

ROLE OF COMPUTED TOMOGRAPHY IN ACUTE TRAUMATIC HEAD INJURY PATIENTS-A CROSS SECTIONAL STUDY

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ABSTRACT

Background: CT is the single primary modality in the evaluation of patients with acute head injuries. With these, a study was taken to find various clinic-radiological patterns of head injuries and to correlate the CT features with clinical operative findings. **Material and Methods:** A cross-sectional study was conducted in Dept. of Radiodiagnosis, JNIMS in which all patients referred for NCCT following acute head trauma were included. After collecting background information on socio-demography, clinical history and Glasgow Coma Scale, all the patients were subjected to non-contrast CT scan was done. **Results:** Young adults between 21 and 40 years of age were the most affected group (38.3%), with a male predominance (61.2%). Regarding the mode of injury, RTAs (46.4%) emerged as the most common cause of TBI, followed by falls (24.5%) and assaults (20.4%). Skull fractures were seen in 76.2% of abnormal CT scans (40.8% of all patients). Extradural hematoma (EDH) was seen in 43.8% with strong association of EDH with skull fractures. Subdural hematomas (SDH) were present in 13.3%. Subarachnoid hemorrhage (SAH) was seen in 18.1%. Cerebral contusions were seen in 14.3% with 3.8% DAI detection rate in our study. Patients with severe TBI (GCS \leq 8) exhibited a higher incidence of intracranial pathology, particularly contusions, hematomas, and midline shift. Moderate TBI (GCS 9–12): 91% had abnormal CT findings, indicating that CT is essential for risk stratification and management. Almost all patients with severe TBI (GCS \leq 8) exhibited critical intracranial pathology, requiring intensive monitoring and possible surgical intervention. **Conclusion:** CT scanning remains the primary imaging modality for diagnosing intracranial injuries following head trauma, particularly within the first 48 hours. Its role is crucial in initial assessment, treatment planning, follow-up and long-term management, enabling timely and accurate intervention for patients with acute head injuries. Early CT imaging, combined with GCS-guided clinical assessment, is essential for prompt diagnosis, risk stratification, and management of TBI patients in tertiary care settings.

INTRODUCTION

Traumatic Brain Injury (TBI) is characterized as damage to the brain caused by an external force, leading to an alteration in its normal function. This injury can occur due to various mechanisms, including blunt trauma such as in motor vehicle accidents or falls or rotational forces as seen in shaken baby syndrome or severe whiplash.^[1]

Traumatic Brain Injury (TBI) is a global health concern, leading to disability, mortality, and long-term neurological issues. According to the World Health Organization (WHO), nearly 10 million individuals worldwide sustain TBI annually (WHO, 2015). The impact is especially severe in developing

countries like India, where factors such as road accidents, falls, and violent incidents contribute significantly to its prevalence.^[2]

Various mechanisms causing trauma to brain lead to diverse pathological changes in the brain, such as contusions, hemorrhages, edema, and skull fractures. The complexity of TBI comes from its broad spectrum of clinical presentations, ranging from altered consciousness and focal neurological deficits to cognitive impairments and psychiatric disturbances, with severity depending on the extent and location of the injury.

Traumatic Brain Injury in India: A Growing Concern

Traumatic Brain Injury (TBI) has emerged as a significant public health issue in developing nations

like India, driven by rapid urbanization, increasing population, and a raise in road traffic accidents. According to the National Crime Records Bureau (NCRB) 2022 report, road accidents remain the leading cause of accidental deaths, accounting for 171,100 fatalities and 423,158 injuries in 2022.

TBI is not solely limited to road accidents; other contributing factors like falls, violence, and sports-related injuries. The situation is particularly concerning in rural and semi-urban areas, where limited access to trauma care, inadequate road safety regulations, and delayed medical interventions exacerbate patient outcomes. States like Uttar Pradesh, Tamil Nadu, and Maharashtra reported the highest number of traffic accident fatalities, collectively accounting for 34.6% of all such deaths in India.^[3]

Manipur: A Region with Unique Challenges

Manipur, located in the northeastern part of India, presents a distinct context for the study of TBI. The state is characterized by a rugged, hilly terrain and a relatively underdeveloped healthcare infrastructure. The incidence of road traffic accidents, particularly involving motorcycles, has been steadily rising in recent years due to increased vehicular traffic and the poor condition of roadways. The mountainous geography also contributes to a higher frequency of falls, often resulting in head injuries, especially in rural areas where people are more likely to travel in risky conditions. Additionally, regions such as Manipur have seen a significant rise in traffic accident cases, increasing from 366 in 2021 to 510 in 2022, highlighting the need for improved road safety measures and emergency healthcare accessibility. The growing burden of TBI underscores the necessity for enhanced trauma care facilities, improved imaging services, and widespread public awareness campaigns, especially in regions where healthcare resources remain constrained.^[3]

Moreover, Manipur's healthcare system is often overwhelmed due to the increasing number of trauma cases, which often go undiagnosed or poorly managed due to the lack of specialized trauma care, also the availability of advanced imaging modalities like CT scans is limited to a few major hospitals, which significantly affects the timely diagnosis of TBI.

This study aims to explore the patterns of traumatic brain injuries in the region, specifically focusing on the CT profiles of acute head trauma patients at a tertiary care center in the state of Manipur.

MATERIALS AND METHODS

A Cross-sectional study was conducted in the Department of Radiodiagnosis, Jawaharlal Nehru

Institute of Medical Sciences (JNIMS), Imphal during the period Jan 2023 – July 2025. The study participants were patients of all ages and genders referred for non-contrast computed tomography brain (NCCT Brain) following acute head trauma. Patients with prior neurological deficits or history of previous head injury, acute head injury associated with spinal injury, polytrauma, on anticoagulant therapy, prior CNS infections or known CNS pathologies, intoxicated patients and those who were not willing to participate were excluded.

A sample size of 196 was calculated based on overall CT positivity of 50.9% in acute head trauma cases from a previous study, a 95% confidence level and an absolute allowable error of 7. Participants were recruited consecutively.

At enrollment, data were recorded by using a pre-tested proforma. It had sections on (i) socio-demography (ii) clinical history including cause of trauma, time since injury and mode of transport (iii) initial assessment for Glasgow Coma Scale (GCS), vital signs and neurological deficits and (iv) Non-contrast CT (NCCT) Brain findings. A GE Healthcare 50 CT scanner, Model 5858588-2, China was used for it. With patient supine positioned, head first and arms by their side, scout AP and lateral was taken for marking scan extent from C2 vertebra to vertex directed caudocranially with slice thickness <1mm. Tube voltage was kept at 120 kVp for adults and 100 kVp for children.

Data were analyzed using SPSS version 27.0 (IBM Corp., Chicago, IL, USA) and GraphPad Prism. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Comparisons of means between independent groups were performed using the unpaired t-test. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Completed data sets could be collected from 196 participants which included 120 (61.2%) and 74 females (37.8%) and two third gender. Age-wise, majority of them (75, 38.3%) belonged to 21-40 years. The various modes of injury were road traffic accidents (91, 46.4%), fall (48, 24.5%), assault (40, 20.4%) and others (17, 8.7%). Abnormal CT images could be seen in 60.4% of RTA, 43.8% in falls, 52.5% of assault cases and 47.1% of other modes of injuries. And this was found to be statistically significant (p=0.033).

Table 1: Distribution of participants by mode of injury

Mode of Injury	Frequency (%)	Abnormal CT (%)	p-value
RTA	91 (46.4)	55 (60.4)	0.033
Fall	48 (24.5)	21 (43.8)	
Assault	40 (20.4)	21 (52.5)	
Others	17 (8.7)	8 (47.1)	

Table 2 shows the distribution of the participants by Glasgow Coma Scale and CT findings. A total of 137 patients (69.9%) had a mild GCS of 13-15, while 46 patients (23.5%) had a moderate score of 9-12 whereas, the remaining 13 patients (6.6%) had a severe score of 3-8. CT abnormality could be

observed in one-third (37.2) of the mild GCS category whereas, it could be seen in 91.3% and 92.3% of the moderate and severe categories, respectively. This difference was found to be statistically significant ($p=0.27$).

Table 2: Glasgow Coma Scale (GCS) Distribution

GCS Category	CT Abnormal (%)	CT Normal (%)	Total (%)	p-value
Mild (13–15)	51 (37.2)	86 (62.8)	137 (69.9)	0.027
Moderate (9–12)	42 (91.3)	4 (8.7)	46 (23.5)	
Severe (3–8)	12 (92.3)	1 (7.7)	13 (6.6)	
Total	105	91	196	

Nearly half of the patients (43.7%) showed skull fracture on CT. This was followed by extradural hemorrhage (25.2%) followed by subarachnoid hemorrhage, subdural hematoma, cerebral

contusions, diffuse axonal injury etc. Out of all the CT abnormalities, skull fracture was the commonest abnormality seen (76.2%), which was followed by extradural hematoma (43.8%). [Table 3]

Table 3: Specific CT Abnormalities Observed

Lesion Type	Frequency (%)	Percentage of all CT abnormalities
Skull Fracture	80 (43.7)	76.2
Extradural Hematoma	46 (25.2)	43.8
Subarachnoid Hemorrhage	19 (10.4)	18.1
Subdural Hematoma	14 (7.6)	13.3
Cerebral Contusions	15 (8.2)	14.3
Diffuse Axonal Injury	4 (2.1)	3.8
Other Findings	5 (2.8)	4.8

Table 4 shows the presenting symptoms among patients with acute head trauma. Headache was the most common complaint, reported by 123 patients (62.8%). Loss of consciousness was noted in 116 cases (59.2%), vomiting in 73 cases (37.2.1%), ENT

bleed in 45 cases (23.0%) and seizures in 29 cases (14.8%), These clinical features are critical indicators for the need to perform CT imaging. The high prevalence of headache and loss of consciousness underscores their diagnostic importance.

Table 4: Clinical Presentations (Symptoms)

Symptom	Normal CT (Present)	Abnormal CT (Present)	Normal CT (Absent)	Abnormal CT (Absent)	p-value
Headache	54	69	37	36	0.4399
Loss of consciousness	42	74	49	31	0.0009
Vomiting	26	47	65	58	0.0285
Altered Sensorium	11	23	80	82	0.105
Seizures	9	20	82	85	0.05
ENT Bleed	6	39	85	66	<0.0001
Speech Disturbance	4	18	87	87	0.0095
Sensory Loss	4	11	87	94	0.1843
Limb Weakness	3	15	88	90	0.016

Some of common CT findings seen are depicted below (Figures 1-5).



Figure 1: Traumatic Cerebral contusion with surrounding edema in bilateral frontal lobes more on right frontal lobe causing mass effect and midline shift

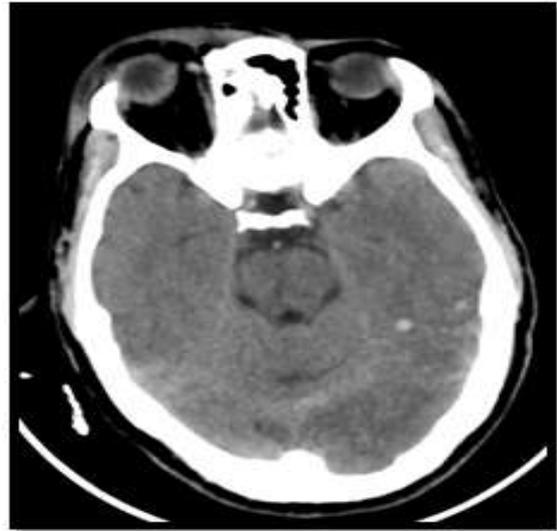


Figure 4: Two punctate hyperdensities at left parietal grey-white matter junction suggesting diffuse axonal injury. MRI revealed the same with few other locations in the right side also

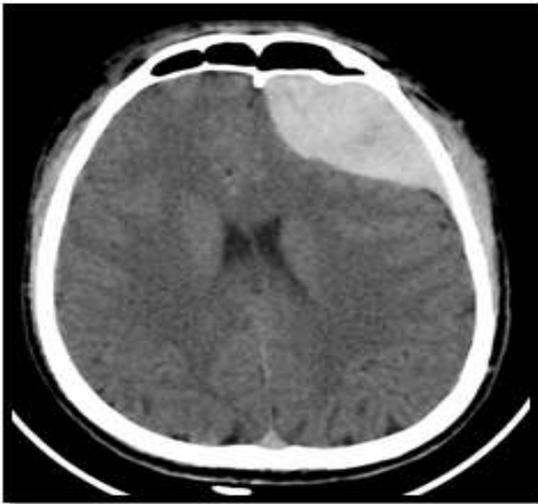


Figure 2: Hyperdense hemorrhagic collection in biconvex shape representing an acute epidural hematoma at left frontal region

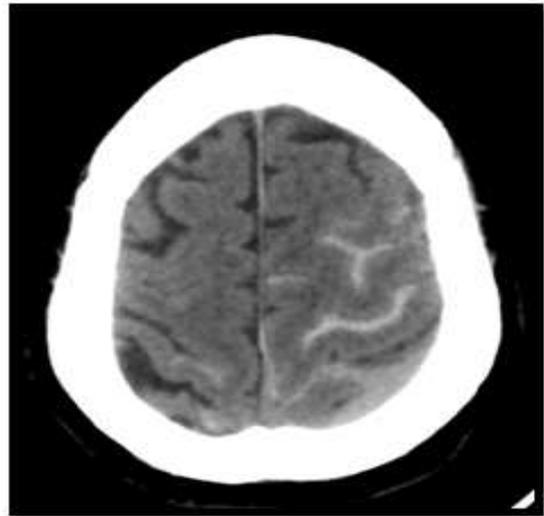


Figure 5: Hyperdense streaks within left frontal and parietal sulci following RTA suggesting traumatic subarachnoid hemorrhage

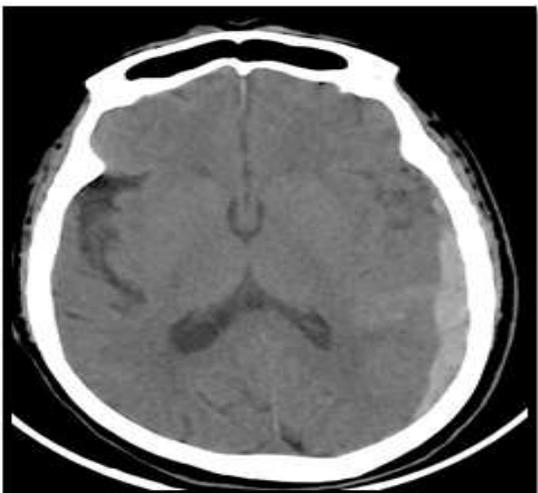


Figure 3: Crescent shaped hyperdensity along the left temporoparietal convexity representing acute subdural hematoma

DISCUSSION

1. Demographic Patterns and Mode of Injury

The study revealed that young adults between 21 and 40 years of age were the most affected group, accounting for 38.3% of cases. There was a clear male predominance (61.2%), which aligns with findings from multiple previous studies indicating that males are at a higher risk for TBI due to greater exposure to high-risk activities such as driving, construction work, and contact sports. Similar demographic patterns have been observed in studies by Gupta et al,^[4] and Kirankumar et al,^[5] where the majority of TBI cases were reported in males in the age group of 21–30 years.

Regarding the mode of injury, RTAs (46.4%) emerged as the most common cause of TBI, followed

by falls (24.5%) and assaults (20.4%). This trend is consistent with previous epidemiological studies on head trauma in India and other developing nations, where motor vehicle accidents account for 50–60% of TBIs. The rising incidence of RTAs, particularly in urban areas, highlights the need for enhanced traffic regulations, strict enforcement of helmet and seatbelt laws, and public awareness campaigns on road safety.

Falls were the second leading cause, predominantly affecting older adults and children. The high incidence of fall-related TBIs in the elderly can be attributed to age-related balance impairments, osteoporosis, and frailty, which increase the risk of intracranial hemorrhages, even with low-impact trauma. A study by Maharjan et al,^[6] emphasized that fall-related TBIs were more frequent in pediatric and geriatric populations.

Assault-related TBIs (20.4%) were also a significant contributor, particularly among younger males. This suggests that interpersonal violence remains an important public health issue requiring targeted interventions such as violence prevention programs, mental health support, and community policing.

2. CT Findings and Their Clinical Implications

We found skull fractures in 76.2% of abnormal CT scans (40.8% of all patients). This is similar to the 82% skull fracture prevalence reported in the Singh Tomar et al,^[7] study in India. Extradural hematoma (EDH) was seen in 43.8% of abnormal scans, which is higher than the 35% EDH rate reported by Rao DVR et al,^[8] but lower than the 54.7% reported by Yadav et al.^[9] The strong association of EDH with skull fractures in our study aligns with global findings.

Subdural hematomas (SDH) were present in 13.3%, which is lower than the 21% SDH rate reported by Adeyekun et al,^[10] but within the range observed in multiple international studies. The high incidence of extradural hematomas (EDH) and subdural hematomas (SDH) highlights the importance of early detection and timely neurosurgical intervention, as these injuries can lead to rapid neurological deterioration if left untreated.

Our study found subarachnoid hemorrhage (SAH) in 18.1% of abnormal CT scans, similar to the 16.4% rate in the study by Mebrahtu-Ghebrehwet et al,^[11] in Eritrea.

Cerebral contusions were seen in 14.3%, which is lower than the 43.4% reported by Yadav et al,^[9] but closer to the 16% rate observed by Avtar et al,^[12] in India.

Our 3.8% DAI detection rate is lower than the 10–15% range reported in studies using MRI for better sensitivity, such as those by Aquino et al,^[13] and Buttram et al.^[14] This emphasizes the limited role of CT in diagnosing mild DAI, reinforcing the need for MRI in select cases.

3. Correlation Between Glasgow Coma Scale (GCS) and CT Findings

A significant association was observed between lower GCS scores and abnormal CT findings

($p=0.027$). Patients with severe TBI (GCS ≤ 8) exhibited a higher incidence of intracranial pathology, particularly contusions, hematomas, and midline shift. This aligns with previous studies, where GCS ≤ 8 correlated with increased risk of neurosurgical intervention and mortality. Mild TBI (GCS 13–15): 53.3% had normal CT findings, suggesting that clinical assessment alone may suffice in select cases, reducing unnecessary radiation exposure. Moderate TBI (GCS 9–12): 91% had abnormal CT findings, indicating that CT is essential for risk stratification and management. Severe TBI (GCS ≤ 8): Nearly all cases exhibited critical intracranial pathology, requiring intensive monitoring and possible surgical intervention.

The findings of this study have important regional implications. The dominance of RTAs highlights the urgent need for: strict enforcement of helmet and seatbelt laws, road infrastructure improvement, public awareness campaigns and strengthening of pre-hospital trauma care.

Furthermore, the strong correlation between GCS and CT abnormalities supports the continued use of GCS-guided imaging protocols in emergency settings.

Although this study provides valuable insights into the CT profile of TBI in acute head trauma patients, certain limitations must be acknowledged. The study being a cross-sectional one lacks follow-up on patient outcomes post-discharge. Again, there was limited use of MRI. Future studies should incorporate advanced imaging modalities for a comprehensive assessment of TBI.

CONCLUSION

The study reaffirms that, CT scanning remains the primary imaging modality for diagnosing intracranial injuries following head trauma, particularly within the first 48 hours. Its role is crucial in initial assessment, treatment planning, follow-up and long-term management, enabling timely and accurate intervention for patients with acute head injuries. Early CT imaging, combined with GCS-guided clinical assessment, is essential for prompt diagnosis, risk stratification, and management of TBI patients in tertiary care settings. Strengthening road safety measures, improving pre-hospital trauma care, and ensuring timely access to CT facilities are crucial to reducing the burden of head injury in Manipur.

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