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ABSTRACT

Background. The high mortality rate of a cranial bullet injury, the catastrophic damage of vital tissue, and the frequency of gunshot accidents made managing such cases highly effortful in neurosurgical trauma centres. One category of these injuries is the gravitational bullet injury, in which the bullet's movement depends on gravity after losing its kinetic energy. This paper aims to describe the conservative treatment plan we applied for a patient who suffered an intracranial gravitational bullet injury.

Case description. The patient presented with a cranial bullet injury that migrated caudally to his lateral ventricle. This unapproachable location of the bullet made the surgical intervention undoable. Therefore, after the implication of resuscitative management, the patient went under heavy observation with a suitable follow-up plan. The patient's short-term outcome was excellent, and his Glasgow coma scale was 15 at the discharge.

Conclusion. Conservative management in a gravitational bullet is one of the possible methods to reach the best outcome in non-operable patients. Such measures are highlighted in this case, even when a complication like a bullet migration may occur.

INTRODUCTION

Cranial bullet injuries constitute a frequent clinical challenge for neurosurgeons in trauma centers. The impact of such injury includes damage to vital tissue and subsequent complications. A missile bullet injury is considered to have a high mortality rate that ranges from 51% to 84% (10). On the other hand, gravitational bullet injury, also known

Keywords

gravitational bullet injury,
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as falling bullet injury, occurs when the bullet loses its acceleration and kinetic energy; therefore, its movement will depend only on gravity. In this situation, the bullet does not have a cavitory effect, and the damage will be less dramatic than the missile bullet injury (2). It is noteworthy that there is inadequate mention of the indications of conservative management regarding gravitational bullet injury in the literature, especially the rare phenomena of bullet migration.

The aim of this article is to discuss the conservative management steps of gravitational bullet injury and the remarkable outcome of the patient despite the critical location of the bullet and its consequent craniocaudal migration.

CASE DESCRIPTION

Thirty-three years old male with unremarkable past medical history was admitted to the neurosurgical emergency department due to a bullet head injury. His transfer to the hospital was delayed more than one hour because he lives in a rural area. The initial assessment revealed that one entry wound was positioned on the upper part of the frontal bone, slightly right to the Bregma area; neither an exit wound nor other concomitant injury has been found. GCS was 14 (E4M5V5) at the admission. He presented with a severe headache with no motor deficit. His vitals were stable, and pupils were equally round and reactive to the light and accommodation. Initial skull X-ray was performed, which documented an intracranial bullet (Fig 1, 2). Computed tomography (CT) scan was done, which revealed a foreign body with moderate volume subarachnoid hemorrhage (SAH) (Fig 3. E).

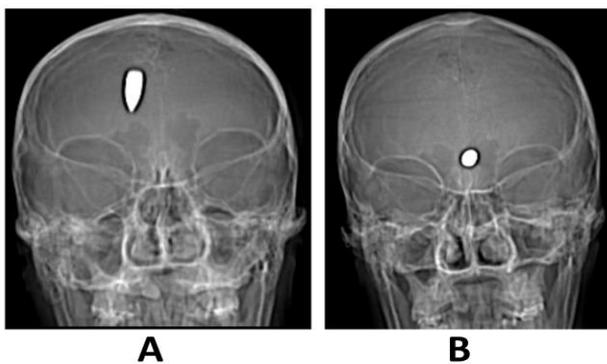


Figure 1. Head x-ray in coronal view, **A:** before bullet migration, **B:** after bullet migration.

Resuscitative measures were performed with conservative management, including wound

debridement with intravenous effusion of antibiotics, including Ampicillin-sulbactam, Metronidazole, and Cefotaxime for one week in addition to Paracetamol, anticonvulsant (Phenytoin) and Ranitidine. The next day's follow-up CT revealed the migration of the bullet to the occipital horn of the right lateral ventricle (Fig 4. H). No surgery was done for him, and he went under heavy observation. The patient was discharged from the hospital after one week of observation.

The patient's GCS was 15 at the discharge, with Blood pressure 150/65. The follow-up strategy includes repeated imaging that will be conducted every three months to monitor the site of the bullet and the subsequent complications.

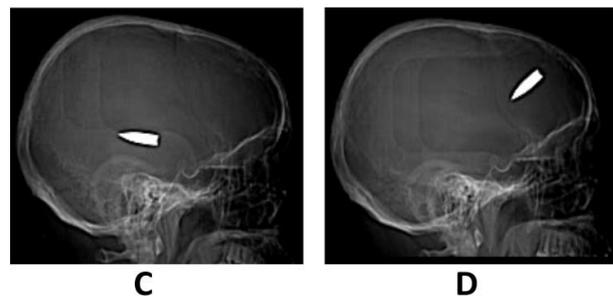


Figure 2. Head x-ray in sagittal view, **D:** before bullet migration, **C:** after bullet migration.

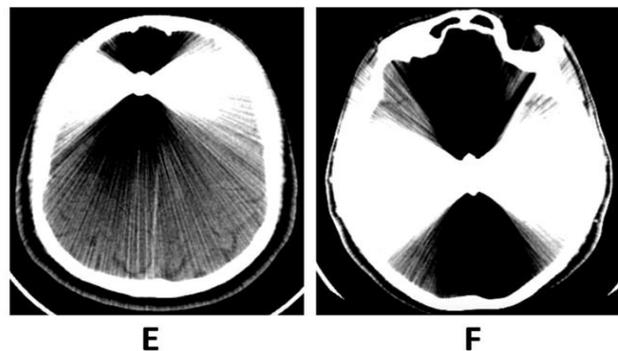


Figure 3. Head CT in cross-sectional view, **E:** before bullet migration, **F:** after bullet migration.

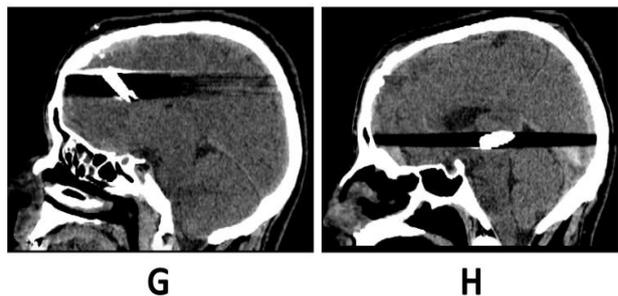


Figure 4. Head CT in sagittal view, **G:** before bullet migration, **H:** after bullet migration.

DISCUSSION

Avoiding invasive measures through a conservative management strategy to preserve vital anatomical structures constitutes a relatively infrequent approach in cranial bullet injuries. One of the compelling situations in which a neurosurgeon will implement conservative management is when a migrating intracranial bullet is positioned in an inaccessible site. Bullet fragment migration has been reported in 0.06-4.2% of bullet injury cases (13). Since the additional neurological deficit could result from the removal of the bullet, managing such cases is challenging (2,10). Additionally, several studies revealed no remarkable association between retained bullet fragments and infection and no associated seizure occurrence (9,14), favoring conservative management for such critical cases.

This paper aims to observe the effectiveness of conservative management regarding inaccessible cranial bullets and the patient's short-term outcome.

Regarding the gravitational bullet effect mechanism, there are three velocity phases (2). The first one is the explosive acceleration after the gun's firing, the second phase represents the velocity's deceleration due to gravity's effect, and the third phase starts when the bullet movement changes in a downward direction with accelerated velocity. After these phases, the bullet reaches the terminal velocity, which depends on multiple factors, including the bullet material, angle of firing, and flight characteristics (7,11). The action of gravitational force on the bullet, the flow of cerebrospinal fluid (CSF), the vessels pulsation, and finally, the local tissue damage and the consequent edema with tissue softening are all considered factors that would enable the bullet's movement inside the cranial cavity. The migration will stop by gliosis and the formation of fibrotic scar tissue in a healing process that can take several weeks to years to be completed (3,6). The availability of firearms and the rise of terrorist-related aggressiveness have increased the incidence of missile injuries. Indeed, one of the frequent events in which there is a traditional aerial firing is the marriage ceremony which led to an increased incidence of gravitational bullet injuries (3).

The ventricular system is one of the most vulnerable sites in craniocerebral bullet injuries. The main reasons for this are the fragility of its structures and its critical site with proximity to vital vascular and neural structures as for the circle of Willis, which are

located below the frontal horn and the body of the lateral ventricles. Moreover, the choroidal arteries have a close correlation with the lateral ventricles. Another crucial relation to the ventricles represents the course of the venous channels that drain the deep white and gray matter surrounding the lateral and third ventricles and the basal cisterns into the brain's deep venous system, which include the internal cerebral vein, basal vein, and great vein of Galen. These channels pass subependymally through the walls of the lateral ventricles (5).

Regarding the conventional management of head bullet injury, resuscitative stabilization must be done according to international trauma life support guidelines. Then, accurate identification of wound entry sites, monitoring the intracranial pressure, and administering prophylactic anticonvulsants and tetanus toxoids (1,15). It is essential to mention that the leading cause of mortality in falling bullet injuries is a cerebral hernia resulting from increased intracranial pressure (12). After that, individual-based assessment must be applied before making surgical decisions. To illustrate the previous statement, many studies advocated removing the bullet if it is accessible and the removal procedure will not cause severe morbidity. These studies include Özkan study (16) and the study of Kumar et al. (8). In contrast, there were two reported cases by Zafonte et al. (16) Of spontaneous migration that caused a neurological collapse in which the two conditions were improved after applying surgical management.

The severity of complications associated with the migration of intracranial projectiles often contributes to poor prognostic consequences (8). These complications are divided into two categories; the first one will include bullet lethality with the entering of shattered bone fragments and bleeding. The second category represents the development of seizure foci, neural tissue necrosis, pressure effect of the foreign body, and different types of intracranial infections. This category also includes hydrocephalus, a predicted complication of an intraventricular bullet (13).

In our case, after adequate resuscitation of the patient according to advanced trauma life support (ATLS) protocol by the well-trained neurosurgical team in the emergency department, he was admitted to the operating room for meticulous wound debridement. CT imaging demonstrated that

bullet removal is more dangerous than leaving it inside the ventricle. Thus, surgical intervention was not considered an option.

The initial GCS of the patient is One of the most important predictors of outcome (12). As for our case, GCS was 14 (E4M5V5). The patient received an intravenous fluid and antibiotics, including Ampicillin-sulbactam, Metronidazole, and Cefotaxime. Palliative measures were performed to relieve his pain using analgesia. Anticonvulsant drugs, including Phenytoin, were given to avoid the complication of the development of seizure foci in addition to Ranitidine. The next day, a follow-up CT was performed to guide further management, revealing the bullet's migration to the occipital horn of the right lateral ventricle. The migration of the bullet made it even more unapproachable; hence, no operation was conducted, and he went under heavy observation. The patient was discharged from the hospital after one week of careful surveillance.

At the discharge, the patient's GCS was 15. His blood pressure was 150/65. His follow-up strategy involves repeated imaging every three months to monitor the site of the bullet in addition to regular neurological examination to manage the predicted complications.

The follow-up plan has further significance because the bullet might migrate again and give rise to more damage. For instance, in 2010, Castillo-Rangel *et al.* reported the case of a 9-year-old female who had an intracranial bullet injury. No surgical intervention had been performed, and she was discharged after being conservatively managed by a healthcare team. Later and after twenty-seven years, she suffered several symptoms, including thoracic pain, bladder/bowel habitus changes, and bilateral lower extremity weakness. The imaging revealed that the bullet had migrated and is now at the T4 level. Thus, it was surgically removed (4).

To sum up, everything has been stated so far, removing deep-seated bullets could raise the potential for morbidity and mortality. Nevertheless, leaving the bullet inside the brain tissue may result in its migration, and a correspondingly significant neurological deficit will occur. This fact decided whether to apply surgical treatment or convey conservative management, a severe challenge in neurosurgical departments. Finally, implementing efficient guidelines and the documentation of similar

cases would ensure better patient care in such compelling circumstances.

CONCLUSION

It is essential to acknowledge that gravitational bullet injury cases need more documentation in the literature to be oriented with manageable complications like bullet migration and individualized treatment plans. Regarding our case, the bullet settled in the lateral ventricle, which made it inaccessible. The excellent recovery of the patient and the critical location of the bullet encouraged to go with conservative management.

Abbreviations

Glasco coma scale = GCS;
Computed tomography = CT;
Subarachnoid hemorrhage = SAH.

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