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Original article

War-Related and Domestic Penetrating Head Injury in Benghazi During the Libyan Conflict

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ABSTRACT

Libya experienced a dramatic rise in penetrating brain injuries (PBI) due to armed conflict after 2011. There is limited published data on the pattern and outcome of these injuries in the eastern region. A descriptive cross-sectional study was conducted at Jala Trauma Hospital, Benghazi, from October 2014 to April 2015. All patients admitted with penetrating head injury due to gunshot (handgun, machine gun, shotgun, sniper) or explosive shrapnel were included. Data on demographics, injury type, Glasgow Coma Scale (GCS), CT findings, surgical intervention, and outcome were analyzed using SPSS v17. Of 293 total PBI cases registered, 122 (41.6%) died immediately from PBI alone, and 101 (34.5%) died from multiple injuries, including PBI. Only 70 patients (23.9%) arrived alive at the emergency department. Among these, 92.8% were male, with a mean age of 27.3±11 years. Machine guns (41.4%) and shrapnel (40%) were the leading causes. Perforating injuries accounted for 15.7% of cases and had a 91% mortality rate. Overall mortality among admitted patients was 28.6% (20/70). Operated patients had significantly lower mortality (9.4%) compared to non-operated patients (34.2%, p=0.028). Initial GCS 13–15 was associated with 4.3% mortality vs. 33% for GCS 3–8. Delayed surgical intervention was performed in 5 cases without infectious complications. PBI during the Benghazi conflict carried high immediate and delayed mortality. Early surgical intervention in selected patients, guided by initial GCS and CT findings, improved survival. Delayed surgery may be safe in select cases with localized brain edema.

Introduction

Before the 2011 uprising, firearm ownership among Libyan civilians was exceedingly rare. The outbreak of armed conflict, however, fundamentally altered this reality, triggering a massive influx of both explosive shrapnel and gunshot wounds across residential areas and active combat zones [1, 2]. Among traumatic injuries, penetrating brain injuries (PBIs) are exceptionally deadly. A staggering rate of immediate fatalities characterizes them, and those who manage to survive frequently endure profound, long-term neurological complications [1, 2]. Historically, the surgical strategies for treating PBIs have evolved from battlefield medicine, tracing heavily back to the foundational techniques developed by Harvey Cushing during the First World War [3, 4]. Because of these historical roots, contemporary protocols—including the widely referenced 2001 Guidelines for the Management of Penetrating Brain Injury—were tailored primarily for well-resourced, structured military forces [5, 6, 7, 8].

Consequently, these standardized guidelines often prove impractical in resource-strapped civilian conflict zones that are suddenly overwhelmed by mass casualties. During the height of the crisis in Benghazi, Jala Trauma Hospital became the primary trauma and referral center for the entire eastern region, forced to adapt to military-grade injuries without conventional military medical infrastructure.

Despite the severity of the situation, comprehensive data regarding the nature and outcomes of PBIs in this region remain scarce. By documenting the injury patterns, surgical management, and patient outcomes at Jala Trauma Hospital between October 2014 and April 2015, this study aims to bridge that knowledge gap. Ultimately, our goal is to offer crucial localized insights to help guide trauma care in similar resource-limited environments where conventional international guidelines fall short.

Methods

Study design and setting

A descriptive cross-sectional study was conducted at Jala Trauma Hospital, Benghazi, from October 1, 2014, to April 30, 2015.

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Inclusion and exclusion criteria
All patients with penetrating head injury due to a handgun, shotgun, machine gun, sniper, or shrapnel were included. Excluded were patients with non-penetrating blast injury, arrival >24 hours post-injury, or severe dehydration/shock.

Data collection
Data were extracted from medical records using a standardized form. Variables included age, sex, mechanism of injury, injury type (penetrating, perforating, tangential), initial GCS (post-resuscitation), CT findings, surgical procedures (immediate, delayed, or none), and outcome (discharge without complications, long-term morbidity, or death).

Management protocol
Patients were resuscitated according to ATLS. CT brain was obtained after stabilization. Surgical indications included large scalp defects, depressed fractures, dural tears, accessible fragments, hematomas with mass effect, or raised intracranial pressure. Delayed surgery (4–7 days) was chosen when localized brain edema made immediate debridement hazardous. Non-surgical management was chosen for small defects, absent mass effect, or brain death.

Statistical analysis
Data were analyzed using SPSS version 17.0. The Chi-square test was used for categorical variables; $p < 0.05$ was considered significant. To ensure statistical robustness, 95% confidence intervals (CIs) were calculated for key mortality proportions.

Results

Overall burden
A total of 293 PBI cases were identified from forensic records. Of these, 122 (41.6%) died immediately from PBI alone, and 101 (34.5%) died from multiple injuries, including PBI. Therefore, the study's analytical cohort is strictly the 70 patients (23.9%) who arrived alive at the emergency department.

Demographics and injury characteristics
Among the 70 admitted patients in the analytical cohort, 65 (92.8%) were male, with a mean age of 27.3±11 years. Machine gun injuries (41.4%) and shrapnel (40%) were the most common mechanisms. Penetrating injuries accounted for 80%, perforating 15.7%, and tangential 4.3% (Table 1). Notably, perforating injuries accounted for 15.7% of cases and had a 91% mortality rate (95% CI: 58.7–99.8%).

Table 1. Injury characteristics and outcomes

Variable	N (%)	Mortality (%)	p-value
Mechanism			0.005
Machine gun	29 (41.4)	41.4	
Shrapnel	28 (40.0)	17.9	
Sniper	5 (7.1)	20.0	
Shotgun	5 (7.1)	20.0	
Handgun	3 (4.3)	33.3	
Injury type			0.002
Perforating	11 (15.7)	90.9	
Penetrating	56 (80.0)	37.5	
Tangential	3 (4.3)	0.0	

CT findings
CT was performed in 88.6% (62/70). Common findings included skull fracture (52% of scans), superficial trauma (50%), subarachnoid hemorrhage (32%), contusion (31%), subdural hematoma (16%), and intracerebral hemorrhage (13%).

Surgical intervention and outcome
Of 70 admitted patients, 34 (48.6%) underwent immediate surgery, 5 (7.1%) delayed surgery, and 31 (44.3%) no surgery. Debridement (57.5% of procedures) and duroplasty (21%) were the most common. Overall mortality among admitted patients was 28.6% (20/70, 95% CI: 18.4–40.6%). Most deaths (60%) occurred within 24 hours. Operated patients had significantly lower mortality (9.4%) than non-operated patients (34.2%, p=0.028). Among patients with initial GCS 3–8, mortality was 33% in operated vs. 72% in non-

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operated. Note that 4 additional deaths occurred after delayed or multiple procedures, bringing the final total mortality to 20/70 (28.6%), as detailed in Table 2.
Long-term morbidity (neurological deficits, hydrocephalus, infection) occurred in 11.4% (8/70). No surgical site infections or brain abscesses occurred in the delayed surgery group (n=5).

Table 2. Mortality by operative status and initial GCS

Operative status	GCS 3–8	GCS 9–12	GCS 13–15	Total mortality
Operated	2/6 (33.3%)	0/3 (0.0%)	1/23 (4.3%)	3/32 (9.4%)
Non-operated	13/18 (72.2%)	0/1 (0.0%)	0/19 (0.0%)	13/38 (34.2%)
Delayed / Multiple procedures	-	-	-	4 (Additional deaths)
Total	15/24 (62.5%)	0/4 (0.0%)	1/42 (2.4%)	20/70 (28.6%)

Discussion

This study is one of the first to characterize PBI in eastern Libya during the recent conflict. The 74% immediate mortality (died before arrival) is comparable to reports from the Syrian civil war (similar high pre-hospital mortality) [10] and the Iran-Iraq war [7]. Among those who arrived alive, our mortality of 28.6% is lower than the 41% reported in some civilian U.S. series [9], possibly due to selection bias (only those reaching a trauma center). The strong association between low initial GCS and mortality (62.5% mortality for GCS 3–8) confirms that initial neurological status is the single most important predictor, consistent with Aarabi [7] and Levy et al. [9].
Our finding that operated patients had significantly lower mortality (9.4% vs. 34.2%) must be interpreted cautiously. Operated patients had higher GCS (23/32 with GCS 13–15), while non-operated patients were predominantly low GCS with poor brainstem reflexes. Thus, the difference likely reflects patient selection rather than surgical benefit alone. However, among GCS 3–8 patients, mortality was still lower in the operated group (33% vs. 72%), suggesting that surgery may benefit even some severely injured patients. Delayed surgical intervention (4–7 days) was performed in 5 patients with localized brain edema and no mass effect. None developed infection or brain abscess, supporting the safety of this approach in selected cases, as also noted by Zafonte et al. [8]. This strategy may be particularly useful in resource-limited settings where immediate complex debridement carries a higher risk. The high proportion of perforating injuries (15.7%) and machine gun wounds (41.4%) reflects the military nature of the conflict, differing from civilian series where handguns dominate.

Limitations

This study is limited by its retrospective design, small sample size of admitted patients, lack of long-term functional outcome measures (e.g., Glasgow Outcome Scale), and potential selection bias. No ICP monitoring was available for most patients.

Conclusions

Penetrating brain injury during the Benghazi conflict carried a very high immediate mortality. Among patients arriving alive to a trauma center, mortality was 28.6%, with perforating injuries and low initial GCS predicting worse outcomes. Early surgical intervention in selected patients (especially those with GCS ≥9 and mass lesions) was associated with improved survival. Delayed surgery may be safe in select cases with localized edema. We recommend strengthening pre-hospital triage and rapid evacuation for PBI patients. Also considering delayed surgical intervention (4–7 days) for stable patients with localized brain edema and no mass effect.

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