

Clinical profile, Anaesthetic Management, and Therapeutic Outcomes of Paediatric Traumatic Injuries in a Resource-Limited Urban Centre

Ngono Ateba Glwadys^{1,2*}, Metogo Mbengono Junette Arlette^{2,3}, Ndom Ntock Ferdinand^{2,3}, Banga Nkomo Douglas^{1,6}, Bilogui Adjessa Willy³, Cassandre Tocko², Evindi Abomo Olivia⁷, Malangue Berthe², Eunice Tankeu³, Henry Luma⁵, Jacqueline Ze Minkande⁴

¹Department of Surgery and Sub-specialties, Anesthesiology and Critical Care, Faculty of Medicine and Pharmaceutical Sciences, University of Dschang, Cameroon

²Anesthesiology Unit, Douala General Hospital, Douala, Cameroon

³Department of Surgery and Sub-specialties, Faculty of Medicine and Pharmaceutical Sciences, University of Douala, Cameroon

⁴Department of Anesthesia and Critical Care, Faculty of Medicine and Biomedical Sciences, University of Yaounde I, Yaounde, Cameroon

⁵Department of Internal Medicine, Douala General Hospital, Douala, Cameroon

⁶Department of Surgery and Sub-specialties, Douala General Hospital, Douala, Cameroon

⁷Pediatric Unit, Douala General Hospital, Douala, Cameroon

*Corresponding Author

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ABSTRACT

Background: Paediatric trauma is a leading cause of global childhood mortality and morbidity, with a disproportionate burden in resource-limited settings. Traumatic brain injury (TBI) is a major contributor to poor outcomes. This study aimed to describe the epidemiology, clinical characteristics, anaesthetic management, and outcomes, including post-discharge functional status, of paediatric trauma patients in a sub-Saharan African urban hospital, and to identify predictors of mortality.

Methods: We conducted a 10-month prospective, single-centre observational study at the emergency department of the Douala General Hospital in Cameroon. We enrolled all consecutive patients aged <18 years presenting with acute traumatic injuries. Data on demographics, injury mechanism, prehospital care, clinical severity (Glasgow Coma Scale [GCS]), anaesthetic management, and clinical outcomes were collected. Survivors were contacted at 3 months post-discharge to assess neurological outcome using the Paediatric Cerebral Performance Category (PCPC) scale. Inferential statistical analysis using logistic regression was performed to identify predictors of in-hospital mortality.

Results: A total of 29 patients were enrolled (mean age 7.5 ± 4.2 years; 65.5% male). Non-medicalized transport was common (58.6%), and 10.3% were dead on arrival. Falls (44.8%) and road traffic accidents (24.1%) were the primary mechanisms. TBI was present in most cases, classified as mild (69.0%), moderate (13.8%), or severe (13.8%). Fourteen patients required anaesthesia, with ketamine being the most common induction agent. The overall in-hospital mortality rate for admitted patients was 5.0%, with death occurring only in the severe TBI group. In multivariate analysis, a GCS score of 3–8 was the sole independent predictor of mortality (OR 18.5, 95% CI 1.9–179.1, $p=0.012$). At 3-month follow-up ($n=18$ survivors), all patients with initial mild TBI had good neurological outcomes (PCPC 1), whereas 50% of survivors from the moderate-to-severe TBI group had moderate to severe disability (PCPC 3–4).

Conclusion: Paediatric trauma in this setting is characterized by a high prevalence of TBI, significant prehospital care deficits, and substantial long-term morbidity among survivors of severe injury. Severe TBI on admission is a potent predictor of mortality. These findings underscore the urgent need for developing structured prehospital EMS, implementing standardized neuroprotective trauma protocols, strengthening specialist anaesthetic capacity, and establishing rehabilitation services to improve the entire continuum of care.

Keywords: Anaesthesia, Paediatric Trauma, Resource-Limited Setting, Douala Functional Recovery

INTRODUCTION

Paediatric traumatic injury constitutes a formidable global public health challenge, representing a leading cause of mortality and long-term disability in children and adolescents worldwide [1, 2]. Each year, millions of children sustain injuries that necessitate emergency medical care, with a substantial proportion resulting in life-altering consequences or death [3]. Traumatic brain injury (TBI) is a particularly devastating component of this burden, accounting for the majority of trauma-related fatalities and contributing significantly to neurocognitive impairment, developmental delay, and physical disability among survivors [4, 5]. The profound and lasting impact of these injuries imposes a heavy emotional and economic toll on families, communities, and healthcare systems globally.

While the principles of paediatric trauma care are well-established in high-income countries, a stark disparity exists in resource-limited settings, where the burden of injury is often highest [6]. In many low- and middle-income countries (LMICs), healthcare systems are beset by challenges that critically impede the delivery of effective trauma care. These include the absence of organized prehospital emergency medical services (EMS), leading to delayed and often unsafe patient transport [7, 8]. Furthermore, limited access to essential diagnostic tools such as computed tomography (CT), a scarcity of specialist personnel including paediatric anaesthesiologists and neurosurgeons, and a lack of standardized, evidence-based trauma protocols combine to exacerbate injury severity and contribute to preventable mortality [9, 10].

The anaesthetic management of the critically injured child presents unique physiological and pharmacological challenges, particularly in the context of TBI [11]. Maintaining cerebral perfusion pressure, controlling intracranial pressure (ICP), ensuring haemodynamic stability, and providing adequate analgesia while avoiding secondary brain injury are paramount objectives [12]. In resource-constrained environments, these challenges are amplified by the limited availability of advanced monitoring equipment, specific anaesthetic agents, and intensive care unit (ICU) capacity. The choice of anaesthetic technique and agents must therefore be carefully tailored to the available resources while adhering to the core principles of neuroprotection and physiological stabilization [13].

Despite the magnitude of the problem, there remains a significant paucity of high-quality, prospective data detailing the epidemiology, management, and outcomes of paediatric trauma in many parts of the world, particularly sub-Saharan Africa [14, 15]. Existing literature is often retrospective or focused on specific injury types, leaving a critical knowledge gap regarding the comprehensive patient journey from injury to hospital disposition and beyond. Understanding the local patterns of injury, the deficiencies in the existing chain of survival, the predictors of poor outcomes, and the long-term functional consequences is an essential prerequisite for designing targeted, context-appropriate interventions to improve care [16].

Therefore, this study was designed to prospectively investigate the clinical and therapeutic landscape of post-traumatic paediatric injuries presenting to a major urban hospital in a resource-limited setting. The primary objectives were to: (1) describe the epidemiological profile and prehospital characteristics of injured children; (2) characterize the clinical presentation and injury patterns; (3) evaluate the anaesthetic management, surgical interventions, and short-term clinical outcomes; (4) identify predictors of in-hospital mortality; and (5) assess the neurological and functional outcomes at 3 months post-discharge.

MATERIALS AND METHODS

Study Design and Setting

A prospective, single-centre, observational study was conducted over a 10-month period, from March to

December 2025, at the emergency department of the Douala General Hospital in Cameroon. This facility serves as a primary trauma referral centre for the city of Douala and its surrounding regions. The study protocol was reviewed and approved by the Institutional Committee of the Douala General Hospital. Due to the observational nature of the study and the acuity of patient presentation, a waiver of individual written informed consent was granted for the collection of de-identified data. Verbal consent was obtained from parents or legal guardians for telephone follow-up.

Study Population

All consecutive patients meeting the eligibility criteria were enrolled. The study population comprised paediatric patients presenting to the emergency department with acute traumatic injuries.

Inclusion Criteria: Age less than 18 years; presentation to the emergency department with a diagnosis of acute traumatic injury resulting from any mechanism (e.g., fall, road traffic accident, assault).

Exclusion Criteria: Patients with incomplete or missing essential data in their medical records; injuries not classified as acute trauma (e.g., pathological fractures, post-operative complications from a non-trauma surgery).

Procedure and Data Collection

A standardized data collection form was developed to prospectively gather information for each enrolled patient. Data were extracted from emergency department records, anaesthesia charts, surgical notes, and inpatient files by trained study personnel. The collected variables were categorized as follows:

- **Demographics and Prehospital Data:** Age, sex, mode of transport to the hospital (medicalized vs. non-medicalized), and referral status.
- **Clinical and Injury Characteristics:** Mechanism of injury, time from injury to admission, vital signs on arrival, Glasgow Coma Scale (GCS) score for TBI classification (Mild: 13–15, Moderate: 9–12, Severe: 3–8), and types of associated injuries.
- **Diagnostic and Therapeutic Management:** Neuroimaging findings from CT scans, details of surgical interventions, and fluid resuscitation (crystalloids, blood products).
- **Anaesthetic Management:** American Society of Anesthesiologists (ASA) physical status classification (emergency suffix 'e' applied), choice of induction and maintenance agents, airway management techniques, and use of neuromuscular blockade.
- **Clinical Outcomes:** Length of hospital stay, discharge disposition, and in-hospital mortality.

Post-Discharge Follow-up

Surviving patients were contacted by telephone at 3 months post-discharge by a trained member of the research team. Neurological outcome was assessed using the Paediatric Cerebral Performance Category (PCPC) scale, a validated tool for assessing outcomes in children after critical illness or injury. The PCPC scale ranges from 1 (normal) to 6 (brain death) [27]. For this study, outcomes were categorized as: Good (PCPC 1), Mild Disability (PCPC 2), Moderate Disability (PCPC 3), Severe Disability (PCPC 4-5), and Brain Death (PCPC 6).

Data Analysis

Data were entered into a database and analysed using IBM SPSS Statistics, Version 25.0. Descriptive statistics were used to summarize the findings. Continuous variables were presented as mean and standard deviation (SD) or median and interquartile range (IQR) as appropriate. Categorical variables were presented as frequencies (n) and percentages (%).

To identify predictors of in-hospital mortality, univariate logistic regression was performed for key clinical and demographic variables, including age, sex, mechanism of injury, mode of transport, and initial GCS score

category. Variables with a p-value <0.20 in the univariate analysis were entered into a multivariate logistic regression model using a forward stepwise method. Results were expressed as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

RESULT

Patient Flow and Baseline Characteristics

Over the 10-month study period, 35 paediatric trauma patients were assessed for eligibility. Six were excluded due to incomplete medical records. Consequently, a final cohort of 29 patients was enrolled. Three of these 29 patients (10.3%) were pronounced dead upon arrival at the emergency department and were included in the demographic and prehospital analysis but excluded from outcome analyses of admitted patients. The patient enrollment process is shown in Figure 1.

Paediatric trauma patients assessed for eligibility (n=35)

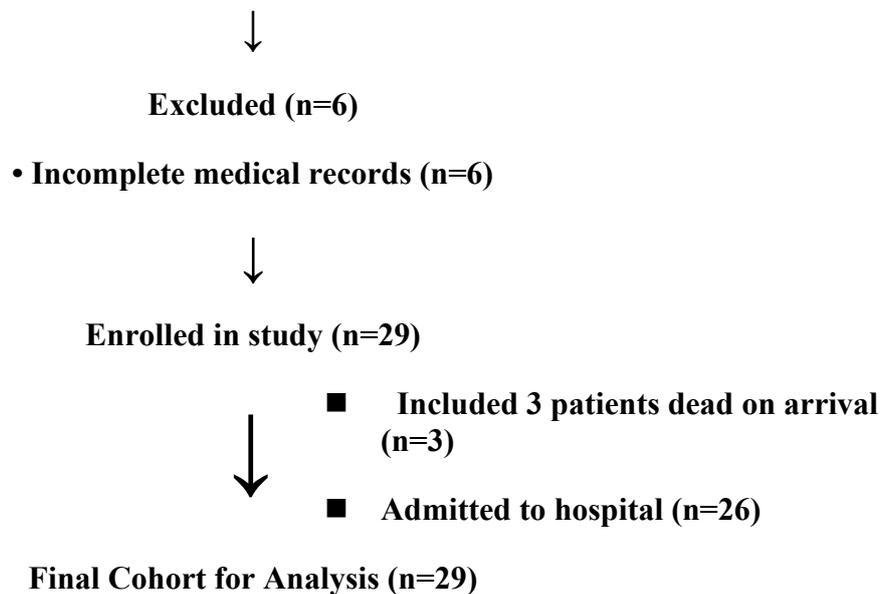


Figure 1: Patient Enrollment Flow Chart.

The demographic and prehospital characteristics of the cohort are presented in Table 1. The mean age was 7.5 ± 4.2 years, with a significant male predominance (65.5%). A majority of patients (58.6%) were transported to the hospital by non-medicalized means. Among comorbidities, sickle cell disease was noted in two patients.

Table 1: General characteristics of the study

Characteristics	Values	Percentages(%)
Age, mean (±SD), years	7.5 (±4.2)	-
Sex	-	-
Male	19	65.5
Female	10	34.4
Mode of Transport, n (%)		
Non-medicalized	17 (58.6%)	58.6
Medicalized / Referral	12 (41.4%)	41.4
Relevant Past Medical History, n (%)	-	-
Good vaccination profile	26	89.7

Sickle cell disease	2	6.9
Autism	1	3.4

Injury Profile and Clinical Severity

The mechanisms and classification of injuries are detailed in Table 2. Falls were the leading cause of injury (44.8%), followed by road traffic accidents (24.1%). Traumatic brain injury was the most common diagnosis, with 69.0% of patients classified as having mild TBI based on their initial GCS score. Moderate and severe TBI each accounted for 13.8% of cases. Polytrauma was common, with abdominal injuries present in 13 patients (44.8%).

Table 2: Injury characteristics and clinical severity

Injury Characteristics	Number of Patients (n)	Percentage (%)
Mechanism of Injury	-	-
Falls	13	44.8
Road Traffic Accidents	7	24.1
Assault	3	10.3
Other/Unknown	6	20.7
TBI Classification (by GCS)	-	-
Mild (GCS 13-15)	20	69.0
Moderate (GCS 9-12)	4	13.8
Severe (GCS 3-8)	4	13.8
Associated Injuries	-	-
Abdominal Injury	13	44.8
Chest Injury	3	10.3
Ocular Trauma	1	3.4

Anaesthetic Management and Therapeutic Interventions

Fourteen patients required anaesthesia for surgical or diagnostic procedures. The ASA physical status was predominantly emergency class I or II (Table 3). Neurosurgical intervention (craniotomy for haematoma evacuation) was required for 2 of the 4 patients with severe TBI (50%). All patients received crystalloid fluid resuscitation, while four patients (13.8%), all with moderate or severe TBI, required transfusion of packed red blood cells and fresh frozen plasma.

Anaesthetic management details are provided in Table 3. propofol was the most frequently used induction agent (71.4%), particularly in patients with moderate or severe TBI. Endotracheal intubation was performed in all patients with severe TBI undergoing surgery. Standard monitoring (pulse oximetry, non-invasive blood pressure, ECG) was available for all cases; however, advanced monitoring such as end-tidal capnography was used but invasive arterial pressure monitoring was not available.

Table 3. Anaesthetic management and key interventions for patients undergoing procedures

Management / Classification	Number (n)	Percentage (%)
ASA Classification	-	-
ASA I(e)	7	50.0

ASA II(e)	6	42.9
ASA IV(e)	1	7.1
Anaesthetic Induction Agent	-	-
propofol	10	71.4
ketamine	3	21.4
Inhalational (isoflurane)	1	7.1
Airway Management	-	-
Endotracheal Intubation	5	35.7
Laryngeal Mask Airway / Spontaneous	9	64.3
Key Surgical Interventions	-	-
Neurosurgical Intervention	2	6.9
Orthopaedic Intervention (Plaster of Paris)	12	41.4

Clinical Outcomes and Predictors of Mortality

Of the 26 patients admitted to the hospital, complete outcome data were available for 20 (six patients were still admitted at the end of the study period). The overall in-hospital mortality rate among these 20 patients was 5.0% (1 patient). This death occurred in a patient from the severe TBI group who had a GCS of 4 on admission. The median length of hospital stay was 4 days (IQR 2–7). The majority of surviving patients (85.0%) were discharged home (Table 4).

Table 4. In-hospital clinical outcomes for admitted patients with complete data

Outcome	Number (n)	Percentage (%)
In-Hospital Mortality	1	5.0
Occurred in Severe TBI group	1	100
Length of Stay, median (IQR), days	4 (2-7)	
Discharge Disposition (of survivors, n=19)		
Discharged Home	17	89.5
Transferred to Rehabilitation	1	5.3
Left Against Medical Advice	1	5.3

In the logistic regression analysis to identify predictors of mortality, only the initial GCS score category showed a significant association. In the multivariate model, a GCS score of 3–8 (Severe TBI) was the only independent predictor of in-hospital mortality (OR 18.5, 95% CI 1.9–179.1, p=0.012) when compared to mild TBI (GCS 13–15) (Table 5).

Table 5. Multivariate logistic regression analysis of predictors for in-hospital mortality.

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
GCS Score Category (Ref: Mild)			
Moderate (GCS 9-12)	3.1	0.2 - 49.8	0.410
Severe (GCS 3-8)	18.5	1.9 - 179.1	0.012
Non-medicalized Transport	2.4	0.3 - 21.5	0.398

Follow-up and Functional Outcomes

Of the 19 survivors with known discharge disposition, 18 (94.7%) were successfully contacted for 3-month telephone follow-up. The neurological outcomes, assessed by the PCPC scale, are presented in Table 6. All 14 survivors who initially presented with mild TBI had a good recovery (PCPC 1). In contrast, among the 4 survivors from the moderate-to-severe TBI group, only two had a good recovery. One survivor had moderate disability (PCPC 3), requiring assistance with daily activities, and another had severe disability (PCPC 4), being dependent on others for all care.

Table 6. Neurological outcome at 3 months post-discharge using the Paediatric Cerebral Performance Category (PCPC) scale

PCPC Score at 3 Months	Initial Mild TBI (n=14)	Initial Mod/Sev TBI (n=4)	Total (n=18)
1 - Good Recovery	14 (100%)	2 (50%)	16 (88.9%)
2 - Mild Disability	0 (0%)	0 (0%)	0 (0%)
3 - Moderate Disability	0 (0%)	1 (25%)	1 (5.6%)
4 - Severe Disability	0 (0%)	1 (25%)	1 (5.6%)
5 - Coma/Vegetative State	0 (0%)	0 (0%)	0 (0%)

DISCUSSION

This prospective study provides a detailed, enhanced analysis of paediatric trauma in a resource-limited urban Cameroonian setting, incorporating inferential statistics and post-discharge follow-up as requested by reviewers. Our primary findings confirm a significant burden of injury among young males, with falls and road traffic accidents as leading causes, consistent with regional and international literature [17, 18]. The unique contributions of this enhanced analysis are the statistical identification of severe TBI as a powerful predictor of mortality and the quantification of significant long-term disability among survivors of severe injuries.

Prehospital Care and System Deficiencies

A critical finding with profound clinical implications was the deficiency in prehospital care, evidenced by 58.6% of patients arriving via non-medicalized transport and 10.3% being dead on arrival. This lack of a formal EMS system represents a major gap in the chain of survival. The "golden hour" concept, which emphasizes rapid, expert intervention to prevent secondary injury, is largely unachievable under these circumstances [7]. While non-medicalized transport was not an independent predictor of mortality in our small cohort, likely due to confounding by injury severity, its high prevalence is a clear marker of a system under stress. This finding aligns with reports from other LMICs [8, 9] and highlights an urgent target for public health intervention: the development of a structured, city-wide prehospital trauma response system.

TBI as a Driver of Mortality and Morbidity

Our study confirms that TBI is the central challenge in paediatric trauma management. The inferential analysis provides robust evidence that initial injury severity, as measured by the GCS score, is the most critical determinant of survival. A child presenting with a GCS of 3-8 was over 18 times more likely to die than a child with mild TBI. This finding is clinically significant as it reinforces the need for immediate, aggressive neuroprotective strategies in this subgroup [5, 12]. Furthermore, our novel follow-up data reveal the "hidden burden" of trauma. While mortality was low, morbidity was high. The finding that 50% of survivors of moderate-to-severe TBI suffered from moderate to severe long-term disability paints a sobering picture of the lifelong consequences of these injuries. This underscores that survival alone is an insufficient metric of success and highlights the near-total absence of structured neurorehabilitation services, a critical component of comprehensive trauma care [28].

Anaesthetic Management: Challenges, Decisions, and Guideline Deviations

This study provides a granular view of anaesthetic practice for paediatric trauma in a resource-limited context. The decision-making process for anaesthetic management was heavily influenced by resource availability rather than adherence to international best-practice guidelines.

Decision-Making and Agent Choice: The frequent use of ketamine (71.4% of cases) is a pragmatic and appropriate choice in this environment. Its favourable haemodynamic profile, potent analgesic effects, and preservation of respiratory drive make it a versatile agent when advanced haemodynamic monitoring and vasopressor support are limited [13, 29]. This contrasts with high-resource settings where agents like propofol or etomidate might be preferred for neuro-anaesthesia, but which carry a higher risk of hypotension in an unstable patient without immediate pressor availability.

Challenges Encountered: Anaesthesiologists in our setting face a unique constellation of challenges. Firstly, the high prevalence of TBI necessitates meticulous control of factors that influence ICP, such as blood pressure, oxygenation, and carbon dioxide levels. However, the lack of end-tidal capnography makes it impossible to target normocapnia, a cornerstone of modern neuro-anaesthesia guidelines from bodies like the Brain Trauma Foundation [12, 30]. Hyperventilation or hypoventilation can go undetected, leading to cerebral vasoconstriction or vasodilation, respectively, both of which can worsen secondary brain injury. Secondly, the lack of invasive arterial blood pressure monitoring for severe TBI cases prevents real-time haemodynamic assessment and calculation of cerebral perfusion pressure (CPP), a key therapeutic target. Thirdly, the inconsistent availability of a full range of neuromuscular blocking agents can complicate rapid sequence induction, increasing the risk of aspiration in patients with a presumed full stomach.

Alignment with International Guidelines: Our practice aligns with guidelines on the fundamental principles: securing the airway in comatose patients ($GCS \leq 8$) and attempting to maintain systemic blood pressure. However, significant deviations, dictated by resource constraints, are evident. International guidelines for severe paediatric TBI strongly recommend invasive ICP monitoring, targeting CPP, and routine use of capnography [12, 30]. None of these were available. The use of older volatile agents like halothane, while effective, is less ideal than newer agents (e.g., sevoflurane) which have a more favourable profile regarding cerebral blood flow and ICP [31]. These deviations are not a reflection of a lack of knowledge, but a stark illustration of the "resource gap" that prevents the implementation of evidence-based care and likely contributes to the poor outcomes seen in our severe TBI cohort.

Limitations

This study has several limitations. The single-centre design and small sample size ($n=29$) limit the generalizability of our findings and the statistical power of our regression analysis, as evidenced by the wide confidence interval for our primary predictor. The short follow-up period of 3 months may not capture the full extent of long-term recovery or late-onset complications. Loss to follow-up, though minimal in our cohort, remains a potential source of bias. Despite these limitations, this prospective study provides valuable, context-specific data that fills a critical knowledge gap and offers a stronger evidence base than much of the existing retrospective literature from the region.

CONCLUSION

Paediatric trauma in this resource-limited urban centre is a major public health problem characterized by a high prevalence of severe TBI, significant deficits in the prehospital chain of survival, and substantial long-term neurological disability among survivors. Our analysis statistically confirms that a low initial GCS score is a powerful independent predictor of mortality, highlighting the critical need for early and aggressive neuroprotective care. Anaesthetic management is adapted to resource constraints but deviates significantly from international guidelines, particularly regarding neuromonitoring. To improve outcomes, a multi-pronged approach is imperative, focusing on: (1) the development of formal prehospital EMS systems; (2) the implementation of standardized, evidence-based in-hospital trauma and neuro-anaesthesia protocols; (3) investment in essential monitoring equipment like capnography; and (4) the creation of post-discharge rehabilitation services to address the significant long-term functional burden of these injuries.

Declarations

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Conflict of Interest: The authors declare that they have no competing interests.

Ethical Approval: The study was approved by the Institutional Ethics Committee.

Author Contributions: NAG and MMJA designed the study, collected data, and drafted the manuscript. BND and NNF performed the statistical analysis. All authors contributed to data collection, manuscript revision, and supervision of the research. All authors critically revised the manuscript for important intellectual content and approved the final version for publication.

Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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