



Head Injury and Intracranial Hemorrhage in Western Region of Libya

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Abstract

Objective: To determine how frequently patients who have experienced head trauma have intracranial bleeding

Materials and Methods: This study concluded a total of 206 patients with criminal head injury, 176 from Tripoli governorate hospitals and 30 cases from Zawia governorate hospital, the study was conducted in the Department of Forensic Medicine department of the judicial expertise center. The age of cases ranged from 11 to 80 years old, cases from both sex were included.

Results: 25 (15.3%) of the 206 head injury patients had traumatic intracranial bleeding visible on a computed tomography scan. In the 25 patients, there were 9 (36%) subdural hemorrhages, 5 (20%) subarachnoid hemorrhages, 7 (28%) epidural hemorrhages, and 4 (16%) intraparenchymal hemorrhages. The 165 patients had 71 (43.1%) road traffic accidents, 39 (23.6%) history of falls, and 55 (33.33%) other types of traumatic injuries. It was found that the age range of 16 to 30 years had the highest frequency of cerebral bleeding. Intracranial hemorrhage was more common in men (72%) than women.

Conclusion: According to this study, a CT scan revealed intracranial hemorrhages in 15.3% of head injury patients. The most frequent type of hemorrhage in this study was subdural. Compared to other traumatic injuries, the presence of cerebral bleeding was most frequently related to traffic accidents.

Keywords: Intracranial Hemorrhage; Computed Tomography; Subdural Hematoma; Extradural Hematoma; Subarachnoid Hematoma

Abbreviations

TBI: Traumatic Brain Injury; PCS: Post-Concussion Syndrome; PTSD: Post-Traumatic Stress Disorder; ANS: Autonomic Nervous System; CTE: Chronic Traumatic Encephalopathy

Introduction

Head injury is defined as any form of trauma that results in damage to the scalp, skull, or underlying brain tissue. It is broadly classified into two categories based on the integrity of the skull. Open head injury occurs when a penetrating

object-such as a projectile or bullet-breaches the skull, causing direct damage to brain tissue and its surrounding membranes. Closed head injury, by contrast, refers to any injury in which the skull remains intact; it is most commonly caused by blunt force or impact trauma. Epidemiological data indicate that more than 30% of all vehicle-related trauma cases involve head injuries [1].

Closed head injuries are further classified into contact injuries and acceleration-deceleration injuries. The two most severe subtypes of acceleration-deceleration injury — acute subdural hematoma and diffuse axonal injury—are

also among the most clinically and medicolegally significant. Experimental evidence has demonstrated that acceleration forces sustained over an impact duration exceeding 20–25 milliseconds, as typically encountered in road traffic collisions, are capable of inducing acceleration-deceleration injuries. Conversely, an impact duration of 5–10 milliseconds is more commonly associated with the development of acute subdural hematoma [2].

Mild head injury is generally not life-threatening and does not typically result in permanent disability. However, a subset of patients may experience prolonged physical, cognitive, or behavioral disturbances following the initial trauma. This observation prompted Sanford to assert that “minor head injury may not be minor after all.” The diagnostic significance of persistent post-traumatic symptoms remains a subject of clinical debate, and a validated prognostic index for predicting outcomes in children with mild head injury has yet to be established. The etiology of post-traumatic syndrome is multifactorial, and several contributing risk factors remain incompletely understood [3].

Skull fractures occur when an applied mechanical force exceeds the elastic threshold of the calvaria. The resulting fracture pattern is determined by multiple variables, including the magnitude and direction of the applied force, the mass and shape of the impacting object, the velocity of impact, the local anatomy of the skull, and the physical properties of the bone itself, such as cortical thickness and the region of impact [4].

André P [5] described two principal categories of skull fractures: vault fractures and base-of-skull fractures. Vault fractures are further subdivided into open or closed types, as well as depressed or non-depressed types. Fractures of the vault are frequently associated with epidural hemorrhage, which may be arterial or venous in origin. Arterial epidural hematomas typically arise from laceration of the middle meningeal artery by a bony spicule at the fracture site, whereas venous hematomas result from oozing at the fracture edges and tend to expand more slowly than their arterial counterparts.

Traumatic brain injury (TBI) may result in significant and lasting impairment of an individual’s physical, cognitive, and psychosocial functioning. It represents a major global public health burden and has been projected to surpass numerous other conditions as a leading cause of death and disability in the coming decades [6]. TBI is responsible for approximately half of all trauma-related deaths at accident scenes and constitutes a primary cause of mortality, morbidity, and socioeconomic loss. Coma is among the most serious sequelae of severe head injury.

Head injury is also the leading cause of death in cases of child abuse, particularly among infants and young children. In this population, violent shaking-with or without associated impact-can produce severe brain injury characterized by acute subdural hemorrhage, cerebral hypoxia, and diffuse axonal injury. This clinical constellation is referred to as shaken-impact syndrome and has been documented in various global settings [7]. Severe abusive head injury is considerably less common in older children, and no pathognomonic injury pattern has been identified in this age group.

In cases of fatal blunt trauma, injury to the head and neck is a common finding. A lethal impact to the head may result in a skull fracture, a cervical spine fracture, or both, depending on the biomechanical characteristics of the event. Death in such cases is typically attributable to concurrent injury to the central nervous system [8].

Post-concussion syndrome (PCS) is a clinical condition characterized by the persistence of somatic, cognitive, and psychological symptoms following a concussive head injury. Many of these symptoms are non-specific, commonly encountered in the general population, and cannot be regarded as pathognomonic of mild TBI per se [9].

Manifestations of PCS may include:

- Persistent headache and dizziness
- Nausea and generalized fatigue
- Sleep disturbance and insomnia
- Tinnitus and sensory hypersensitivity
- Memory impairment and difficulty concentrating
- Difficulty understanding or communicating with others
- Generalized muscle weakness
- Functional impairment affecting self-care and occupational performance

In the majority of cases, symptoms resolve within approximately three months; however, some patients require specialist referral for further evaluation. Management may involve a neurologist, who specializes in disorders of the nervous system, or a psychiatrist where psychological sequelae predominate.

Post-traumatic stress disorder (PTSD) and TBI frequently co-occur, given that brain injuries are often sustained in the context of psychologically traumatic events. PTSD is characterized by a constellation of symptoms including anxiety, hyperarousal and hypervigilance, anger dysregulation, intrusive flashbacks, and recurrent nightmares. A significant proportion of these features may be attributable, in part, to dysregulation of the autonomic nervous system (ANS) following structural brain injury.

Neuroimaging evidence indicates that TBI frequently induces white matter damage to pathways within the anterior limb of the internal capsule and the uncinate fasciculus-structures that interconnect neocortical networks with subcortical and limbic regions involved in autonomic regulation. Disruption of these pathways may result in diminished inhibitory control of the ANS, thereby increasing vulnerability to stress-related disorders [10].

The diagnostic distinction between PTSD and TBI is complicated by the substantial overlap in their symptomatology. Confusion and post-traumatic amnesia-hallmark features of mild TBI-are often unwitnessed and rely upon the subjective recall of a period of altered consciousness, thereby introducing the risk of recall bias. Psychological and psychiatric symptoms frequently evolve over weeks to months, and anxiety, affective disturbance, irritability, and insomnia may compound and amplify the somatic symptom burden, particularly headache.

Importantly, a period of loss of consciousness does not confer protection against the subsequent development of PTSD. Emerging evidence suggests that post-concussive symptoms following mild TBI may be more substantially driven by psychological stress responses than by neurological injury per se, pointing toward stress-focused therapeutic interventions as potentially optimal in the management of many mild TBI cases.

Concussion constitutes a significant public health concern, with an estimated 3.8 million cases occurring annually in the United States alone. The number of reported concussions has doubled over the past decade, a trend attributable in part to heightened public and clinical awareness. This increased awareness has been driven, in large measure, by widespread media coverage of neuropathological findings in deceased professional American football players, whose post-mortem examinations revealed tau protein deposits consistent with chronic traumatic encephalopathy (CTE). The publicization of "second impact syndrome"-despite ongoing scientific debate regarding the validity of this entity-has further contributed to a marked increase in patients presenting for concussion assessment and management.

Materials and Methods

Study Design and Setting

A retrospective observational study was conducted at the Department of Forensic Medicine, Judicial Expertise Center, encompassing cases from Tripoli and Zawia governorates. The study period extended over four years, from January 2021 to December 2024.

Study Population

A total of 206 patients with confirmed assault-related head injuries were included in the study. Of these, 176 cases were collected from hospitals in Tripoli governorate and 30 cases from Zawia governorate hospital. Patients ranged in age from 11 to 80 years and included both males and females. Living patients were admitted to hospitals in Tripoli or Zawia, while fatal cases underwent full medico-legal autopsy at the Department of Forensic Medicine.

Inclusion and Exclusion Criteria

Inclusion Criteria

Cases were included if the following conditions were met:

- Head injury was clearly documented as the primary cause of morbidity or mortality.
- Injuries involved structural, anatomical, or functional damage to the head, including lacerations, hemorrhage, ecchymosis, skull fractures, or bleeding from the ears.
- Adequate documentation was available through medical records, police reports, or witness accounts.

Exclusion Criteria

Cases were excluded if:

- Multiple body injuries contributed to the cause of death.
- Documentation of injury circumstances was incomplete.

Special Case Subgroup

Thirty cases from Zawia hospital involved patients with depressed skull fractures following criminal assault. All underwent surgical management, including elevation of depressed bone fragments and cranial reconstruction using titanium mesh.

Data Collection

Data were obtained from the following sources:

- Clinical examination records
- Hospital medical reports
- Radiological investigations (plain radiographs and CT scans)
- Autopsy findings (fatal cases)
- Police reports and witness statements

The following variables were recorded for each case: age, sex, area of residence (urban or rural), type and mechanism of trauma, type and location of skull fracture, type and site of intracranial hemorrhage, treatment modality, outcome, and post-treatment complications.

Classification of Cases

Cases were stratified into two outcome groups:

- Group 1 (Non-Fatal): Patients who survived the head injury.
- Group 2 (Fatal): Patients who died at the scene, during transport, or following hospital admission.

Clinical and Forensic Assessment

Living Cases

Assessment of surviving patients included: comprehensive medical examination following hospital discharge; collection of hospital records and radiological imaging; and review of neurosurgical consultation records where applicable.

Fatal Cases

All fatal cases underwent complete medico-legal autopsy, comprising: external examination of the body; dissection of the cranial, thoracic, and abdominal cavities; removal of the skullcap for detailed evaluation of fracture patterns; examination of the meninges and brain tissue for contusions, lacerations, and hemorrhage; and photographic documentation of all findings.

Fracture and Brain Injury Assessment

Skull fractures were classified into the following types: linear (fissure), diastatic, comminuted, and depressed fractures, as well as cases involving extensive bone loss. Fractures were localized to the frontal, parietal, temporal, occipital, or multiple regions, including skull base involvement. Brain injuries assessed included contusions, lacerations, and intracranial hemorrhage (epidural, subdural, subarachnoid, and intracerebral). Multi-site fractures were frequently associated with skull base fractures and

concomitant injury to brain tissue and cranial nerves.

Radiological Assessment

All admitted patients underwent non-contrast CT scanning of the head. CT imaging was used to identify skull fractures, epidural and subdural hematomas, subarachnoid hemorrhage, and cerebral contusions. Plain radiographs were additionally used in selected cases, particularly those involving firearm injuries, to identify retained bullets or metallic fragments.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 16. Categorical variables were compared between groups using the Chi-square test. Continuous variables, including age, were analyzed using a one-way analysis of variance (ANOVA). A p-value of ≤ 0.05 was considered statistically significant. Cross-tabulation was performed to evaluate associations between outcome (fatal vs. non-fatal) and variables including age, sex, area of residence, type of trauma, fracture pattern, treatment modality, and complications.

Results

A total of 206 patients with head injury were included in the study. Of these, 96 (46.6%) were classified as non-fatal (Group 1) and 110 (53.4%) as fatal (Group 2).

Mechanism of Injury and Outcome

Blunt trauma was the most common injury mechanism overall (Table 1) and was associated with significantly higher survival rates. Firearm injuries, by contrast, demonstrated near-complete lethality, with 100% mortality in bullet-related cases ($p < 0.01$).

Trauma Type	Non-Fatal (n=96)	Fatal (n=110)	p-value
Blunt	94 (66.2%)	48 (33.8%)	<0.01
Firearm (bullet)	0 (0%)	50 (100%)	
Firearm (shots)	2 (33.3%)	6 (66.7%)	
Cut-contused	0 (0%)	6 (100%)	

Table 1: Mechanism of Injury and Outcome.

Sex Distribution

No statistically significant difference was observed between males and females with respect to outcome ($p =$

0.096). However, males were considerably more frequently affected, accounting for the large majority of cases (Table 2).

Sex	Non-Fatal	Fatal	p-value
Male	86 (45.9%)	101 (54.1%)	0.096
Female	10 (52.6%)	9 (47.4%)	

Table 2: Sex Distribution and Outcome.

Residence and Injury Pattern

Head injuries were significantly more prevalent in rural areas, which also exhibited higher mortality rates ($p < 0.01$) (Table 3). Firearm injuries were predominantly

rural in distribution, accounting for 93.1% of all firearm-related cases.

Residence	Non-Fatal	Fatal	p-value
Rural	61 (38.4%)	98 (61.6%)	<0.01
Urban	35 (74.5%)	12 (25.5%)	

Table 3: Residence and Outcome.

Skull Fracture Type and Outcome

Depressed and fissure fractures were associated with survival, whereas comminuted and multiple-type fractures

were strongly associated with mortality ($p < 0.01$). All cases of comminuted skull fracture resulted in death (Table 4).

Fracture Type	Non-Fatal	Fatal	p-value
Fissure	32 (57.1%)	24 (42.9%)	<0.01
Depressed	48 (92.3%)	4 (7.7%)	
Comminuted	0 (0%)	6 (100%)	
Multiple types	6 (7.7%)	72 (92.3%)	
No fracture	10 (71.4%)	4 (28.6%)	

Table 4: Skull Fracture Type and Outcome.

Site of Skull Fracture and Outcome

Fractures involving multiple sites were strongly associated with mortality, whereas isolated occipital

fractures demonstrated complete survival in this cohort ($p < 0.01$) (Table 5).

Fracture Site	Non-Fatal	Fatal	p-value
Frontal	10 (71.4%)	4 (28.6%)	<0.01
Parietal	26 (65.0%)	14 (35.0%)	
Temporal	36 (75.0%)	12 (25.0%)	
Occipital	6 (100%)	0 (0%)	
Multiple sites	8 (9.5%)	76 (90.5%)	
No fracture	10 (71.4%)	4 (28.6%)	

Table 5: Site of Skull Fracture and Outcome.

Intracranial Hemorrhage and Outcome

Extradural hemorrhage was associated with the highest survival rate. Subarachnoid hemorrhage and multi-site hemorrhage were strongly associated with mortality (p

<0.01). All cases of subarachnoid hemorrhage in this cohort were fatal (Table 6).

Hemorrhage Type	Non-Fatal	Fatal	p-value
Extradural	38 (79.2%)	10 (20.8%)	<0.01
Subdural	44 (62.8%)	26 (37.2%)	
Subarachnoid	0 (0%)	6 (100%)	
Multiple sites	14 (17.1%)	68 (82.9%)	

Table 6: Type of Intracranial Hemorrhage and Outcome.

Treatment and Investigations

CT imaging was performed in all non-fatal cases (100%) and in 27.3% of fatal cases admitted to hospital. Surgical

intervention was significantly more common among survivors ($p < 0.01$) (Table 7).

Variable	Non-Fatal	Fatal	p-value
CT performed	96 (100%)	30 (27.3%)	<0.01
Surgical intervention	58 (60.4%)	10 (9.1%)	

Table 7: Investigations and Treatment By Outcome Group.

Complications in Surviving Cases

Complications were frequent among surviving patients who underwent surgical intervention. Trepine craniotomy without reconstruction was associated with a 100%

complication rate, whereas primary reconstruction was associated with significantly fewer complications ($p < 0.01$) (Table 8).

Treatment Type	With Complications	Without Complications	p-value
Conservative management	18	20	<0.01
Trepine only (decompressive)	28	0	
Reconstruction	1	29	

Table 8: Complications by Treatment Modality in Surviving Cases.

Age and Outcome

Fatal cases were significantly older than non-fatal cases (mean age 47.9 ± 18.2 years vs. 34.3 ± 15.5 years; $p = 0.036$),

indicating that increasing age was a significant predictor of mortality (Table 9).

Group	Age Range (years)	Mean \pm SD	p-value
Non-Fatal	12–72	34.3 ± 15.5	0.036
Fatal	11–80	47.9 ± 18.2	

Table 9: Age Distribution by Outcome Group.

Discussion

Head injury remains a major contributor to trauma-related mortality and long-term disability worldwide. Approximately half of all trauma-related deaths involve head injury, underscoring its considerable clinical and public health importance.

In this study of 206 assault-related head injuries, the overall fatality rate was 53.4%, reflecting the high severity of trauma in this cohort. Firearm injuries emerged as the dominant mechanism of fatal injury, whereas blunt trauma was the most common cause among survivors. This pattern is consistent with previous studies demonstrating the high lethality of firearm-related head trauma, which produces

combined penetrating injury and cavitation effects resulting in extensive and often irreversible brain damage [11,12].

The predominance of male patients is consistent with the existing literature and most likely reflects greater exposure to interpersonal violence and high-risk environments. However, sex was not significantly associated with mortality in this study, indicating that injury severity and mechanism are more important determinants of outcome than sex alone [13].

A key finding was the strong association between rural residence and both the incidence and mortality of head injury. This disparity may be explained by greater civilian firearm availability in rural areas, longer patient transport distances, delayed access to emergency care, and limited neurosurgical resources. Similar rural-urban disparities have been reported elsewhere, where delayed intervention is known to significantly worsen clinical outcomes [14].

Fracture pattern was a critical determinant of prognosis. Comminuted and multi-site skull fractures were strongly associated with mortality, reflecting high-energy mechanisms and extensive structural cranial damage. In contrast, isolated depressed and fissure fractures were more commonly observed among survivors, likely attributable to lower-impact mechanisms. These findings are consistent with prior work demonstrating that fracture complexity correlates with force magnitude and overall injury severity [15,16].

The site and extent of intracranial hemorrhage also had a substantial impact on outcomes. Extradural and subdural hemorrhages were more frequently associated with survival, likely owing to their amenability to early detection by CT imaging and subsequent surgical evacuation. In contrast, subarachnoid hemorrhage and multi-site intracranial bleeding were strongly associated with mortality, reflecting deeper and more diffuse patterns of brain injury. These findings reinforce the principle that both the type and anatomical distribution of intracranial hemorrhage are key prognostic determinants [17,18].

Age was an additional significant predictor of outcome, with older patients demonstrating markedly higher mortality. This is consistent with well-established evidence showing that advancing age is associated with reduced physiological reserve, greater susceptibility to secondary brain injury, and poorer neurological recovery following TBI [19,20].

With regard to clinical management, CT imaging was essential for diagnosis and was performed in all surviving cases, affirming its role as the primary diagnostic modality in head injury assessment [21,22].

Surgical intervention, particularly decompressive craniotomy, was frequently required; however, it was associated with a high rate of post-operative complications in this cohort. The most prevalent complication was the persistent cranial bone defect, which may produce long-term neurological and functional sequelae.

Post-operative complications among surgically treated survivors included seizures, cognitive deficits, memory impairment, and the syndrome of the trephined. While decompressive craniotomy can be life-saving in selected cases, these findings highlight the necessity for careful patient selection, enhanced post-operative monitoring, and the wider adoption of reconstructive strategies-particularly titanium mesh cranioplasty-to minimize long-term morbidity [23-28].

Conclusion

Assault-related head injury is associated with high mortality, particularly when caused by firearm trauma. The findings of this study identify the following as the most important predictors of poor outcome:

- Firearm-related injury mechanism
- Comminuted or multiple skull fractures
- Multi-site intracranial hemorrhage and subarachnoid hemorrhage
- Advanced age
- Rural area of residence

Conversely, blunt trauma, isolated skull fractures, and extradural hemorrhage were associated with more favorable outcomes. These findings underscore the importance of injury mechanism, fracture pattern, and hemorrhage type in determining prognosis.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

- Implement stricter regulatory measures to reduce civilian access to firearms, particularly in rural areas.
- Expand emergency and neurosurgical services in rural regions to reduce delays in definitive care and improve survival outcomes.
- Ensure early CT imaging for all patients presenting with suspected head injury, as timely diagnosis is critical for guiding management.
- Promote the adoption of primary reconstructive techniques, including titanium mesh cranioplasty, following decompressive craniotomy, in order to minimize the long-term morbidity associated with persistent cranial defects.
- Conduct further targeted research on high-mortality

injury patterns, particularly comminuted skull fractures and traumatic subarachnoid hemorrhage, with the aim of identifying novel therapeutic strategies to reduce case fatality rates.

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