Role of Computed Tomography in Diagnosing and Managing Traumatic Brain Injury and its Correlation with Glasgow Coma Scale (GCS) in Tertiary Care Hospitals, Peshawar

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ABSTRACT

Background: Traumatic brain injury (TBI) requires rapid clinical and radiological assessment. Glasgow Coma Scale (GCS) scores and computed tomography (CT) findings provide complementary information.
Objective: To assess the association between GCS scores and brain CT findings among patients with TBI presenting to two tertiary-care hospitals in Peshawar.
Methods: A retrospective cross-sectional study of 384 patients undergoing non-contrast brain CT after head trauma was conducted at Lady Reading Hospital and Hayatabad Medical Complex from November 2025 to February 2026. Non-probability convenience sampling was used. Data were analysed using SPSS version 22, with correlation, chi-square and Mann–Whitney U testing as reported in the source manuscript.
Results: Of 384 patients, 221 (57.6%) were male. Falls accounted for 141 (36.7%) injuries and road traffic accidents for 133 (34.6%). Abnormal CT findings were recorded in 178 (46.4%). GCS showed a weak negative correlation with abnormal CT findings (reported Spearman rho = −0.279; $p < 0.001$). Patients with abnormal CT findings had lower GCS ranks (Mann–Whitney U = 12,489; $p < 0.001$).
Conclusion: Lower GCS scores were associated with a greater frequency of abnormal brain CT findings. Clinical assessment and CT imaging should be interpreted together; the study does not establish a causal or management-outcome effect.

Keywords: Traumatic brain injury; Glasgow Coma Scale; computed tomography; intracranial haemorrhage; hematoma.

INTRODUCTION

Head injuries are a major cause of neurological impairment, morbidity, and mortality, particularly among young people. They may result in physical and psychological disabilities, with road traffic accidents (RTAs), falls, assaults, and sports injuries being important causes. Globally, traumatic brain injury (TBI) affects millions of people annually and disproportionately impacts young adult males. RTAs remain the leading cause of TBI, particularly in low- and middle-income countries, where the burden is expected to increase. [1,2,3,4,5]

Computed tomography (CT) has revolutionized the diagnosis and management of TBI and is considered the gold standard for evaluating acute traumatic brain injuries. It enables rapid identification of skull fractures, cerebral edema, contusions, and intracranial hemorrhages, facilitating timely clinical intervention. [6,7] However, CT has limitations, including radiation exposure and reduced sensitivity for detecting small contusions and diffuse axonal injury (DAI). In resource-limited settings such as Pakistan, unnecessary CT examinations can increase financial and healthcare burdens. Furthermore, intracranial abnormalities may occasionally become apparent several hours after the initial injury, emphasizing the importance of clinical monitoring and appropriate imaging decisions. [8,9]

The Neuroimaging Radiological Interpretation System (NIRIS), introduced in 2018, provides a structured approach to TBI reporting by classifying imaging findings into five categories (NIRIS 0–4), each corresponding to a management pathway. This system aims to improve radiological interpretation and clinical decision-making. [10]

The Glasgow Coma Scale (GCS) is a widely used clinical tool for assessing consciousness following head injury. It evaluates eye opening, verbal response, and motor response, producing scores from 3 to 15. TBI is classified as mild (13–15), moderate (9–12), or severe (≤8), supporting emergency triage and clinical management. [11,12] Despite its widespread use, GCS has limitations, including inter-rater variability, difficulty assessing intubated or sedated patients, and the influence of intoxication, hypoglycemia, hypothermia, and polytrauma. Moreover, patients with relatively preserved GCS scores may still have significant intracranial abnormalities detectable on CT.[13]

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Evidence suggests that lower GCS scores are associated with a greater likelihood of abnormal CT findings. Combining GCS with CT-based classification systems, including the Marshall CT Classification and Rotterdam CT Score, may improve prediction of mortality, hospital stay, and neurological outcomes compared with either assessment alone. [14,15] Similarly, Niaz et al. reported a significant relationship between GCS scores and NIRIS categories, highlighting the complementary role of clinical and radiological assessments in evaluating TBI severity. [16]

In Pakistan and South Asia, TBI represents a significant public health concern, primarily due to RTAs, increasing motorization, urbanization, and inadequate road safety infrastructure. [17] Peshawar, particularly through tertiary care facilities such as Lady Reading Hospital (LRH) and Hayatabad Medical Complex (HMC), receives trauma patients from across Khyber Pakhtunkhwa and surrounding areas. Despite the considerable burden, local evidence regarding the relationship between GCS scores and CT findings remains limited. [18] Furthermore, TBI is frequently underreported in Pakistan, and delayed or inadequate treatment, particularly in rural areas, remains a challenge. [19]

Understanding the relationship between clinical severity and CT findings is essential for improving patient assessment, optimizing CT utilization, and developing evidence-based triage protocols. Therefore, this study was designed to evaluate the relationship between Glasgow Coma Scale scores and CT scan findings among patients with traumatic brain injury presenting to two major tertiary care hospitals in Peshawar, Pakistan.

METHODOLOGY

A retrospective cross-sectional study was conducted to investigate the relationship between Glasgow Coma Scale (GCS) scores and computed tomography (CT) findings among patients presenting with traumatic brain injury (TBI). The study was based on a review of previously documented hospital records.

The study was carried out in the emergency departments and radiology departments of Lady Reading Hospital (LRH) and Hayatabad Medical Complex (HMC), Peshawar, over a four-month period, extending from November 2025 to February 2026.

The required sample size was determined using the formula (n=Z^2p(1-p)/d^2), considering an assumed prevalence of abnormal CT findings of 50%, a 95% confidence level, and a 5% margin of error. Based on these parameters, the calculated sample size was 384 patients. Participants were selected through a non-probability convenience sampling technique.

Patients of either gender aged one year or older were eligible for inclusion if they had suspected or clinically diagnosed TBI and had undergone non-contrast CT brain imaging following head trauma. Patients with a history of previous cranial surgery, pre-existing neurological disorders, anticoagulant use, or known bleeding disorders were excluded from the study.

Ethical approval was obtained from the Research Committee of the Institute of Health Sciences, Peshawar, along with administrative permission from LRH and HMC. Official permission letters were submitted to the respective heads of the radiology departments before data collection. Relevant information was retrieved from existing hospital records in accordance with the approved ethical procedures.

Statistical analysis was performed using SPSS version 22. Continuous variables, including age and GCS scores, were summarized as means and standard deviations, whereas categorical variables, such as gender and CT findings, were presented as frequencies and percentages. The Chi-square test was applied to determine associations between CT findings and GCS severity categories (mild, moderate, and severe). Additionally, Spearman's rank correlation was used to assess the relationship between GCS scores and the severity of CT findings.

RESULTS

The analysis included 384 patients with suspected or clinically diagnosed traumatic brain injury. The demographic, clinical, and radiological findings are presented in the following tables

Table 1. Demographic characteristics and mechanism of injury (N = 384)

Characteristic	Category	n (%)
Sex	Male	221 (57.6)
	Female	163 (42.4)
Injury mechanism	Fall	141 (36.7)
	Road traffic accident	133 (34.6)
	Physical assault	42 (10.9)
	Other	68 (17.7)
Vomiting	Present	105 (27.3)
	Absent	279 (72.7)

Table 2. Reported CT findings (N = 384)

Imaging finding	Present, n (%)	Absent, n (%)
Abnormal CT overall	178 (46.4)	206 (53.6)
Skull fracture	321 (83.6)	63 (16.4)
Haemorrhage	178 (46.4)	206 (53.6)
Haematoma	232 (60.4)	152 (39.6)

The reported frequencies for skull fracture and haematoma require verification because they exceed the total number of patients classified as having abnormal CT findings.

Table 3. Reported relationship between GCS and imaging findings

Comparison	Statistic	P value
GCS and abnormal CT	Spearman rho = −0.279	<0.001
GCS and haemorrhage	Reported r = −0.279	<0.001
GCS and haematoma	Reported r = −0.118	0.020
GCS and skull fracture	Reported r = −0.069	0.179
GCS ranks, normal vs abnormal CT	220.87 vs 159.66; U = 12,489; Z = −5.455	<0.001

The correlation test used for these analyses should be verified against the original statistical output.

Table 4. Cause of injury by CT findings

Cause	Normal CT, n	Abnormal CT, n	Total
Road traffic accident	72	61	133
Physical assault	24	18	42
Fall	79	62	141
Other	31	37	68
Total	206	178	384

Reported chi-square = 2.317; df = 3; p = 0.509.

Table 5. Vomiting by CT findings

Vomiting	Normal CT, n	Abnormal CT, n	Total
No	153	126	279
Yes	53	52	105
Total	206	178	384

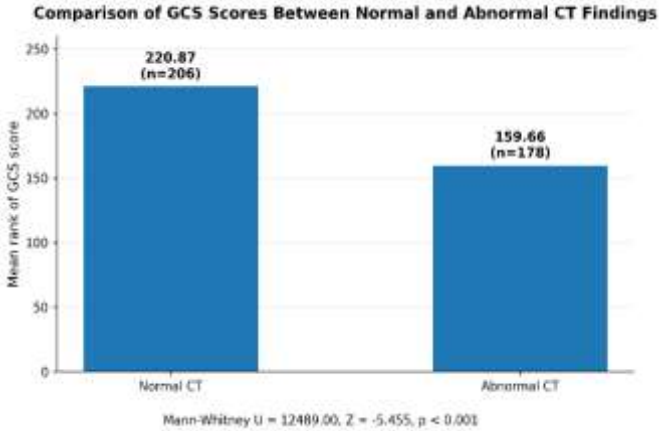
Reported chi-square = 0.584; p = 0.445.

Table 6. Diagnostic classification of low GCS against abnormal CT

GCS classification	Abnormal CT	Normal CT	Total
Low GCS	136	114	250
Normal GCS	42	92	134
Total	178	206	384

Sensitivity = 136/178 = 76.4%; specificity = 92/206 = 44.7%; PPV = 136/250 = 54.4%; NPV = 92/134 = 68.7%. The original manuscript incorrectly reports a PPV of 68.7%. The cut-off value used to classify patients into low and normal GCS groups should be specified.

Figure 1. Comparison of scores



DISCUSSION

An essential component of emergency trauma care is assessing the link between immediate neuroimaging and real-time clinical assessment. This study examined the relationship between initial Glasgow Coma Scale (GCS) scores and findings on non-contrast head CT scans immediately following traumatic brain injury (TBI). Our data demonstrated a significant association, indicating that the likelihood of detecting structural damage on CT scans increases as a patient's level of consciousness decreases. The mean GCS score among patients with normal CT scans was significantly higher than that among patients with traumatic abnormalities. These findings support previous studies showing that altered consciousness is associated with intracranial injury.[20]

When considering the primary causes of these injuries, falls (36.6%) and road traffic accidents (34.6%) were the most common causes in our study. This distribution is consistent with regional findings showing that falls and road traffic accidents are among the leading causes of acute hospital admissions for neurotrauma. [21] However, our statistical analysis revealed no significant association between the specific cause of injury and abnormal CT findings (p = 0.509), despite the differences in kinetic forces involved in road traffic collisions and typical slip-and-fall incidents.

These findings suggest that the mechanism of injury alone may not accurately predict intracranial pathology. Clinicians cannot rely solely on the mechanism of injury to avoid or postpone CT imaging because even a low-velocity fall, particularly in elderly patients, can result in severe intracranial bleeding comparable to that caused by high-speed collisions. [22]

When examining specific clinical symptoms, a similar pattern was observed. Although head trauma guidelines generally identify vomiting as an important warning sign, our data showed no statistically significant association between vomiting and abnormal CT findings (p = 0.445). This finding highlights the limitations of relying on isolated clinical symptoms when assessing intracranial injury.

This observation is supported by previous trauma studies suggesting that isolated vomiting may occur due to transient autonomic disturbances or vestibular irritation rather than an expanding intracranial mass lesion or increased intracranial pressure. [23] Consequently, relying on vomiting as an independent screening indicator may result in the failure to identify underlying structural abnormalities.

When different types of intracranial bleeding were examined, the most significant findings emerged. In addition to a weak negative correlation with cerebral hematomas ($r = -0.118$, $p = 0.020$), a significant, moderately negative correlation was observed between initial GCS scores and the presence of any intracranial bleeding ($r = -0.279$, $p < 0.001$). These findings are consistent with previous studies emphasizing the association between reduced consciousness and structural brain injury.

As mass effect develops, structural CT findings, including midline shift, may demonstrate a strong negative correlation with initial GCS scores ($r = -0.770$, $p = 0.001$), reflecting the potential impact of intracranial pressure and brain displacement on consciousness.[24] Furthermore, previous trauma research indicates that combining baseline GCS scores with structural injury severity classification systems may improve the prediction of early mortality and unfavorable long-term neurological outcomes.

However, this relationship has limitations, particularly among patients with mild TBI (GCS 13–15). Recent clinical research highlights that patients exposed to confounding acute factors, such as alcohol intoxication, may demonstrate reduced GCS scores despite relatively mild or normal early CT findings. Conversely, patients with initially preserved GCS scores may experience neurological deterioration due to progressive cerebral contusions or delayed hematoma expansion. These diagnostic limitations emphasize the importance of timely CT imaging rather than relying exclusively on bedside clinical observations.

However, our study found no statistically significant correlation between GCS scores and the presence of skull fractures ($r = -0.069$, $p = 0.179$). Although 83.6% of patients in our study had skull fractures, their presence did not necessarily indicate impaired consciousness. This observation highlights an important clinical distinction: skull fractures do not invariably indicate severe underlying brain injury, particularly when the fracture does not produce substantial damage to the underlying brain tissue. Therefore, osseous injuries and intracranial parenchymal injuries represent distinct pathological conditions requiring different clinical considerations.

Lastly, comparisons with previous research highlight the variability in TBI presentations according to patient demographics, hospital arrival times, and institutional trauma protocols. Differences in the reported relationships between GCS scores and specific extra-axial hematomas further demonstrate the complex nature of neurotrauma. These findings reinforce the limitations of clinical scoring systems as substitutes for definitive radiological assessment. Ultimately, although the GCS is a valuable instrument for assessing and monitoring consciousness, it cannot independently identify or characterize all underlying structural abnormalities. Therefore, prompt clinical assessment combined with appropriate CT imaging remains essential for accurate diagnosis and effective management of TBI.

CONCLUSION

In this hospital-based study, lower Glasgow Coma Scale scores were statistically associated with abnormal CT findings among patients undergoing evaluation for traumatic brain injury. The clinical GCS assessment and CT findings offered complementary

information; neither a causal effect nor an improvement in patient management outcomes can be inferred from this cross-sectional analysis. Confirmation of the internally inconsistent imaging frequencies and diagnostic calculations is necessary before definitive publication.

Ethical Approval
Ethical approval for this study was obtained from the relevant Institutional Review Board (IRB) or Ethics Review Committee of the participating tertiary care hospitals in Peshawar, Pakistan, before commencement of data collection. The ethical approval details and reference number should be provided.

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

Author Contributions
Conceptualization: Hoor Manal, Aliya
Methodology: Maryam, Urwa Umar
Data Collection: Hoor Manal, Nabeel Ahmad, Jalwa Shah
Formal Analysis: Aliya, Maryam
Writing – Original Draft: Hoor Manal, Urwa Umar
Writing – Review & Editing: Aliya, Nabeel Ahmad, Jalwa Shah
All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Informed Consent
Written informed consent was obtained from all participants or their legally authorized representatives before data collection.

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Conflict of Interest
No.

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Declaration of AI-Assisted Language Editing
Grammarly AI was used for language and grammar correction, while Gemini AI was used for figure generation.

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