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Diagnostic Utility of Non-Contrast Computed Tomography in Traumatic Brain Injury: A Prospective Observational Study at a Tertiary Care Centre in North India

Shubham Arora[1], Arun Kumar Gaur[2], Hemant Kumar[3], Shubhankar Tyagi[4], Sumeet Bhargava[5]

[1]Resident Doctor, Department of Radio-Diagnosis, GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India.
[2]Associate Professor, Department of Radio-Diagnosis, GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India.
[3]Assistant Professor, Department of Radio-Diagnosis, GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India.
[4]Resident Doctor, Department of Radio-Diagnosis, GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India.
[5]Professor, Department of Radio-Diagnosis, GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India.

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Corresponding Author:

Dr. Shubham Arora
Resident Doctor Department of Radio-Diagnosis GS Medical College and Hospital, Pilkhuwa, Uttar Pradesh, India
Email:
shubhamarora655@gmail.com

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ABSTRACT

Background: Traumatic brain injury (TBI) is a major cause of mortality and disability worldwide and constitutes a significant public health burden, particularly among young adults. Rapid identification of intracranial injuries is crucial for appropriate management and improved outcomes. Non-contrast computed tomography (CT) remains the primary imaging modality in the acute evaluation of head trauma owing to its rapid acquisition, widespread availability, and high diagnostic accuracy

Aim: To evaluate the diagnostic utility of non-contrast computed tomography in patients presenting with traumatic brain injury and to determine the distribution of intracranial lesions and skull fractures detected on CT imaging

Methods: This prospective observational study was conducted in the Department of Radiodiagnosis, GS Medical College and Hospital, Hapur, over an 18-month period from January 2024 to June 2025. A total of 150 adult patients with traumatic brain injury underwent non-contrast CT examination. Clinical characteristics, Glasgow Coma Scale (GCS) scores, CT findings, management strategies, and outcomes were analyzed. Statistical analysis was performed using SPSS software, and $p < 0.05$ was considered statistically significant.

Results: The majority of patients were males (61.3%), with road traffic accidents accounting for 78% of injuries. Cranial fractures were identified in 74.7% of patients. Cerebral edema (67.3%) and cerebral contusions (61.3%) were the most common intracranial findings. Subdural hemorrhage was observed in 49.3% of cases, followed by subarachnoid hemorrhage (36%), extradural hemorrhage (16.7%), and intraventricular hemorrhage (4.7%). Midline shift was present in 24% of patients. Surgical intervention was required in 17.3% of cases. Overall mortality was 8.7%, with poor outcomes predominantly observed in patients with severe GCS scores and extensive intracranial injury.

Conclusion: Non-contrast CT remains the cornerstone imaging modality in traumatic brain injury. It provides rapid and accurate detection of intracranial hemorrhage, skull fractures, cerebral edema, and mass effect, facilitating timely management and prognostication.

Keywords: Traumatic brain injury; Computed tomography; Head injury; Intracranial hemorrhage; Skull fractures; Glasgow Coma Scale.

INTRODUCTION

Traumatic brain injury (TBI) is a major cause of mortality and long-term disability worldwide, particularly among young adults. It represents a significant public health burden and contributes substantially to trauma-related hospital admissions and deaths. Road traffic accidents remain the leading cause of TBI in developing countries, followed by falls and assaults.[1–3] Early diagnosis and accurate assessment of intracranial injuries are essential for timely management and improved outcomes. Computed tomography (CT) is the imaging modality of choice in the acute evaluation of head trauma because of its rapid acquisition, widespread availability, and high sensitivity for detecting skull fractures and intracranial hemorrhage. CT enables prompt identification of extradural hemorrhage, subdural hemorrhage, subarachnoid hemorrhage, cerebral contusions, cerebral edema, and other traumatic lesions that influence treatment decisions and prognosis.[4–7]

Recent advances in neurotrauma research have emphasized the prognostic significance of CT findings. Several CT-based scoring systems, including the Stockholm and Helsinki CT scores, have been developed to improve outcome prediction in patients with traumatic brain injury. Furthermore, large multicenter studies such as CENTER-TBI and TRACK-TBI have highlighted the critical role of CT imaging in injury characterization, risk stratification, and clinical decision-making.[3],[10-12]

Despite improvements in trauma care, traumatic brain injury continues to be associated with considerable morbidity and mortality. Evaluation of CT findings remains essential for determining injury severity, guiding management, and predicting outcomes. Therefore, the present study was undertaken to evaluate the diagnostic utility of non-contrast computed tomography in traumatic brain injury and to analyze the spectrum of radiological findings and their clinical significance in patients presenting to a tertiary care centre.

MATERIALS AND METHODS

Study design and setting. This prospective cross-sectional observational study was conducted in the Department of Radiodiagnosis, GS Medical College and Hospital, Hapur, Uttar Pradesh, India, over a period of 18 months from January 2024 to June 2025.

Sample size. Using an expected traumatic brain injury prevalence of 25.7% (**Saishree et al**) 95% confidence and 7% absolute precision, the required sample was 138 patients.

Participants. A total of 150 adult patients with traumatic brain injury presenting to GS Medical College and Hospital, Hapur, between January 2024 and June 2025 were included in this prospective study. Patients aged ≥18 years presenting within 24 hours of trauma with a Glasgow Coma Scale (GCS) score ≤14 underwent non-contrast CT head examination and were enrolled consecutively. Patients younger than 18 years, pregnant women, those with GCS >14, and individuals with pre-existing non-traumatic intracranial pathology were excluded.

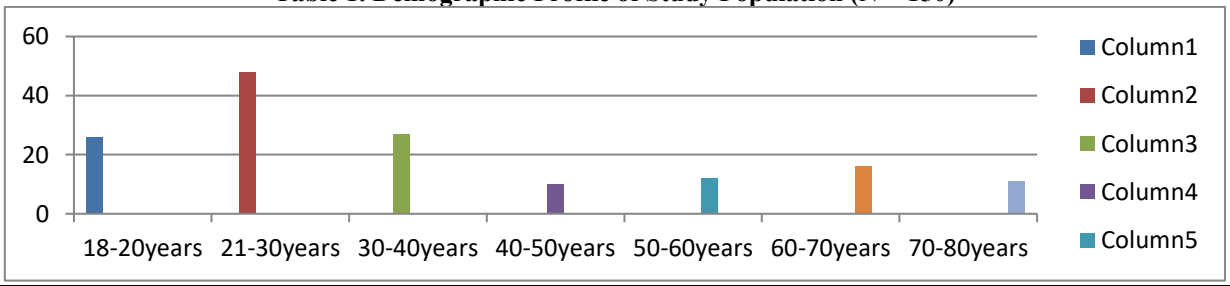
Procedure. After obtaining informed consent, eligible patients presenting with traumatic brain injury underwent detailed clinical evaluation, including assessment of Glasgow Coma Scale (GCS) score. Non-contrast CT of the head was performed using a 128-slice multidetector CT scanner. Images were reviewed for skull fractures, intracranial hemorrhages, cerebral contusions, cerebral edema, pneumocephalus, and midline shift. Clinical and radiological findings were recorded in a structured proforma and correlated with management and patient outcomes.

Statistical analysis. Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Descriptive statistics were used for data analysis. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages..

RESULTS

A total of 150 patients with traumatic brain injury were included in the study. The study population comprised 92 males (61.3%) and 58 females (38.7%), with a male-to-female ratio of approximately 1.6:1.Most patients belonged to the younger age group of 18–35 years (64.7%), indicating a higher burden of traumatic brain injury among economically productive individuals.

Table 1. Demographic Profile of Study Population (N = 150)



Road traffic accidents were the most common cause of injury, accounting for 78% of cases.
Falls from height constituted 20.6% of cases, while assault was responsible for 2% of injuries.

Table 2. Mechanism of Injury

RTA/FFH/Assault	Frequency	Percentage (%)
Assault	3	2
FFH	31	20.6
RTA	116	78
Total	150	100.0

In Glasgow Coma Scale Distribution At presentation, moderate traumatic brain injury was the most common category.

Table 3. Distribution According to GCS Score

GCS	Frequency	Percentage (%)
MILD >13	36	24%
MODERATE (9-12)	75	50%
SEVERE (<9)	39	26%
Total	150	100.0

Among Major CT Findings, Cranial fractures were the most common CT abnormality identified.
Among intracranial lesions, cerebral edema and cerebral contusions were the predominant findings.

Table 4. Major CT Findings

CT FINDING	FREQUENCY	Percentage (%)
CRANIAL FRACTURES LINEAR/DEPRESSED	112	74.66
ORBITAL FRACTURES	44	29.33
NASAL FRACTURES	33	22
ZYGOMATICOMAXILLARY FRACTURES	40	26.66
MANDIBLE FRACTURES	6	4
EDH	32	21.33
SDH	74	49.33
SAH	54	36
IVH	7	4.66
CEREBRAL CONTUSION	92	61.33
CEREBRA OEDEMA	101	67.33
PNEUMOCEPHALOUS	28	18.66

Most patients recovered completely following treatment. However, a subset developed neurological deficits or succumbed to their injuries. The mortality rate observed in the present study was 8.7%. Mortality was predominantly associated with severe traumatic brain injury and extensive intracranial abnormalities.

Table 5: Outcome of patients following Traumatic brain injury

Outcome	Frequency	Percentage (%)
Death	13	8.66
LAMA	6	4
Neurological deficit	14	9.33
Recovered	117	78
Total	150	100.0

Among patients who died, subdural hemorrhage was the most frequently observed hemorrhagic lesion, followed by intraventricular hemorrhage and extradural hemorrhage.

Table 6: Mortality among trauma patients related to intracranial hematomas

HAEMATOMA	MORTALITY
EDH	3
SDH	5
SAH	2
IVH	3

Patients with cerebral edema , intraventricular hemorrhage , significant midline shift, and severe Glasgow Coma Scale scores demonstrated the poorest outcomes.

DISCUSSION

Traumatic brain injury (TBI) remains a major cause of morbidity and mortality worldwide and continues to pose a significant public health challenge, particularly in developing countries.[1,2] In the present study, males constituted 61.3% of the study population, with a male-to-female ratio of approximately 1.6:1. Similar male predominance has been reported in previous studies and may be attributed to greater occupational exposure, outdoor activities, and increased involvement in road traffic accidents.[1,3,13]

Road traffic accidents accounted for 78% of injuries and represented the most common mechanism of trauma in our study. This finding is consistent with previous Indian and international studies that have identified vehicular accidents as the leading cause of traumatic brain injury.[1,3,13] The predominance of young adults among the affected population further emphasizes the socioeconomic impact of TBI, as it primarily affects individuals in their most productive years.

Computed tomography remains the cornerstone of imaging in acute head trauma due to its rapid acquisition, widespread availability, and excellent sensitivity for detecting intracranial hemorrhage and skull fractures.[4–7] In the present study, cranial fractures were identified in 74.7% of patients and represented the most common radiological finding. Linear fractures were more frequent than depressed fractures, similar to observations reported by Lolli et al. and Wintermark et al.[6,7] The high prevalence of fractures highlights the value of multidetector CT in detecting osseous injuries and associated intracranial complications.

Among intracranial abnormalities, cerebral edema (67.3%) and cerebral contusions (61.3%) were the most frequent findings. These lesions are important indicators of primary brain injury and are associated with increased risk of neurological deterioration. Previous studies have similarly identified cerebral edema as a major determinant of poor outcome because of its association with raised intracranial pressure and secondary brain injury.[2,5]

Subdural hemorrhage was the most common extra-axial hemorrhage in our study, occurring in 49.3% of patients, followed by subarachnoid hemorrhage (36%) and extradural hemorrhage (16.7%). These findings are comparable with previously published neurotrauma studies.[4–7] Subdural hematomas are often associated with severe injury mechanisms and have been linked to increased morbidity and mortality. In contrast, extradural hematomas, although less frequent, are clinically significant because timely surgical evacuation can result in favorable outcomes.

Intraventricular hemorrhage was identified in a small proportion of patients (4.7%) but demonstrated a strong association with mortality. Similar observations have been reported by Mata-Mbemba et al., who identified intraventricular hemorrhage as an independent predictor of poor neurological outcome following traumatic brain injury.[14] Midline shift was observed in 24% of patients and was frequently associated with severe injury and neurosurgical intervention. Significant midline shift reflects mass effect and intracranial hypertension and remains an important prognostic marker.[10,11] The majority of patients were managed conservatively, while surgical intervention was required in 17.3% of cases. CT findings played a critical role in identifying patients requiring burr-hole evacuation or decompressive craniectomy. Recent multicenter studies such as CENTER-TBI and TRACK-TBI have emphasized the importance of CT imaging not only for diagnosis but also for treatment planning and prognostication.[3,4,10]

The overall mortality rate in the present study was 8.7%. Poor outcomes were predominantly observed in patients with severe Glasgow Coma Scale scores, extensive intracranial hemorrhage, cerebral edema, intraventricular hemorrhage, and significant midline shift. These findings are consistent with previous literature demonstrating that both clinical severity and CT characteristics independently influence outcome following traumatic brain injury.[10,14]

The present study reinforces the indispensable role of non-contrast CT in the evaluation of traumatic brain injury. CT provides rapid and accurate assessment of traumatic intracranial lesions, facilitates early clinical decision-making, and offers valuable prognostic information. Its widespread availability and diagnostic accuracy continue to make it the first-line imaging modality in patients presenting with acute head trauma.

Limitations

The present study was conducted at a single tertiary care centre with a relatively limited sample size. Long-term neurological and functional outcomes were not assessed. Future multicentric studies with larger populations and extended follow-up are required to further validate these findings.

CONCLUSION

Traumatic brain injury remains a significant cause of morbidity and mortality, particularly among young adults. Early diagnosis and accurate assessment are essential for timely management and improved outcomes.

The present study demonstrates that non-contrast computed tomography is an indispensable imaging modality in the evaluation of traumatic brain injury. CT effectively identifies cranial fractures, extra-axial hemorrhages, intra-axial injuries, cerebral edema, pneumocephalus, intraventricular hemorrhage, and mass effect.

A significant association was observed between CT findings, Glasgow Coma Scale scores, management requirements, and clinical outcomes. Patients with severe traumatic brain injury, cerebral edema, intraventricular hemorrhage, and substantial midline shift demonstrated poorer outcomes and higher mortality.

In conclusion, computed tomography remains the cornerstone imaging modality in traumatic brain injury because of its rapid availability, high diagnostic accuracy, and prognostic value. CT findings provide critical information that guides clinical decision-making, neurosurgical intervention, and outcome prediction, thereby improving patient management and reducing preventable mortality.

Declarations

Ethics approval: The study was approved by the Institutional Ethics Committee of GS Medical College and Hospital, Hapur.

Funding: No external funding was received for this study.

Conflict of interest: The authors declare no conflict of interest.

Author contributions: All authors contributed to study design, data acquisition, analysis and manuscript preparation, and approved the final version.

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