Civilian Gunshot Wounds to The Head: A Case Report, Clinical Management, and Literature Review.

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Case report

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Abstract

Background: Civilian Gunshot wounds to the head refers to the brain injury caused by projectiles such as gun projectiles and various fragments generated by explosives, gunpowder, etc. as a power launch or explosion. Gunshot wounds to the head is the deadliest of all gun injuries, according to literature statistics, the survival rate is only 9%.[1] Due to the strict management of various types of firearms, they rarely occur, so the injury mechanism, injury and trauma analysis, clinical management, and surgical standards are almost based on military experience, and there are few related reports especially the head suffered a fatal blow more than once in a short time. We report a case with a return to almost complete recovery despite the patient suffered shots on the head twice in a short period of time.

Case Presentations: We present a case of a 53-year old male who suffered twice gunshot injuries to the head under unknown circumstances. On initial presentation the patient had a Glasgow Coma Score of 6, unable to communicate, loss of consciousness. The first bullet penetrated from the right frontal area and finally reached the right occipital lobe. When the patient subconsciously covers his head with his hand, the second bullet through the patient's right palm bone, entered from the right frontotemporal, and stayed deep in the lateral sulcus. The patient had a cerebral hernia when he was admitted to the hospital, and immediately entered the operating room for rescue after a compute tomography scan. After two foreign body removals and one skull repair, the patient recovered completely.

Conclusions: Gunshot wounds to the head have a high mortality rate and usually require aggressive management. Evaluation of most gunshot injuries requires extremely fast imaging examination upon arrival at the hospital followed by proactive treatment against infection, seizure and increased intracranial pressure. Surgical intervention is usually necessary, and its key point usually includes the timing of the operation, the method of operation, and the scope of the operation.

Introduction

The surgical management of gunshot wounds to the head (GWH) is still a challenging issue in neurosurgery.[2] Even after the experience acquired during the two World Wars and multiple local wars, the surgical management of such patients still needs further discussion because mortality and morbidity remain high despite of technological improvement in the last decades.[2,3] Neurosurgeons vary considerably on their approaches to GWH. Studies have shown that age of the patient, high preoperative Glasgow Coma Score (GCS), lack of pupil abnormalities, and absence of intracerebral hematoma are predictors of a good prognosis.[2]

The largest retrospective studies to date have shown that penetrating GWH are very often fatal even with appropriate medical and surgical treatment: 71% dying at the scene, 66–90% dying before reaching a hospital, and up to a 51% survival rate among those reaching the hospital alive.[1,4,5] We highlight the current management guidelines, prognostic factors, and survival outcomes in patients with penetrating GWH. We report a case that is unique due to its successful outcome and return to almost complete recovery despite twice gunshots on his head and a low GCS. We defined the almost complete recovery as the ability that patients are able to complete simple, repetitive farming activities by himself without the care of his family.

Case Report

A 53-year old male with twice GWH to his right cerebral hemisphere presented with a GCS of 6 to the hospital. Physical Examination: He was hemodynamically stable and intubated, there were two adjacent bullet holes in the patient's right frontal area, and no ballistic exit was seen. Neurological examination: his right pupil was fixed and dilated, and his left pupil was 2.5 mm and reactive. He can withdraw painful stimuli and no verbal. Computed tomography (CT) scan of the head revealed the bullet trajectory with right frontal comminuted fracture and bony and metallic fragments in the right frontal lobe and right occipital lobe. There was also some brain tissue swelling with midline shift to the left and subarachnoid hemorrhage (Fig. 1). Since the patient had a brain herniation at the admission, he was taken to the operating room immediately for debridement and decompressive craniectomy after the first CT scan. Considering the specificity of the patient's intracranial hematoma location and foreign body location, we performed the extended pterional approach and decompressive craniectomy in time. We did not temporarily remove the foreign body in the occipital lobe but waited for the patient's vital signs to stabilize after the first operation and then evaluated whether it was suitable for removal or keep. The patient recovered well after the first operation with no infection or brain abscess development and was underwent the second operation 2 weeks later to remove the foreign body in the occipital lobe (Fig. 2). He was discharged home 7 days later. The patient came in for a 3 week, 3 months, 1 year follow up and was underwent the repair of skull defect during recovery. The patient underwent a head CT reexamination at 3-month post trauma that revealed hydrocephalus but without any discomfort. During subsequent follow up, hydrocephalus did not continue to develop, and the head CT yielded no new or concerning findings, so we did not take additional clinical management. Now this patient was followed up for a year, during which his GCS reached 15 and did not experience seizures and other neurological symptoms.

Discussion

Prehospital treatment

Based on the outcomes of prospective study, all GWH patients should initially receive aggressive resuscitation.[6] Patients with stable vital signs should be examined by CT scan. If the patient's GCS score after resuscitation is 3 to 5 and no operable hematomas are present, then no further therapy should be offered.[3,6] All patients with a GCS score greater than 5 should receive aggressive surgical therapy.[3,6] However, some recent retrospective studies have shown that GCS at admission and the status of pupils and hemodynamic situation seem to be the most significant predictors of outcome in penetrating GWH. CT scans, bi- or multilobar injury, and intraventricular hemorrhage were correlated with poor outcome. Patients with a GCS >8, normal pupil reaction, and single lobe of brain injury may benefit from early aggressive management.[7] After undergoing a quick primary survey, all the victims of GWH with a GCS <9 should be intubated, oxygenated, and ventilated. The systolic blood pressure should be kept below 90 mmHg. After secondary survey and resuscitation, the patients should have a CT scan of the head.[2,7,8] In our case, although our patient could breathe when the emergency physician arrived at the scene, they still intubated him in time, which also won us valuable time for the subsequent emergency treatment. It has been proved by Thomas W et al that preventing secondary injuries from hypoxia and hypotension by field resuscitation improved the patients' outcomes.[6] Although Kaufman et al. did not specify whether the GCS score was performed before or after resuscitation, a few patients with GCS scores of 3 to 5 clearly have the potential for a reasonable recovery. Using the admitting GCS score to categorize the patients' extent of injury and then to predict outcome is only valid if the patient's best score is not obscured by other conditions like hypoxia, hypotension, or operable hematomas; otherwise, it is difficult to make an accurate prognosis. In addition, GCS scores obtained after resuscitation eliminate the secondary causes of a decreased level of consciousness and accurately predict the extent of the initial injury and the patient's outcome.[6] In a 5-year retrospective review of 132 civilian patients with craniocerebral GSW, increasing survival was associated with aggressive resuscitation in all patients, and resuscitation with blood products and hyperosmolar fluids were independently associated with survival GCS 3-5 and bihemispheric injury should not prevent early resuscitation, but a decision for expectant supportive care should come when the patient has been stabilized and then reassessed as some may improve. It is therefore the post resuscitation GCS that should be used for decision making.[4] Acute traumatic coagulopathy (ATC) may develop in patients with isolated head injury (which includes GWH) and in the setting of multiple injuries with major blood loss and shock.[9,10]This latter scenario includes GWH. The diagnosis of acute traumatic coagulation disorder should be predicted rapidly before admission, and the treatment should be prepared as soon as possible. Massive transfusion protocols have been developed in many trauma center: replacement of blood and clotting components should be prepared at the admission.[11] However, the optimal ratio of various of plasma substitute and blood products is uncertain and remains under investigation.[12]

We summed up the prehospital treatment of GWH: early aggressive resuscitation; correct hypotension, hypoxia; maintain control of persistent bleeding; early intervention of ATC with the experience of emergency physician; urgent CT scan.

Imaging studies

It has become the consensus of neurosurgeons all over the world that patients with brain injury are sent to the imaging center for head CT scan as soon as they arrive at the hospital. Plain radiographs of the head can be helpful in assessing bullet trajectory, the presence of large foreign bodies, and the presence of intracranial air. However, when CT scanning is available, plain radiographs are not essential and are not recommended as a routine.[13] No imaging technique is faster and more accurate than CT scan. It has almost no taboos except for pregnant women. A CT scan of the head defines the bullet’s trajectory, entry and exit sites, extent of intracranial fragments and proximity to major blood vessels and the ventricles, pressure on the ambient cistern. In addition, scan of the head will determine the need for surgery and define the strategy for surgical treatment. It is the recommended imaging modality with 5 mm-thick continuous slices along the Reid line from the vertex to the foramen magnum for evaluating cranial trauma.[14] Patients who are found to have risk factors on CT scans, including intracerebral hematomas, orbital and facial craniocerebral injury, patients with projectiles penetrating two or more ventricles, trajectories close to vertebrobasilar vessels, cavernous sinus, the dural venous sinuses, the Sylvian fissure and anterior circulation should undergo CT angiography(CTA), and if necessary, routine Digital Subtraction Angiography(DSA) to rule out traumatic intracranial aneurysms.[13,15] In our case, because of the emergency situation at that time, our patient was pushed into the operating room without CTA imaging after admission, but coincidentally, we found a middle cerebral bifurcation aneurysm when explored the lateral fissure, and then clipped it (Fig. 3). In the absence of CTA imaging, the evacuation of hematoma will be very passive for the aneurysms found suddenly, which taught us a lesson. Fortunately, the aneurysms were not ruptured, so we clipped it safely. Obviously, this aneurysm has nothing to do with this injury. We speculate that this is not a traumatic aneurysm, but an unruptured aneurysm. Fortunately, both bullets avoided this aneurysm. Can we make a bold proposal? If time permits, head CTA should be obtained in all patients regardless of whether such patients have a high risk of vascular injuries of the brain. It can not only understand the vascular injury, but also exclude the vascular abnormality of the patients themselves, which will play a key role in the final design of the operation.

Magnetic Resonance Imaging (MRI) studies are generally not recommended due to the uncertainty of bullet composition. Moreover, In such an emergency, it is impractical to implement imaging modalities that are time consuming to obtain.[13]

Surgical management

There is controversy regarding surgical management in patients with a GWH. Most of the current treatment is based on data derived from retrospective observational military and civilian studies.

Minor gunshot injuries to the brain with nonpenetrating wound such as tangential wound, ricocheting wound may only require local debridement, closure and antibiotics. More severe focal injuries with hemorrhage and fragments without mass effect may also only require local exploration via a small craniotomy. Tubular wound and penetrating wound are still great challenges for the neurosurgeon. Severe penetrating injuries will require extensive surgery, even more, if a decision is made to operate. This may include debridement, evacuation of hematomas, decompressive craniectomy, dural repair and stereotaxic technique.

Recent evidence indicates that after a satisfactory primary debridement, the risk of deep intracranial infections decreases sharply. In such circumstances there is no need for secondary debridement. Long-term follow-up of such patients from the Vietnam, Iran-Iraq, and Israel-Lebanon wars indicates that without complicating risk factors such as Cerebrospinal Fluid(CSF) leakage, the chance of intracranial infection is not increased.[16] When intractable intracranial hypertension or malignant brain swelling is found at the time of CT scan or surgical exploration, decompressive craniectomy could be life-saving.

Experience during Operation Iraqi Freedom has indicated that decompressive craniectomy can offer an invaluable surgical technique for controlling intracranial pressure or impending brainstem compression.[17–21] Decompressive craniectomy has been used in civilian GWH and seems to be of value when there is extensive hemispheric swelling that is not responsive to maximum medical management .

In several studies, patients underwent debridement and decompressive craniectomy together. Kaufman et al. reported 20 survivors and 8 no survivors who had major debridement and decompressive craniectomy. In the study of Grahm et al., 43% of patients underwent decompressive craniectomy specifically for debridement. Dosoglu et al.6 reported 47 patients who underwent operation, which included debridement and decompressive craniectomy. The concern in performing concurrent debridement and decompressive craniectomy is the potential development of cerebral abscesses.[6,22,23] Some authors have advocated a less aggressive cleaning procedure preserving as much brain tissue as possible[24,25], while some others have suggested a more aggressive approach consisting of debridement of necrotic tissue, hematoma evacuation, removal of bone fragments and foreign material as much as possible, establishing hemostasis, and dural closure.[26–28] Surgical intervention is not recommended for multilobular injuries and a GCS below 5 owing to lack of survival benefit.[6,29] Grahm et al. do not recommend surgery in the absence of any significant hematoma or a bihemispheric or multilobar injury, or when GCS is above 6-8.[30] The great challenges and dilemmas for the neurosurgeon treating a severe GWH are whether to pursue surgery and survival of the patient at all costs or alternately, whether to pursue quality of survival, so as to provide the expected treatment for selected patients.[3] In many cases, the results may not be easy to predict, which makes surgeons in the choice of their treatment in moral dilemma, but also largely subject to the treatment willingness of patients' families.

In our case, we decided to carry out the following operation plan: first, we quickly resected the temporal bone for decompression, then cut the dura mater to clear the wound along the trajectory and removed the temporal bullet and bone fragments. We did not aspirate much brain tissues, nor did we remove the occipital bullet fragment in the first operation. We just aspirate the broken brain tissues and hematoma in the temporal lobe and hemostasis, and at the same time, we clip a lucky one unruptured aneurysm. This decision was dictated by several factors: CT scan shows that the midline of brain is deviated and there are signs of continuing increased intracranial hypertension; the choice of extended pterional approach can not only reduce the pressure of brain, but also remove the temporal bullet fragments and necrotic brain tissue at the same time; according to the CT scan (Fig. 1), because the projectile trajectory in the occipital region is not clear and there is no space-occupying effect, the occipital bullet fragment was left in place for the moment. 2 weeks later, our patient recovered well with no infection or brain abscess development and was underwent the keyhole approach to remove the occipital bullet fragment (Fig. 2).

Clinical management

Intracranial hypertension (ICH) is one of the major predictors of prognosis in patients with penetrating head trauma, with higher values associated with worse outcomes. And ICH is the primary cause of mortality in patients with head trauma, and is a known contributor to secondary brain injury.[31] However, The need for intracranial pressure (ICP) monitoring is not as well defined in postoperative management of patients with civilian GWH in the management and prognosis of penetrating brain injury.[1,32,33] Commonly used methods for ICP correction are the infusion of hypertonic saline and mannitol, short-term hyperventilation, CSF drainage, barbiturates and paralytics, and finally decompressive craniectomy. Correction of ICP should be started at ICP values higher than the threshold of 20 mmHg registered for 5 min and longer.

Hyperventilation can be an efficient method for correcting ICH caused by cerebral hyperemia. When using hyperventilation, one should monitor whether oxygen supply to the brain is sufficient by measuring blood oxygen saturation in the jugular vein. SvjO2 indices lying within 55-75% are considered normal, provided that oxygenation of arterial blood is sufficient. The normal PbrO2 is 25-35 mm Hg at oxygen tension in the arterial blood of 80—100 mm Hg. PaCO2 needs to be maintained at 36-40 mm Hg. Mean blood pressure should be maintained above 90 mm Hg during the whole duration of intensive care. However, preventative hyperventilation (PaCO2<35 mm Hg) within first 24 hours has been shown to carry a risk of worsening cerebral perfusion by decreasing cerebral perfusion pressure.[31]

Short-term hyperventilation is permitted in the case of abrupt worsening of the neurological status or for persistently raised ICP despite the use of sedatives, muscle relaxants, hyperosmolar solutions and CSF drainage.[34,35] In our case, hyperventilation is a temporary measure for reducing increased intracranial pressure. Our patient has been undergoing noninvasive ICP monitoring since the first operation and return to the intensive care unit. In the next 48 hours, he was given continuous low concentration oxygen therapy, and his GCS score reached 10 on the second day after surgery.

Civilian GWH are open, contaminated wounds that violate the scalp, skull, dura, and brain parenchyma. Devitalized brain tissue and retained bone fragments are media suitable for bacterial growth. Most of the contaminating organisms are those of skin flora and primarily Staphylococcus epidermidis.[36,37] Patients with unknown immunization status and a contaminated wound to the head should receive a tetanus toxoid-containing vaccine intramuscularly and 250 units of human tetanus immune globulin at a different site than the tetanus toxoid.[38] Although not supported by any prospective randomized controlled study, the use of prophylactic broad spectrum antibiotics is appropriate for patients with PBI since these wounds are considered to be contaminated.[39] According to the current US military guidelines, patients should receive cefazolin for 5-7 days.[40] Helling et al. stated that antibiotics, usually cephalosporins for blood-brain barrier penetration, were routinely administered to all patients, and no instances of post-operative brain abscesses were reported.[41,42]

Seizure is another common complication seen in patients with traumatic brain injury, with the incidence ranging from 1.1% to 53%. Posttraumatic seizures (PTS) are classified as early if the first seizure occurs within 7 days of the trauma, or late, if the first seizure develops one week after trauma.[43–45] Seizures were most often generalized with or without focal onset. Although there is no prospective study to indicate the efficacy of prophylactic antiseizure medications after a PBI, it has been recommended that patients be covered for about the first week after injury with a medication such as phenytoin or carbamazepine.[46,47] Anticonvulsants such as phenytoin and carbamazepine are recommended for patients in the acute-phase of severe traumatic brain injury with a high risk of seizure development. Results of class I studies show that preventative therapy with phenytoin, carbamazepine, phenobarbital, or valproate is not effective against late seizure onset in patients with traumatic brain injury.[34]

Complications

The implanted material along with necrotic brain and bone fragments are usually at the entrance of the incurred brain wound and if not well debrided can act as a nidus for infection.[39]Among the dreadful complications of GWH are CSF leaks or fistulas, which have been variably reported in from 0.63 to 8.9% of patients. They are more frequent in patients with ventricular involvement and incomplete dural and scalp closure, the chance of infection was increased 20 times in patients with CSF fistulas. The rate of gram-negative infection was also 3 times higher in patients with CSF fistulas when compared with patients having no CSF fistulas. Patients whose wounds are complicated by fistulas have more extensive wounds. If the ventricle is penetrated, it is not hard to imagine that CSF finds its way through the missile tract into the subdural space and leaks through suture lines of dural graft and skin. Bizhan Aarabi et al recommend repeated lumbar puncture, spinal thecal drainage, or even insertion of a shunt in selected patients until the scalp suture line was healed completely.[48] In addition to the usual complications produced by penetrating head injuries, late-onset intracerebral hemorrhage caused by rupture of traumatic aneurysms (TAs) has been a major cause of death. Early diagnosis of these vascular insults with prompt attention to a proper diagnostic and therapeutic protocol may prevent such potentially fatal events. The following are high risks of developing into TAs: passage of missile or bone fragments through areas of crowded vasculature and/or through the skull base, that is, through Reil's triangle or from one hemisphere to the other; a remarkable amount of hematoma within the entrance pathway that is visible on the predebridement CT scan; multiple shells or bone fragments scattered in paths that branch into various directions. The appropriate time for performing angiography to locate a TA is during the first 10 days after injury.[49]

Angiography should be performed as soon as possible after encountering a high-risk patient. Surgery to treat TAs is a difficult challenge because they usually do not have a neck that is suitable for clipping. Traumatic aneurysms should either be excluded from the main circulation by means of a trapping procedure or they should be coagulated. In case the harboring vessel is a major artery, coating the aneurysm with muslin or fibrin glue or excision of the TA after extracranial-intracranial bypass might be the preferred method of surgery.[50,51] In war conflicts and in younger patients, Hunterian ligation of extracranial vessels harboring expansile and/or symptomatic TAs or AVFs is a very effective therapy and will usually not compromise cerebral blood perfusion.[50]

Conclusion

To summarize, GWH represent a high-mortality emergency for trauma surgeons. Aggressive management is essential in order to improve prognosis and patient outcomes. This case describes a patient who successfully recovered after twice injuries to the head. He underwent aggressive debridement and medical prophylaxis against seizures and infections. Given the severity of his injuries, he had a remarkable outcome and returned to family and activities of daily living following a short hospital course.

Abbreviations

GWH: gunshot wounds to the head, GCS: Glasgow Coma Score, CT: Computed tomography, ATC: Acute traumatic coagulopathy, CTA: CT angiography, DSA: Digital Subtraction Angiography, MRI: Magnetic Resonance Imaging, CSF: Cerebrospinal Fluid, ICH: Intracranial hypertension, ICP: intracranial pressure, PTS: Posttraumatic seizures, TAs: traumatic aneurysms.

Declarations

Ethics approval and consent to participate:The study was approved by the Ethics Committee of Qinghai University, and written informed consent was obtained from the patient and his legal guardians.

Consent for publication:The written informed consent for publication was obtained from the patient and his legal guardians.

Availability of data and materials:The data supporting the conclusions of this article is included within the article.

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Figures

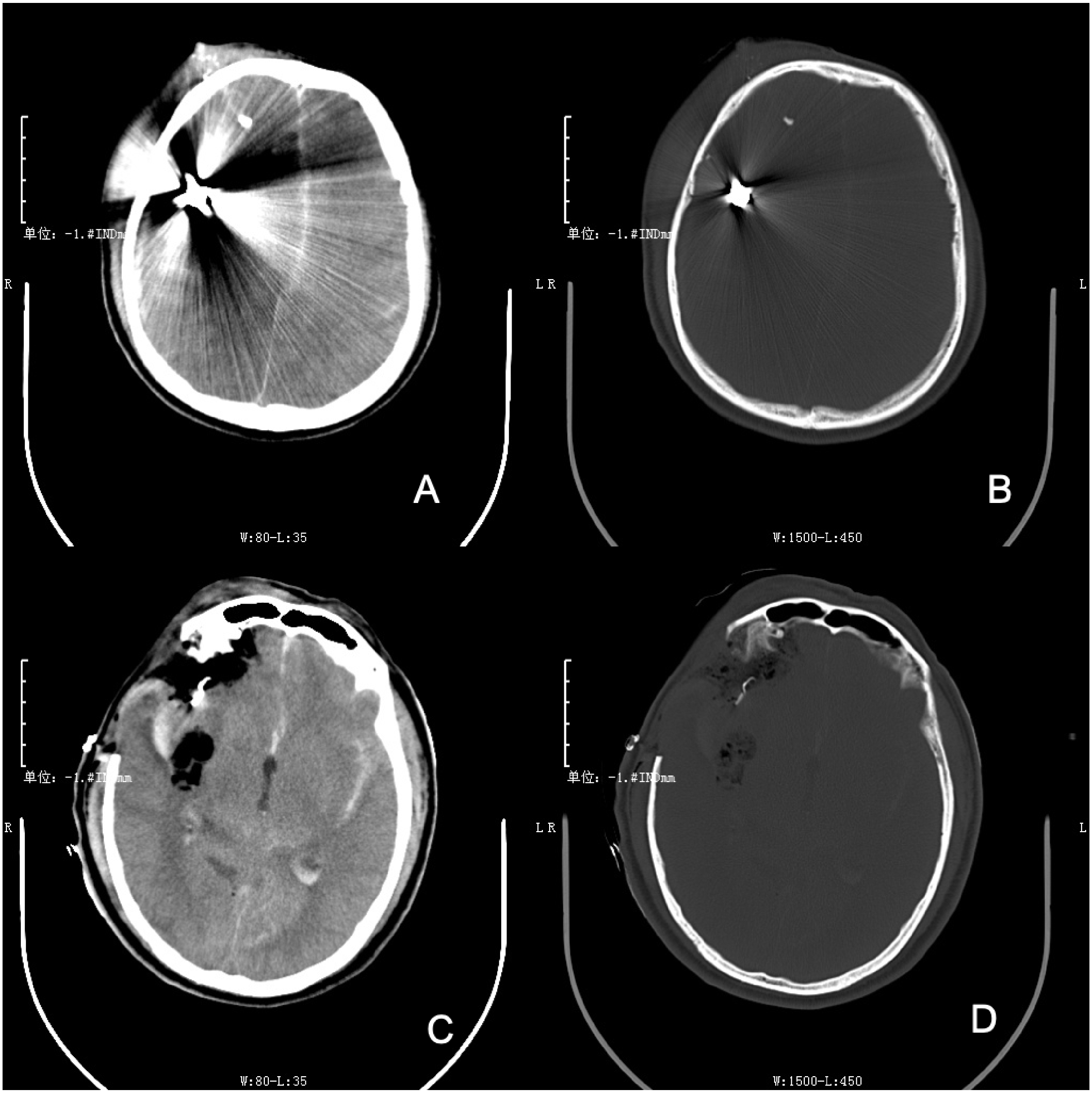

Figure 1

Admission CT, (A) soft tissue windows and (B) bone windows, showing the metal artifacts from the bullet case. Postoperative CT scan on the same day in soft tissue windows (C) and bone windows (D) after decompressive craniectomy.

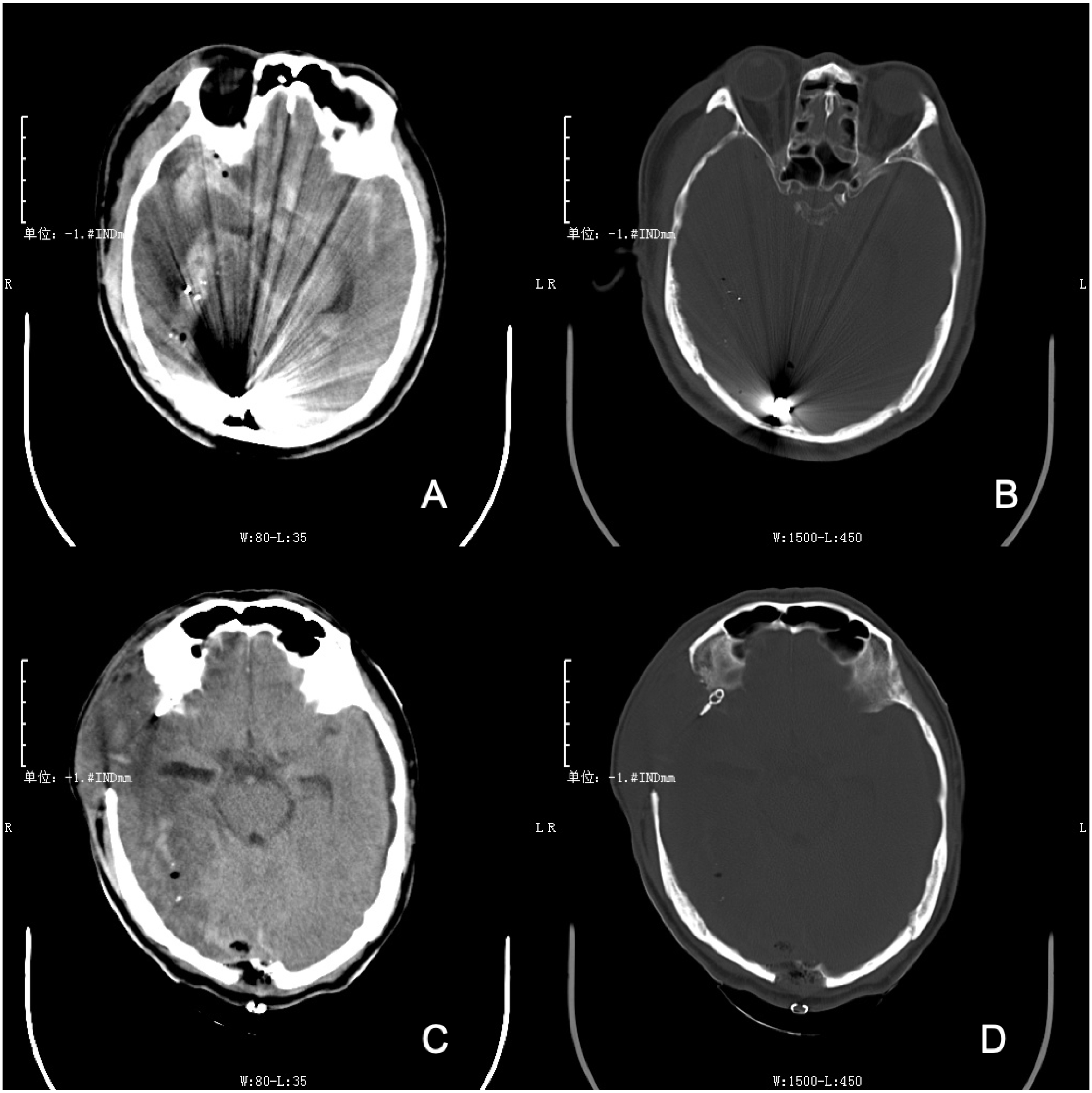

Figure 2

Admission CT, (A) soft tissue windows and (B) bone windows, showing the bullet fragment in the occipital lobe. Postoperative CT scan in soft tissue windows (C) and bone windows (D) after the second operation, clearly showing the skull window accommodating some swelling.

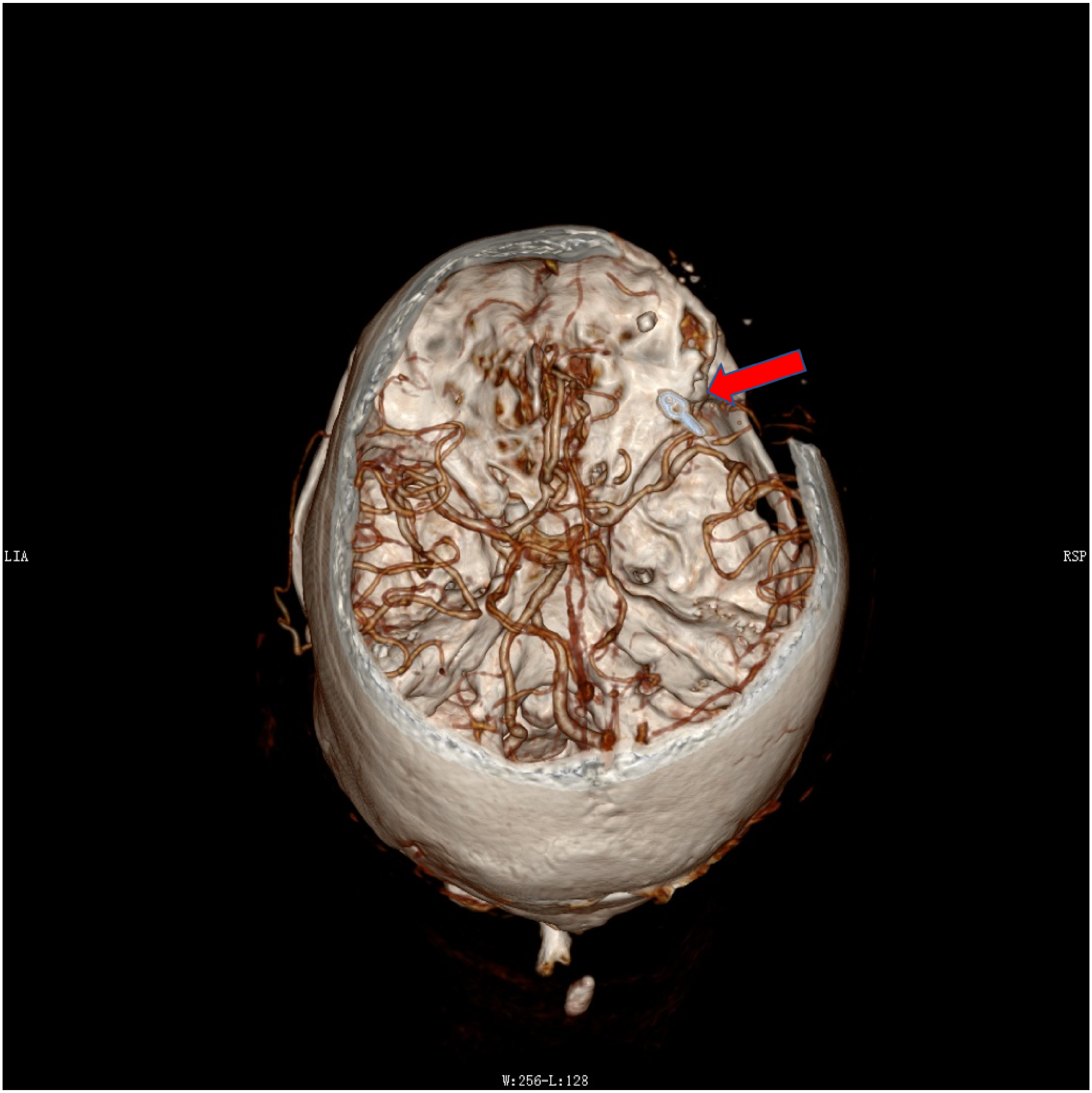

Figure 3

In this three-dimensional CT image, the arrow demonstrates the aneurysm clip at M3 of the right middle cerebral artery. This is an unruptured aneurysm that we found by accident during the first operation. We clipped the aneurysm while exploring the deep foreign body.