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Orbitocranial penetrating injury by a metallic foreign body. Case report and anatomical considerations

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Abstract: Orbitocranial penetrating injuries (OPI) represent a rare type of head injuries encountered in clinical practice. These appear after falls or motor vehicle accidents and are more frequent among children. We present the case of a male patient with OPI, associated with large frontal hemorrhagic contusion, with minimal periorbital trauma findings related to brain injury. Knowing and understanding the clinical anatomy of the orbit and the patterns of injuries in OPI are mandatory, since failure in detecting intracranial complications may lead to the increase of the neurological morbidity, visual loss and death.

Key words: orbitocranial penetrating injury, orbital roof fractures, transorbital penetrating brain injury, visual acuity loss

Introduction

Orbitocranial penetrating injuries (OPI) represent about 24% of penetrating head injuries in adults and 45% in children (36), and they represent a significant threat for the intracranial and ocular structures. OPI occur relatively rare among adults and more frequent in children and teenagers, because they are prone to injuries while they play games in inappropriate ways (29, 37).

Short case report

We present the case of a 38 year old male patient hospitalized at the 2nd Neurosurgery

Clinic of “Prof. Dr. N. Oblu” Emergency Clinical Hospital Iasi with an OPI by a metallic foreign body within the context of a work accident. On admission, the patient’s GCS was 15, with headache and bradypsychia, and the local ophthalmologic exam revealed a hematoma of the upper right eyelid (Figure 1. A), a wound in the upper angle and a right eyelid ptosis (Figure 1. B.), with absence of the foreign metallic body because the patient has pulled it out by himself immediately after the accident. The ophthalmologic exam also concluded that the visual acuity of the right eye was no light perception. The slit lamp

examination of the anterior segment of the right eye showed a subconjunctival hemorrhage and corneal oedema. Dilated fundus exam of the right eye revealed the absence of the red reflex and hemorrhage in the vitreous. The visual acuity of the left eye was 6/6. The slit lamp examination of the anterior and posterior segment of the left eye revealed a normal anterior and posterior segment. The head CT scan showed an orbitocranial penetrating injury (Figure 2, 3) with a complex fracture in the right orbital roof and intracranial migration of the bone fragments (Figure 2, 3) and right frontal contusion associated with a frontal intracerebral hemorrhage (Figure 2.C-F). The ocular ultrasound (B-Scan Ocular Ultrasound) of the right eye showed retinal detachment, vitreous hemorrhage and choroidal hematoma (Figure 3. F). Prognosis related to brain lesions was favorable, but with loss of the visual function in the right eye.

Discussion

The orbit is a osseous structure shaped as a horizontal pyramid, with a quadrangular base formed by the orbital rim, and with triangular orbital walls that converge to the apex, where the superior orbital fissure (SOF), inferior orbital fissure (IOF) and optic canal (OC) are found (12, 36) (Figure 4. B). Two important anatomical characteristics make the orbit vulnerable to OPI: 1. the pyramid shape which makes that penetrating objects to be directed towards the apex, and SOF, IOF (posterior portion) and OC (35) allowing the passage to the middle cranial fossa and 2. thin walls,

which make the orbit the most vulnerable structure of the skull (3).

Depending on the kinetic energy, OPI can be classified into two main categories, and also the kinetic energy directs the damage pattern: OPI with low-velocity and OPI with high-velocity. The OPI severity does not depend only on this kinetic energy, but also on the size and the shape of the foreign body, its entry point, its force and trajectory (24, 29).

OPI with low-velocity makes the penetrating foreign bodies to be directed by the orbit's configuration towards the apex and to cross to the cranial cavity through SOF, IOF or OC, injuring nerve and vascular structures, such as: cranial nerves III, IV, V, VI, cavernous sinus, carotid artery and arteries of the Willis circle (16), suprasellar cistern, brainstem or temporal lobe (1, 2, 26, 27, 33, 34, 39). For OPI with low-velocity, the most frequent injury pattern encountered in 68% of cases is represented by the damage of temporal lobe, brainstem and cavernous sinus (36).

In OPI with low-velocity, foreign bodies usually penetrate the orbit through the medial canthus (10), and due to its shape characteristics, it offers direct access towards the cranial cavity through SOF, IOF and OC, even in absence of globe injury or of a significant bone fracture (4). So that in case of OPI with low-velocity, intracranial brain injury may occur in presence of minimal periorbital trauma, without bone fractures. The explanation would be represented by toughness of the sclera coat and the motility of the eyeball within the surrounding bed of intraorbital fat (11, 26) that protects eyeball

from penetration during OPI with low-velocity (36).

OPI with higher-velocity usually cause fractures of the orbital walls, and their penetration in cranial cavity is directed by the trajectory of the penetrating bodies (17, 23, 30, 32). So that the foreign bodies, which are vertically directed (upward), would perforate the roof of the orbit, causing frontal lobe injury (7, 14, 18, 21), and those horizontally directed would perforate lamina papyracea of ethmoid bone or the posterior orbital wall (3, 6, 15, 23). If the high velocity is high enough, along the 45 grade angle of the lateral wall, foreign bodies can cross midline and destroy the collateral structures (11). Out of all OPI with higher-velocity, the most frequent are those that perforate the orbital roof and they usually appear when the patient falls into objects that are directed in an upward direction (29). In these situations, the thin superior orbital plate of the frontal bone in the anterior cranial fossa floor is fractured, causing frontal lobe injury. According to some authors, the great incidence of those OPI with roof fractures is due to the instinctive tendency of humans to extend the neck backwards in a defensive position at the moment of orbital trauma (28, 32). Because at the time of trauma humans avoid turning their heads, this may guide horizontally approaching objects into the medial canthus region and along the medial orbital wall (22). In our patient's case, the foreign body penetrated the orbit at the medial canthus and followed a posterior, medial and superior trajectory through the orbital roof (Figure 3. A, B, D, E) with a foreign body

penetrating the frontal lobe and causing a contusion and frontal hemorrhage (Figure 2).

If in OPI with low-velocity the ocular complications are minimal or even absent, this is not the case for OPI with high-velocity, such as pellet and nail gun injuries or work accidents, in which despite the small diameter of penetrating foreign body, there is important damage done to the eye globe (2, 32, 36). The most frequent ocular complications encountered are: ocular laceration, retrobulbar hematoma, proptosis and optic nerve damage with severe loss of vision (19, 31), and in our patient's case, despite the minor damage done to the eyelid (Figure 1), the damage done to the globe was severe: eyelid ptosis, vitreous hemorrhage, retinal detachment (Figure 1, Figure 3. C, F), with loss of the visual function in the right eye.

Based on the anatomic patterns of injuries, Turbin et al. (2006) has classified the ocular surface in four zones: zone 1 includes central, lateral, upper eyelid or superior conjunctival entry points; zone 2 includes central, lateral, lower eyelid, or conjunctival entry points; zone 3 includes all medial and canthal cutaneous zones of entry points, subclassified in zone a, b and c (upper, middle, lower) and zone 4, which includes lateral upper and lower eyelid and conjunctival lacerations (zone 1 + zone 2) (36) (Figure 4).

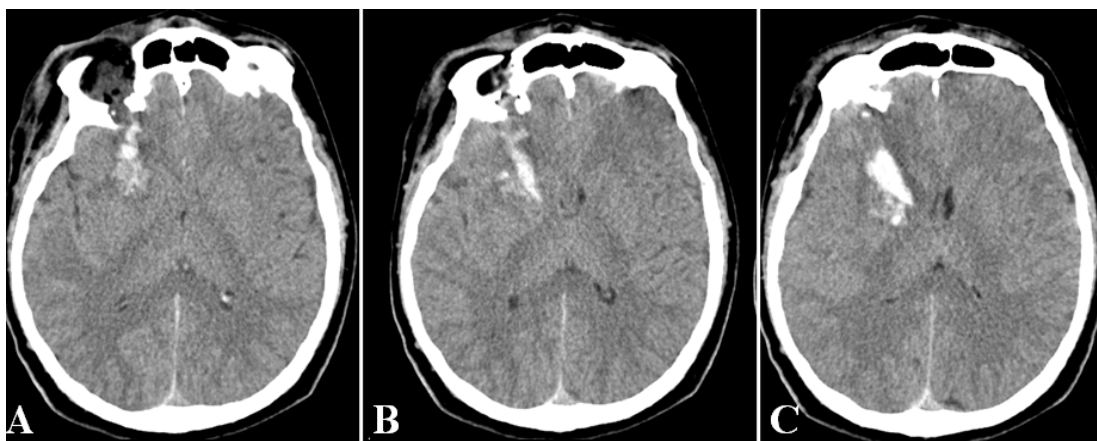
In regards to brain injury, the pathophysiology of OPI with high-velocity is similar to closed head injuries, such as intracranial hemorrhage or cerebral contusion, but on the other hand, OPI are prone to infections (13). In the brain, the initial event in OPI with high-velocity is

represented by direct crushing and laceration along the tract of penetrating injury. Brain swelling or bleeding due to cerebral contusion, which leads to increase of intracranial pressure, occur secondarily. Most deaths by OPI are due to hemorrhage or ischemia secondary to damage of blood vessels (5).

Immediate complications of OPI are intracerebral hematoma, brain contusion, intraventricular hemorrhage, pneumocephalus, cranial nerve damage, brainstem injury and cerebrovascular injury (25, 38), while delayed complications are orbital cellulitis, endophthalmitis and retinal detachment (8, 9, 20), cerebrospinal fluid fistula, carotid-cavernous fistula, meningitis and cerebral abscesses, traumatic aneurysm and delayed intracranial hemorrhage (20). Fortunately for our patient, there were no delayed complications, the neurologic prognosis being a good one, except for the visual function. The literature also considers that in absence of direct injury of brainstem and laceration of major cerebral vessels, the prognosis is overall good in OPI (20).



Figure 1 – Periorbital ecchymosis with sutured wound on the medial canthus of the right eyelid (blue arrows) (A); Subconjunctival hemorrhage in the right eye and the entry point of foreign metallic body on the right medial canthus (blue arrows) (B)



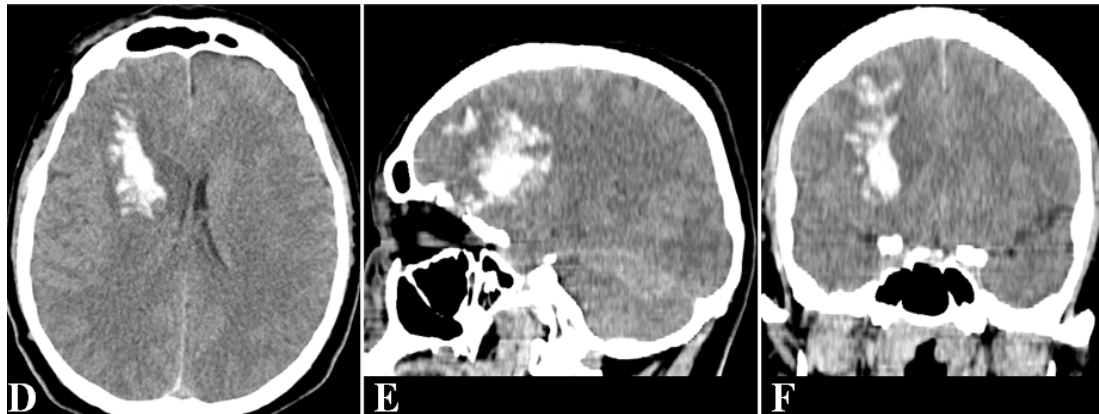


Figure 2 - Head CT-scan with: right orbital roof fractures (A, B); right frontal contusion and intracerebral hemorrhage (C-F) that respects the trajectory of the foreign body in intracranial cavity



Figure 3 – Complex fracture in the right orbital roof (A, B, D, E). 3. C. Vitreous hemorrhage and choroidal hematoma of the right eyeball; Ocular ultrasound (B-Scan) that shows retinal detachment, vitreous hemorrhage, and choroidal hematoma (F)

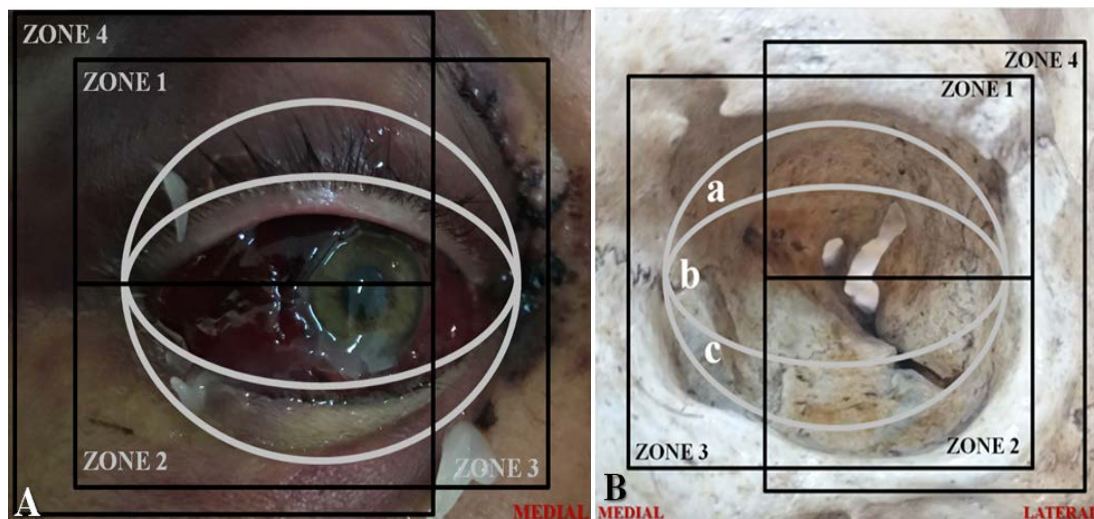


Figure 4 - Turbin's diagram of ocular surface applied to our patient (36) (A). To observe zone 3 for entry of foreign body; schematic diagram of ocular surface, adapted after Turbin 2006 (36) (B) (Dr. Mihaela Turliuc's personal collection)

Conclusion

Knowing and understanding the clinical anatomy of the orbit and the patterns of injuries in OPI are mandatory for an early diagnosis, as well as developing a surgical plan if needed. In this regard, modern imaging techniques, such as CT, MRI and angiography, are helpful.

Accidents or falls, which involve foreign bodies, should raise suspicions of brain injury, even in the absence or in case of minimal ocular or neurological findings, because failure in detecting intracranial complications may lead to increase of neurological morbidity, visual loss and death.

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