Section: Radio-Diagnosis

Original Research Article

ROLE OF COMPUTED TOMOGRAPHY IN THE EVALUATION OF TRAUMATIC BRAIN INJURIES- AN OBSERVATIONAL STUDY

Rushikesh Raghunath Ukhale[1], Saurabh Bhopale[2], Pradeep Kulkarni[3]

[1]Assistant Professor, Department of Radio-Diagnosis, Prakash Institute of Medical Sciences, Islampur, Sangli, Maharashtra, India.
[2]PG Resident, Department of Radio-Diagnosis, Prakash Institute of Medical Sciences, Islampur, Sangli, Maharashtra, India.
[3]Professor, Department of Radio-Diagnosis, Prakash Institute of Medical Sciences, Islampur, Sangli, Maharashtra, India.

Received : 12/04/2026
Received in revised form : 21/05/2026
Accepted : 08/06/2026

Keywords:
Traumatic Brain Injury (TBI), Computed Tomography (CT) Head Injury, Intracranial Hemorrhage Skull Fracture, Cerebral Contusion Glasgow Coma Scale (GCS).

Corresponding Author:
Dr. Pradeep Kulkarni,
Email: kulkarnipradeep099@gmail.com

DOI: 10.47009/jamp.2026.8.3.150

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (3); 832-837

ABSTRACT

Background: Traumatic brain injury (TBI) is a leading cause of mortality and long-term disability, especially in developing countries like India where road traffic accidents are common. Rapid diagnosis is essential to prevent secondary brain injury. Computed tomography (CT) is the imaging modality of choice in acute head trauma due to its speed, accessibility, and high sensitivity for acute hemorrhage and fractures. **Aim:** To evaluate the role of computed tomography in the assessment of traumatic brain injuries and to correlate CT findings with clinical severity. **Materials and Methods:** This observational study included 150 patients with a history of head trauma who underwent non-contrast CT brain imaging at a tertiary care hospital (PIMS & R, Ishwarpur Dist. Sangli). Clinical data including age, sex, mechanism of injury, and Glasgow Coma Scale (GCS) were recorded. CT findings were analyzed and correlated with clinical severity. **Results:** Road traffic accidents were the most common cause of injury. Common CT findings included cerebral contusions, extradural hematoma, subdural hematoma, subarachnoid hemorrhage, skull fractures, cerebral edema, and midline shift. Severity of CT findings showed strong correlation with low GCS scores. **Conclusion:** CT is an indispensable tool in the initial evaluation of traumatic brain injury. It plays a crucial role in diagnosis, grading of severity, and guiding management decisions.

INTRODUCTION

Traumatic brain injury is defined as an alteration in brain function or other evidence of brain pathology caused by an external mechanical force. It represents a significant global health problem, particularly in low- and middle-income countries. In India, TBIs account for a substantial proportion of trauma-related hospital admissions and deaths.

The clinical presentation of TBI varies from mild concussion to severe coma. Early identification of intracranial injuries is vital, as secondary brain damage due to hypoxia, ischemia, or raised intracranial pressure can worsen outcomes. Imaging plays a central role in early diagnosis.

Computed tomography has revolutionized the management of head injury patients. Non-contrast CT can rapidly detect acute hemorrhage, fractures, mass effect, and brain edema, making it the first-line investigation in emergency settings.

Review of Literature

General Role of CT in Traumatic Brain Injury

Computed tomography has been established as the primary imaging modality in the evaluation of acute traumatic brain injury since its introduction in the 1970s. Numerous international and Indian studies have demonstrated that non-contrast CT is highly sensitive in detecting acute intracranial hemorrhage, skull fractures, mass effect, and cerebral edema. Its rapid acquisition time and wide availability make it indispensable in emergency settings.

Jennett and Teasdale emphasized the importance of early CT imaging in head injury patients to identify surgically treatable lesions. Subsequent studies have confirmed that early CT-guided intervention significantly reduces mortality.

Extradural Hematoma (EDH)

Extradural hematoma is commonly associated with skull fractures, particularly involving the temporal bone and middle meningeal artery injury. CT typically demonstrates a hyperdense biconvex extra-axial collection which is limited by suture lines. Studies by Bullock et al. and Indian authors have shown that early CT detection of EDH allows prompt surgical evacuation, resulting in excellent outcomes when treated early.

Subdural Hematoma (SDH)

Subdural hematomas are more commonly seen in high-velocity injuries and elderly patients. On CT, acute SDH appears as a crescent-shaped hyperdense collection crossing suture lines. Maas et al. demonstrated that SDH is associated with higher mortality compared to EDH due to associated parenchymal injury. Indian studies have reported SDH as the most common intracranial lesion in severe head injury.

Subarachnoid Hemorrhage (SAH)

Traumatic subarachnoid hemorrhage appears as hyper densities within the basal cisterns, sulci, and fissures. CT is highly sensitive in the acute phase. Several studies have correlated the presence of traumatic SAH with poor neurological outcome due to vasospasm and secondary ischemia.

Extradural (Epidural) Hematoma: A well-defined, biconvex (lentiform) hyperdense extra-axial collection is seen adjacent to the inner table of the skull, causing localized mass effect on the underlying cerebral cortex. Sutural margins are respected. **Subdural Hematoma:** A crescent-shaped hyperdense extra-axial collection is noted along the cerebral convexity, crossing sutural boundaries and causing mild effacement of adjacent cortical sulci. **Subarachnoid Hemorrhage:** Hyperdense blood is seen within the subarachnoid spaces, involving cortical sulci and basal cisterns.

Diffuse Axonal Injury (DAI)

Diffuse axonal injury results from shearing forces during acceleration-deceleration injuries. CT findings may be subtle or even normal, showing small hemorrhagic foci at the gray-white matter junction, corpus callosum, or brainstem. Multiple studies highlight CT limitations in DAI detection, with MRI being superior; however, CT remains crucial for excluding associated life-threatening lesions.

Description: Multiple tiny hyperdense foci (microhaemorrhage, red arrows). From the top to the bottom: Junction between gray–white matter (frontal lobes), corpus callosum (splenium) and right thalamus. Note the intraventricular haemorrhage within the right occipital horn

CT-Based Classification Systems

The Marshall CT classification categorizes traumatic brain injuries based on diffuse injury, presence of mass lesions, and degree of midline shift. The Rotterdam CT score further refines prognostication by including basal cistern status and intraventricular hemorrhage. Several international and Indian studies have validated these scoring systems as reliable predictors of outcome.

Indian and International Studies

Indian studies by Agrawal et al., Chawla et al., and Gupta et al. have demonstrated demographic patterns similar to global data, with male predominance and road traffic accidents as the leading cause. International studies consistently highlight CT as the cornerstone of acute TBI evaluation.

Aims and Objectives

Aim

To evaluate the role of computed tomography in the evaluation of traumatic brain injuries.

Objectives

1. To analyze CT findings in patients with traumatic brain injury.
2. To correlate CT findings with Glasgow Coma Scale.
3. To determine the role of CT in guiding management decisions.
4. To identify common patterns of traumatic intracranial lesions.
5. To assess the limitations of CT in traumatic brain injury evaluation.

MATERIALS AND METHODS

The study was carried out in the Department of Radiology at Prakash Institute of Medical Sciences and Research, Urun-Ishwarpur, a tertiary care teaching hospital affiliated to Maharashtra University of Health Sciences, Nashik. This was a retrospective observational study conducted in period of a year or 12 months. The study included patients presenting with history of head injury who underwent CT Brain plain scan of the brain during the study period.

A total of 150 cases were included in this study. Patients of all age groups and both sexes with definite history of traumatic head injury and who underwent non-contrast CT brain examination were included. Patients having non-traumatic intracranial pathologies, postoperative changes or follow-up CT scans were used in exclusion criteria of this study.

CT examinations were performed on a multidetector 32 slice siemens CT scanner. Non-contrast axial sections of the brain were obtained from the skull base up to the vertex using 5 mm slice thickness and reconstructed in 1.5 mm slice thickness. Images were evaluated in both brain window and bone window settings for assessment of intracranial injuries and skull fractures. The reconstructed images were reviewed for better visualization of fractures and associated intracranial abnormalities.

The CT scans were studied for various traumatic findings including cerebral contusions, extradural hematoma, subdural hematoma, subarachnoid hemorrhage, intraparenchymal hemorrhage, cerebral edema, skull fractures, and midline shift. Severity of head injury was assessed clinically using the Glasgow Coma Scale (GCS). Based on Glasgow coma scale score, patients were categorized into mild, moderate, and severe head injury groups. CT findings were correlated with GCS categories to evaluate the relationship between imaging abnormalities and severity of injury.

The collected data were entered in Microsoft Excel sheet and analyzed using appropriate software for the statistics. Descriptive statistics were used for analysis of demographic profile, mode of injury, and CT findings. Association between CT findings and Glasgow Coma Scale categories was assessed using Chi-square test. A p-value less than 0.05 was considered statistically significant study.

RESULTS

Demographic Profile

A total of 150 patients were included in the study. The majority were males (approximately 75%), with the most commonly affected age group being 21–40 years.

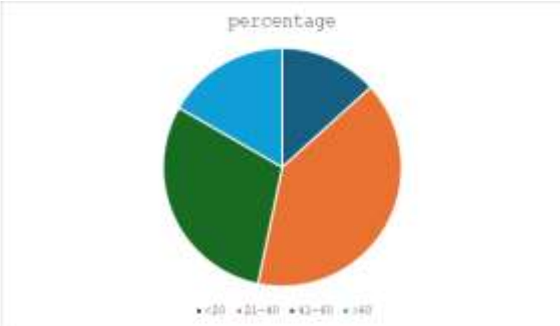

Table 1: Age Distribution of Patients

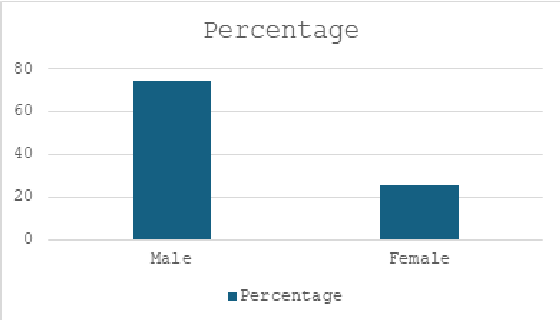

Table 2: Sex Distribution

Mechanism of Injury

Road traffic accidents were the most common mechanism of injury, followed by falls and assaults.

Table 3: Mechanism of Injury

Mechanism	Number	Percentage
Road traffic accident	95	63.3%
Fall	35	23.3%
Assault	20	13.4%

CT Findings

Table 4: Lesion-wise Distribution of CT Findings

CT Finding	Number of Patients	Percentage
Cerebral contusion	65	43.3%
Extradural hematoma	30	20.0%
Subdural hematoma	40	26.7%
Subarachnoid hemorrhage	35	23.3%
Intraparenchymal hemorrhage	28	18.7%
Skull fracture	55	36.7%
Cerebral edema	45	30.0%
Midline shift	32	21.3%

Correlation of CT Findings with GCS

Patients with low GCS scores showed higher incidence of multiple intracranial lesions, cerebral edema, and midline shift.

Table 5: GCS vs CT Findings

GCS Category	Normal CT	Single Lesion	Multiple Lesions
Mild (13–15)	30	25	5
Moderate (9–12)	10	20	15

ISSN (O): 2687-5365; ISSN (P): 2753-6556

GCS Category	Normal CT	Single Lesion	Multiple Lesions
Severe (<8)	2	10	33

DISCUSSION

The present study evaluated the role of Computed Tomography (CT) in 150 patients with traumatic brain injury (TBI), focusing on demographic profile, mechanism of injury, spectrum of CT findings, and correlation with Glasgow Coma Scale (GCS). The observations obtained were compared with previously published national and international studies and showed considerable agreement with established literature.

Demographic Profile

In the present study, the majority of patients belonged to the 21–40 years age group, with males constituting nearly 75% of the study population. This demographic pattern is comparable with the observations of Marshall LF et al., Maas AIR et al., and Stein SC et al., who reported a predominance of young adult males in TBI cases. Young males are more frequently involved in outdoor activities, high-speed travel, occupational hazards, and interpersonal violence, making them more susceptible to head injuries.

The male predominance observed in this study is also consistent with the findings of Servadei F et al. and Lobato RD et al., where males accounted for approximately 70–80% of TBI patients. Similar observations were reported in Indian studies, including that by Deepak NA et al., emphasizing that traumatic brain injury remains more prevalent among economically productive age groups.

Mechanism of Injury

Road traffic accidents (RTAs) were the leading cause of TBI in the present study (63.3%), followed by falls (23.3%) and assaults (13.4%). These findings strongly correlate with the studies conducted by Becker DP et al. and Narayan RK et al., where RTAs were considered as the primary mechanism of severe head injury.

Indian studies similarly demonstrate a high incidence of RTA-related head trauma due to increasing vehicular density, inadequate road safety measures, and inconsistent helmet use. The proportion of falls observed in this study is comparable to that reported by Huisman TA et al., especially among pediatric and elderly populations. Assault-related injuries formed the smallest proportion, which is similar to the findings of Stein SC et al.

The predominance of RTAs in the current study supports the global epidemiological trend described by Saatman KE et al., who emphasized that motor vehicle accidents remain the leading cause of moderate-to-severe TBI in developing nations.

CT Findings

Cerebral Contusions

Cerebral contusions were the most common CT finding in the present study, observed in 43.3% of patients. This observation correlates well with the studies by Gentry LR and Zimmerman RA, who described cerebral contusions as one of the commonest manifestations of blunt head trauma detectable on CT.

The high frequency of contusions in this study may be attributed to acceleration-deceleration injuries commonly seen in RTAs. Similar lesion prevalence has also been reported in studies by Eisenberg HM et al., where contusions were commonly associated with poor neurological outcomes when multiple or bilateral.

Extradural Hematoma (EDH)

Extradural hematoma was identified in 20% of patients in the present study. This frequency is comparable to the observations made by Lobato RD et al., who found EDH in approximately 15–25% of severe head injury cases.

The association of EDH with skull fractures observed in the present study also parallels classical findings in literature. CT has been universally recognized as the investigation of choice for rapid diagnosis of EDH because of its ability to demonstrate the characteristic biconvex hyperdense collection and associated mass effect.

Subdural Hematoma (SDH)

Subdural hematoma was noted in 26.7% of patients. This finding is consistent with studies by Servadei F et al., who identified acute SDH as one of the most important prognostic indicators in TBI.

The incidence reported in the present study is similar to the results of Marshall LF et al. Acute SDH was frequently associated with cerebral edema and midline shift in severe injury groups, findings that correlate with poorer clinical outcomes reported in earlier literature.

Subarachnoid Hemorrhage (SAH)

Traumatic SAH was observed in 23.3% of patients. Similar frequencies were described by Eisenberg HM et al. and Lee B et al. The presence of SAH is clinically important because it often reflects significant underlying parenchymal injury and correlates with increased morbidity.

Intraparenchymal Hemorrhage (IPH)

Intraparenchymal hemorrhage was identified in 18.7% of cases, comparable with the findings reported by Chastain CA et al. The study emphasized that intraparenchymal hemorrhages are commonly associated with diffuse brain injury and are predictive of unfavorable neurological outcomes.

Skull Fractures

Skull fractures were detected in 36.7% of patients. Similar observations were reported by Zimmerman RA et al. and Gentry LR. CT was found to be highly sensitive in identifying calvarial fractures, depressed fractures, and associated intracranial complications.

The existence of fractures with extradural hematomas in the present study is similar to the established pathophysiological mechanisms discussed in previous literature.

Cerebral Edema and Midline Shift

Cerebral edema was present in 30% of cases, while midline shift was observed in 21.3%. These findings closely parallel those of Narayan RK et al. and Marshall LF et al., who demonstrated that cerebral edema and significant midline shift are associated with increased intracranial pressure and poor prognosis.

The present study similarly demonstrated that patients with severe GCS scores had a significantly higher incidence of edema and midline shift, reaffirming CT's prognostic value.

Correlation of CT Findings with Glasgow Coma Scale (GCS)

An important observation in the present study was the strong correlation between severity of GCS and abnormal CT findings. Patients with mild GCS,[13-15] predominantly showed either normal CT scans or isolated lesions, whereas severe GCS (<8) was associated with multiple intracranial lesions, cerebral edema, and midline shift.

These findings are in close agreement with the studies conducted by Teasdale G and Jennett B, who originally established the GCS as a reliable clinical predictor of head injury severity.

Similarly, Marshall LF et al. demonstrated that severe GCS scores correlate strongly with diffuse injury patterns and poor outcomes on CT. Maas AIR et al. further emphasized that combining clinical scoring systems with CT findings significantly improves prognostic accuracy.

The predominance of multiple lesions among severe GCS patients in the present study is also shows similarities to the observations by Eisenberg HM et al., who showed that the burden of intracranial lesions on CT is directly related to mortality and neurological deficits.

Overall Role of CT in Traumatic Brain Injury

The observations in the present study strongly support the established role of CT as the primary imaging modality in traumatic brain injury. Comparable to the conclusions drawn by Wintermark M et al., CT provides rapid, accurate and widely available assessment of intra or extra-axial hemorrhage, skull fractures, cerebral edema and mass effect.

The present findings reaffirm that CT not only aids in diagnosis but also assists in triaging patients, guiding surgical intervention, predicting prognosis, and monitoring disease progression. The excellent correlation between CT findings and clinical severity in this study further validates the importance of early CT evaluation in all moderate and severe head injury patients.

Overall, the present study findings are largely concordant with both international and Indian literature, thereby reinforcing the role of computed tomography in the evaluation and clinical management of traumatic brain injuries.

CONCLUSION

Computed tomography is the cornerstone imaging modality in the evaluation of traumatic brain injuries. It provides rapid and reliable information that is critical for diagnosis, assessment of severity, and management planning. CT findings correlate well with clinical severity and help identify patients requiring urgent neurosurgical intervention.

Limitations of the Study

- Limited sensitivity for diffuse axonal injury.

Lack of long-term outcome correlation.

Future Scope

Advanced CT techniques such as CT perfusion and dual-energy CT may further improve evaluation of traumatic brain injury. Integration of imaging with clinical scoring systems may enhance prognostication.

REFERENCES

1. Adams JH, Doyle D, Ford I, Gennarelli TA, Graham DI, McLellan DR. Diffuse axonal injury in head injury: definition, diagnosis and grading. Histopathology. 1989;15(1):49-59.
2. Becker DP, Miller JD, Ward JD, Greenberg RP, Young HF, Sakalas R. The outcome from severe head injury with early diagnosis and intensive management. J Neurosurg. 1977;47(4):491-502.
3. Gentry LR. Imaging of closed head injury. Radiology. 1994;191(1):1-17.
4. Marshall LF, Gautille T, Klauber MR, Eisenberg HM, Jane JA, Luerssen TG, et al. The outcome of severe closed head injury. J Neurosurg. 1991;75(Suppl):S28-S36.
5. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. Lancet. 1974;2(7872):81-84.
6. Lee B, Newberg A. Neuroimaging in traumatic brain imaging. NeuroRx. 2005;2(2):372-383.
7. Wintermark M, Sanelli PC, Anzai Y, Tsiouris AJ, Whitlow CT. Imaging evidence and recommendations for traumatic brain injury. AJNR Am J Neuroradiol. 2015;36(2):E1-E11.
8. Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, et al. The Canadian CT Head Rule for patients with minor head injury. Lancet. 2001;357(9266):1391-1396.
9. Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PMC. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000;343(2):100-105.
10. Maas AIR, Hukkelhoven CWPM, Marshall LF, Steyerberg EW. Prediction of outcome in traumatic brain injury. J Neurotrauma. 2005;22(10):1025-1039.
11. Servadei F, Nasi MT, Giuliani G, Cremonini AM, Cenni P, Zappi D, et al. CT prognostic factors in acute subdural hematomas. Acta Neurochir (Wien). 2000;142(2):131-136.
12. Lobato RD, Rivas JJ, Cordobes F, Alted E, Perez C, Sarabia R, et al. Acute epidural hematoma: analysis of factors influencing outcome. J Neurosurg. 1988;68(1):48-57.
13. Stein SC, Ross SE. Mild head injury: a plea for routine early CT scanning. J Trauma. 1992;33(1):11-13.
14. Huisman TA. Intracranial traumatic injuries in children: imaging findings. Eur Radiol. 2005;15(3):582-592.
15. Zimmerman RA, Bilaniuk LT, Gennarelli T. Computed tomography of shearing injuries of the cerebral white matter. Radiology. 1978;127(2):393-396.
16. Chastain CA, Oyoyo U, Zipperman M, Joo E, Ashwal S, Shutter L, et al. Predicting outcomes of traumatic brain injury by imaging modality and injury distribution. J Neurotrauma. 2009;26(8):1183-1196.
17. Eisenberg HM, Gary HE Jr, Aldrich EF, Saydjari C, Turner B, Foulkes MA, et al. Initial CT findings in 753 patients with severe head injury. J Neurosurg. 1990;73(5):688-698.

18. Narayan RK, Greenberg RP, Miller JD, Enas GG, Choi SC, Kishore PR, et al. Improved confidence of outcome prediction in severe head injury. J Neurosurg. 1981;54(6):751-762.
19. Saatman KE, Duhaime AC, Bullock R, Maas AIR, Valadka A, Manley GT. Classification of traumatic brain injury for targeted therapies. J Neurotrauma. 2008;25(7):719-738.
20. Deepak NA, Patel ND, Chavda SV, Shah GV. Role of computed tomography in evaluation of traumatic brain injury. Int J Res Med Sci. 2015;3(7):1682-1686.