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Penetrating Head Trauma in Rural Children: Practices Associated with Increased Morbidity

Abdoulaye Diop[1*], Natacha Maria Sambou[1], Adja Seynabou Diallo[1], Aureol Kodia[2], Momar Code Ba[2]

[1]Neurosurgery Department, Ziguinchor Regional Hospital, Ziguinchor, Senegal
[2]Neurosurgery Department, Fann National University Hospital Center, Dakar, Senegal
Email: *a.diop@univ-zig.sn

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Abstract

Penetrating brain injuries are characterized by the presence of brain matter through a bone orifice of traumatic origin. These traumatic brain injuries are rare, accounting for about 0.4% of traumatic brain injuries, and their causes are multiple. In this manuscript, we report six rare cases of penetrating head injuries in children over a one-year period treated in our department. They are particularly serious due to the intracranial vascular lesions that can occur immediately, as well as the major complications occurring at a distance, such as infection and epilepsy. The observations reported in this manuscript are peculiar because of their circumstances and mechanisms of occurrence, the penetrating object that caused the traumatism, the actions taken at the scene of the accident and during pre-hospital care, and the resulting infectious complications.

Keywords

Penetrating Head Injuries, Children, Rural Areas

1. Background

Penetrating brain injuries lead to cranio-cerebral wounds through the intrusion of a wounding agent, causing a dural breach and establishing direct communication between the subarachnoid spaces and the external environment. Although these penetrating cranio-cerebral injuries are relatively rare, representing about 0.4% of all brain injuries, they are often associated with significant morbidity and mortality [1]. While the majority of penetrating injuries in Western countries result from gunshot wounds, it is surprising to note that it is completely different in developing countries. A wide range of non-missile or non-projectile penetrating injuries has been reported, using weapons such as knives, scissors, pencils, iron

bars, nails, chopsticks, etc. Injuries resulting from these types of objects generally involve a small area with a relatively low-speed impact. Their prognosis and evolution depend on the nature of the penetrating object, the site of the injury, and the depth of penetration [2]. The prognosis of intracranial stab wounds is generally much better than that of injuries that transmit higher kinetic energy, as long as the patient does not suffer from major intracranial hemorrhage or vascular disruption [2] [3]. Management combines surgical repair with broad-spectrum antibiotic therapy [4]. Ziguinchor is a very isolated agricultural region in southern Senegal, and some areas of this region are very far from neurosurgical centers, which constitutes an obstacle to managing head injuries, especially in children. The aim of this work is to report the etiological features and management of penetrating cranial injuries in children in a rural setting, from the site of the accident to the reference hospital structure.

2. Observations

2.1. Observation 1

A 6-year-old boy with no reported pathological history was admitted to the emergency room 6 hours after a traumatic brain injury following a playful accident. He reportedly received a metal bar to the frontal area during fruit-picking, which pierced the brain parenchyma. This was removed at the scene of the accident by an adult. The child reportedly had a seizure with a postictal coma and two episodes of vomiting. The clinical examination upon admission showed altered consciousness with a Glasgow score of 10, the pupils were isocoric and reactive to light, and he presented with left hemiparesis. The cranio-facial examination revealed a rounded left fronto-lateral wound with metal debris (**Figure 1(a)**). The emergency brain CT scan showed a cranio-cerebral injury with intraparenchymal contusion lesions along the path of the bar and pneumocephalus (**Figure 1(b)**). He was admitted to intensive care intubated and sedated, and wound debridement was performed the same day. In the operating room, a cranio-cerebral wound with the exit of brain matter through the skin opening was noted. We proceeded with irrigation using saline solution followed by sealing of the dura breach. Broad-spectrum antibiotic therapy based on third-generation cephalosporins was initiated. On postoperative day 3, the child presented with an infectious syndrome and meningeal stiffness. Lumbar puncture showed hypoglycorrhachia and hyperproteinemia. Following the infectious disease specialist's instruction, the antibiotic doses were increased, leading to favorable outcome. Upon clinical follow-up at one month, the child was conscious, there was an improvement in the seizures, but he still had slight left hemiparesis.

2.2. Observation 2

This case we are reporting is about a 10-year-old child who suffered a traumatic brain injury caused by a domestic accident. The child allegedly fell when climbing a wall with his head landing on a metal bar. It crossed the orbit, then the cerebral

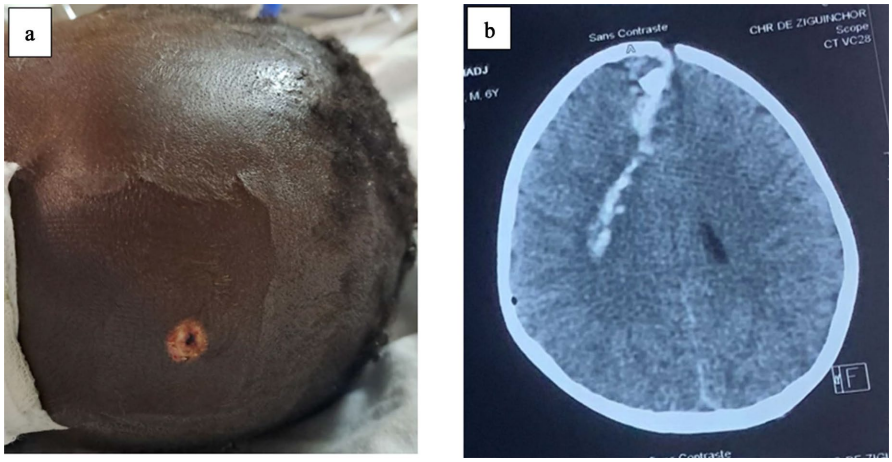

Figure 1. Preoperative image showing a round left lateral frontal wound with metal debris (a) and a cerebral CT scan without contrast agent injection in parenchymal window in axial cut showing a cranio-cerebral wound with contusion lesions in the parenchyma along the path of the bar and pneumencephalus (b).

parenchyma with an outlet orifice at the right parietal area. The extraction of the bar was done at home by his older sibling and the child was admitted in the ER one hour after the accident. He presented initially with altered consciousness with a Glasgow Coma Scale rated to 9 (E2V2M5), left hemiplegia and right anisocoria. Craniofacial examination showed a right periorbital swelling with a penetrating wound corresponding to the inlet orifice of the metal bar and a parietal wound on the same side corresponding to the outlet orifice. The rest of the clinical examination was within normal limits. The emergency brain CT-scan showed intraparenchymal hemorrhagic contusions with edema as well as bone fragments along the path of the metal bar and a slight right fronto-parietal acute subdural hematoma (**Figure 2(a)**). There was no intracerebral hematoma. CT angiography was not performed. The child benefited from a trimming of the parietal and periorbital wounds at the operative theater. It consisted of a removal of bone fragments of the parietal area with removal of the contused brain tissue and thorough washing with isotonic saline solution. Hemostasis was performed through diathermy. The dural shores were clogged and the skin was closed in two planes. The periorbital wound was closed in one plane. Preoperatively, the patient had benefited from tetanus seroprophylaxis, antibiotic prophylaxis with ceftriaxone at a dose of 2 grams per day as well as antiepileptic prevention. On the seventh day after surgery, the patient experienced severe headaches associated with persistent vomiting. Laboratory analysis showed hyperleukocytosis and elevated CRP at 96 mg/L. Brain CT-scan with injection of contrast material showed an extensive abscess along the path of the bar (**Figure 2(b)**), justifying a second surgical procedure which consisted of puncture to remove pus in order to run bacterial analysis. The postoperative outcome was favorable, with an improvement of the signs of intracranial hypertension, regression of the left hemicorporeal motor deficit as well as normalization of the biological parameters. The bacteriologic analysis isolated a stain of

staphylococcus aureus. Intravenous antibiotic therapy adapted to the sensitivity of the germ was pursued for 21 days, then oral treatment based on phenicols was started. The postoperative follow-up brain CT-scan performed two months after the second operation showed a regression of the abscess with persistence of intraparenchymal bone fragments.

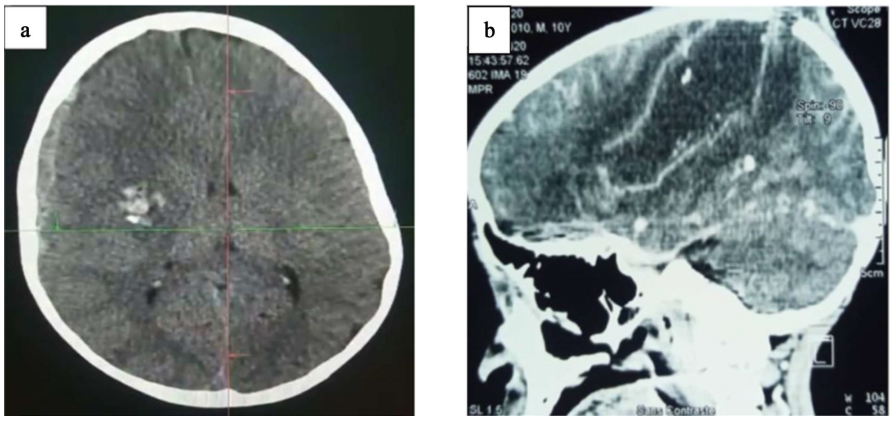

Figure 2. Non contrast cerebral CT-scan showing some outbreaks of oedemato-hemorrhagic contusions with intraparenchymal bone debris along the path of the bar and asmall right fronto-parietal acute subdural hematoma (a); Brain CT-scan with injection of contrast material performed one week after the trauma showing an extended brain abscess along the path of the bar (b).

2.3. Observation 3

A 11-year-old boy, with no reported pathological history, was admitted to the ER five days after his traumatic brain injury. He was reportedly hit by an iron bar on the skull during fruit picking. The bar that pierced the skull was removed by his uncle at the scene of the accident. The child subsequently had headaches, he had not vomited nor had convulsive seizures. He was initially treated in a health facility in his village where the wound got dressed, and he was sent home with painkillers. Five days after the accident, the child presented in our facility with intense headaches associated with vomiting in a fever context. Upon admission, he was conscious, pupils were isocoric and light-responsive and the child had no neurological deficits. The craniofacial examination showed a circular frontoparietal wound about 1 cm in diameter with necrotic margins. A brain computed tomography was performed, and showed a frontoparietal craniocerebral wound with intraparenchymal bone splinters (**Figure 3(a)**) and a presuppurative lesion around it (**Figure 3(b)**). The laboratory check-up showed neutrophil leukocytosis and a CRP elevated to 90 mg/L. He thus benefited from a trimming of the craniocerebral wound with a wound-centered craniotomy. Intraoperatively, the enlargement of the dural breach allowed the extraction of intraparenchymal bone flakes and drainage of moderate quantity of pus. A sample was taken for bacteriology and broad-spectrum antibiotic therapy was started. The post-operative outcome was favorable. Bacteriology had not shown any germ. The child was conscious and had

no deficit. Third-generation cephalosporin-based antibiotic therapy combined with metronidazole was administered.

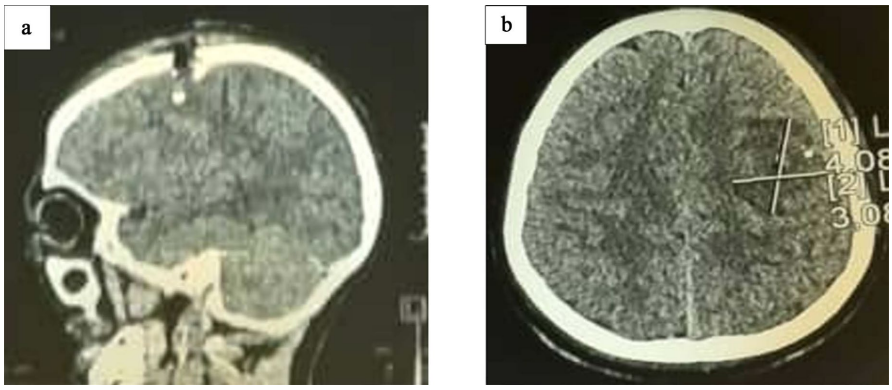

Figure 3. Non-contrast CT showing a left frontoparietal cranio-cerebral injury with intraparenchymal bone fragments (a) and a pre-suppurative lesion around (b).

2.4. Observation 4

A 13-year-old adolescent with no particular pathological history was admitted to the emergency room for a traumatic brain injury after falling from a tree allegedly 7 meters high, with cephalic reception. He presented an initial loss of consciousness of about 10 minutes long, without vomiting or convulsions. Initial treatment was provided on the same day at a peripheral health center. The scalp wound was sutured and dressed; he was prescribed analgesic and amoxicillin-clavulanic acid, then discharged. Five days later, the parents brought him to our facility for an infection of the wound, in a context of headaches and vomiting. Upon admission to the emergency room, the child presented a Glasgow coma scale of 15. There was no sensory or motor deficit. The pupils were isocoric and reactive to light. The craniofacial examination revealed a left basi-frontal suppurating wound, with a foul odor, along with swelling of the face. The remainder of the clinical examination was within normal limits. The laboratory work-up showed hyperleukocytosis and a CRP elevated to 96 mg/L. A brain CT scan revealed a depressed skull fracture of the left frontal bone with numerous fragments, intraparenchymal foreign bodies and an adjacent hemorrhagic and edematous contusion (**Figure 4(a)**). During surgical exposure, we uncovered a craniocerebral wound with subcutaneous suppuration, bone splinters and an intraparenchymal wood fragment (**Figure 4(b)**). A removal of bone fragments with removal of the wood fragment was performed, the dural edges were sutured and the skin was closed in two planes. The cytobacteriological analysis of the pus collected and the fragment of wood extracted intraoperatively did not identify any germ. Antibiotic treatment based on third-generation cephalosporin at meningeal dose, combined with metronidazole, was initiated, as well as antiepileptic treatment. The clinical outcome was favorable, with resolution intracranial hypertension signs and normalization of biological parameters. At the one-month clinical follow-up, the child was asymptomatic; However, the brain CT scan with injection of contrast agent requested could not

be carried out due to lack of resources.

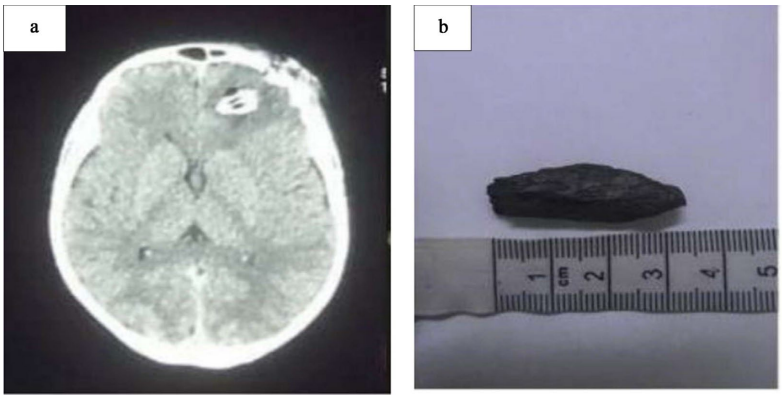

Figure 4. Cerebral CT scan without contrast agent injection in parenchymal window showing a cranio-cerebral injury with the presence of a foreign body intra-parenchymal in the left frontal lobe.

2.5. Observation 5

An 8-year-old girl, with no particular pathological history, was admitted for traumatic brain injury resulting from an assault. The child was reportedly stabbed by his aunt. The initial examination showed clear consciousness with a Glasgow coma scale rated to 15, the pupils were isocoric and light-responsive. No neurological deficit had been objectified. Craniofacial examination revealed a frontal para-sagittal wound with a knife in place (**Figure 5(a)**). The rest of the clinical examination was normal. Emergency brain CT showed a frontal craniocerebral wound (**Figure 5(b)**). The child benefited from a trimming of the wound, consisting of a craniectomy circumscribing the entrance hole of the knife that we removed afterwards. Surgical exploration objectified a dural breach without involvement of the superior sagittal sinus and without parenchymal lesions. The postoperative course was favorable. At the clinical check-up two months after the trauma, the child was conscious and showed no clinical signs.

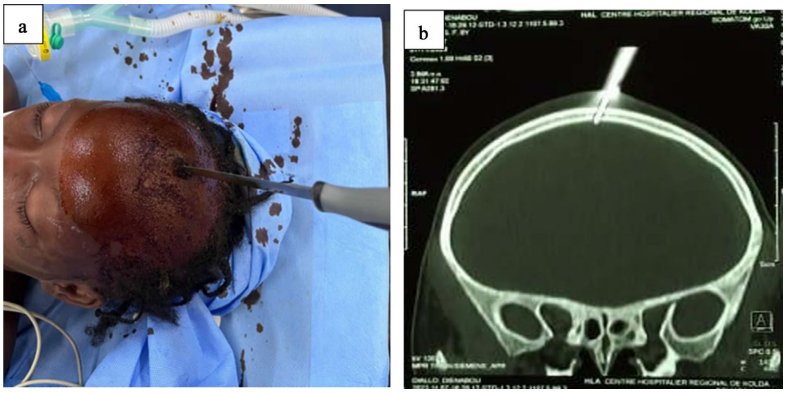

Figure 5. Preoperative image showing a mid-frontal stab wound (a) with a non-contrast coronal section CT scan displaying an intra-cranial foreign body (b).

2.6. Observation 6

A 5-year-old boy with no reported pathological history, was admitted in our unity 24 hours after a traumatic brain injury following a domestic accident. The child accidentally received a blow to the scalp from a piece of wood while picking mangoes. He reportedly experienced an initial loss of consciousness and two episodes of vomiting at the scene of the accident. Initial care was provided at a peripheral health center, and the wound was somehow dressed. The child was referred the day after the accident for further care in our facility. The examination at the entrance showed a clear consciousness with a Glasgow score of 15, the pupils were isocoric and light-responsive. No neurological deficits were noted. Craniofacial examination revealed a right posterior parietal wound with a hollow of a fragment of wood (**Figure 6(a)**). The brain CT performed showed a depressed right parietal fracture with intraparenchymal bone fragments and pneumencephaly (**Figure 6(b)**). The child benefited from wound trimming on the same day. Upon surgical exploration, we detected an osteomeningeal breach caused by the foreign body. The postoperative course was favorable and the child was discharged from the hospital on day 3 after surgery. At clinical check-up at one month, the child was conscious and had no neurological deficit.

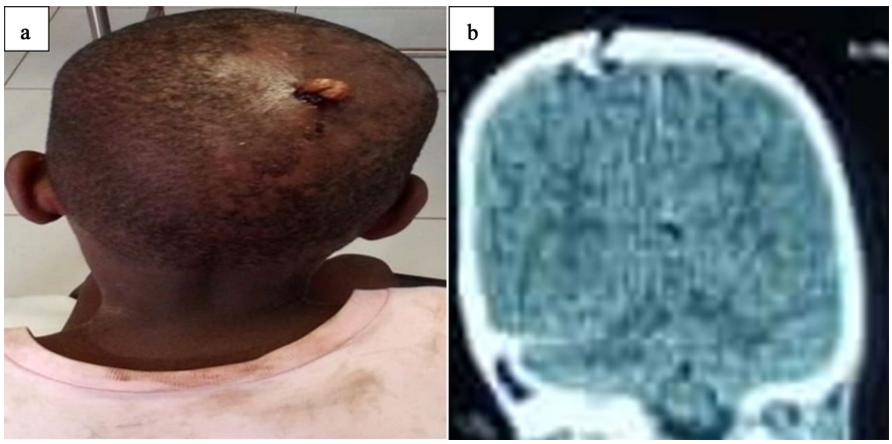

Figure 6. Preoperative photograph showing a right parietal wound with a piece of wood piercing the skull (a); brain CT scan in parenchymal window showing a right posterior parietal craniocerebral wound with the presence of an intraparenchymal foreign body (b).

3. Discussion

Penetrating head injuries are rare, accounting for approximately 0.4% of all head injuries [1]. They often occur in traffic accidents, workplace accidents or suicide attempts [5] [6]. Their severity depends on the underlying injuries, the risk of hemorrhage in the initial phase and the risk of sepsis secondarily [1]. In three of our cases, the accident was caused by an iron bar: in the first case, during a domestic accident, and in the other two, during fruit picking. In all three situations, the iron bar that had pierced the skull was removed at the scene of the accident by an adult before any brain imaging examinations were performed. For the fifth pa-

tient, a sharp knife was pointed at the scalp. This act of abuse exposed the child to major complications due to injury to the superior sagittal sinus. Unlike the other children, in whom the foreign body was removed at home with a series of infectious complications, in this child, the metal was removed in our facility with favorable postoperative results. These incidents, which occurred in areas far from neurosurgical and radiological referral centers, exposed these children to a significant risk of hemorrhage that could quickly be life-threatening. Indeed, cerebral computed tomography is now the key examination in the neuroradiological assessment of patients with penetrating head injuries. However, the high risk of traumatic aneurysm justifies the systematic performance of a cerebral angiography scan before the extraction of a foreign body [7] [8]. It was not performed because the metal had already been removed at home in the case of the three children. In the case of the fourth child, there were no suspicious images of vascular lesions on the brain CT scan. Surgical removal of the metal is indicated to prevent or reduce secondary lesions and late complications. To achieve this, the procedure must be performed as soon as possible. There is no standard strategy for the surgical removal of foreign bodies. The procedure must be as minimally traumatic and damaging as possible. Careful analysis of radiological examinations and a thorough knowledge of brain anatomy can help to remove the metal safely [5]. Some authors have proposed intraoperative radiological examinations to detect early intracranial hemorrhages secondary to the extraction of a foreign body [9]. Craniectomy is the optimal surgical approach for the removal of intracranial metal breaching the dura mater, as it allows for control in the event of hemorrhage during the procedure. For foreign bodies that have not penetrated the dura mater, simple removal under local anesthesia can be performed. However, blind removal of intracranial foreign bodies carries many dangers: it can immediately lead to the rebleeding from a large vessel [3].

Patients with penetrating brain injury involving a non-sterile foreign body are at risk of developing infections such as brain abscesses and meningitis [1]. Four of our patients developed infectious complications, including a brain abscess along the path of the metal in two children, and meningitis and subcutaneous suppuration in two others. In these patients, the infection was thought to be secondary to the presence of foreign bodies or intracranial bone fragments, or to cerebrospinal fluid leakage. Bacteriological analysis of the pus isolated a germ in only one of our patients. Broad-spectrum antibiotics are the most recommended; these can offer better results as they cross the blood-brain barrier. The choice of antibiotic and the duration of antibiotic therapy depend on the location of the foreign body and each team's practices [1] [10]. For our patients with infectious complications, antibiotic therapy based on Ceftriaxone combined with metronidazole was used based on the antibiogram and on the advice of our infectious disease specialists, with satisfactory results in all our patients. Post-operative monitoring assesses the patient's neurological status using the Glasgow Coma Scale (GCS). It also looks for signs of epileptic seizures, cerebrospinal fluid (CSF) leakage, and

endocrine and infectious disorders. CSF leakage occurs in 0.5% to 3% of cases of penetrating head trauma [2].

This complication has not been observed in our patients. In addition to the follow-up brain CT scan, which must be performed within 72 hours to check for secondary complications such as hematomas in the surgical site, it is advisable to repeat the CT angiogram and cerebral arteriography 2 to 3 weeks later [4]. These two examinations will look for a pseudo-aneurysm linked to vascular damage caused by the foreign body. Three of our patients underwent post-operative cerebral computed tomography. The initial Glasgow Coma Scale (GCS) score prior to treatment is an important prognostic factor. An initial GCS score of less than 15 is predictive of an unfavorable outcome [3] [11]. Treatment was successful, with a satisfactory clinical outcome in all of our patients. Two of our children were left with mild hemiparesis as sequelae. Post-traumatic epilepsy, observed in one of our patients, occurs in 30% to 50% of penetrating brain injuries [4]. It may require prophylactic anticonvulsant treatment. The post-traumatic epilepsy observed in our first patient in the acute phase improved after one month of antiepileptic treatment.

4. Conclusion

Penetrating brain injury is a rare condition with a significant morbidity and mortality rate in children. The severity of clinical signs depends on the location of the brain injury and also associated intracranial vascular lesions. Infections and intracranial vascular lesions are the main complications to be on the lookout for. The treatment strategy is guided by the patient's hemodynamic status, but nothing should delay surgery.

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Conflicts of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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