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Case Report

Craniocerebral injury by penetration of a T-shaped metallic spanner: A rare presentation

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Abstract

Background: Craniocerebral injuries caused by penetration of metallic foreign bodies present a significant challenge to neurosurgeons as an extensive surgery may be required, leading to high morbidity and mortality.

Case Description: We describe a unique case of penetrating brain injury (PBI) caused by a T-shaped metallic spanner in an assault victim. The patient presented with profuse bleeding from the scalp and necrotic brain tissue evident at the point of entry of the retained short arm of the spanner. Skull X-ray and head computerized tomography (CT) revealed the short arm of spanner penetrating the left parieto-occipital lobe of the brain, extending up to the contralateral occipital lobe. Safe removal of the retained spanner was achieved with a craniectomy and durotomy. Postoperative CT revealed no residual metallic foreign body, and patient had a good functional and neurological outcome at six months' follow up.

Conclusion: To the best of our knowledge, the successful surgical treatment of a PBI caused by a similar metallic object has not been reported in scientific literature previously. The case is also unique considering the fact that it was managed within the medical and diagnostic constraints of an East African country.

Key Words: East Africa, metallic foreign body, neurosurgical management, penetrating brain injury

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INTRODUCTION

Penetrating brain injuries (PBIs) caused by metallic foreign bodies are exceptionally rare among civilian populations.[6,19] Nonmissile, low-velocity stab wounds are even rarer within this group. Nails, knives, screwdrivers, electric drills, needles, or ballpoint pens have been reported to cause PBIs.[11–14,18,24,25,30,32,42] These injuries present a significant management challenge as extensive surgery may be required, which can result in significant morbidity and mortality.[6,36]

In this article, we report a case of a retained intracranial T-shaped metallic spanner, which was surgically removed in an assault victim. To the best of our knowledge, the successful surgical treatment of a PBI caused by a similar metallic object has not been reported in scientific literature previously. The case is also unique considering the fact that it was managed within the resource constraints of an East African country.

CASE REPORT

A 22-year-old Chinese male presented with an intracranial T-shaped metallic spanner to the Aga Khan Hospital, Dar es Salaam, Tanzania. The patient was a mechanic by profession. While working in a garage, he had a quarrel with a fellow mechanic who attacked him with a T-shaped metallic spanner. He presented to the hospital approximately 2 hours after the injury, and was still bleeding profusely from the scalp. Necrotic brain tissue was evident at the point of entry of the retained short arm of the spanner [Figure 1a]. His vitals were stable on arrival with a blood pressure of 130/80, heart rate of 69 beats/minute, and temperature of 37°C. However, he was irritable and restless. He gradually became drowsy, with spontaneous eye opening initially and later to command and mild pain only. He had confused speech, however, he was localizing well. The speech deficits were difficult to document because of the language barrier. He became unconscious approximately 2 hours after admission. As digital subtraction angiography (DSA) is not available in the whole country (to the best of our information), there was no way to assess the potential involvement of major sinuses. Magnetic resonance imaging (MRI) was not possible due to the presence of the intracranial metallic rod. Skull X-ray and head computerized tomography (CT) scan were done, which revealed the short arm of the T-shaped spanner penetrating the left parieto-occipital lobe of the brain, extending into the contralateral occipital lobe [Figure 1b]. The situation was explained to the attendants and the patient was brought to the operating room with the retained spanner approximately 3 hours after admission and the intervention was designated as high risk. Perioperatively, the brain was severely edematous and necrotic brain with foreign debris was present in the track. Owing to the nonavailability of a craniotome or a Gigli saw chain (risk of any movement of retained foreign body leading to further cortical/vascular injury precluded the transfer of the patient to a better-equipped neurosurgical facility), a decompressive craniectomy was done with multiple burr holes. The intracranial part of the metallic spanner was slowly removed followed by debridement and irrigation of the track with normal saline and hydrogen peroxide [Figure 1c-e]. The perioperative course was uneventful; surgery lasted for 3 hours. The patient was successfully extubated in the intensive care unit (ICU) approximately 6 hours after surgery. He initially showed mutism, followed by disoriented and confused speech till postoperative day 3. He was, however, moving all four limbs, and no seizure activity was noted. The patient was suspected to have some visual field abnormality; however, a complete visual field examination could not be done by an ophthalmologist because of the language barrier. Mannitol (0.5 g/kg/dose) and furosemide (40-80 mg/dose) were given pre-, intra-, and postoperatively for the control of intracranial pressure (ICP). Postoperatively, mannitol was continued for 48 hours tapering the dose down to 25 g per i.v. infusion every 4 hours. Intravenous augmentin (1 g every 8 hours), amikacin (15 mg/kg/day divided into 3 equal dosages), and metronidazole (single preoperative dose of 15 mg/kg, and 2 doses of 7.5 mg/kg 6 and 12 hours after surgery) were given pre- and postoperatively during the first week; antibiotic regimen was changed to oral second-generation cephalosporin for the second week (based on empirical evidence). No seizure prophylaxis was given. Postoperative CT scan (day 3) revealed the hyperdense track of the removed short arm of the spanner. No residual foreign body was noted. The patient was discharged on postoperative day 6. On day 12, stitches were removed. At that time, he was speaking fluently. He

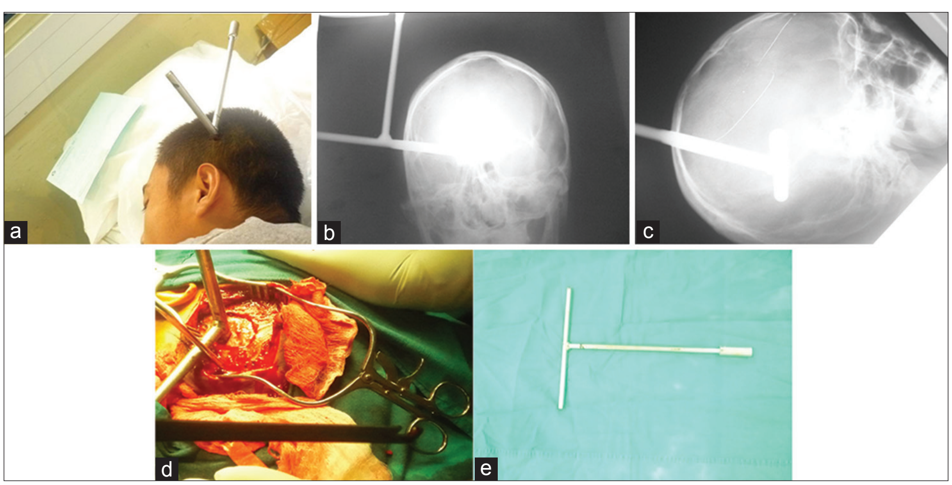

Figure 1: (a) Photograph of the patient showing the T-shaped metallic spanner penetrating the vault for a left parietal entry point. (b) Skull radiograph demonstrating the T-shaped metallic spanner penetrating the left parieto-occipital lobe of the brain. (c) Intraoperative photograph of craniectomy in preparation for the removal of the retained metal spanner. (d) Postoperative CT scan (Day 3) of the patient showing the craniectomy wound defect along with the hyperdense tract of the removed short arm of metallic spanner. The tract is extending to the contralateral cerebral hemisphere. (e) T-shaped metallic spanner after surgical removal

did not have any infectious complication or seizure activity until his last follow up, approximately 6 months after the surgery, at which point he was fully functional. Afterwards, the patient returned to China and a cranioplasty was done there. Follow-up information was obtained from the family by telephone with the help of a translator. No clinical deficits or symptoms resembling syndrome of the trephined were reported.

DISCUSSION

Although less prevalent than closed head trauma, PBI carries a worse prognosis.[6,36] In civilian populations, most of such injuries are caused by high-velocity objects, which result in more complex injuries and lead to high mortality.[18] PBI caused by nonmissile, low-velocity objects represents a rare pathology among civilians, with better outcome because of more localized primary injury.[6,24] Such injuries are usually caused by violence, accidents, or even suicidal attempts.[11-14,19,23,24,34,40] Several objects have been reported in association with PBI.[11-14,18,24,25,30,32,42] The case reported by us, however, is the first one describing an intraparenchymal retained metallic spanner with complete radiological studies and management details.

Optimum management of PBI requires a good understanding of the mechanism of injury and its pathophysiology. As most of the PBIs are caused by missiles or projectiles, an understanding of ballistics is imperative. Ballistics is the study of the dynamics of projectiles; wound ballistics is the study of the projectile's action in tissue.[5,20,22]

The ability of bullets, shrapnel, and low-velocity objects such as knives and arrows to penetrate the brain depends on their energy, shape, the angle of approach, and the characteristics of intervening tissues (skull, muscle, mucosa, etc.).[5,15,20,22] Based on the principles of ballistics, the T-shaped metallic spanner can be classified as a low-energy object causing the PBI in our case, and was, thus, expected to cause less severe brain damage.

Head X-ray and CT scan should be done if there is any suspicion of an intracranial penetrating injury. The value of CT scan in diagnosing intracranial injuries from missile and nonmissile penetrating injuries is well documented in the literature.[15] MRI can be potentially dangerous when there are retained ferromagnetic objects because of possible movement of the object in response to the magnetic torque[18] but can be a useful modality if the PBI is caused by a wooden object.[4,17] If intracranial penetration is confirmed, a cerebral angiography should also be performed to exclude vascular injury.[15] A careful radiological investigation before the surgical extraction of the intracranial foreign body not only determines the extent of injury but also helps to identify the safest route for its removal. Every possible precaution must be taken to prevent undue movements of the sharp edges of the intracranial object, which may lead to secondary injury to the pericontusional brain tissue.[15,37]

Surgical exploration is warranted for PBI when deemed necessary. The procedure recommended in literature is debridement of necrotic brain tissue, removal of accessible bone or foreign body fragments only when the neurological risk is not increased, removal of intracranial hematomas with significant mass effect, and watertight closure of dural defects.[14,18] However, it remains debatable what technique, craniotomy or craniectomy, is best suited to achieve the best results. No statistically significant advantage of one technique over the other has been described in reports of morbidity and mortality rates associated with two procedures.[18,39] We performed a craniectomy primarily due to the nonavailability of a craniotome or Gigli saw. Nonetheless, the outcome was good in our patient.

The complication rates in penetrating stab injuries are significantly higher than in closed head injuries. There is a higher risk of cerebrospinal fluid (CSF) leakage or brain abscess development because of the disruption of the dural barrier.[15,31] Also, the risk of posttraumatic epilepsy is higher probably due to direct traumatic injury to the cerebral cortex with subsequent scarring. It is reported that the more severe the injury to the brain, according to the Glasgow coma scale (GCS), the higher the risk for the development of posttraumatic epilepsy.[1,15] Approximately 30-50% of patients suffering a PBI will develop seizures.[15] It is estimated that up to 10% of them will appear early (first 7 days after the trauma). Although the initial studies did not confirm the beneficial effect of the prophylactic anticonvulsants administration, more recent ones recommend the prophylactic anticonvulsants use in the first week after injury. It is acceptable not to use prophylactic anticonvulsants at all in case of smaller, less serious trauma. Besides, the use of anticonvulsants beyond the first 7 days of injury is not recommended.[15,37] We did not administer anticonvulsants to our patient.

Vascular complications after PBI range from under 5% to 40% in various reports.[18,29,32] Traumatic aneurysms formation is the most commonly described vascular injury.[7,14,18,25,29] Preoperative cerebral angiography is recommended when there is a suspicion of vascular injury. Features associated with higher risk of vascular injuries development in missile wounds include orbitofacial or pterional PBI, presence of intracranial hematoma and injuries with fragments crossing two or more dural compartments.[4,14,18,35] An angiography is also strongly recommended in case of delayed and/or unexplained subarachnoid hemorrhage or intracranial hematoma development.[3,4,7,18,25] The importance of angiography in the diagnosis of vascular complications lies in the bad outcome associated with this pathology when it is not aggressively treated. Sometimes, vascular injuries are delayed in onset, appearing even weeks or months after the trauma, and an initial negative angiography is not conclusive. When suspicion is maintained, repeating the test 2-3 weeks after the trauma is recommended.[7,14,18,25] In our case, there was no way to determine the vascular injury as the cerebral angiography is not available at any center in Tanzania.

Infectious complications are not uncommon after PBI, and they are also associated with higher morbidity and mortality rates. They are more frequent when CSF leaks, air sinus wounds, transventricular injuries or those ones crossing the midline occur.[3,17] *Staphylococcus aureus* is the most frequently associated organism. Intravenous prophylactic broad-spectrum antibiotic therapy is recommended in all cases and must be started as soon as possible. Currently, it is recommended to maintain it for at least 7-14 days.[3,15]

In PBI cases, an unfavorable outcome and high mortality have been indicated with bilateral hemispheric injury, multilobe injury, transventricular trajectory, brainstem injury, intracerebral hematoma, or cerebral contusion with an associated mass effect, and missile and bony fragmentation away from the trajectory.[16,33] Kim *et al*. have reported an unfavorable outcome in 60.0% and 66.7% of patients in the group of transventricular or bihemispheric injuries and bi- or multilobar injuries, respectively.[26] In our opinion, the angle of impact of the foreign body in the current case led to sparing of brainstem, hypothalamus, pineal region, motor strip, and venous sinuses and major vessels. Spontaneous brain herniation through the bony defect may have helped to mitigate the increase in ICP and provided us time to intervene. Thus, despite this being a bihemispheric injury, it was not fatal, and a favorable outcome was achieved. However, supra-angular gyrus and occipital lobe deficits could have occurred in this patient. A Wernicke-type speech disturbance could have been there in early postoperative phase but were difficult to precisely document due to language barrier. Similarly, visual disturbances were also difficult to precisely analyze. We did a thorough wound debridement and maintained the patient on empirical antibiotic regimen; infectious complications were not observed, however, the possibility of delayed abscess/fistula/traumatic aneurysm formation cannot be completely ruled out.

As discussed earlier, the modern management of PBI is generally considered a neurosurgical specialty that relies mainly on the use of various neuroradiologic modalities, broad range of antibiotics, and sophisticated operative skills. These facilities are not frequently available to patients injured in underdeveloped African countries such as Tanzania. However, these constraints do not preclude the successful management of PBI in these countries. Adrill and Gidado have reported successful management of PBI despite the comparably modest available armamentarium for evaluation and surgical care.[8] Similarly, many other successfully managed cases of PBI have been reported from Africa.[2,28,35,38] Our case further corroborates the notion that the multiple limitations of neurosurgical practice in an African nation do not prevent the successful management of select cases of penetrating head trauma.[8]

Tanzania is one of the politically stable countries in the region of East Africa. Monetarily, Tanzania is among the poorest 10% of the world's nations. The nation's gross domestic product in 2011 was estimated to be $64.71 billion, with a reported per capita income of $1500.[10,27] According to the WHO estimates, Tanzania spends $57 per person per year on health as compared with US expenditure $7,960 per person per year. There are very few neurosurgeons; according to our information, five neurosurgeons for a population of 44 million; and according to a published report, 1 neurosurgeon per 12.8 million inhabitants,[41] and almost all are practicing in the city of Dar es Salam. The Neurosurgery Unit of Aga Khan Hospital is the second in the country and first nongovernment hospital with this subspecialty. According to our information, there are very few MRI machines and CT scanners in the whole country. To the best of our knowledge, angiography set up is not available in the country. South Africa, Kenya, India, Germany, and USA are the health tourism-based options for the neurosurgical patients for common issues, and, of course, not many patients can afford this luxury. Trauma and violence incidence are increasing, but the country has minimum trauma care facilities available. Traumatic brain injury is reported to account for the majority of burden of neurosurgical diseases by two independent studies in Tanzania.[9,41] In the rural settings, trauma caused by assault is the most common cause of TBI as compared with road traffic accidents in urban settings.[9,21,41]

In a developing country like Tanzania, there are many impediments to expeditious health care provision such as lack of finances, inadequate transportation, lack of emergency medical services, poorly equipped medical and diagnostic facilities, and scarce medical and surgical treatment options.[8] Such shortcomings result in higher morbidity and mortality. It is described that majority of deaths after PBIs occur in the initial 24 hours, and the majority of these are within 3 hours after the injury. The absence of rapid evacuation system like an ambulance or helicopter trauma service, thus, leads to higher mortality. Owing to the scarcity of neurosurgeons, many neurosurgical cases are handled by family practitioners and general surgeons who have very limited expertise in treating neurosurgical problems. Under these circumstances, proper provision of health care is a daunting task, and more so for sophisticated specialties such as neurosurgery itself. As a rule, the degree of permanent neurologic deficit associated with low-velocity penetrating skull wounds is determined by the site and depth of initial injury, the rapidity of operative exploration and debridement, the avoidance of delayed secondary injury and other complications.[8,15] It is reported that centralization of head injury patients in specialized regional trauma centers markedly improves the clinical results.[15] As described earlier, such specialized centers are not available in many of the African countries. Nonetheless, close attention to the basic perioperative and intraoperative principles, even with the modest capacities of an East African hospital, may result in a functional neurologic outcome in selected patients.

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