Penetrating brain injury caused by tired bullet: First report from Somalia

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ABSTRACT

Background: Brain injuries caused by a tired bullet can range from headaches to severe brain injury and death. The question which poses a dilemma is whether extraction of retained bullets could decrease the late complications. This study aims to investigate the radiological findings, the neurological status of the patients, and different modalities of management for craniocerebral tired bullet injury.

Method: This study retrospectively reviewed 21 patients with a tired bullet injury to the brain who were admitted into our hospital over five years. All patients were assessed for the Glasgow outcome scale as outpatients.

Result: Of the 21 patients in the study, 11 (52.3%) were males, and 10 (47.6%) were females. The most common entry point of the bullet was frontal in 8 (38.0%) patients, followed by parietal in 7 (33.3%), and orbital in 5 (23.8%). The mortality rate was 23.8% (n = 5 patients). Bad outcomes were documented in patients with low GCS, with all patients who died having a GCS of (3–8). Bullet retrieval was performed for 7 of 21 patients, while all patients who were not candidates for emergency operation underwent local wound debridement. The GOS score was good [4 and 5] in 71.4% (15 of 21 patients).

Conclusion: This study revealed that two-thirds of patients with tired bullet injury underwent conservative treatment with an excellent long-term outcome, particularly for patients with high GCS on admission. The mortality rate was high among children under 15 years and those with a GCS of 3–8.

1. Introduction

When a bullet is fired into the sky, it loses its energy and falls, so the injuries from this bullet are called tired bullet or falling bullet injuries. Usually, they are unintended gunfire in which the injured person is away from the shooter. It is common in times of national celebrations, conflicts between military and civilians, and weddings [1,2].

The degree of brain damage will depend on the energy of the bullets, so a gunshot with low velocity always has favorable outcomes compared to a high-velocity gunshot. Low-velocity bullets cause penetrating brain injury rather than perforating [3]. Conservative treatment is the only management for some patients, while surgical management is indicated in other patients. Appropriate management is necessary to decrease the risk of early and late complications.

Neurological status on admission, the extent of the brain damage, patient transport, and surgical techniques are predictive variables for complications and outcomes [4]. Complications can be early (during the first week after wounding) and late (more than that period). Early complications are intracranial hematomas, infections, seizures, and cerebrospinal fluid leakages. Psychiatric illness, seizures, brain abscess, hydrocephalus, and moving bullet are late complications [5,6].

This study aims to investigate the radiological findings, the neurological status of the patients, and different modalities of management for craniocerebral tired bullet injury.

2. Method

This retrospective study included twenty-one patients with penetrating brain injury due to tired bullets admitted into the Neurosurgery Department of Mogadishu Somalia Turkish Training and Research Hospital between January 2017 and December 2021. All patients were brought to the hospital emergency department. None were shot directly.
and all patients were away from the incident area. Patients who had exit wounds, metallic foreign bodies other than bullets, and patients who were dead on arrival were excluded from the study.

Medical services were provided to all patients with a correction of the airway, breathing, and circulation. Neurological examination and examination of the wound were performed. Patients with less than eight Glasgow coma scale (GCS) were intubated. After resuscitation, all patients underwent brain computed tomography (CT) scans (Figs. 1 and 2).

Brain edema was treated for patients with clinical or radiologic features of raised intracranial pressure with mannitol. All patients received prophylactic anticonvulsants with phenytoin. Ceftriaxone was given to all patients with or without metronidazole. All patients were hospitalized, and control brain CT scans were performed.

Surgical candidate patients were operated on immediately after resuscitation for patients with GCS ≥5. Procedures include craniotomy or craniectomy (if there is extensive contamination of the wound), debridement, removal of all accessible foreign bodies, and hematoma evacuation.

Patients were followed up for complications with brain CT scans. We sent the patients to a psychiatrist for consultations, and all patients were assessed for the Glasgow outcome scale (GOS) as outpatients.

The ethics approval form was received from the ethical review board of Mogadishu Somalia Turkish Training and research hospital (APR NO: MSTRH/9195). Patients gave their informed permission. This study was carried out following the Helsinki Declaration’s contents. The study has been reported in line with the STROCSS criteria [7].

The data was collected using Microsoft excel and was analyzed using Statistical Package for Social Sciences software version 26. Descriptive data analysis was used to analyze the analytic parameters. The frequencies and percentages, as well as the mean ± (SD), were presented. The cross-tabulations and chi-square test was used to detect the significant association between the variables. P value < 0.05 was considered statistically significant.

3. Results

Of the 21 patients in the study, 11 (52.3%) were males, and 10 (47.6%) were females. The Ages ranged from 6 to 60 years, with a mean age of 21.1 ± 5.24. Pediatric patients (i.e., <15 year) were constituted 47.6% (n = 10). Regarding the GCS of the patients, 38% [8] of patients had a GCS between 3 and 8, while 33.3% (n = 7) had a score between 9 and 12 (Table 1).

![Fig. 1. Axial brain CT demonstrates a metallic foreign body in the occipital lobe.](image)

3.1. Radiological findings

All patients had a brain CT scan after resuscitation. The most common entry point of the bullet was frontal in 8 (38.0%) patients, followed by parietal in 7 (33.3%), orbital in 5 (23.8%), and temporal in 1 (4.7%). None of the patients had an exit point (all patients have retained bullets). The bone defect was < 2 cm in 19 (90.4%) patients, 2 cm in 1 (4.7%) patient, and > 2 cm in 1 (4.7%) patient. All patients had associated intracranial pathologies, which included: intracerebral hematoma in 19 (90.4%) patients, a bone fragment in 13 (61.9%) patients, subarachnoid hemorrhage in 5 (23.8%) patients, subdural hematoma in 3 (14.2%) patients, and intraventricular hemorrhage in 2 (9.5%) patients. The bullet location was ipsilateral to the entry side in 11 (52.3%) patients, 8 (38.0%) patients were contralateral to the entry side (crossed the mid-sagittal line of the brain), and the rest of the two (9.5%) patients, the bullet was in the midline (one in the superior sagittal sinus and the other in the posterior fossa).

3.2. Management

Patients not candidates for emergency cranial operation (n = 14, 66.7%) underwent local wound debridement and primary wound closure in the emergency department. Total operated cases were 7 (33.3%). Bullet retrieval was performed for 7 (33.3%) patients. Six (85.7%) of those seven patients were operated on within 24 h of admission, while the other was operated on six months later. The surgical technique was free hand craniotomy or craniectomy with debridement of the dead tissues, removal of bone fragments, hematoma evacuation, and bullet extraction. None of the operated cases has died.

3.3. Complications

The early complication rate was 9.5% (2 of 21 patients), with one patient having early onset seizure and the other developing meningitis with staphylococcus aureus as the causative agent. Late complications occurred in 16 surviving patients, comprising chronic headache in 75% (12 of 16 patients), Psychiatric symptoms in 68.7% (11 of 16 patients), moving bullet in 31.2% (5 of 16 patients), hydrocephalus in 25% (4 of 16 patients), seizure in 25% (4 of 16 patients), and permanent neurological deficit in 18.7% (3 of 16 patients). None of the patients developed brain abscesses (Table 2). Regarding Psychiatric symptoms, ten patients developed behavioral changes, and one patient with PTSD.

3.4. Prognosis

The mortality rate was 23.8% (5 of 21 patients). The mortality rate was high among children under 15 years, accounting for 80%. All patients who died had a GCS of 3–8 score. None of the patients with GCS more than eight died. Patients with high GCS at admission have favorable outcomes. GOS score was good [4and5] in 71.4% (15 of 21 patients) (Table 3).

4. Discussion

Tired bullets have a vertical angle. Even though the kinetic energy is lower than that of directly fired gunshots, these injuries can be serious [8]. Sometimes, the diagnosis of tired bullet injury may be challenging because of the small injury wound. Patients may appear to have normal general physical examination apart from a decreased level of consciousness, as we have noticed in one of our cases [9].

Tired bullet injuries usually have less mortality rate compared to other gunshot wounds to the head [10]. In our study, the overall mortality rate was 23.8%. In a series of 125 patients with craniocerebral gunshot wounds, Liebenberg et al. recorded a mortality rate of 69%, which is higher than the rate we reported in our cohort [10]. Tsuei et al. also reported a nearly similar mortality rate of 31% [11]. Clark and
colleagues reported that there were no survivors in patients treated conservatively with a GCS score of 3, as well as in patients submitted to surgery with a preoperative score of 4–5(4). The outcome of bullet head injury depends on age, Glasgow coma score on admission, the reactivity of the pupils, associated intracranial pathologies (hematomas, retained bullets), and structures injured through its cerebral course [12,13].

Complications of penetrating craniocerebral wounds can be early (during the first week after wounding) or late (after that period). Postoperative hematomas, infections, early onset seizures, and cerebrospinal fluid fistulas (CSFFs) are among the early complications, whereas moving foreign body intracranially, seizures, brain abscesses, psychiatric illnesses, and posttraumatic hydrocephalus represent late complications [14]. Retained foreign bodies, wound age, wound site, the extent of brain damage, and surgeries performed outside the neurosurgical services are considered risk factors for developing complications [3].

Smith and colleagues revealed that patients with retained bullets have more severe depression and a poorer quality of life compared with patients without retained bullets [15]. In contrast, none of our patients had depression.

In our study, bullet migration was noted in a quarter of survivors. Wood and associates reported a lower bullet migration rate of 10%. Jefferson reported a case of spontaneous movement of a bullet in the cerebrum, which was associated with softening of the surrounding brain tissue and abscess formation [15]. Tudor et al. documented that no patients had migrating metallic foreign bodies in 45 patients with retained metallic bodies [6].

Late seizures were seen in 25% of surviving patients in our study, and only one patient had an early seizure episode. In a study of 16 patients with gunshot wounds to the brain, Tsuei et al. documented that 18% of the patients developed seizures [11]. An analysis of 107 civilian craniocerebral gunshot wounds observed postoperative seizures in six cases. Several authors believe there is no relation between retained foreign bodies and seizure [10].

In our study, four patients developed hydrocephalus. Tudor et al. investigated the complications of missile craniocerebral injuries during the Croatian Homeland War. The authors reported that 1.7% of the patients developed hydrocephalus [6]. None of our patients developed brain abscesses, which agrees with the cohort study of 20 patients with retained intracranial pellets [14]. These authors reported that none of their cases developed brain abscesses during the follow-up period. The infection rate in the recently reported series of missile head wounds varied between 6% and 28.6% [12]. Retained intracranial bone fragments are recognized as a potential source of infection. A higher incidence of abscess formation has been demonstrated in cases with a retained foreign body and bone fragments than in those without them [13]. On the other hand, several scholars have proven contrariwise, reporting that there is no association between retained missiles and the development of infection. Management approaches to tired bullet injuries of the brain are controversial [16]. The main indications for removal of intracranial retained bullets include patients who are undergoing surgery for the evacuation of hematoma or significant cerebral swelling and bullet with easily accessible or superficial, retained bullet causing the development of an abscess, neurological deterioration because of its migration, bullets within the ventricular system because of their propensity of causing hydrocephalus, heavy metal toxicity, and to avoid all complications those can originate from the retained bullets in easily accessible bullets without causing additional neurological deficits. Less common indications for

Table 1
Correlation between Glasgow Coma Scale (GCS) scores on admission and mortality rate of the patients.

| GCS   | No. (%) | Mortality rate. (%) | p-value |
|-------|---------|---------------------|---------|
| 13-15 | 6 (28.5%) | 0(0%)               | <0.001  |
| 9-12  | 7(33.3%) | 0(0%)               |         |
| 3-8   | 8(38.0%) | 5(52.8%)            |         |

Table 2
Late complications of tired bullet injury to the brain in 16 surviving patients.

| Late complications      | No. (%) |
|-------------------------|---------|
| Chronic headache        | 12(75%) |
| Behavioral change       | 10 (62.5%) |
| Moving bullet           | 5 (31.2%) |
| Seizure                 | 4 (25%) |
| Hydrocephalus           | 4 (25%) |
| Permanent neurological deficit | 3 (18.7%) |
| PTSD                    | 1 (6.2%) |
| Brain abscess           | 0       |

Table 3
Outcome of tired bullet injuries according to Glasgow outcome scale score.

| Outcome     | GOS | Frequency | Percentage |
|-------------|-----|-----------|------------|
| Good recovery | 5   | 14        | 66.6%      |
| Mild disability | 4   | 1         | 4.7%       |
| Moderate disability | 3   | 1         | 4.7%       |
| severe disability | 2   | 0         | 0%         |
| Dead         | 1   | 5         | 23.8%      |

Fig. 2. Axial and sagittal brain CT shows a metallic bullet foreign body in the parietal lobe extending to the superior sagittal sinus.
bullets. Different strategies have been suggested to manage bullet head injuries with retained foreign bodies [17]. Conservative treatment; minimal or superficial wound debridement; small craniotomy or craniectomy followed by simple debridement of the entrance gutter; and classic craniotomy and aggressive debridement of all the necrotic brain tissue, hematoma, and retrieval of in-driven bone and metal fragments are the mainstay management approaches.

Local wound debridement was done in 15 of our patients, while the other six underwent emergency operations with classic craniotomy. In a series of twenty-three patients injured by falling bullets, 74% of the cases underwent extensive surgery with bullet extraction while the other 26% of the cases bullet left retained [18]. Minimal debridement was not only for unsalvageable patients but a treatment for many patients with missile head injuries. Simple wound closure may be treated for patients with low-velocity missile wounds to the head.

Searching for retained deep-seated bullets increases the risk of brain damage, so several studies do not advocate the exploration of such bullets [2]. It has been reported that reoperation for retained bone fragments is not beneficial. Bullectomy is advantageous to patients who wish to have MRIs. Bullets [2]. It has been reported that reoperation for retained bone fragments is not beneficial. Bullectomy is advantageous to patients who wish to have MRIs.

Strengths and limitations: 1) this is a retrospective single-center-based study, although it is the sole tertiary and referral hospital. 2) The small sample size 3) The size of the bullet was not measured, which may negatively impact the patient outcome. The present study is the first report that investigates the patients’ radiological findings, neurological status, and different management modalities for craniocerebral tired bullet injury.

5. Conclusion

This study revealed that two-thirds of patients with tired bullet injury underwent conservative treatment with an excellent long-term outcome, particularly for patients with high GCS on admission. The mortality rate was high among children under 15 years and those with a GCS of 3–8.

Long-term follow-up is recommended for patients with intracranial foreign bodies for late complications. Though tired bullets have better outcomes than direct gunshot injuries, tired bullets can cause significant brain injury with poor outcomes.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Ethical approval

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Author contribution

1. Raqib Abdirahman Mubarik; Manuscript writing. Data analysis and Interpretation.
2. Mehmet kaan ÜNGOREN: Background theory and revising the text.
3. Ismail Gedi Ibrahim: Radiological diagnosis and scientifically reviewed.
4. Hassan Abdirahman mubarak: Part of discussion and Proofreading.
5. Abukar Mohamed osman: reviewed patients’ data and Part of abstract writing.

Registration of research studies

1. Name of the registry: Not applicable
2. Unique Identifying number or registration ID: Not applicable
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

Guarantor

Raqib Abdirahman Mubarik MD.

Consent

Authors have taken written consent from the patient or patients’ parent. And will be available on request.

Conflicts of interest

Authors have no financial or personal conflict that can influence this work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jamsu.2022.104870.

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