Right-to-Left Displacement of an Airgun Lead Bullet after Transorbital Entry into the Skull Complicated by Posttraumatic Epilepsy: A Case Report

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Penetrating head injury is a serious open cranial injury. In civilians, it is often caused by non-missile, low velocity flying objects that penetrate the skull through a weak cranial structure, forming intracranial foreign bodies. The intracranial foreign body can be displaced due to its special quality, shape, and location. In this paper, we report a rare case of right-to-left displacement of an airgun lead bullet after transorbital entry into the skull complicated by posttraumatic epilepsy, as a reminder to colleagues that intracranial metal foreign bodies maybe displaced intraoperatively. In addition, we have found that the presence of intracranial metallic foreign bodies may be a factor for the posttraumatic epilepsy, and their timely removal appears to be beneficial for epilepsy control.

Key Words: Penetrating head injury · Foreign body migration · Posttraumatic epilepsy.

INTRODUCTION

Penetrating head injuries (PHI) account for approximately 0.4% of all traumatic brain injuries (TBI)3. In civilians, it is often caused by non-missile type, low velocity flying objects such as projectiles, wood, debris, or skull fragments, entering the cranial cavity through anatomically weak areas such as the external auditory canal or orbit11. In China, non-missile PHI is mostly caused by air guns, which have slow velocity and low kinetic energy, and the injuries are mostly blind tube injuries, often forming intracranial foreign bodies. There are few reports of displacement of intracranial metallic foreign bodies complicated by posttraumatic epilepsy (PTE). In this paper, we report a case of right-to-left displacement of an airgun lead bullet after transorbital entry into the skull complicated by PTE. The patient in this case underwent two surgeries within 2 years: the first surgery mainly removed the broken bone fragments in the brain, but the lead bullet foreign body was not found due to its intraoperative displacement from the right hemisphere to the left. One year later, the patient was re-admitted due to PTE seizures frequently and strongly requested to remove the intracranial lead bullet foreign body. There-
for we operated the second surgery, during which the foreign body was successfully removed and the epilepsy was effectively controlled.

CASE REPORT

On March 18, 2020, a 40-year-old male was accidentally shot by an airgun lead bullet through the left eyeball into his skull, resulting in the lead bullet retained in his brain.

On March 19, 2020, he presented to the emergency department, where the physician performed computed tomography (CT) scan of the head and found a foreign body retained in the frontal horn of the right lateral ventricle (Fig. 1A-D), then he was admitted to the neurosurgery department. He was admitted with a clear consciousness, stable vital signs, a Glasgow coma scale (GCS) score of 14 and a previously healthy body. He underwent an operation to remove the intracranial foreign body on the same day after completing the preoperative examination.

Some of the bony foreign bodies were removed during the operation, but the lead bullet foreign body was not successful-

![Fig. 1](https://example.com/fig1.png)

**Fig. 1.** Location of the intracranial foreign body before and after the first surgery. A-D : Preoperative. E-H : Postoperative. The red dots in (C, D, G, and H) indicate the intracranial foreign body which is reconstructed in 3D.

![Fig. 2](https://example.com/fig2.png)

**Fig. 2.** The first surgical procedure. A : The skin incision design. B : The arrow in the middle indicates a brain surface wound. C : Intraoperative ultrasound, the highlighted area in the center of the figure is a foreign body shadow, which cannot be located. D : Intraoperative X-ray, the red arrow indicates a foreign body, which cannot be located despite the use of surgical instruments.
ly found due to intracranial displacement. We inability to locate it accurately by intraoperative X-ray and ultrasound (Fig. 2). The postoperative cranial CT showed that the foreign body was moved from the preoperative right lateral ventricular frontal horn to the left lateral ventricular frontal horn (Fig. 1E-H). We decided to treat with him conservatively and not do the second craniotomy for the patient after communicated with his relatives.

During hospitalization, we performed regular lumbar punctures to extract cerebrospinal fluid for bacterial culture, which showed no bacterial growth. After 1 month of hospitalization, he was discharged on April 18, 2020 with well-wound healing, blindness in the left eye and no other abnormal symptoms. He was seizure-free during hospitalization and continued out-of-hospital medication to prevent seizure.

After discharge from hospital, he was followed up by regular outpatient visits and telephone calls. He had several seizures separately at 4, 8, 11, and 12 months after the operation. One year later, the seizures occurred monthly with no apparent pattern and lasted from a few seconds to a few minutes separately. The sodium valproate couldn’t control his seizures.

So, he visited the neurology clinic to adjust the treatment prescription to a combination of sodium valproate and levetiracetam, which reduced his seizures.

On December 20, 2021, he had a serious seizure. So, he re-admitted to the hospital on December 27, 2021, with a strong desire to remove the intracranial foreign body. The intracranial foreign body was successfully removed on December 29, 2021 (Fig. 3). The sodium valproate was applied intravenously but one seizure occurred during hospitalization. We completed the electroencephalography (EEG) for him, but we did not detect typical epileptic waves. He was discharged from hospital on January 14, 2022. Sodium valproate was administered out of hospital to prevent seizure. He had no seizures after followed up 8 months.

**DISCUSSION**

The airgun is the most common factor to PHI among civilians. The mechanism of injury from airguns is primarily derived from the kinetic energy of the pellet. Due to the low ki-
In this case, the CT played an important role, as it directly clarified the displacement of the lead bullet and the location of the intracranial foreign body after the first operation. The use of X-rays only showed us a two-dimensional plane of information during the first operation. That made us difficult to locate the foreign body accurately. The use of intraoperative TCS can be helpful in the localization of foreign bodies sometimes.

Displacement of the intracranial foreign body

Displacement of the intracranial foreign body is a rare phenomenon. The displacement is related to the qualities of the foreign body itself (e.g., mass, shape, surface, etc.) and the initial intracranial location (e.g., the foreign body is not easily displaced when proximity to bone, blood vessels, meninges, etc.). There is still considerable controversy regarding the management of intracranial foreign bodies. Some scholars believe that the metallic foreign bodies cannot be removed when they are located in deep vital structures, with small in size or has life-threatening by operation. However, for lead bullets and cranial fragment bodies, they should be removed completely because of increased toxicity and chance of infection compared with other foreign bodies. In addition, intracranial shrapnel or projectiles >5 mm in diameter need to be completely removed because they are prone to foreign body displacement and can cause local brain tissue hyperplasia inducing epilepsy or toxic effects on brain tissue (especially lead and aluminum bullets). However, Karadas et al. suggested that in cases without complications, where the foreign body is located deep and difficult to remove by surgery, the operation is not necessary and regular follow-up is sufficient.

However, intraoperative management of intracranial foreign body displacement has not been reported. There are no uniform criteria about the time to remove intracranial metallic foreign bodies. If the displacement of the intracranial foreign body occurs within a few hours of trauma, it is difficult to successfully remove it through surgery. For this reason, some investigators have suggested that intracranial foreign bodies should be accurately localized and removed 2 to 3 weeks after the injury. When they are easier to be removed as they are held in place by proliferating fibrous connective tissue or encapsulated by fibrous tissue. However, intraoperative management of intracranial foreign body displacement has not been reported.

In this case, the intracranial metallic foreign body was easily displaced because of its large mass, spherical shape and smooth surface. We therefore suggest that intracranial dis-
PTE

PTE is an important complication affecting the quality of life of patients and can be divided into early (≥7 days) and late (>7 days) epilepsy. The incidence of PTE is 3.8% to 4.2% in all types of TBI\(^1\). There is no direct evidence as to whether PHI in combination with intracranial foreign bodies increases the incidence of PTE. Based on this case, we consider that the presence of an intracranial metallic foreign body may precipitate seizures. Because this patient had frequent seizures after the first surgery, this may have been due to the trauma itself or the retention of the intracranial metallic foreign body. In contrast, the patient’s seizures were effectively controlled after the second successful surgery to remove the intracranial metal foreign body.

The pathogenesis of PTE is unclear. Aarabi et al.\(^1\) suggested by multivariate regression analysis that GCS scores and motor deficits are associated with the development of epilepsy. Recent studies have concluded that excitotoxicity, neuroinflammation, oxidative stress, and neurodegeneration are the main causative factors in PTE\(^1\). Towner et al.\(^2\) reported that the retention of lead bullets in the body resulted in a sustained increase in lead levels and toxic effects, and that the lead levels decreased rapidly after surgical removal of the lead bullets and the symptoms were effectively relieved. In this case, the patient had a GCS score of 14 and no motor deficits, so it was considered that seizures might be related to the type of foreign body. In other words, the intracranial metallic foreign body may increase the probability of PTE, which may be related to the slow release of metallic toxic ions from metallic substances acting on local brain tissue and causing abnormal local electrical activity.

There are no clear protocols on how to effectively prevent PTE. But there is clinical practice recommend the administration of drugs such as phenytoin sodium and carbamazepine to control epilepsy within 1 week after injury\(^5\). Although there is evidence that the use of these prophylactic antiepileptic drugs may reduce early seizures, there is no evidence of benefit for late epilepsy\(^5\). For those with severe seizures, antiepileptic drug therapy is preferred, but the surgery can be tried after evaluation of the condition for those with well-localized and limited seizure foci\(^5\).

In late epilepsy patients with intracranial retention of for-
eign bodies, it has not been investigated whether removal of the foreign body can improve epileptic symptoms. In this case, the patient applied sodium valproate for seizure prevention during the first hospitalization and did not experience seizures, which supports the effectiveness of early antiepileptic drug application. However, the patient had several seizures during the follow-up period, and after adjusting the medication prescription, seizures continued and was more serious than before. Therefore, we decided to have a surgery for the patient again, and the intracranial foreign body was successfully removed. The patient underwent seizures at the fourteenth day after the reoperation, which may be related to the trauma of the reoperation. But we did not find typical seizure waves after monitoring the EEG. However, based on EEG topographic (Fig. 4) changes since the patient’s injury, we hypothesized that the patient may have a confined epileptic lesion in the right frontal lobe of the brain, but this epileptic lesion did not correspond to the location where the foreign body was located after its displacement. However, after removal of the intracranial foreign body, the patient’s seizures were significantly relieved compared with before (continued follow-up for 8 months without seizures). Therefore, we conjecture that the removal of the intracranial metallic foreign body may contribute to the control of PTE by reducing the release of toxins from the metallic foreign body.

In addition, the reduction of psychological stress after the intracranial foreign body was removed from the patient in this case may have contributed to the control of PTE also. As some studies have concluded that psychological stress is an important trigger and sometimes the cause of seizures. However, the relationship between changes in psychological factors and the progression of PTE still needs to be confirmed by further clinical studies.

CONCLUSION

PHI caused by airgun pellets often forms intracranial foreign bodies, and such intracranial foreign bodies can shift in position during early surgery because of their mass, shape and surface smoothness. Therefore, if a foreign body is difficult to be found during the surgery, it may be displaced, and it is particularly important to accurate its location at this time. If it is hard to locate the foreign bodies during the operation, the surgery should be stopped and have the CT scan to certain the location. If the foreign body is confirmed to be displaced, symptomatic treatment, such as anti-infection, can be administered firstly. The surgery can be considered for the patient to remove the foreign body after it has been fixed by the around brain tissue. If an intracranial foreign body is present in the patient, especially a metallic foreign body, complicated with PTE, it may be facilitated to control the PTE by removing the metallic foreign body. Those may due to reduce the release of toxins from the metallic foreign body and reduce the patient’s psychological stress.

AUTHORS’ DECLARATION

Conflicts of interest
No potential conflict of interest relevant to this article was reported.

Informed consent
Informed consent was obtained from the patient.

Author contributions
Conceptualization : HW, JH; Data curation : CW, JZ, ZW, HL; Formal analysis : JH, CW, AL; Funding acquisition : JH; Methodology : JH, HW, CW; Project administration : JH, HW; Visualization : CW, DW, JH; Writing - original draft : CW; Writing - review & editing : JH, CW

Data sharing
None

Preprint
None

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https://doi.org/10.3340/jkns.2022.0234
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