BILATERAL DECOMPRESSIVE CRANIECTOMY IN A PATIENT WITH HEAD INJURIES DUE TO GUN PROJECTILE: A CASE REPORT

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We don’t have conflict of interest.

This study received no funding from any comercial, academic or governmental entity.
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Abstract
A 38-year-old male patient with multiple skull injuries caused by a small-caliber firearm projectile whose entry hole was the right eye after being attacked when leaving his home. Consequently, he presented head trauma with multifragmented fracture of the cranial vault causing exposure of the brain mass in the bilateral frontoparietal region and complete injury to the right eyeball with fracture of the orbit in its posterior, lateral, medial, roof and floor walls. He was transferred to the General Hospital of Axapusco, where the patient was received with 8 points on the Glasgow scale and a simple tomography of the skull was performed, observing injury to both hemispheres, bilateral subarachnoid hemorrhage, parasagittal hemorrhagic contusions and cerebral edema, predominantly affecting to the corpus callosum and cingulum. Therefore, hinge-type decompressive craniectomy and debridement in the first 12 hours of trauma were determined as surgical treatment. It should be noted that a favorable recovery was obtained without associated complications. It is concluded that the surgical treatment of choice is early decompressive craniectomy when the patient presents less than 9 points on the Glasgow Coma Scale at admission, the injury along the path of the wound is bihemispheric and posterior fossa, the time that elapses from the injury to the performance of the surgery is within the first 12 hours, there is pupillary reactivity, and the age of the patient is greater than 35 years.

Key Words: Bilateral decompressive craniectomy, Hinge/floating craniotomy, Gunshot wounds, Case report

Background

Gunshot wounds can be caused by projectiles or by fragments generated during the explosion (1) and are the most common cause of penetrating head trauma (TBI). It is estimated that the mortality rate from firearm injuries ranges between 21% and 88% (2), however, some authors mention that the survival rate is only 9% (1). TBI is most frequently inflicted by small caliber (0.22–0.38) and low velocity (less than 304.8 m/s) projectiles launched at a range of less than 50 m (3).

It is worth mentioning that injuries caused by firearm projectiles differ from those caused by traffic accidents, falls and sports injuries in that they have greater tissue loss, loss of anatomy, bleeding, and tissue maceration (4). This is related to the energy and shape of the projectile, angle of injury and the characteristics of the tissues involved. In this way, as the projectile travels through the brain parenchyma, it injures the surrounding tissue creating a path of permanent injury, in addition, it is
preceded by a sonic wave that also causes damage. For their part, high-velocity projectiles generate cavitation that expands and collapses progressively, creating new brain damage with each expansion-collapse cycle (1,3).

Despite the fact that decompressive craniectomy (DC) is indicated as treatment, it presents debatable results; for example, the evaluation of DECRA (Decompressive Craniectomy in Patients with Severe Traumatic Brain Injury) through RESCUEicp (Randomized Evaluation of Craniectomy Surgery for Uncontrollable Elevation of Intracranial Pressure) and RESCUE-ASDH (Randomized Evaluation of Craniectomy Surgery for Patients undergoing acute subdural hematoma evacuation) have shown higher rates of disability in survivors after traditional DC. (5)

Therefore, articulated craniotomy (HC), also called "hinge" or "floating" type, is presented as an alternative to traditional DC, since it is a surgical technique that allows adequate decompression and reduction of intracranial pressure while eliminating the need for a secondary cranioplasty, better results are predicted (Table 1). (6)

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<th>Probability of good prognosis</th>
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</tr>
<tr>
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<td>5</td>
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</table>

**Table 1.** Gressot Functional Outcome Prediction Staging System.
A point is assigned when the Glasgow Coma Scale (GCS) is 3 to 5 points, non-reactive pupils are present, and if age >35 years. Two points are assigned if the projectile trajectory caused a bihemispheric and posterior fossa lesion. (9)

**Case presentation**

Present the case of a 38-year-old male patient, who was attacked when leaving his home. He presented polytrauma to the skull due to a firearm projectile with an entry hole in the right eye (Figure 1.A), which caused a fracture of the orbit in its posterior, lateral, medial, roof, floor walls and complete loss of the right eyeball and extraocular muscles, accompanied by exposure of a brain mass in the bilateral frontoparietal region (Figure 1.B), due to the multifragmented and comminuted fracture due to the projectile exit orifice (Figure 1.C), in addition, the horizontal direction of the firearm projectile caused injury in both hemispheres accompanied by bilateral subarachnoid
hemorrhage (SAH) (arrow), parasagittal hemorrhagic contusions (circle) and cerebral edema as shown in Figure 1.D.

Additionally, he suffered several bullet wounds in both lower limbs, with an entry hole on the lateral side and an exit hole on the medial side. Paramedical personnel arrived ten minutes after the event, the patient was found with 15 GCS points (O4, V5, M6), awake, with coherent and congruent language; with the brain exposure described above.

**Figure 1.** A) Entry of the projectile through the right eyeball (arrow). B) Skull wound with exposure of brain mass (date). C) 3D reconstruction of skull by computed tomography (CT); view from the cranial vault that show the projectile exit orifice (circle). D) Bilateral subarachnoid hemorrhage (SAH) (arrow) and parasagittal hemorrhagic contusions (circle).

Initially, he is transferred to the General Hospital of Axapusco (regional hospital) where the patient is received with 8 points on the GCS (O2, V2, M4), for which advanced airway management, medical treatment and resuscitation are started in accordance with the ATLS Guidelines for the management of trauma. Subsequently, he was transferred to the Regional Hospital 1º de Octubre for management by Neurosurgery, performing the surgical treatment 8 hours and a half after injury.

In the initial diagnosis carried out by sagittal CT scan of the skull, the trajectory of the projectile and the depth of the lesion were observed, which affected up to the portion of the corpus callosum and cingulum, for which reason, it was decided to perform a bilateral frontoparietal decompressive craniectomy hinge type with simple drainage towards the periphery preserving the bone in the midline to avoid injuring the superior sagittal sinus (Figure 2.A).

During surgery, coexistence of a subdural hematoma and a cortical contusion (cortical burst) was found in the right precentral and left postcentral gyrus accompanied by tearing of the dura mater, therefore, the opening of the dura mater was completed, preserving the part close to the superior longitudinal sinus, removing bone splinters, for this it was necessary control the moderate bleeding present in the superior longitudinal sinus by means of compression and cottonoids for 1:30 hours during the surgical procedure (Figure 2.B).

Given the initial neurological status and the lesions found during the intraoperative period, the patient was not extubated and was admitted to the Intensive Care Unit (ICU) with 5 points on the modified Rankin scale (standard measure of neurological disability), where he remained with sedation for 3 days, later, the neurological window was made with an adequate response, remaining two more days in the ICU without sedation; for a total stay of five days during which he was maintained with a
tracheostomy and gastrostomy scheme. Next, he was extubated and transferred to the neurosurgery service with 4 points on the modified Rankin scale, where he remained for 17 days under the same scheme. At the end of his stay he was discharged from the hospital with 3 points on the modified Rankin scale, left brachioradial hemiparesis, strength 3/5 on the Daniels scale, total loss of the eye, tracheostomy and gastrostomy.

Lastly, as part of the postoperative management, he was sent to rehabilitation and a postoperative control was performed one month and twenty-two days after the operation by means of a CT scan of the skull in coronal section, where the re-expansion achieved by the encephalic tissue (Figure 2.C). In addition, at a follow-up appointment, the patient presents a GCS 11 points, left hemiparesis with strength 4/5 on the Daniels scale, without tracheostomy or gastrostomy, with oral tolerance, coherent language, with adequate vocalization, without complications. However, the prognosis remains guarded for function and quality of life.

**Figure 2.** A) Transoperative control and B) 3D reconstruction of postoperative CT. C) Postoperative control with CT; coronal section of the skull

**DISCUSSION**

Within the injuries produced by firearms, two categories can be highlighted; the primary lesion, which is determined by the ballistic properties of the projectile; and secondary injury, which are generated by bone and metal fragments (7). In this way, the mortality of the lesions depends on the site of the wound and the trajectory, where bihemispheric wounds stand out, as in the case presented above, because according to Martins et al. present a mortality rate of 96.2% and 100% in posterior fossa wounds (8). Consequently, 70% of patients with TBI die 24 hours after the injury and patients with TCE have a survival of less than 10% (9).

On the other hand, the greatest challenge neurosurgeons face when treating gunshot wounds is to discern between performing surgery and guaranteeing patient survival at all costs or seeking quality of survival in selected patients. The dilemma lies in deciding which type of patients are candidates for surgical treatment, considering not only the trajectory of the projectile but also the patient’s hemodynamic status and the GCS on arrival at the emergency department. (10)

However, there is consensus that when the patient arrives at the emergency room, priority should be given to stabilization, which includes the ABCD of all trauma patients. Once the scalp lesion has been identified, complementary imaging studies
should be performed, since they can determine the trajectory of the projectile and the injured structures. Likewise, it helps to determine the treatment plan, including the type of surgery to be performed, therefore, CT of the skull with bone reconstruction has become the study of choice (11).

In relation to the above, Graham et al (12), defend that surgical treatment is viable in patients with GCS between 6 and 8 with 20% satisfactory results, while patients with bihemispheric or multilobular involvement of the dominant hemisphere have poor results. In contrast, Joseph et al. defend that aggressive management in patients with a low GCS score (3 to 5) or with bihemispheric lesions produces a better survival capacity, going from 10% to 46%. (13)

As for minor injuries from a firearm projectile, that is, non-penetrating injuries such as tangential injuries, they require lavage and debridement with subsequent antibiotic treatment. Whereas, focal lesions with active hemorrhage, bone or metallic fragments and without mass effect require surgical exploration, specifically, craniotomy directed at the lesion areas. Finally, severe injuries such as transventricular or bihemispheric injuries require extensive surgery with debridement, drainage of hematomas, decompressive craniectomy, dural repair, and management by stereotaxis. (2,14).

According to a RESCUEicp study (15) which focused on demonstrating its effectiveness compared to medical treatment in the presence of intracranial hypertension, it was concluded that decompressive (bifrontal) craniectomy reduces the days spent in the ICU and decreases mortality in these patients, but that the survivors do not present adequate functionality, with a higher incidence of vegetative state or neurological sequelae.

However, Qiu et al. in 2009 (11) conducted randomized studies comparing the results of decompressive craniectomy at different time intervals in which it is performed, that is, within the first 24 hours of trauma (early) and after 24 hours after trauma (late); against medical treatment. They determined that early unilateral decompressive craniectomy in patients with radiographic signs of herniation was superior in reducing intracranial pressure, reducing mortality, and presenting better functional outcomes for the patient.

Due to the fact that the patient in the clinical case presented an indication for surgical treatment based on the Gressot staging system for predicting functional results, bifrontal decompressive craniectomy was decided on, supported by the tomography findings; obtaining functionally favorable results for the patient.

CONCLUSION

Penetrating brain injuries from a firearm projectile continue to represent injuries with high mortality and a challenge for neurosurgeons. However, some predictive factors...
such as the Glasgow Coma Scale less than 9 points at admission, the correct identification of the structures injured by the path of the wound, the time that elapses from the injury to the performance of surgery and the age of the patient allow to decide an adequate surgical treatment resulting in a favorable prognosis for the patient with an adequate functional evolution for his age as in the case presented. In relation to this, aggressive management was essential, that is, decompressive craniectomy and debridement within the first 12 hours of trauma, it should be noted that, despite the location of the lesions and the complications that this entails, such as infection of the surgical wound, definitive neurological deficit, cerebrospinal fluid fistula and infection in the right eye due to direct injury by projectile, did not occur in the patient, probably due to the speed of management given based on the predictive factors already described, consequently, a favorable recovery was obtained without associated complications and it is concluded that the surgical treatment of choice is early decompressive craniectomy when the determining factors of the Gressot staging system for predicting functional results are present.

We don’t have conflict of interest.

This study received no funding from any commercial, academic or governmental entity.

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