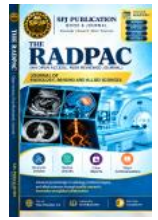




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Original Research

Role of Non-Contrast Computed Tomography in the Initial Evaluation of Traumatic Brain Injury: A Cross-Sectional Study

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ABSTRACT

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Background: Traumatic brain injury (TBI) is a major cause of morbidity and mortality worldwide, particularly in emergency settings. Rapid and accurate imaging is essential for early diagnosis and management. Non-contrast computed tomography (NCCT) remains the first-line imaging modality for evaluating acute head trauma.

Aim: To assess the diagnostic role and spectrum of findings of non-contrast CT in the initial evaluation of patients with traumatic brain injury.

Materials and Methods: A hospital-based cross-sectional study was conducted on 156 patients with suspected TBI who underwent NCCT of the brain. CT findings were analyzed in relation to demographic data, mechanism of injury, and Glasgow Coma Scale (GCS) score.

Results: Abnormal CT findings were observed in 112 patients (71.8%). The most common findings were cerebral contusions (38.5%), skull fractures (34.6%), and intracranial hemorrhage (31.4%). Severe TBI cases showed a significantly higher incidence of multiple CT abnormalities.

Conclusion: Non-contrast CT plays a crucial role in the early evaluation of traumatic brain injury by rapidly identifying life-threatening intracranial lesions and guiding emergency management decisions.

Keywords: Traumatic Brain Injury, Non-Contrast CT, Head Trauma, Intracranial Hemorrhage, Emergency Imaging

INTRODUCTION

Traumatic brain injury (TBI) is a major public health concern and remains one of the leading causes of death and long-term neurological disability worldwide. ^[1,2] The burden of TBI is particularly high in low- and middle-income countries, where rapid urbanization, increasing motor vehicle use, and limited trauma care infrastructure contribute to higher incidence and poorer outcomes. ^[3] Road traffic accidents are the most common cause of TBI, followed by falls, interpersonal violence, and sports-related injuries. ^[4] Individuals affected by TBI often experience a wide spectrum of clinical manifestations, ranging from mild concussion to severe brain damage with permanent functional impairment. Early and accurate identification of intracranial injury is crucial in the management of TBI, as delayed diagnosis may lead to secondary brain injury, increased morbidity, and mortality. ^[5] Timely intervention based on imaging findings can significantly influence clinical decision-making, including the need for neurosurgical intervention, intensive monitoring, or conservative management. ^[6] Therefore, neuroimaging forms a cornerstone in the initial evaluation of patients presenting with head trauma. Among available imaging modalities, non-contrast

computed tomography (NCCT) of the brain is widely accepted as the first-line investigation in acute traumatic brain injury. [7] NCCT is fast, readily available in emergency settings, and highly effective in detecting acute intracranial haemorrhage, skull fractures, cerebral contusions, mass effect, and midline shift. [8] These features make it particularly valuable in unstable patients and in situations where rapid clinical decisions are required. Although magnetic resonance imaging (MRI) offers superior sensitivity for detecting diffuse axonal injury and subtle parenchymal lesions, its limited availability, longer acquisition time, and higher cost restrict its routine use in the acute trauma setting. [9,10] NCCT provides immediate and reliable information that directly influences emergency management, especially in identifying lesions requiring urgent surgical intervention. [11] Given the continued reliance on NCCT in emergency neuroimaging, it is essential to understand the spectrum of CT findings in patients with traumatic brain injury and their clinical relevance. This study was therefore undertaken to evaluate the role of non-contrast CT in the initial assessment of TBI and to analyze the pattern of intracranial findings in patients presenting with head trauma. [12]

Aim: To evaluate the role of non-contrast computed tomography (NCCT) in the initial assessment of traumatic brain injury (TBI). **Objectives:** To determine the frequency of abnormal NCCT findings, identify the common intracranial lesions detected, correlate CT findings with the severity of TBI, and assess the usefulness of NCCT in guiding early clinical management.

MATERIALS AND METHODS

Study Design and Setting: A cross-sectional observational study was conducted in the Department of Radiology of a tertiary care hospital over a period of six months.

Study Population: A total of 156 patients with clinically suspected traumatic brain injury referred for NCCT brain were included.

Inclusion Criteria: Patients of all genders aged ≥ 18 years. History of blunt head trauma. Patients undergoing NCCT within 24 hours of injury

Exclusion Criteria: Penetrating head injuries. Patients with known intracranial pathology prior to trauma. Postoperative cases. Patients with incomplete clinical data.

Imaging Technique: All patients underwent noncontrast CT of the brain using a multidetector CT scanner. Axial sections were obtained with standard brain window and bone window settings. Additional reformatted images were reviewed when required.

Data Collection and Analysis: Clinical data including

age, gender, mechanism of injury, and Glasgow Coma Scale (GCS) score were recorded. CT findings were categorized and analyzed using descriptive statistics. Association between CT findings and TBI severity was assessed.

RESULT

Demographic and Clinical Characteristics: A total of 156 patients with traumatic brain injury (TBI) underwent non-contrast computed tomography (NCCT) of the head during the study period. The study population comprised 102 males (65.4%) and 54 females (34.6%), demonstrating a male predominance. The mean age was 39.6 ± 15.8 years, with the highest proportion of patients occurring during the third and fourth decades of life. Road traffic accidents were the predominant mechanism of head injury, accounting for **91 cases (58.3%)**, followed by falls (29.5%), assaults (7.7%), and sports-related injuries (4.5%), as illustrated in Figure 1.

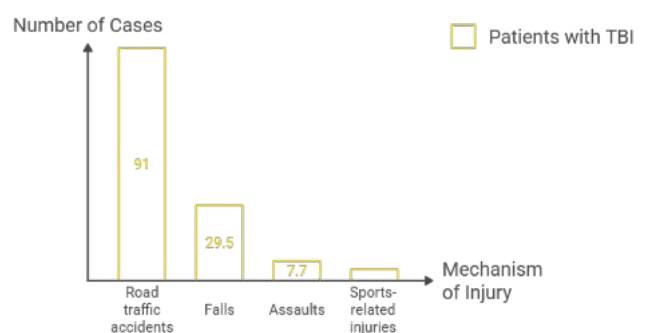


Figure 1. Mechanisms of Traumatic Brain Injury

NCCT Findings and Pattern of Intracranial Injury: NCCT demonstrated intracranial abnormalities in 112 patients (71.8%), whereas 44 patients (28.2%) showed no detectable intracranial abnormality, as illustrated in Figure 2.

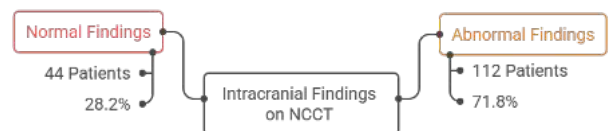


Figure 2. Intracranial Findings on NCCT

Multiple traumatic abnormalities were observed in a proportion of patients. Cerebral contusion was the most frequently identified CT abnormality, present in 60 patients (38.5%), followed by skull fractures in 54 (34.6%) and intracranial hemorrhage in 49 (31.4%). Among specific hemorrhagic lesions, subdural hematoma was identified in 36 patients (23.1%), followed by subarachnoid hemorrhage in 28 (17.9%) and epidural hematoma in 22 (14.1%). Cerebral edema was present in 41 patients (26.3%), while midline shift was

observed in 19 patients (12.2%). The distribution of CT abnormalities is presented in Table 1.

Table 1. Distribution of NCCT Findings in Patients with TBI

CT finding	Number of patients (n=156)	Percentage (%)
Cerebral contusion	60	38.5
Skull fracture	54	34.6
Intracranial hemorrhage	49	31.4
Subdural hematoma	36	23.1
Cerebral edema	41	26.3
Subarachnoid hemorrhage	28	17.9
Epidural hematoma	22	14.1
Midline shift	19	12.2

Note: Percentages exceed 100% because some patients had more than one CT abnormality.

Association Between CT Findings and TBI Severity:

Based on the Glasgow Coma Scale (GCS), 88 patients (56.4%) had mild TBI (GCS 13–15), 41 (26.3%) had moderate TBI (GCS 9–12), and 27 (17.3%) had severe TBI (GCS ≤8). A clear relationship was observed between increasing TBI severity and the extent of intracranial abnormalities on NCCT. Patients with severe TBI demonstrated a substantially higher frequency of multiple intracranial lesions, cerebral edema, and midline shift compared with patients with mild TBI.

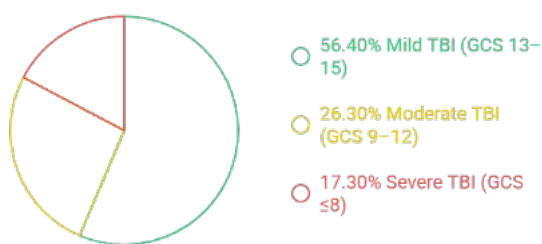


Figure 3. Distribution of TBI Severity Levels

Multiple intracranial lesions were identified in approximately 74% of patients with severe TBI, compared with 22% of those with mild TBI. Similarly, midline shift was present in 48% of severe TBI cases, compared with only 5% of mild cases. Cerebral edema showed a comparable severity-dependent pattern, occurring in 62% of severe TBI patients compared with 12% of patients with mild TBI. These findings demonstrate an increasing burden of structural intracranial abnormalities with increasing clinical

severity of TBI and highlight the value of NCCT in the early assessment of patients with significant head trauma.

DISCUSSION

Traumatic brain injury (TBI) is an important cause of morbidity and mortality, particularly among young and economically active individuals. In the present study, males constituted 65.4% of the study population, with a mean age of 39.6 ± 15.8 years. This male predominance is consistent with the greater exposure of men to road traffic, occupational, and outdoor activities associated with traumatic injury. Road traffic accidents (RTAs) were the leading mechanism of injury, accounting for 58.3% of cases, highlighting the continuing importance of road trauma as a major cause of head injury.

Role of NCCT in Traumatic Brain Injury: NCCT demonstrated intracranial abnormalities in 112 patients (71.8%), confirming its utility as an initial imaging modality in acute TBI. Its rapid acquisition, wide availability, and high sensitivity for acute hemorrhage, skull fractures, cerebral contusions, cerebral edema, and mass effect make it particularly valuable in emergency settings. In the present study, cerebral contusion (38.5%) was the most frequent abnormality, followed by skull fracture (34.6%) and intracranial hemorrhage (31.4%). Among hemorrhagic lesions, subdural hematoma (23.1%) was more common than epidural hematoma (14.1%). These findings reflect the heterogeneous patterns of structural injury produced by blunt head trauma. Cerebral edema was identified in 26.3% of patients, whereas midline shift was present in 12.2%. Both findings are clinically important because they indicate significant intracranial mass effect and may be associated with increased intracranial pressure and the risk of neurological deterioration. Their recognition on initial NCCT can therefore facilitate timely neurological or neurosurgical assessment.

Association with TBI Severity: A severity-dependent pattern of CT abnormalities was observed. Patients with severe TBI (GCS ≤8) demonstrated substantially higher frequencies of multiple intracranial lesions, cerebral edema, and midline shift than patients with mild TBI. Multiple lesions were present in 74% of severe cases compared with 22% of mild cases, while midline shift occurred in 48% and 5%, respectively. Cerebral edema was also considerably more frequent among severe TBI patients (62% vs. 12%). These findings indicate that increasing clinical severity is associated with a greater burden of structural intracranial injury on NCCT and support the use of CT findings alongside GCS for early risk assessment.

Clinical Implications: The findings reinforce the role of NCCT as the principal initial imaging investigation in acute TBI. Rapid identification of hemorrhage, fractures,

edema, and mass effect can assist in clinical triage, monitoring, and decisions regarding neurosurgical consultation or intervention. This is particularly relevant in resource-limited settings where immediate MRI availability may be restricted. Nevertheless, NCCT has limited sensitivity for certain injuries, particularly diffuse axonal injury, subtle brainstem injury, and some early ischemic changes. MRI may therefore be indicated when neurological findings are unexplained by NCCT or when clinically suspected injuries require further characterization.

CONCLUSION

Non-contrast CT is a rapid, accessible, and effective first-line imaging modality for the initial evaluation of traumatic brain injury. In this study, NCCT identified intracranial abnormalities in 71.8% of patients, with cerebral contusion, skull fracture, and intracranial hemorrhage being the most frequent findings.

DECLARATION

Ethical Approval: The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC). All procedures were performed in accordance with the ethical standards laid down in the Declaration of Helsinki (2013).

Informed Consent: Informed consent was obtained from all participants or their legally authorized representatives prior to inclusion in the study.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

Funding: No funding was received for this study from any public, commercial, or non-profit organization.

Data Availability: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contributions: All authors contributed equally to the study conception, data collection, analysis, and manuscript preparation. All authors read and approved the final manuscript.

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