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Original Research Article

ROLE OF NON-CONTRAST COMPUTED TOMOGRAPHY IN THE EVALUATION AND PROGNOSTICATION OF CRANIOCEREBRAL TRAUMA: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Craniocerebral trauma (CCT) is a major cause of morbidity and mortality worldwide, particularly among young adults. Prompt identification of intracranial lesions is essential for effective management and improved outcomes. Computed tomography (CT) has become the primary imaging modality in the acute evaluation of head injury due to its rapid acquisition, wide availability, and high diagnostic accuracy. This study was designed to evaluate the role of computed tomography in patients with craniocerebral trauma and to analyse the spectrum of CT findings in relation to clinical severity.

Materials and Methods: This prospective cross-sectional study included 200 patients with craniocerebral trauma who underwent non-contrast CT of the brain at a tertiary care center. Clinical severity was assessed using the Glasgow Coma Scale (GCS). CT findings were evaluated for skull fractures, extra-axial haemorrhages, intra-axial lesions, diffuse cerebral edema, and mass effect. Data were analysed using descriptive statistics.

Results: Young adult males were the most commonly affected group, and road traffic accidents were the predominant mode of injury. Abnormal CT findings were observed in 92% of cases. Linear skull fractures were the most frequent fracture type. Subdural hematoma and cerebral contusions were the most common intracranial lesions. Moderate and severe head injuries showed a higher prevalence of significant CT abnormalities, including diffuse cerebral edema and midline shift.

Conclusion: Computed tomography plays a crucial role in the early detection and characterization of intracranial injuries in craniocerebral trauma. It facilitates timely intervention, aids in prognostication, and remains the imaging modality of choice in the acute setting.

Keywords: Craniocerebral trauma, Traumatic brain injury, Computed tomography, Glasgow Coma Scale, Intracranial hemorrhage, Multidetector CT.

INTRODUCTION

Craniocerebral trauma (CCT) remains a leading cause of mortality, long-term disability and socioeconomic loss worldwide, disproportionately affecting adolescents and young adults involved in road traffic incidents and high-energy trauma. Recent global burden estimates demonstrate a rising incidence of traumatic brain injury (TBI) and substantial geographic variation in cause and outcome, underscoring the continuing public-health urgency of improved prevention, triage and acute care pathways.[1]

Computed tomography (CT) of the head has become the corne imaging in suspected CCT because it is rapid, widely available, highly sensitive for acute haemorrhage and skull fracture, and well suited to unstable or ventilated patients who cannot tolerate longer MRI examinations. CT not only detects life-threatening extra-axial collections (epidural, subdural, subarachnoid hemorrhage) and large intraparenchymal bleeds, but also provides critical information on mass effect, midline shift, and basal cistern status that directly inform neurosurgical decision-making and early prognostication.[2,3]

Because of the need to balance diagnostic utility, radiation exposure and resource use, validated clinical decision rules (such as the Canadian CT Head Rule) are widely used to identify which patients with mild head injury require immediate CT scanning. These rules based on variables such as Glasgow Coma Scale (GCS) score, loss of consciousness, suspected skull fracture, vomiting and focal neurological signs have safely reduced unnecessary imaging while maintaining high sensitivity for clinically significant intracranial lesions. Implementation of such rules improves consistency of emergency practice and optimizes CT utilization in busy trauma centres.[4]

Contemporary trauma guidelines emphasize an integrated approach in which imaging findings are combined with clinical assessment to guide early management. The fourth edition of the guidelines from the Brain Trauma Foundation includes imaging-driven recommendations for the timing of CT, indications for repeat imaging, and thresholds for neurosurgical referral, reflecting the central role of CT in acute care pathways for moderate and severe TBI. Prompt detection and evacuation of surgically treatable lesions (for example large epidural hematoma with mass effect) remains a key determinant of survival and neurological outcome.[5]

While MRI offers superior sensitivity for non-haemorrhagic parenchymal injury, diffuse axonal injury and small microhaemorrhages particularly on susceptibility-weighted and diffusion sequences MRI is generally reserved for the subacute or chronic phase, or where CT is non-diagnostic despite persistent neurological deficit. Recent comparative assessments confirm that CT and MRI are complementary: CT is preferred for rapid emergency assessment, and MRI provides incremental diagnostic detail that can explain prolonged impairment when CT is normal.[6,7]

Given evolving CT technology (multidetector acquisition, thinner slices and advanced post-processing) and the persistent burden of CCT, there is a continuing need to characterize CT-detected injury patterns in local patient populations and to correlate imaging features with clinical severity and outcomes. Such data support triage algorithms, guide neurosurgical resource planning and reinforce public-health interventions targeted at the dominant causes of injury in each region. The present study (see uploaded study protocol) therefore examines the spectrum of NCCT findings in patients with craniocerebral trauma and evaluates their relationship with clinical severity and the need for urgent intervention.

MATERIALS AND METHODS

This prospective cross-sectional study was conducted in the department of Radiodiagnosis at Alluri Sitarama Raju Academy of Medical Sciences (ASRAM), Eluru from January 2025 to December 2025. A total of 148 cases with craniocerebral trauma hospitalized in surgical wards were recruited. Cases referred for CT scan with craniocerebral trauma and willing to participate were included. Cases with hypertension, diabetes mellitus, with bleeding disorders, history of previous cerebrovascular, hepatic injury, hepatic injury, splenic injury and not willing to participate were included. Written informed consent was obtained from all the cases and study protocol approved by the institutional ethics committee.

Clinical Evaluation:

A detailed clinical history was obtained for each patient, including mechanism and mode of injury, time since injury, and associated symptoms such as loss of consciousness, vomiting, seizures, or focal neurological deficits. Neurological status at presentation was assessed using the Glasgow Coma Scale (GCS). Based on GCS score, patients were categorized as having mild (GCS 13–15), moderate (GCS 9–12), or severe head injury (GCS ≤8).

CT Imaging Protocol:

All patients underwent non-contrast computed tomography (NCCT) of the brain using a multidetector CT scanner. Axial images were acquired from the skull base to the vertex with appropriate slice thickness. Additional thin sections and bone window reconstructions were obtained wherever necessary to evaluate skull fractures. Standard brain and bone window settings were used for optimal assessment of intracranial and osseous abnormalities.

Image Interpretation:

CT images were independently reviewed by experienced radiologists. The scans were evaluated for the presence of skull fractures, extra-axial haemorrhages (epidural, subdural, and subarachnoid hemorrhage), intra-axial lesions (cerebral contusions and intracerebral hemorrhage), intraventricular hemorrhage, diffuse cerebral edema, mass effect, midline shift, and herniation. The location and extent of lesions were documented.

Outcome Measures:

The primary outcome measure was the detection and characterization of intracranial lesions on CT. Secondary outcomes included correlation of CT findings with clinical severity as assessed by GCS and identification of lesions requiring urgent neurosurgical intervention.

Statistical Analysis

Data were recorded in a Microsoft Excel spreadsheet and analysis was conducted using SPSS v.26.0. Descriptive statistics were used to summarize demographic variables, clinical parameters, and CT findings. Results were expressed as frequencies and percentages.

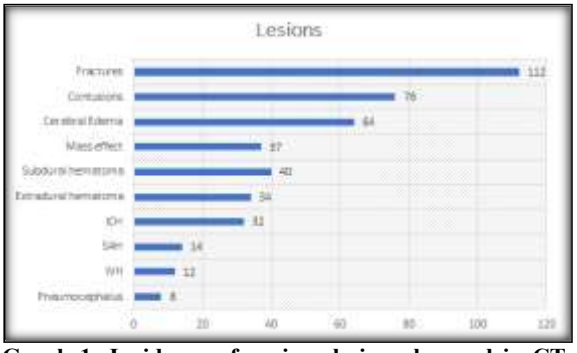
RESULTS

Table 1: Sociodemographic profile of study participants.

Parameters	Total no of cases (n=148)	
	Frequency	Percentage
Age (In years)		
0-20	22	14.8%
21-30	46	31.08%
31-40	34	22.9%
41-50	24	16.2%
51-60	10	6.75%
>60	12	8.10%
Gender		
Male	124	83.78%
female	24	16.2%

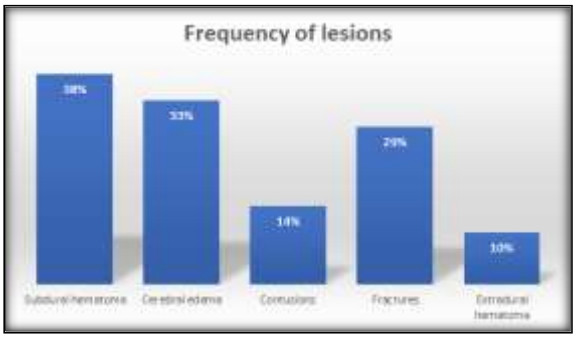
Table 2: Fracture profile among study participants.

Parameters	Total no of cases (n=148)	
	Frequency	Percentage
Mode of injury		
Road traffic accident	102	68.9%
Falling	39	26.35%
Assault	07	4.72%
Grading of head injury (GCA score)		
Mild (13-14)	65	43.91%
Moderate (9-12)	53	35.81%
Severe (<8)	30	20.27%
Type of fracture		
Linear	82	55.4%
Depressed	16	10.8%
Skull base	14	9.45%
Cranio-cerebral injuries		
Normal CT scans	16	10.8%
Abnormal CT scans	132	89.2%



Graph 1: Incidence of various lesion observed in CT scan.

*ICH-Intracerebral hematoma, SAH-Subarachnoid hemorrhage, IVH-Intraventricular hemorrhage.



Graph 2: Frequency of lesions in the cases who expired (n=21).

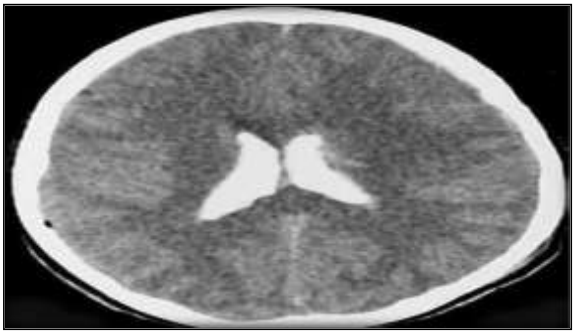


Figure 1: Axial NECT image shows hyperdense blood filling the body of the lateral ventricles on both sides in a patient of trauma

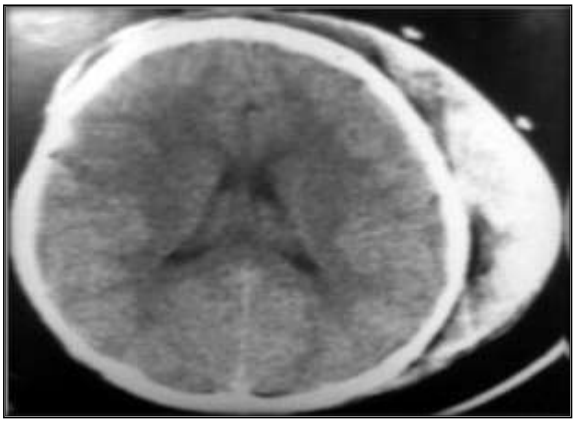


Figure 2: Axial NECT in a patient with trauma shows SUBGALEAL HEMATOMA in the left parietal region

DISCUSSION

Craniocerebral trauma (CCT) continues to represent a major public health burden, particularly in low- and middle-income countries where road traffic accidents (RTAs) predominate. In the present study, the majority of patients were young males in the 21–30-year age group, and RTAs constituted the leading mode of injury. These findings are consistent with global epidemiological patterns reported by the World Health Organization, which highlights RTAs as a principal cause of traumatic brain injury (TBI) among economically productive age groups. Similar demographic trends have been documented in multicentric analyses published in PubMed- and Scopus-indexed journals, emphasizing male predominance due to greater exposure to vehicular travel and occupational risks.[8,9]

The high proportion of abnormal CT scans (89.2%) in our cohort underscores the central role of non-contrast computed tomography (NCCT) in acute head injury evaluation. This aligns with current neurotrauma guidelines from the Brain Trauma Foundation, which recommend immediate CT imaging in moderate to severe TBI and in selected mild cases with risk factors.[10] Previous large-scale observational studies have reported abnormal CT findings in 70 to 90% of moderate-to-severe head injuries, supporting the diagnostic yield observed in our study.[2,11] The sensitivity of CT for detecting acute hemorrhage, skull fractures, and mass effect explains its continued dominance as the first-line imaging modality in emergency settings.

Skull fractures were predominantly linear (55.4%), followed by depressed and skull base fractures. Linear fractures are commonly associated with RTAs and may coexist with underlying intracranial hemorrhage. Prior studies have shown that the presence of skull fracture significantly increases the probability of intracranial lesions, particularly epidural hematoma.[12] Depressed fractures, although less frequent, carry a higher risk of cortical laceration and infection, often necessitating surgical intervention. Our findings reinforce the importance of meticulous bone window evaluation in NCCT protocols.

Regarding intracranial lesions, extra-axial haemorrhages and cerebral contusions were common findings, paralleling earlier radiological series.[13] Subdural hematoma (SDH) is typically associated with acceleration-deceleration injuries and is more frequent in moderate to severe TBI, whereas epidural hematoma (EDH) often correlates with temporal bone fractures and arterial bleeding. The pattern of lesions observed in our study corresponds with the pathophysiological mechanisms described in classical neurotrauma literature.[14] Furthermore, subarachnoid hemorrhage (SAH) detected on CT has been recognized as an independent predictor of poor outcome, particularly when associated with diffuse cerebral edema.[15]

Correlation of CT findings with Glasgow Coma Scale (GCS) grading demonstrated that severe head injury (GCS ≤8) was strongly associated with multiple intracranial lesions, mass effect, and midline shift. This relationship has been validated in prognostic models such as the Marshall CT classification and Rotterdam scoring system, which integrate imaging features with clinical parameters to predict mortality (16). Several studies have consistently shown that compressed basal cisterns, significant midline shift (>5 mm), and extensive hemorrhage are associated with higher mortality and unfavourable functional outcomes.[2] The frequency of lesions among expired cases in our series further supports the prognostic relevance of CT-based indicators.

Notably, 10.8% of patients had normal CT scans despite clinical features of head injury. This subset likely represents cases of concussion or diffuse axonal injury (DAI) not readily apparent on NCCT. Magnetic resonance imaging (MRI), particularly susceptibility-weighted imaging (SWI), has been shown to be more sensitive for detecting microhaemorrhages and non-haemorrhagic axonal injury.[7] However, due to logistical constraints and the need for rapid decision-making, CT remains the preferred initial modality in acute settings.

The predominance of RTAs in our cohort is consistent with epidemiological data from developing regions, where enforcement of traffic regulations and helmet use may be suboptimal.[8] Preventive strategies including road safety legislation, public awareness campaigns, and early trauma care systems are essential to reduce the incidence and severity of TBI. Imaging studies such as ours contribute to resource planning by identifying patterns of injury and the proportion requiring neurosurgical intervention.

From a management perspective, early identification of surgically treatable lesions such as large EDH, SDH with significant midline shift, or depressed fractures facilitates timely neurosurgical referral. Evidence suggests that rapid evacuation of mass lesions within the “golden hour” significantly improves survival.[17] The high prevalence of abnormal CT findings in moderate and severe TBI groups in our study highlights the need for immediate imaging access in tertiary care centres.

Our study has certain limitations. Being a single-center study, the findings may not be fully generalizable. Additionally, long-term functional outcomes were not assessed. Future prospective studies integrating CT-based scoring systems with clinical follow-up would provide more comprehensive prognostic insights.

In conclusion, the present study reaffirms that NCCT is indispensable in the evaluation of craniocerebral trauma. The spectrum of CT abnormalities correlates strongly with clinical severity and outcome, and early detection of surgically significant lesions remains crucial for reducing mortality. Continuous refinement of imaging protocols and integration with

clinical decision rules will further enhance patient triage and management in acute neurotrauma care.

CONCLUSION

In conclusion, computed tomography remains the imaging modality of choice in the acute assessment of craniocerebral trauma. Its speed, availability, diagnostic accuracy, and compatibility with emergency care settings make it indispensable in trauma management. Early CT evaluation, combined with thorough clinical assessment, plays a critical role in guiding treatment decisions, predicting outcomes, and improving overall patient care in head injury cases.

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