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Severe Traumatic Brain Injury in an Indigenous Child from the Western Amazon Following a Collision Between Two Canoes – A Case Report

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ABSTRACT

Head trauma is a leading cause of mortality in children in developing countries, often resulting from motor vehicle or motorcycle accidents. The Amazon region, however, presents unique characteristics. Here, one of the primary modes of transportation is canoes, wooden vessels designed for river travel. This paper describes a case involving a two-year-old indigenous child from the Mundurucu ethnic group, residing in the municipality of Borba in the Amazonas State. The child was involved in a collision between two canoes, suffering severe head trauma as the bow of a canoe penetrated the frontal region of the skull.

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Introduction

Traumatic brain injury (TBI) is a primary cause of death and disability in the pediatric population and can lead to a multitude of traumatic injuries including lesions in the scalp, skull, and brain tissue [1]. The approach to managing TBI in children differs from adults due to several factors, including age-dependent structural changes, variations in injury mechanisms linked to the child's physical abilities, and the challenges inherent in the neurological evaluation of these patients [2]. Children's scalps are highly vascularized, leading to significant blood loss even from small wounds [3]. Consequently, children exhibit distinct pathological responses to brain injury and display related neurological symptoms.

Recent advancements in diagnostic imaging have significantly enhanced patient care, assisting healthcare providers in accurately evaluating and diagnosing pediatric TBIs [3]. However, access to such technology is not uniform worldwide. In many developing countries, these crucial tools are often unavailable, thereby affecting the diagnosis, treatment, and prognosis of children affected by TBI [1].

Epidemiology

Traumatic brain injury (TBI) is a broad and inclusive term designating a wide range of pathology that results from an external force to the cranium and underlying brain. TBI poses a significant healthcare concern from the time of initial insult until many years later when long-term sequelae may manifest. In the United States alone, an estimated 475,000 children aged 0-14 suffer a TBI each year. TBI results in over 7,000 deaths, 60,000 hospitalizations, and 600,000 emergency department (ED) visits annually among American children [4, 5]. Similarly, TBI affects the pediatric population worldwide. Studies have shown that TBI contributes to more than half of pediatric injuries in Iran, around 20% of trauma ED admissions in India, and around 30% of pediatric injuries in Korea [6, 7]. Furthermore, TBI affects more than 486 adolescents per 100,000 people per year in Australia and approximately 280 children out of 100,000 people in the United Kingdom [8, 9].

Compared to their adult counterparts, children suffering head injury warrants particular concern given the developmental consequences of early brain damage. Analyzing domestic data, Schneier et al. identified TBI as the leading cause of child death and long-term disability, and among the most frequent causes of interruption to normal child development [10]. The worldwide incidence of pediatric TBI ranges broadly from 12 to 486 persons per 100,000, depending upon individual reports' inclusion criteria. Three US studies reported incidence between 70-75 per 100,000 [9-13].

Among reports documenting incidence figures, most reported rates between 47 to 280 per 100,000, with the highest rates from

Australia and the lowest from northern European countries [8-13]. Male children were affected more commonly by TBI than their female counterparts in all but one report [14]. The gender gap was greatest in Australia with males injured nearly three times more often than females [15]. The lowest gender difference (1.05:1) was reported in a Nigerian study, while most reported a ratio around 1.8:1 (M:F).

The mean age of children ranged from 3.2 to 10.4 years (median 6.8), though many reports identified multiple peak ages of injury [16, 17]. A bimodal distribution with the greatest injury occurrence in very young (0-3) and older (15-18) children was described by several authors [18]. A Chinese study identified 63% of injuries occurring in patients aged 0-2 years [19]. Two other studies from east Asia found more than half of pediatric TBI occurred in patients aged 4 years or less [20].

In contrast, in most US populations and in the single Iranian series, older patients (>14 years) constituted the largest subgroup suffering from TBI [21]. In a US study of more than 25,000 subjects, multivariate analysis found that older age independently predicted a longer hospital stay and higher total healthcare costs [10]. Overall, the role of race and socioeconomic status in determining the likelihood for TBI in pediatric populations is unclear due to limited data being reported on these topics. Racial and ethnic distribution of injury was reported in a minority of series, and none reported figures corrected for baseline racial distributions within the study populations themselves [14]. A single US study found that African American children involved in traffic accidents were more likely than Caucasians to require hospitalization and to suffer death [1]. Studies from the US and UK found that children from a lower socioeconomic background experienced higher rates of TBI [4].

Unintentional injuries primarily lead to brain injuries, which are most likely to result in death or permanent disability. In the United States of America, approximately 475,000 children aged 0 - 14 years suffer from TBI annually. Of these, 90% return home with mild injuries; 37,000 require hospitalization, and 2,685 succumb to their injuries. The annual death rate is higher for children under four years, with a rate of 5:100,000 [1]. Boys are found to have more emergency consultations than girls. Children younger than four years often sustain injuries from falls but are also victims of abusive injuries and motor vehicle accidents [2]. The rate at which radiographic studies were performed ranged widely by study, and findings were documented variably. Generally, unremarkable computed tomography (CT) findings were discovered in the majority of patients (58-92%) in studies that included mostly mild TBI14,16,26. Among patients with positive imaging findings, skull fractures (19-45%) and contusions (15-61%) were the most common abnormality [22]. Extra-axial collections were reported in many series and included subdural hematoma in 1 to 12% and epidural hematoma in 1 to 19% of pediatric TBI. The majority of pediatric TBI (>90% in most studies) was managed nonoperatively [17, 23]. Expectedly, reports including only severe head injury reported higher rates of surgery for TBI (21-63%) [16]. Among surgical interventions, placement of external ventricular drain (19-47%) and craniotomy/craniectomy for hematoma evacuation (37-48%) were most frequently performed, followed by fracture elevation (13-23%) [18].

Recovery from TBI was good in more than 90% of patients in reports that included greater than 90% mild TBI, a pattern which remained independent of country or region. However, in studies from the US and Sweden with more than 35% severe TBI, the proportion of patients with a 'good' or 'full' recovery, fell to ~50% [24, 25]. In two East Asian reports including only mild TBI, over 90% of patients were discharged after a short period of observation in the ED. Most US studies reported higher rates of admission, though the majority of patients were discharged from the hospital in good condition without undergoing surgical intervention [26]. The rate at which radiographic studies were performed ranged widely by study, and findings were documented variably. Generally, unremarkable computed tomography (CT) findings were discovered in the majority of patients (58-92%) in studies that included mostly mild TBI [17]. Among patients with positive imaging findings, skull fractures (19-45%) and contusions (15-61%) were the most common abnormality [22]. Extra-axial collections were reported in many series and included subdural hematoma in 1 to 12% and epidural hematoma in 1 to 19% of pediatric TBI [6].

Mechanism of pediatric TBI ranged broadly across populations and age groups. Generally, motor vehicle collisions (MVC) (6-80%) and falls (5-87%) accounted for the majority of injuries, followed by abuse and other forms of non- accidental trauma (2-12%) and sports-related injury. Falls accounted for more than 50% of pediatric TBI in Chinese populations as well as in reports from Nepal, Turkey, and India [27]. In most of these studies, young children (<4y) made up the largest age subgroup. Excluding one US series of isolated skull fractures, among western populations, falls accounted for less TBI (range 8-45%) than in Asian and African populations [5-28]. Non-accidental trauma in the form of assault or child abuse was responsible for < 10% of pediatric TBI with the highest rates coming from a population in Nigeria (10%) and another in Malaysia (9%) [14]. Rates of non-accidental trauma in the US ranged from 1-8% (median 4%), though this included both child abuse and adolescent assault [29]. Sports-related TBI was far more common in the US and Australia (2-29%) than in Asian countries (.7- 2%) [6-8].

Abusive head trauma (AHT) is particularly common in young infants aged less than two years; approximately 30 out of every 100,000 infants aged less than one year are hospitalized for AHT [4]. There are no reported cases of TBI caused by canoe collisions. Thus, it becomes evident that there are no studies evaluating the pattern of cranial injuries in the Amerindian populations of South America. Herein, we report on the reality experienced by these peoples even today.

Case Report

This report presents the case of a two-year-old indigenous child from the Mundurucu ethnic group, residing in the municipality of Borba, located in the interior of the State of Amazonas. The river journey from this municipality to the capital takes approximately 12 hours. Borba is situated at an altitude of 24 meters, with geographic coordinates of 4° 23'18'' South, 59° 23'18'' West.

In the Amazon region, especially within indigenous communities, the primary mode of transportation is via canoes. These wooden vessels are designed to navigate the region's rivers, thereby facilitating the transportation of people and goods. In this particular case, the young child was traveling with his parents in the bow of their canoe when it collided with another canoe traveling in the opposite direction. The bow of the oncoming canoe struck the child's frontal region, causing severe head trauma and significant facial injuries. The child was initially treated in the city of Borba, after which he was transferred to the city of Manaus, the capital of the State of Amazonas, via an air ambulance ICU. The accident occurred around 9:00 am, and the child was presented for evaluation at the Neurosurgery Service at 8:00 pm. During this period, the child was taken for treatment to the nearest city, Borba. First aid measures were performed, stabilizing the patient's condition. However, as they did not have imaging tests available, a transfer to Manaus, the capital of the State of Amazonas, was requested.

Figure 1: Indian Canoe
Source: https://www.google.com/search

Figure 2: Little Indian in Operating Room
Source: Cohen, MD, MsC

It took approximately 12 hours of waiting to secure transportation to the state capital. In this region, boats, or river transportation, are the primary means of travel. However, due to the urgency of this case, the dispatch of an air ambulance was requested. This resource is only available in the capital. Thus, the aircraft needs to be prepared in Manaus and then travel to the location to rescue the patient, subsequently delivering them to the tertiary hospital. According to the parents' account, the child remained relatively stable during this period. On-site care included applying compresses to the laceration and contusion wounds, as well as suturing the supra-orbital wound of the right eye. Broad-spectrum antibiotics, ceftriaxone and metronidazole, were also administered to mitigate the risk of secondary infections from the wound itself.

According to the assessment of the air transport physician, since the child was able to breathe spontaneously, appeared confused but responded to commands and actively moved all four limbs, it was decided to use only a nasal mask supplying about 6L of oxygen per minute. The flight returned to Manaus quickly and without complications. After approximately 3 hours of transport from his hometown, the child was admitted to the Hospital Unit for specialized assessment. An initial assessment for multiple trauma was conducted, with a FAST exam performed, which showed no evidence of intra-abdominal collections. The airway remained patent with no signs of obstructions, however, the child showed signs of hypovolemic shock due to blood loss from the scalp injuries. The initial blood pressure was 85 x 50 mmHg. The heart rate was measured at 120 bpm, with decreased peripheral perfusion and an increased capillary refill time of approximately 3 seconds. There were signs of mild dehydration, but urine output remained at about 1 mL/Kg/h. Chest X-rays were taken, with no further abnormalities, so no interventions were required by the general surgery team. Evaluations were also conducted by the orthopedic and trauma team, which identified no other changes in the rest of the body segments.

Upon arrival, the child was utilizing an oxygen mask, with a Glasgow Coma Scale score of 8. Orotracheal intubation was performed and the child was connected to mechanical ventilation. His heart rate upon admission was 120 bpm, with an oxygen saturation of 99% post-intubation, and a capillary blood glucose level of 90 mg/dl. Regarding the neurological assessment, the child exhibited signs of severe cranial trauma, with exposed brain matter on the forehead, an open skull fracture, and an injury to the right orbit. Ipsilateral anisocoria with ocular abduction was observed. Even after orotracheal intubation, the child showed movement in all four limbs without evidence of motor deficits in these segments. After compression with dressings, there was a significant reduction in the cutaneous hemorrhage from the forehead as well as from the exposed brain tissue itself.

Additionally, a nasal cerebrospinal fluid leak was observed, along with signs of a frontal fracture and bilateral orbital roof. The patient was immediately referred for a computed tomography (CT) scan, which revealed a bifrontal fracture with exposure of brain tissue, a skull base fracture with destruction of the anterior cranial base, disconnection of the frontal bone from the orbital roofs, fracture of the right orbital wall, signs of right-sided laminar subdural hemorrhage, and brain contusions in the right frontal lobe.

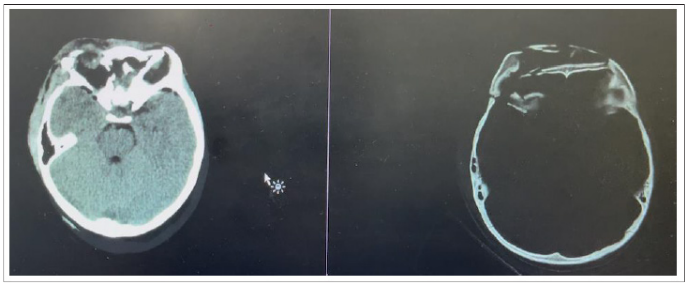

Figure 3: Axial Skull CT
Source: Cohen, MD, MsC

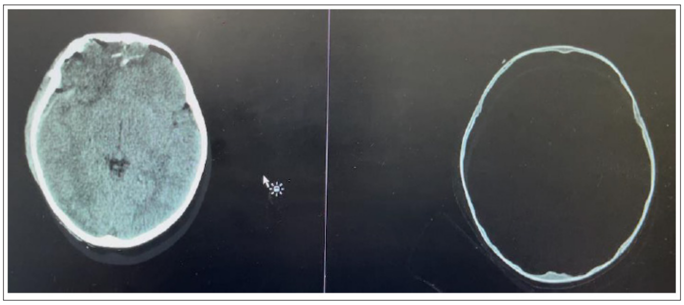

Figure 4: Axial Skull CT
Source: Cohen, MD, MsC

The child was promptly taken to the operating room where a bicoronal incision was made to expose the frontal bone along with the roofs of both orbits. This revealed a disconnect of the frontal bone from the orbits with significant damage to the dura mater and exposed brain tissue. After conducting a bifrontal craniotomy, it was observed that the lower portion of the right frontal bone and the anterior cranial fossa were destroyed, exposing the periorbital fat and signs of cerebral herniation to the crista galli. At this point, the child was hemodynamically stable after being infused approximately 1000mL of crystalloid solution. The floor of the anterior fossa was no longer present, especially the roof of the right orbit, which had been entirely shattered, leading to mild enophthalmos. When elevating the basal portion of the right frontal lobe, a sizable injury to the dura mater was noticed, displaying signs of a cerebrospinal fluid fistula extending to the nasal area.

The initial decision was to drain the intraparenchymal hematomas in the basal frontal regions, identifying the dural borders. No significant vascular injuries were detected, especially from branches of the anterior cerebral artery. However, it was already noticeable that the brain tissue was herniating through the area of the crista galli. After identifying the dural borders, the maximum amount of autologous galea aponeurotica graft was removed so that a duroplasty could be performed, reducing the risk of nasal or orbital cerebrospinal fluid fistula. Biological adhesive was not available in the unit to be instilled along the suture lines.

A rigorous hemostasis of the bleeding points and the performance of a duraplasty. After this step, the duramater was anchored to the bone edge. Lesion debridement was performed, and the remaining bone flap was repositioned. Following this stage, closure was performed in layers. An intracranial pressure catheter was not installed due to its unavailability in the Hospital Unit. The child was subsequently transferred to the Intensive Care Unit.

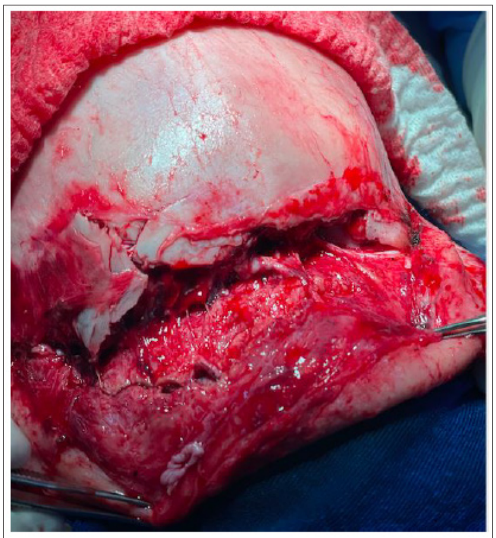

Figure 5: Frontal Bone Exposition
Source: Cohen, MD, MsC

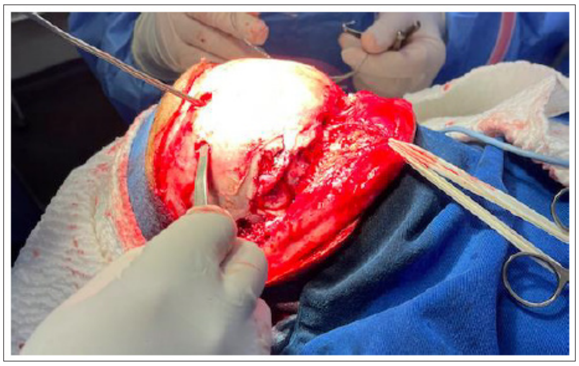

Figure 6: Performing Craniotomy Plus Skull Fracture and Brain Mass Exposure
Source: Cohen, MD, MsC

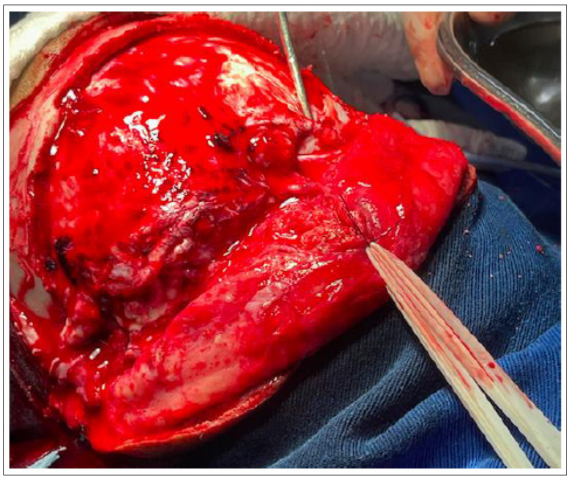

Figure 7: Performing Duroplasty
Source: Cohen, MD, MsC

Figure 8: Anterior Skull Base Fracture
Source: Cohen, MD, MsC

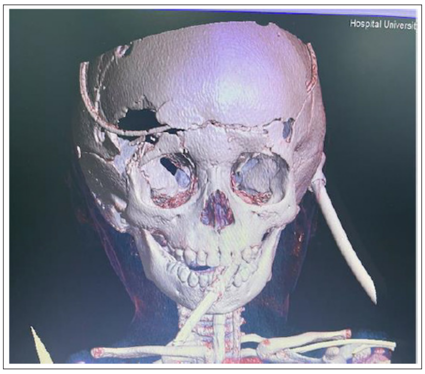

Figure 9: Post Operative Skull CT
Source: Cohen, MD, MsC

After two days in the Intensive Care Unit, the child achieved hemodynamic stabilization, and a control skull computed tomography scan was performed. The scan showed managed frontal contusions, open base cisterns, signs of minor right frontal ischemia, but with adequate control of cerebral edema. On the fifth postoperative day, the child was successfully extubated. Following this stage, the child demonstrated movement in all four limbs, maintained right anisocoria but with almost normal eye movement. He had begun speaking with his parents, and to date, he has not shown any signs of cerebrospinal fluid leakage.

Figure 10: 7th Post Operative Day
Source: Cohen, MD, MsC

After this initial period, the child was discharged from the hospital in good clinical condition. He was conscious and oriented, without focal motor deficits in his limbs, but with partial vision loss in the right eye. About 30 days later, she experienced a nasal cerebrospinal fluid (CSF) fistula leak, with minor dripping that began after exerting physical effort while climbing trees. She returned for another specialized assessment, and when physical exertion was made, rhinorrhea was evident. At this time, he was at a Glasgow Coma Scale of 15, with a Karnofsky Functional Scale score of 90. New imaging exams also revealed the presence of a contained CSF fistula in the right fronto-temporal region. The patient was referred for another surgical procedure with the intent to identify the origin of the cerebrospinal fluid (CSF) fistula and to surgically close it.

Upon reopening the previous incision, it was observed that the suture lines of the dura mater had healed well, but a dural lesion had reoccurred in the crista galli region, perpetuating the CSF fistula. This time, the hospital's management had been requested to purchase dural substitute and biological adhesive for the definitive treatment of this condition. After identifying the leakage points, it was re-sutured with the instillation of the biological adhesive and the interposition of the dural substitute.

Figure 11: CSF Fistula Correction
Source: Cohen, MD, MsC

In conclusion, the child once again showed resolution of the nasal fistula. He completed the antibiotic regimen and was discharged from the hospital without further complications.

Conclusions

The unique characteristics of the Amazon region can present significant challenges to the practice of medicine, especially complex, tertiary specialties such as neurosurgery. However, it can also be highly rewarding when interventions are timely and successful as seen in the presented case. It is imperative that public health policies be implemented to facilitate timely and necessary emergency treatment for these patients.

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