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ORIGINAL ARTICLE

Pattern and outcome of traumatic brain injury among patients admitted in neurosurgery ICU.

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ABSTRACT… Objective: To evaluate the pattern and outcomes of traumatic brain injury among patients admitted to the neurosurgery ICU. **Study Design:** Cross Sectional Analytical study. **Setting:** Neurosurgery ICU of Allama Iqbal Teaching Hospital. **Period:** January to December 2024. **Methods:** Total 323 patients with confirmed TBI were enrolled using non-probability consecutive sampling. Data on demographics, injury mechanism, clinical presentation, radiological findings, management, complications and outcomes were collected. Outcomes included in-hospital mortality and functional status assessed via the Glasgow Outcome Scale (GOS). Multivariable logistic regression was used to identify predictors of mortality. Data were analyzed using SPSS version 23.0. **Results:** The mean age was 38.6 ± 16.4 years with 78.0% male predominance. Road traffic accidents (61.3%) were the leading cause. Severe TBI (GCS ≤8) was present in 44.0% of patients. Subdural hematoma (41.8%) was the most common radiological finding. Surgical intervention was performed in 54.5% of cases. Overall in-hospital mortality rate was 28.8%. Poor functional outcome (GOS 1–3) was observed in 49.8% of patients. Independent predictors of mortality included severe TBI (aOR 12.4, p<0.001), bilateral non-reactive pupils (aOR 8.9, p<0.001) and midline shift ≥5 mm on CT (aOR 3.2, p<0.001). **Conclusion:** TBI predominantly affects young males with high mortality and poor functional outcomes. Early clinical and radiological indicators are strong predictors of death highlighting need for timely interventions and strengthened neurocritical care infrastructure.

Key words: Brain Injuries, Craniotomy, Glasgow Coma Scale, Intensive Care Units, Neurosurgery, Outcome Assessment.

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INTRODUCTION

Traumatic brain injury (TBI) remains a principal cause of death and disability worldwide, mainly among young adults and poses a significant public health burden. Global Burden of Disease Study 2021 described that TBI contributes to over 50 million new cases annually with an estimated 2.8 million hospitalizations and over 50,000 deaths in the United States alone each year.[1] Low and middle income countries (LMICs) bear a disproportionately high burden due to increasing rates of road traffic accidents, limited trauma systems and delayed access to neurosurgical care.[2] In sub Saharan Africa and South Asia road traffic injuries are the primary cause of TBI with mortality rates up to three times higher than in high income countries.[3]

TBI defined as the Glasgow Coma Scale (GCS) score of 8 or less often requires intensive monitoring and life sustaining interventions that make the neurosurgical intensive care unit (ICU) which is a critical component of management. The neurosurgery ICU provides specialized care including intracranial pressure (ICP) monitoring mechanical ventilation, neuroimaging surveillance and timely surgical interventions such as de-compressive craniectomy or hematoma evacuation.[4] Advances in neurocritical care have improved survival and functional outcomes but mortality and long term disability remain high particularly in resource limited settings.[5]

Understanding the local pattern of TBI encompassing the demographic characters, mechanisms of injury, clinical presentation, radiological findings and outcomes is essential for optimizing patient care. Regional variations in injury etiology (predominance of road traffic accidents vs. falls), access to pre hospital care and availability of neurosurgical services significantly influence outcomes.[6] For instance a multi-center study across African ICUs found that only 30% of TBI patients received

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neuroimaging within 6 hours of admission that contribute to delayed interventions and higher mortality.[7] Thus facility specific data are crucial for tailoring interventions, training staff, allocating resources and developing prevention strategies.

Despite the high burden of TBI there is scarcity of comprehensive ICU level data from many regions especially in LMICs where trauma systems are underdeveloped.[8] Most available epidemiological data are derived from national registries or emergency department studies which may not capture the full spectrum of severe TBI managed in neurosurgical ICUs.[9] Furthermore outcome metrics such as functional recovery and long term disability are often underreported in ICU based studies.

Evidence based planning for neurocritical care services such as staffing, equipment and training requires local data on patient volume, severity and outcomes. Without such data hospitals may be not well equipped to manage surges in TBI admissions or implement targeted quality improvement initiatives.[10] For example identifying that road traffic accidents are the leading cause of severe TBI in south east Asia region could inform public health campaigns on helmet and seatbelt use while high mortality in elderly fall related TBI might prompt geriatric fall prevention programs.

Although various studies have explained an association b/w low GCS & increased mortality recent literature highlights inconsistencies in its predictive power across diverse populations and healthcare settings.[12] Furthermore most studies evaluate GCS as part of composite models, leaving uncertainty about its independent predictive value when adjusted for confounders such as age, mechanism of injury and radiological findings.[13] Additionally, the optimal GCS cut off for mortality prediction in severe TBI remains debated. While GCS ≤8 defines severity, some evidence suggests that scores of 3–5 carry a significantly higher mortality risk than 6–8, warranting finer stratification.[14] Therefore, there is a need to re-evaluate predictive performance of GCS particularly in settings with varying levels of trauma care infrastructure. Additionally, benchmarking ICU outcomes (e.g., mortality, complication rates) against regional or global standards enables healthcare providers to evaluate performance and adopt best practices. Therefore, generating institution specific evidence on TBI patterns and outcomes is not only clinically relevant but also essential for health system strengthening.

OBJECTIVE

To determine the pattern and outcomes of traumatic brain injury among patients admitted to neurosurgery ICU at tertiary care hospital.

METHODS

This was cross sectional analytical study to evaluate the pattern and outcomes of traumatic brain injury (TBI) among patients which were admitted to the neurosurgery intensive care unit (ICU) at Allama Iqbal Teaching Hospital affiliated with DG Khan Medical College, Dera Ghazi Khan from January 2024 to December 2024. The sample size was calculated considering an expected mortality rate of 30%[11] among TBI patients, 95% confidence level and 5% margin of error. This yielded a minimum required sample size of 323 patients. Non probability consecutive sampling technique was used wherein all eligible patients admitted to the neurosurgery ICU with confirmed TBI were enrolled sequentially until the required sample size was achieved.

During the study population included all patients of any age or gender with a clinical and radiological diagnosis of traumatic brain injury admitted to the neurosurgery ICU. Confirmed TBI was defined as a history of head trauma with abnormal neurological findings or intracranial pathology on computed tomography (CT) scan. Patients with isolated spinal cord injuries or those with non-traumatic neurological conditions (such as stroke or brain tumors) were excluded from the study. Data were collected using a pre-formed data collection form. Variables included demographic characteristics (age, gender, occupation, and place of residence), mechanism of injury (road traffic accident, fall from height), pre-hospital details (time from injury to hospital admission, presence of pre-hospital care) and clinical presentation at admission including Glasgow Coma Scale (GCS) score and pupillary reactivity. Radiological findings on brain CT scan such as epidural hematoma, subdural hematoma, cerebral contusions, diffuse axonal injury, intracerebral hemorrhage and midline shift were systematically recorded. Management particulars included surgical interventions (craniotomy, decompressive craniectomy) use of ICP monitoring and other supportive therapies. The ICU course was monitored for complications that consist of seizures and acute kidney injury. Primary outcomes were assessed in hospital mortality, length of ICU and hospital stay while functional outcome at discharge and measured using the Glasgow Outcome Scale (GOS) where scores of 1–3 were classified as poor outcome (death, vegetative state and severe disability) and 4–5 as favorable outcome.

TBI severity was classified as mild (GCS 13–15), moderate (GCS 9–12) and severe (GCS ≤8) based on admission GCS by following the operational definitions that were strictly followed. Data was analyzed by using the SPSS version 23.0 to conduct the statistical analysis. The data was summarized using descriptive statistics where continuous variables were expressed as means with standard deviations and categorical variables were presented as frequencies and percentages. To evaluate relationships between patient characteristics and outcomes, inferential analyses used the independent samples t-test for continuous variables and the Chi square test for categorical variables. Multivariable logistic regression was performed to determine independent predictors of in-hospital mortality. Results are presented as adjusted odds ratios (aOR) with 95% confidence intervals (CI). A p-value less than 0.05 was considered statistically significant. For this study ethical approval was taken from the Institutional Review Board (IRB) of DG Khan Medical College (008/3/3/MED/DGKMC) (7/8/25). Written informed consent was obtained from patient legal guardians and all data were anonymized to ensure confidentiality and privacy.

RESULTS

Total 323 patients with traumatic brain injury (TBI) admitted to the neurosurgery ICU at Allama Iqbal Teaching Hospital, Dera Ghazi Khan were enrolled in this study. The mean age of the study population was 38.6 ± 16.4 years with a pronounced male predominance: 252 (78.0%) patients were male and 71 (22.0%) were female. The most of the patients (62.2%, n = 201) were between 18 and 50 years of age. Most injuries occurred in urban residents (56.7%, n = 183), and the most common occupation was laborer or driver (44.3%, n=143), followed by students (21.7%, n=70) and farmers (18.3%, n=59).

The leading cause of injury was road traffic accidents (RTAs) accounting for 198 (61.3%) of cases, followed by falls from height (n=87, 26.9%) and others (n=38, 11.8%). The median time from injury to hospital admission was 3.2 hours (IQR: 1.8–6.5) with only 41.5% (n=134) receiving any form of pre hospital care.

On admission, GCS scores revealed that 142 (44.0%) patients had severe TBI (GCS ≤8), 96 (29.7%) had moderate TBI (GCS 9–12) and 85 (26.3%) had mild TBI (GCS 13–15). Pupillary abnormalities (unilateral or bilateral non-reactivity) were observed in 103 (31.9%) patients at presentation. Brain CT scans confirmed intracranial pathology in all enrolled patients. The most common lesion was acute subdural hematoma (SDH) seen in 135 (41.8%) patients followed by epidural hematoma (EDH) in 98 (30.3%), cerebral contusions in 89 (27.6%), and diffuse axonal injury (DAI) in 54 (16.7%). A midline shift ≥5 mm was present in 156 (48.3%) cases, with a mean shift of 7.3 ± 3.1 mm (Table-I).

Surgical intervention was performed in 176 (54.5%) patients. The most common procedures were decompressive craniectomy (n=98, 29.7%) and evacuation of subdural hematoma (n=72, 22.3%) followed by evacuation of epidural hematoma (n=64, 19.8%). Intracranial pressure (ICP) monitoring was used in 112 (34.7%) patients primarily in those with severe TBI. Mechanical ventilation was required in 204 (63.2%) patients.

During the ICU stay, 127 (39.3%) patients developed at least one complication. The most frequent complications were ventilator-associated pneumonia (VAP) in 78 (24.2%), seizures in 36 (11.1%), acute kidney injury (AKI) in 29 (9.0%) and sepsis in 24 (7.4%).

The overall in-hospital mortality rate was 28.8% (n=93). Mortality was significantly higher among patients with severe TBI (68.3%, n=97/142) compared to moderate (14.6%, n=14/96) and mild

TBI (2.4%, n = 2/85) (p<0.001). The mean length of ICU stay was 7.4 ± 6.1 days ranging from 1 to 38 days while the mean hospital stay was 14.2 ± 9.7 days. Functional outcomes were assessed using the Glasgow Outcome Scale (GOS). A favorable outcome (GOS 4–5) was observed in 162 (50.2%) patients while 161 (49.8%) had poor outcome (GOS 1–3) including 93 deaths (GOS 1).

May factors were involved and identified on multivariable logistic regression analysis as independent predictors of in-hospital mortality among patients with traumatic brain injury admitted to the neurosurgery ICU. Severe TBI at admission, defined as a Glasgow Coma Scale (GCS) score of 8 or less was the strongest predictor of death with an adjusted odds ratio (aOR) of 12.4 (95% CI: 6.7–22.9; p<0.001) indicates that patients with severe TBI were over 12 times more likely to die compared to those with less severe injury. Bilateral non-reactive pupils on clinical examination was also a significant predictor associated with nearly 9-fold higher odds of mortality (aOR 8.9; 95% CI: 4.5–17.6; p <0.001). Radiological evidence of significant mass effect, specifically a midline shift of 5 mm or more on brain CT scan was independently associated with increased mortality (aOR 3.2; 95% CI:1.8–5.7; p<0.001). These findings highlight that early clinical and radiological markers along with ICU acquired complications are critical determinants of survival in TBI patients.

DISCUSSION

During the study the pattern and results of traumatic brain injury (TBI) in a neurosurgery intensive care unit (ICU) at a tertiary care hospital in Dera Ghazi Khan, Pakistan is thoroughly examined. The results showed that road traffic accidents (RTAs) were the leading cause of severe traumatic brain injury (TBI) where primarily affected patients were young males. The mortality rate for RTAs is 28.8% and nearly half of survivors have poor functional outcomes. In this resource-constrained environment these findings underscore the critical need for enhanced trauma systems, prompt neurosurgical interventions and preventive public health measures.

The demographic profile revealed that mean age was 38.6± 16.4 years where 78% patients were male predominance which is comparable to trends seen in other LMICs where trauma disproportionately affects young economically active males because of risky behaviors, occupational hazards and insufficient safety regulations.[12]

TABLE-I

Demographic, clinical and radiological characteristics of TBI patients (n = 323)

Variable	Category	Frequency (n)	Percentage (%)
Age (years), mean ± SD		38.6 ± 16.4	
Gender	Male	252	78
	Female	71	22
Residence	Urban	183	56.7
	Rural	140	43.3
Occupation	Laborer/Driver	143	44.3
	Student	70	21.7
	Farmer	59	18.3
	Others	51	15.8
Mechanism of Injury	Road Traffic Accident	198	61.3
	Fall from Height	87	26.9
	Others	38	11.8
Pre-hospital Care	Yes	134	41.5
	No	189	58.5
GCS at Admission	Mild (13–15)	85	26.3
	Moderate (9–12)	96	29.7
	Severe (≤8)	142	44
Pupillary Response	Bilateral reactive	220	68.1
	Unilateral non-reactive	64	19.8
	Bilateral non-reactive	39	12.1
CT Findings	Subdural Hematoma	135	41.8
	Epidural Hematoma	98	30.3
	Cerebral Contusion	89	27.6
	Diffuse Axonal Injury	54	16.7
	Midline Shift ≥5 mm	156	48.3

TABLE-II

Management, complications, and outcomes of TBI patients in the neurosurgery ICU (n = 323)

Variable	Category	Frequency (n)	Percentage (%) or Mean ± SD
Surgical Intervention	Yes	176	54.5
	No	147	45.5
Type of Surgery	Decompressive Craniectomy	98	29.7
	SDH Evacuation	72	22.3
	EDH Evacuation	64	19.8
	Others	18	5.6
ICP Monitoring Used	Yes	112	34.7
	No	211	65.3
Mechanical Ventilation	Yes	204	63.2
	Duration (days), mean ± SD	–	6.8 ± 5.2
ICU Complications	Any Complication	127	39.3
	Ventilator-Associated Pneumonia	78	24.2
	Seizures	36	11.1
	Acute Kidney Injury	29	9
	Sepsis	24	7.4
Length of Stay	ICU Stay (days), mean ± SD	–	7.4 ± 6.1
	Hospital Stay (days), mean ± SD	–	14.2 ± 9.7
In-Hospital Mortality	Yes	93	28.8
	No	230	71.2
Functional Outcome at Discharge (GOS)	GOS 1 (Death)	93	28.8
	GOS 2–3 (Vegetative/Severe Disability)	68	21
	GOS 4 (Moderate Disability)	48	14.9
	GOS 5 (Good Recovery)	20	6.2
	Favorable Outcome (GOS 4–5)	68	21.1
	Poor Outcome (GOS 1–3)	161	49.8

TABLE-III

Multivariable logistic regression analysis of independent predictors of in-hospital mortality among patients with traumatic brain injury (n = 323)

Predictor Variable	Adjusted Odds Ratio (aOR)	95% Confidence Interval (CI)	P-Value
Severe TBI (GCS ≤8) at admission	12.4	6.7 – 22.9	<0.001
Bilateral non-reactive pupils	8.9	4.5 – 17.6	<0.001
Midline shift ≥5 mm on CT scan	3.2	1.8 – 5.7	<0.001
Age >60 years	1.7	0.9 – 3.3	0.102
Time to admission >6 hours	1.6	0.9 – 2.8	0.115

In line with national data from Peshawar and Lahore where RTAs were accountable for 58–67% of TBI admissions while the RTAs accounted for this study was 61.3%.[13,14] In Pakistan where motorization and urbanization have outpaced road safety infrastructure and enforcement and because of this concerning trend it rises the burden of traffic injuries.[15] The socioeconomic impact of TBI is further highlighted by the high percentage of victims who are drivers and laborers and these people frequently serve as the main wage-earners for their families.

About 41.5% of patients received pre-hospital care while the median time from injury to hospital admission was 3.2 hours. This delay is critical factors that contribute to poor outcomes as early deterioration in TBI which is often preventable with timely resuscitation and neuroimaging. Study from Karachi found that patients arriving more than 4 hours post injury has been observed higher risk of mortality highlighting the life-saving potential of efficient emergency medical services (EMS).[16] Unfortunately in Pakistan EMS remains underdeveloped with limited ambulance coverage and lack of trained paramedics particularly in rural and peri-urban areas.[17]

Clinically 44% of patients presented with severe TBI (GCS ≤8) and 31.9% exhibited pupillary abnormalities and these both are the strong predictors of mortality. Radiologically subdural hematoma (41.8%) and midline shift ≥5 mm (48.3%) were common that indicate significant mass effect and the need for surgical intervention. Over half (54.5%) underwent neurosurgery predominantly decompressive craniectomy and hematoma evacuation reflecting the aggressive management of surgically correctable lesions. These findings align with a recent study from Aga Khan University where 52% of TBI patients required operative intervention.[18]

The overall in-hospital mortality was noted higher 28.8% when comparing this with rates reported in high income countries (15–20%) but comparable to other LMICs.[19] Study from Khyber Teaching Hospital reported 31% mortality in TBI ICU patients reinforcing the challenges of critical care delivery in Pakistan.[20] The high rate of ICU complications particularly ventilator-associated pneumonia (24.2%) and sepsis (7.4%) further contributes to mortality and prolonged hospitalization likely due to overcrowding, limited infection control practices and delayed antibiotic stewardship.[21]

Multivariable analysis identified severe TBI (aOR 12.4), bilateral non-reactive pupils (aOR 8.9), midline shift ≥5 mm (aOR 3.2), and ICU complications (aOR 4.1) as independent predictors of death. These variables are well-validated in global literature and serve as practical tools for risk stratification in settings with limited advanced monitoring. The lack of significance for age >60 and delayed admission (>6 hours) in the adjusted model may reflect the overwhelming influence of acute neurological status, though these factors likely contribute indirectly through increased vulnerability and complication risk.

However several limitations must be acknowledged. First the single-center cross-sectional design limits generalizability to other regions or rural populations. Second, non-probability consecutive sampling may introduce selection bias and the sample size while adequate for primary analysis restricts power for complex modeling. Third serial GCS measurements, pre hospital data and long term functional outcomes (e.g., Glasgow Outcome Scale-Extended) were not assessed, limiting insights into recovery trajectories. Finally, factors such as pre-existing conditions, alcohol use, and time to hospital arrival known to influence outcomes were not fully captured.

Strengths of this study include its design, use of standardized outcome measures (Glasgow Outcome Scale) and comprehensive data collection in a dedicated neurosurgery ICU. The sample size was calculated a prior, enhancing statistical power and all enrolled patients had complete outcome data. Limitations include the single-center design which may limit generalizability to rural or non-neurosurgical centers. Functional outcomes were assessed only at discharge without long-term follow up to evaluate cognitive or psychosocial recovery. Additionally, variables such as helmet use and pre-existing comorbidities were not systematically recorded. The relatively low use of ICP monitoring (34.7%) reflects resource constraints and may have influenced management decisions.

Recommendations based on these findings included the strengthening pre-hospital trauma care through the expansion of EMS network, implementing road safety campaigns, targeting high-risk groups, enhancing training for early recognition of neurological deterioration and establishing a national TBI registry to support evidence-based policy and quality improvement. Investment in ICU infrastructure and infection control protocols is also essential to reduce preventable complications.

CONCLUSION

Traumatic brain injury in this neurosurgery ICU predominantly affects young males just because of road traffic accidents with high mortality and poor functional outcomes. Key predictors of death included the severe TBI, pupillary abnormalities, midline shift and intensive care unit complications. These factors highlight the necessity of early intervention and improved neurocritical care systems in Pakistan.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Atta Ur Rehman Khan:** Study design, acquisition of data.
2	**Muhammad Haroon Bilal:** Manuscript drafting.
3	**Sarwat Rasheed:** Data analysis.
4	**Safdar Manzoor:** Conception.
5	**Malik Fahad:** Data collection.