European Journal of Medical and Health Sciences
Vol 7 | Issue 3 | June 2025
ISSN 2593-8339

RESEARCH ARTICLE

Predictive Factors for Brain Lesions in Pediatric Head Trauma: A Multicenter Study in Madagascar

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ABSTRACT

Pediatric traumatic brain injury (TBI) is a major cause of morbidity and mortality, requiring optimized management to minimize unnecessary radiation exposure. This multicenter retrospective study, conducted on 2,438 hospitalized children with TBI, identified intracranial lesions in 42% of cases using computed tomography (CT). Statistical analysis revealed significant correlations between initial clinical parameters and the presence of intracranial injuries, particularly loss of consciousness and cerebral contusions ($p = 0.03$), as well as repeated vomiting and the detection of intracranial abnormalities ($p = 0.02$). These findings highlight the necessity of a targeted clinical approach for CT prescription, incorporating precise predictive criteria to improve risk stratification and optimize the management of pediatric TBI.

Keywords: Child, Clinical Signs, Computed Tomography, Traumatic Brain Injury.

Submitted: April 02, 2025

Published: June 22, 2025

10.24018/ejmed.2025.7.3.2316

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1. Introduction

Pediatric traumatic brain injury (TBI) is defined as damage to the skull and/or brain resulting from direct or indirect impact, which can lead to injuries of varying severity. It is a significant cause of morbidity and mortality in children. In recent years, there have been several studies that have attempted to identify anamnetic and clinical criteria that predict the presence of intracranial lesions. The main challenge lies in identifying patients at risk of developing such lesions, who may require neurosurgical intervention. Various parameters, including loss of consciousness, neurological deficits, amnesia, post-traumatic seizures, headaches, and vomiting, have been implicated in this evaluation [1]. However, the challenge remains in reliably predicting the presence of intracranial lesions using these elements, either individually or in combination. The objective of this study is to establish the correlation between clinical manifestations and abnormalities identified by brain computed tomography (CT) in children with traumatic brain injury.

2. Methods

This descriptive and analytical retrospective multicenter study was conducted in three neurosurgery departments in Madagascar, including CHU-JRA, CENHOSOA, and CHU-Tambohobe, over a period of twelve months, from January to December 2023, to analyse the medical records of children hospitalized due to traumatic brain injury. The study included 94 patients aged 0 to 15 years who had undergone brain CT scans. Data were collected from hospital registers and analysed using Excel and EPI-INFO 7 software. The parameters that were studied included epidemiological aspects (age, sex, circumstances), clinical aspects (symptoms, Glasgow Coma Scale score), paraclinical aspects (bone and hemorrhagic lesions), as well as therapeutic and evolutionary aspects.

3. Results

Out of 2438 children hospitalized, 94 (3.9%) presented with traumatic brain injury (Fig. 1). The mean age was 6.3 years, with a male predominance (59.57%). Falls were the primary etiology (65.15%), followed by road

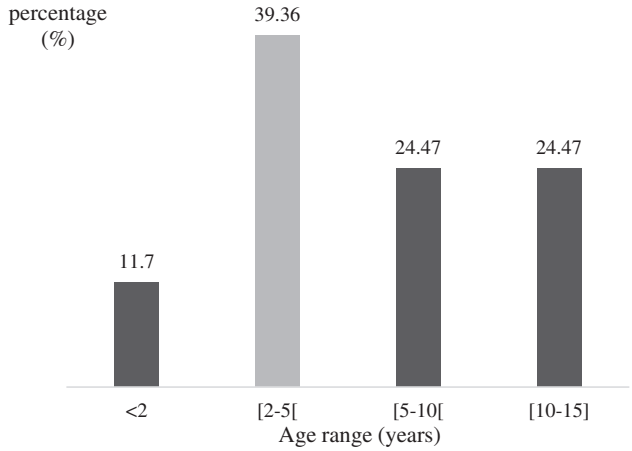

Fig. 1. Distribution by age.

Fig. 2. Craniofacial laceration with post-traumatic frontal bone fracture.

traffic accidents (23%), highlighting the importance of age-appropriate prevention measures. The mean Glasgow Coma Scale score was 13.5, with 62% of patients classified as mild TBI (Glasgow $\geq$ 13), 27% as moderate TBI (Glasgow 9-12), and 11% as severe TBI (Glasgow $\leq$ 8). The most common clinical signs were headaches (47%), vomiting (30%), and altered consciousness (25%). The presence of repeated vomiting was strongly correlated with intracranial lesions detected by CT ($p = 0.02$).

CT scans revealed intracranial lesions in 42% of patients, including epidural hematomas (15%), subdural hematomas (10%), brain contusions (17%), and diffuse cerebral edema (8%). A significant correlation was found between brain contusions and initial loss of consciousness ($p = 0.03$). Additionally, patients with initial Glasgow Coma Scale deterioration had a higher risk of requiring neurosurgical intervention ($p < 0.01$) (Table I).

Conservative treatment was applied in 86.2% of cases, primarily through strict neurological monitoring and analgesia. Neurosurgical intervention was necessary in 13.8% of cases, including evacuation of an expanding hematoma, elevation of a depressed skull fracture, and debridement of a craniocerebral wound (Fig. 2). The mean hospitalization duration was 4.6 days, with a significant difference between mild TBIs (2.9 days) and severe TBIs (7.8 days). The outcome was favorable in 96.8% of cases, with a single death recorded in a polytraumatized patient presenting with uncontrolled severe intracranial hypertension.

4. Discussion

Our study is distinguished by its targeted approach to optimize the management of pediatric TBI by identifying reliable clinical criteria that can rationalize the use of CT and improve the prognosis for young patients. The average age observed (6.3 years) aligns with trends reported in other studies, where children under 7 years old are the most affected due to their motor and cognitive immaturity [1]. Our results show that falls are the leading cause (65.15%), followed by road traffic accidents (23%), which is consistent with epidemiological data described in the literature [2], [3]. Severe TBIs were more frequently associated with road traffic accidents, confirming the need for enhanced prevention measures for these types of events.

The analysis of clinical signs highlights that headaches (47%), vomiting (30%), and altered consciousness (25%) are the most common symptoms. The presence of repeated vomiting was strongly correlated with intracranial lesions detected by CT ($p = 0.02$), which supports the work of Kuppermann *et al.* [2], who recommend including this symptom in the criteria for systematic imaging. Additionally, our results confirm that initial loss of consciousness is a significant predictor of brain contusions ($p = 0.03$), reinforcing current recommendations for monitoring children presenting with this symptom [4] (Table II).

A notable difference in our results compared to other studies is the frequency of intracranial lesions detected by CT. While our study reports a rate of 42%, other research indicates lower rates, ranging from 6.8% to 14% [5], [6]. This variation may be explained by differences in patient inclusion criteria, CT prescription thresholds, and methodologies for analyzing medical images. A possible pathophysiological explanation is that young children have greater cranial elasticity, which reduces the frequency of visible bone fractures but increases the risk of diffuse cerebral lesions [7].

Furthermore, the relationship between a decrease in the Glasgow Coma Scale score and the severity of intracranial lesions ($p < 0.01$) corroborates previous studies showing that children with a Glasgow score below 12 are at higher risk of neurological complications [8]. The importance of this parameter justifies its inclusion in decision-making algorithms for CT scans, to optimize the detection of severe trauma while limiting exposure to unnecessary radiation.

These results emphasize the importance of rigorous clinical evaluation to guide imaging decisions and avoid unnecessary exams. In practice, our results encourage a hierarchical approach to pediatric TBI, incorporating precise criteria for CT prescription. It is essential to standardize management protocols and train clinicians to identify predictive signs of intracranial lesions. Greater awareness among parents and educators about preventive measures, such as wearing helmets and securing home

TABLE I: Correlations Between Clinical Parameters and Intracranial Lesions

Clinical parameters	Associated intracranial lesions	p-value
Initial loss of consciousness	Cerebral contusions	0.03
Repeated vomiting	Presence of lesion on CT scan	0.02
Glasgow score < 12	Need for neurosurgical intervention	<0.01
Clinical cranial deformity	Presence of an embarrure	0.04

TABLE II: Correlation of Results with Other Authors

Clinical parameters	Our study	Kuppermann *et al*. [2]	Osmond *et al*. [3]	Quayle *et al*. [8]
Initial loss of consciousness	$p = 0.03$	Not evaluated	$p < 0.05$	$p = 0.04$
Repeated vomiting	$p = 0.02$	$p = 0.01$	Not evaluated	$p = 0.03$
Glasgow score < 12	$p < 0.01$	$p = 0.005$	$p = 0.002$	Not evaluated
Clinical cranial deformity	$p = 0.04$	Not evaluated	$p = 0.03$	Not evaluated

environments, could reduce the incidence of severe TBIs. Future multicenter prospective studies are needed to refine these criteria and evaluate the impact of such rationalization on healthcare costs and long-term neurological outcomes. These results support those of Osmond *et al*. [3], who demonstrated that patients with a Glasgow score below 12 have an increased risk of requiring neurosurgical intervention.

The clinical and scientific implications of our study are significant, as it helps refine decision-making criteria for CT imaging, reducing unnecessary radiation while ensuring optimal management of pediatric TBI. The implementation of standardized protocols incorporating our results could improve hospital management and optimize medical resources. It is crucial to enhance practitioner training in the rigorous clinical evaluation of TBIs and promote trauma prevention through awareness campaigns for parents and educators. Finally, future multicenter research is needed to validate these criteria on a larger scale and adapt therapeutic strategies based on scientific and technological advancements.

5. Conclusion

This study highlights the correlation between initial clinical parameters and the presence of intracranial lesions in children with traumatic brain injury. The results confirm that initial loss of consciousness and repeated vomiting are significant predictive factors for lesions detected by brain CT. Identifying these clinical criteria helps optimize CT prescription, reducing unnecessary exams while ensuring appropriate management. These findings underline the need for rigorous evaluation and standardization of management protocols to improve the prognosis for young patients.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

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