealt with an orbital haemorrhage, which had indented the eye laterally, and as a result, a myopia of 6.0 D. was found.

In orbital wounds, direct damage to the optic nerve is not uncommon. Injury may involve the nerve in the optic canal, within the orbit or in the scleral canal. It is uncommon for the nerve to be injured directly in the optic canal, the commonest cause of damage in that part being due to fracture, but cases have been published where pointed instruments have passed into the canal and damaged the nerve. A case reported by Hilgartner⁷ showed a complete section of the nerve by a piece of wood, which passed through the canal and cut the nerve outside the apex of the orbit. Haemorrhage plays a large part in the injury of the nerve in this region, especially when damage is due to fracture of the canal walls. von Hölder⁸ states that he never found bleeding into the nerve sheath except in fracture.

According to Berlin⁹ the blood enters the intervaginal space in three ways:—(a) From the cranial cavity; (b) from the damaged vessels in the sheath itself; (c) from rupture of the central vessels, before they enter the nerve. It is stated that the ophthalmic artery is rarely the cause of bleeding as it is very small and tortuous. As a result it yields under pressure and also acts as a protection to the nerve for the lower part of the sheath (Würdemann).¹⁰ Diminution in the size of the retinal vessels in early stages after

an accident suggests bleeding into the nerve sheath. Occasionally this change in the vessels is accompanied by haemorrhage on the disc and retina (Parsons)¹¹.

Injury may involve the orbital part of the optic nerve either before or after the central vessels have entered it. As the ophthalmoscopic signs are different, it is possible clinically to differentiate between lesions of the nerve in these two positions. When damage is behind the entrance of the vessels the fundus looks normal, but atrophy of the nerve follows later, while if the nerve is damaged after the entry of the vessels then the picture is similar to that of embolism of the central artery. A case reported by Kiep¹² is not without interest. A boy was struck in the upper lid with a cane and sustained a laceration through which a probe could be passed 5 cm. backwards towards the apex of the orbit. Although at first there was no response to light yet central vision recovered to 6/18, but the lower half of the visual field did not recover.

Damage to the nerve anterior to the point of entry of the vessels is rare. Parsons¹³ reported a case and collected about a dozen previously reported cases. Lang and MacCallan¹⁴ reported an interesting case of a girl, aged 7 years, who was injured by a garden fork. As the vitreous was infiltrated with blood, they were of the opinion that the original trauma damaged the nerve near the globe, but, as the central vessels were not entirely abolished, they concluded that the injury was behind the point of entry of these vessels into the nerve.

In this paper reference was made to a somewhat analogous case published by Lang,¹⁵ where a partial rupture of the lamina cribrosa had followed a blow on the eye with a clothes prop. This is one of the rare cases of injury of the nerve in the scleral canal. Injury at this point usually results from a penetrating wound of the globe, but Lang's case was due to an indirect injury resulting in a partial avulsion of the optic nerve. After the haemorrhage had cleared, in this particular case, a traumatic excavation was seen, a "coloboma or surgical conus" (Lagrange). Lister and Hine¹⁶ have pointed out that avulsion can take place without division of the nerve sheath.

Injuries of the sensory and motor nerves in the orbit may occur in penetrating wounds, either by direct damage or secondarily from haemorrhage, inflammation or degenerative changes.

Many references have been made to traumatic amaurosis in relation to damage in the region of the supra-orbital nerve, but in the majority of cases, the blindness was most probably due to actual injury along the visual tracts. Certain authorities have described, however, a form of reflex amaurosis after injury in the supra-orbital region, which is similar to that reflex amblyopia, with contraction of visual fields, caused by defective teeth, infection

of the intestinal tract and to sympathetic irritation of iridocyclitis. (Würdemann)¹⁷.

Among sensory lesions neuroparalytic keratitis is occasionally found, but in many cases, this condition is a complication of extreme proptosis.

Lesions of the motor nerves produce disturbances in the motility of the eye and upper lid. Injury affecting the apex of the orbit frequently affects all the nerves as they enter the cavity. It is rare to find a solitary nerve affected; the third case which I described, is rather exceptional in this respect. In this instance there was a lesion of the oculo-motor associated with some damage to the optic nerve. The third cranial nerve has a short intra-orbital trunk which, before it breaks up into upper and lower divisions, is closely associated with the optic nerve. It is logical to assume that the damage to these two structures was located in this region.

Difficulty is often encountered in determining whether limitation of movement is due to damage of a muscle or of its nerve supply. Marbaix¹⁸ reported a case of ptosis following the removal of a foreign body, but it is quite possible that this ptosis was due to actual damage of the levator.

I have found at least one reference to paresis of extrinsic muscles from local concussion. Evans¹⁹ has shown that injury of the optic nerve may also be caused indirectly by a blow in the region of the external angular process of the frontal bone. Some little time ago a case came under my care in which a partial third nerve lesion was caused by a blow on the zygoma. An X-ray showed a fracture of the lower margin of the orbit with a separation of the temporo-maxillary suture. There was a fair amount of orbital haemorrhage and I concluded that the damage to the nerve was secondary to this. It seems to me that, in many cases of concussion, the symptoms produced are caused by haemorrhage.

Damage to the lacrymal gland is rare. Jackson²⁰ collected 13 cases of dislocation, the majority occurring in children. I²¹ reported a case where a piece of barley straw had become embedded in the gland through the upper fornix; this resulted in a condition simulating a gland abscess.

Wounds involving the apex of the orbit result in a communication between the cavernous sinus and the carotid, leading to the production of arterio-venous aneurysms. Usually there is an interval of some months before the characteristic symptoms are seen, but Wecker²² quoted a case of Passavant where a child, aged 9 years, sustained a perforating wound of the orbit from a knitting needle and, soon after, the symptoms of an aneurysmal tumour developed. This aneurysm was supposed to be connected with the lacrymal artery.

Several cases of inclusion of pieces of aniline pencil in the orbital

fat have been recorded. (Juler²³, Marshall²⁴, Bride²⁵, Wissmann²⁶.) This condition produces a peculiar pathological picture due to the action of the aniline dye. The remains of the pencil are usually found in a false cyst containing bluish fluid. Microscopical examination shows a state of fatty necrosis surrounded by an area of intense reaction. Some difficulty in treatment is encountered; Marshall found Dakin's solution (1/40) together with drainage of the cavity to be the best procedure.

Of the very rare complications of orbital wounds mention should be made of the possible rôle of trauma in orbital echinococcosis. (Dudinow)²⁷.

I have been able to collect reports on four cases where the foreign body entered the orbit in a peculiar manner. Shroff²⁸ reported a case where a thorn entered the orbit through the skin at the edge of the upper lid. A small swelling was noticed and when this was opened a thorn an inch in length was removed. Two similar cases were reported where the thorn entered the orbit through the conjunctiva; one, in the region of the caruncle (Sawhney)²⁹, and the other through the inner end of the upper fornix. (Kaul)³⁰. I²¹ have seen two cases where penetration had taken place through the conjunctiva of the upper fornix, the first where a piece of barley straw was embedded in the lacrymal gland, and the second where a straw had entered the orbit at the inner end of the upper fornix.

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A careful history should be taken in all cases of wounds in the region of the orbit; not only must statements be verified, but also, in many cases, leading questions asked. It is always important that the depth of the wound should be investigated. Bleeding is a variable factor; on the whole punctured wounds do not bleed much externally and it has been stated that swelling and bleeding are not so marked where a foreign body is present (Geissler)³¹. Limitation of movement may denote damage to a muscle or to its nerve supply, while a foreign body or a haemorrhage might cause an obstruction to the free movement of the globe.

In many cases the diagnosis of the presence of a foreign body presents no difficulty, as it can be seen or felt with a probe. Exploration by probing, especially when the accident is not recent, is often unfruitful. It is difficult even at the time of an operation to follow a penetrating wound into the fatty tissue of the orbit, and it is, therefore, not remarkable that many small foreign bodies are often unrecognized.

The amount of proptosis does not give an indication of the presence of a foreign body as this might be caused by haemorrhage.

Thin objects can lie in close proximity to the walls of the orbit and are extremely difficult to find.

The history of these accidents can be misleading especially in young children or in cases where the patients have been unconscious. In penetrating wounds from thin objects it is better if possible to obtain the object, in order to discover whether any portion has been broken off and retained. An X-ray of all cases should be made, but too much reliance should not be placed on a negative report, as small pieces of soft wood may not cast a shadow. It is much wiser to explore all doubtful cases, especially where the wound does not heal by first intention; a granulating sinus often leads to the recognition of the presence of a foreign body.

In doubtful cases Jackson²⁰ makes the following rule: "Bear in mind the possibility of the embedding of a foreign body in connection with every wound in this region; but in the absence of definite evidence of its presence and location, do not endanger important structures in the search for it."

Clean wounds call for general surgical treatment. If large, a drain for 24 hours is of advantage, while repair of deeper structures with catgut helps to prevent a collection of blood serum. Dirty wounds must receive a careful toilette and all extraneous matter be removed. Pieces of badly injured tissue are better excised, while all sinuses should be freely opened. Whenever possible their depths should be subjected to visual inspection.

Extreme degrees of orbital haemorrhage may call for interference in the way of relieving pressure behind the globe. Causé³² reported a case of retro-bulbar haemorrhage, with 8 mm. of proptosis, where great relief was obtained by aspirating some 15 c.c. of blood.

Small metallic foreign bodies, especially when they have entered while heated, are often better left. Larger foreign bodies, especially of the nature of wood, should be removed as quickly as possible; it is always easier to remove a recent foreign body than one where inflammatory changes have taken place. Careful localization by X-ray should be made and then the wound enlarged. A generous incision is often of advantage as it is less likely to do damage than the traction necessary to pull an irregularly shaped body through a small wound. Care must be taken not to injure important structures and, whenever possible, divided parts should be carefully sutured. In some cases it may be necessary to remove a badly damaged eye or even to resort to a Krönlein operation.

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THE AFFINITY OF THE VITREOUS BODY TO DILUTE PLASMA GELS

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ONE would feel much happier about the whole question of the vitreous body if it were not so peculiar and different from everything else. In a monograph by one of us issued by this Journal (1930) a study of its physical and chemical properties was presented, wherein it was concluded that it was a gel made up upon the basis of specific protein constituents to which was physically absorbed quite an unusual quantity of watery solution (intra-ocular fluid). It was shown by ultra-microscopic observations that the gel "structure" consisted of minute colloid aggregations arranged in fibrillar form, and while it was pointed out that this resembled closely the appearance of soap gels, it showed little affinity with known organic structures. A further characteristic which seemed to place the vitreous gel in a class by itself was the extreme dilution of the gelable constituent (0.025 per cent.). It seemed of interest to determine if such properties were unique or