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Case Report

Survival After Massive Penetrating Brain Injury by a Vehicle Roof Rack Bolt: A Case Report and Surgical Challenges

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Abstract

Background: Massive non-missile penetrating brain injury (PBI) caused by large industrial or automotive objects is rare and often associated with high mortality. Management becomes particularly challenging when the foreign body is large enough to prevent standard surgical exposure and produces severe metallic artifacts that preclude reliable preoperative vascular imaging.

Case Presentation: A 26-year-old male motorcyclist sustained a right frontal penetrating brain injury caused by a 15-cm-long, 2-cm-diameter metal bolt from a pickup truck's roof rack. On arrival, his Glasgow Coma Scale (GCS) score was 3T (T indicating intubation), and he was hemodynamically stable. Computed tomography (CT) demonstrated transcranial penetration into the right frontal lobe but was severely limited by beam-hardening artifact. Preoperative CT angiography (CTA) was not feasible. Because the size of the impaled object precluded craniotomy prior to removal, emergency extraction was performed along the trajectory, followed immediately by craniotomy, meticulous debridement, duraplasty, and hemostasis. Serial postoperative CTA at 24 hours and 1 week revealed no vascular injury or traumatic aneurysm. The patient regained full consciousness (GCS 15) within 7 days and demonstrated no motor deficits. Mild persistent apathy was noted at 1-month follow-up; however, he had returned to independent daily activities and work.

Conclusion: In selected cases of massive non-missile PBI in which standard preoperative craniotomy and CTA are not feasible, immediate extraction followed by prompt decompression and serial vascular imaging may result in favorable neurological outcomes. Early surgical adaptability and close postoperative surveillance are essential.

Keywords: Penetrating brain injury; Foreign body; Craniotomy; Frontal lobe injury

Introduction

Penetrating brain injuries (PBIs) caused by non-missile, low-velocity objects represent a small proportion of traumatic brain injuries but are associated with substantial morbidity and mortality [1, 2]. Unlike high-velocity gunshot wounds, non-missile PBIs often present unique surgical challenges, including the risk of catastrophic hemorrhage during foreign body removal and the potential for central nervous system infection [2, 3]. An additional challenge arises when large metallic objects generate severe beam-hardening artifacts on computed tomography (CT), limiting accurate anatomical localization and precluding reliable vascular assessment by CT angiography (CTA) [4] Standard surgical principles recommend exposure of the entry site via craniotomy and removal of the foreign body under direct visualization to reduce the risk of secondary vascular injury [2, 3]. However, this classic approach may not be technically feasible when the object is massive, structurally complex, and externally fixed.

We report the clinical course of a patient presenting with a Glasgow Coma Scale (GCS) score of 3T (where "T"

indicates that the patient was intubated) after sustaining a massive frontal PBI caused by a vehicle roof rack bolt. Because of the object's physical dimensions and severe CT imaging artifacts, preoperative CTA and pre-extraction craniotomy were impossible. This case emphasizes the surgical modifications required for massive impaled objects and the importance of vigilant postoperative vascular surveillance.

Case Presentation

A 26-year-old male motorcyclist was brought to the emergency department following a high-speed collision with a pickup truck. A metal bolt from the truck's roof rack, measuring approximately 15 cm in length and 2 cm in diameter, had penetrated the right frontal bone (Figure 1a, b). Emergency responders detached the bolt together with a portion of the truck body at the scene to facilitate transport.

On arrival, the patient was intubated and sedated. His Glasgow Coma Scale (GCS) score was 3T. Pupils were miotic and unreactive, likely secondary to sedative medications. Hemodynamic parameters were stable.

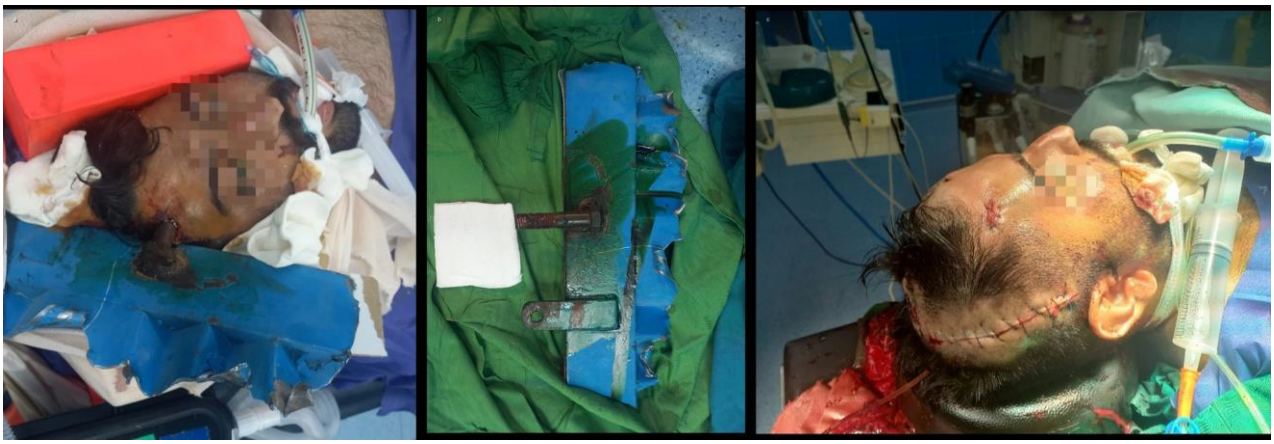

Figure 1: Clinical Presentation and Surgical Outcome

Panel (a): Initial presentation of the patient in the emergency department. The image shows the massive metallic vehicle roof rack assembly firmly impaled into the right frontal region, with the patient stabilized and intubated.

Panel (b): The extracted foreign body following successful neurosurgical intervention. The assembly consists of a large blue metal base and a long protruding bolt that had penetrated the skull and brain parenchyma.

Panel (c): Immediate postoperative appearance after craniotomy, debridement, and dural repair. The surgical site is closed with staples, showing the extent of the scalp incision and the successful removal of the impaled object without additional secondary trauma.

Initial non-contrast CT demonstrated transcranial penetration into the right frontal lobe; however, imaging was severely limited by extensive metallic artifact (Figure 2a, b). Reliable preoperative CTA could not be performed due to beam-hardening artifact. Topogram and bone window reconstructions confirmed intracranial extension within the right frontal region.

Surgical Management

The patient was transferred emergently to the operating room. Because of the large size of the bolt and attached vehicle fragments, craniotomy prior to extraction was technically impossible. After careful irrigation with povidone-iodine, the bolt was gently removed along its trajectory. The tract was temporarily tamponaded with saline-soaked ribbon gauze to control immediate bleeding.

A reverse question-mark incision was performed, followed by rapid craniotomy. Mannitol (1 g/kg) was administered preoperatively for intracranial pressure control. After removal of the gauze, extensive injury to the right superior and middle frontal gyri extending to the frontal pole was identified. Necrotic brain tissue, bone fragments, and hematoma were evacuated using bipolar cautery and suction. Haemostasis was achieved with oxidized regenerated cellulose.

Duraplasty was performed using an autologous pericranial graft. Bone edges at the penetration site were

debrided. One gram of topical vancomycin powder was applied prior to closure. The bone flap was loosely secured to accommodate potential postoperative swelling (Figure 1c).

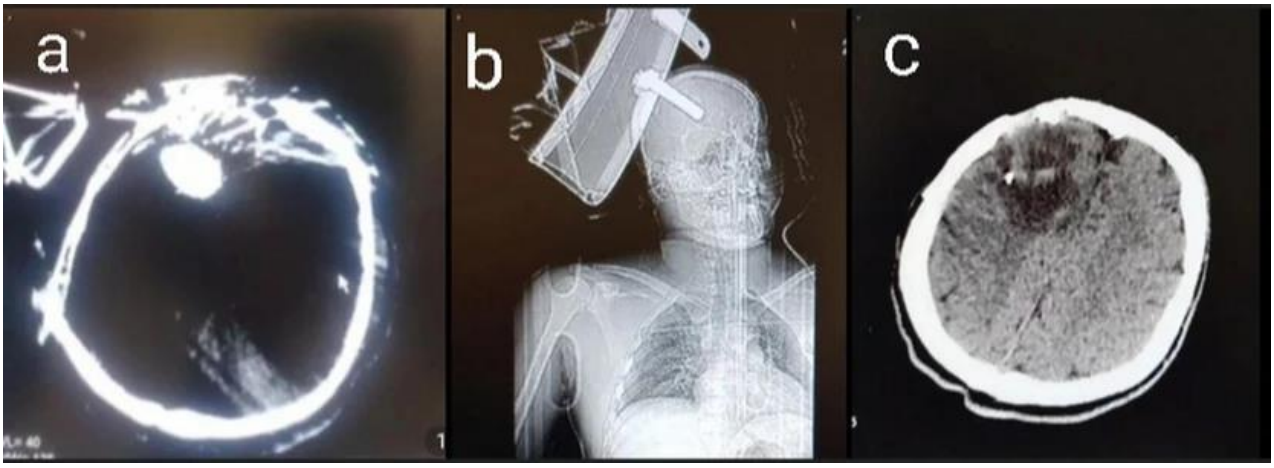

Figure 2: Preoperative and Postoperative Neuroimaging

Panel (a): Axial non-contrast computed tomography (CT) scan showing a massive hyperdense foreign body (metal bolt) penetrating the right frontal bone. Note the extensive beam-hardening artifacts that preclude detailed evaluation of the underlying brain parenchyma and vascular structures.

Panel (b): CT topogram (scout view) demonstrating the intracranial extension of the large metallic bolt and the attached vehicle roof rack fragments, illustrating the massive scale of the impaled object.

Panel (c): Postoperative axial CT scan following emergency foreign body extraction and craniotomy. The image shows the surgical tract in the right frontal lobe with expected post-traumatic changes and early resolution of the mass effect; notably, the major intracranial metallic artifacts have been eliminated, allowing for clearer parenchymal assessment.

Postoperative Course

The patient remained intubated in the intensive care unit for 1 week. Management included prophylactic levetiracetam for 7 days, intravenous vancomycin and ceftazidime for 1 week, and deep vein thrombosis prophylaxis initiated 48 hours after surgery.

Postoperative CT and CTA at 24 hours and again at 1 week demonstrated no vascular injury or traumatic aneurysm formation (Figure 2c).

Within 7 days, the patient improved to a GCS score of 15 and was successfully extubated. Neurological examination revealed full motor strength without focal deficits. Mild apathy and reduced spontaneity were observed. At 1-month follow-up, apathy persisted with minimal change; however, the patient had returned to work as a motorcycle courier and was independent in activities of daily living.

Discussion

This case demonstrates several critical challenges in the management of massive, non-missile PBI. The primary clinical dilemma was the inability to perform a standard craniotomy prior to foreign body removal due to the object's physical size (15 cm) and external fixation [2, 3]. Immediate extraction carried a significant theoretical risk of catastrophic hemorrhage, particularly in the absence of dependable preoperative vascular imaging.

Severe metallic artifact prevented reliable preoperative CTA, thereby increasing uncertainty regarding potential vascular injury [4]. In settings where severe beam-hardening artifacts limit the utility of CT and CTA, plain skull radiography remains a vital, readily accessible alternative. It provides crucial information regarding the object's precise trajectory, depth of penetration, and anatomical relationship with key bony landmarks, assisting in surgical planning when advanced imaging fails. To mitigate the risk of missed vascular injuries, we

executed a strategy of serial postoperative CTA at 24 hours and 1 week. This postoperative surveillance was critical to screen for delayed traumatic vascular complications, including traumatic intracranial aneurysm or pseudoaneurysm formation, which are known risks in penetrating skull base trauma [4, 5].

In the literature, cases involving massive impaled objects—such as construction rebar, industrial bolts, or shotgun bolts—often require deviations from standard neurosurgical guidelines [1, 3]. While systematic reviews advocate for direct visualization of the entire tract via craniotomy before mobilization [1, 5], the physical constraints of a 15-cm protruding bolt make bone flap creation around the object technically impossible. In such scenarios, controlled tract-oriented extraction in the operating theater, combined with aggressive local debridement and immediate reconstruction of the dural and pericranial layers, represents a viable and successful alternative [2, 3].

Infection remains a major driver of morbidity in PBI [6]. In this case, broad-spectrum intravenous antibiotics were administered immediately, and topical intrawound vancomycin powder was applied during closure. The clinical utility of topical vancomycin in contaminated cranial trauma and craniotomies is supported by recent clinical trials, which demonstrate a significant reduction in postoperative surgical site infections without adverse systemic effects [7].

The patient's favorable neurological recovery despite extensive injury to the superior and middle frontal gyri is notable. Although persistent apathy at 1-month follow-up is highly consistent with frontal lobe dysfunction—specifically involving the anterior cingulate and executive networks [8]—his ability to return to daily work reflects remarkable functional preservation. Ultimately, this case highlights that excellent outcomes can be achieved in massive PBI through adaptive surgical techniques and structured postoperative vascular screening.

Teaching Points

Surgical Adaptability in Massive PBI: Standard craniotomy and direct visualization of the trajectory prior to foreign body extraction may be physically impossible in cases of massive, externally fixed objects (such as a 15-cm bolt). Controlled, straight-line manual extraction in the operating room remains a necessary and effective primary approach.

Plain Radiography as an Essential Adjunct: When severe metallic beam-hardening artifacts render preoperative CT and CTA non-diagnostic, plain skull radiography serves as a crucial alternative to delineate object trajectory and relationship to skull landmarks.

Vigilant Postoperative Vascular Screening: In the absence of reliable preoperative vascular imaging, serial postoperative CTA (at 24 hours and 1 week) is should be strongly considered to screen for delayed vascular complications, such as traumatic intracranial pseudoaneurysms.

Favorable Prognosis in Frontal Lesions: Excellent functional recovery and return to work are achievable even after extensive frontal lobe trauma, though clinicians must remain vigilant for chronic neuropsychiatric sequelae such as post-traumatic apathy.

Conclusion

Massive non-missile penetrating brain injury may result in favorable neurological outcomes when rapid surgical intervention and adaptive intraoperative strategy are employed. In situations where preoperative CTA and craniotomy before extraction are not feasible, immediate controlled removal followed by prompt decompression and serial postoperative vascular imaging may be an effective management strategy. Long-term follow-up remains essential to monitor for vascular, infectious, epileptic, and neuropsychological sequelae.

Acknowledgement

Not cleared.

Ethical Statement

Written informed consent was obtained from the patient for publication of this case report and accompanying images. This study was conducted in accordance with institutional ethical standards. No additional ethical approval was required for a single case report.

Declaration of Generative AI and AI-Assisted Technologies

The authors utilized AI-based technologies (ChatGPT-5.5) solely for English language editing and formatting, during the revision of this manuscript. The final

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Conflict of Interest Disclosures

The authors declare no conflict of interests.

Authors' Contributions

A.A.G.: Conceptualization, data collection, manuscript drafting.

K.R.E.: Surgical management, supervision, critical revision of the manuscript.

Both authors approved the final manuscript.

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