RESEARCH PAPER

Role of Computed Tomography Imaging in Traumatic Head Injury and Correlate with Clinical Outcomes

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ABSTRACT

Background:

Traumatic brain injury (TBI) is a common and serious issue. In a country like India, which is rapidly developing, urbanization and industrialization have led to an increase in road transportation, which in turn results in head injuries from road traffic accidents. CT is the current procedure of choice over MRI because it is faster and more readily available. CT is quick, cost-effective, non-invasive method to assess the time and extent of cerebral injury.

Objectives:

To evaluate non-contrast head CT findings in traumatic brain injury, including skull fractures, ventricular changes, cerebral contusions, hemorrhages etc., and to study how common head injuries are, what causes them, and which groups of people (like age and gender) are most affected.

Material & Methods:

This cross-sectional observational study was conducted at NIMS Hospital, Jaipur, Rajasthan on 71 patients with traumatic brain injury over a study period about 6 months who underwent non-contrast CT Head scan and data is taken with participant consent by conducting an interview about the mechanism of injury and by analyzing the clinical findings. Imaging findings were correlated with symptoms.

Results:

In Traumatic Brain Injury, Road Traffic Accidents (RTA) represent the overwhelming majority of traumatic brain injuries, accounting for 70.42% of all cases. Falls constitute the second most common mechanism (21.13%), while physical assault contributes to 7.04% of injuries. The predominance of RTA underscores the critical need for enhanced road safety interventions and preventive strategies targeting vehicular trauma.

Conclusion:

This study demonstrates that computed tomography (CT) is an essential and reliable tool in the evaluation of traumatic brain injury, providing rapid and accurate detection of skull fractures, contusions, intracranial hemorrhage and midline shift.

Keywords: Traumatic Brain Injury (TBI), Intracranial Hemorrhage, Contusions, midline shift, Computed Tomography, Subdural, Subarachnoid, Intraparenchymal, Intraventricular hemorrhages.

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INTRODUCTION

Traumatic brain injury (TBI) is a common and serious issue. In a country like India, which is rapidly developing, urbanization and industrialization have led to an increase in road transportation, which in turn results in head injuries from road traffic accidents. [1] CT is the current procedure of choice over MRI because it is faster and more readily available. CT is quick, cost- effective, non- invasive method to assess the time and extent of cerebral injury. [1]Traumatic brain injury is a widespread and harmful problem in developing nations such as India. The main reason for the rise in road transportation in recent years is urbanization and industrialization, which contribute to a higher occurrence of head injuries due to road traffic accidents.[2] Informed written consent was taken from all the participants. The patients with a head injury, cranio-facial trauma who underwent CT scanning were included in the study. [2]Traumatic head injury is a significant health concern today, often causing death or long-term neurological issues particularly among young adults and middle-aged people.[3]There is evidence that prompt neurological management of TBI can significantly improve outcome, especially if decompression is performed within 48 hours of injury.[3]CT is the most important modality in evaluation of patients with traumatic head injury. Conventional CT is widely accessible, cost- effective, quick to perform and easy to use for patients who require ventilator support, are in traction or agitated. It is the preferred initial imaging method within the first 24 hours after the injury.[1, 2]Based on two observational studies conducted on different continents, contusion, SAH, SDH, IVH are associated with adverse outcomes. These routinely obtained imaging findings can be used to identify patients at risk for unfavorable outcomes and improve clinical trial design.

CT FINDINGS IN HEAD TRAUMA

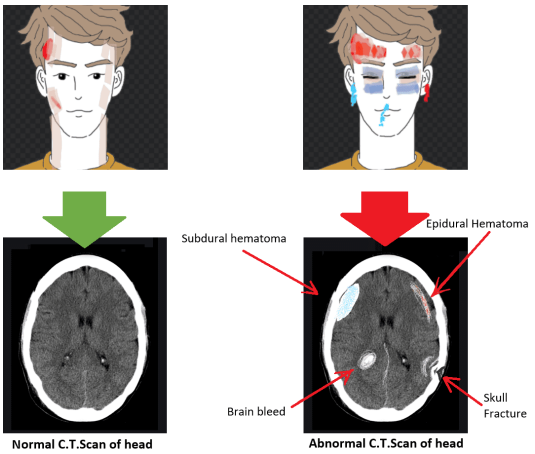

Figure: The above figure on left side is showing a normal non-contrast head CT scan with one showing significant traumatic brain injuries. The "Abnormal C.T. Scan" on the right side of the image highlights three life-threatening conditions often associated with blunt force trauma: an epidural hematoma, a subdural hematoma, brain bleed (intracranial hemorrhage) along a skull fracture.

PATHOPHYSIOLOGY AND CLINICAL ASPECTS

Primary brain injuries result from serious head trauma and cannot be prevented. These injuries are always severe and can be life- threatening. However, if diagnostic and treatment steps are started quickly following a cranio-cerebral injury, additional harm to the brain can be avoided, and the persons' life can be saved within 24 hours. [5] Traumatic Brain Injury is a major cause of illness and death in children. Head CT scans are commonly used to assess the effects of trauma, decide on treatment, and track any complications in early stages. [6]Apart from the patient's demographic profile detailed history and examination was recorded and Special emphasis was laid on history of loss of consciousness, ENT bleed, seizures, vomiting. Qualitative evaluation in some studies stated that several imaging sequences that modify the outcome of the patients, including extra-axial and intra-axial hemorrhage, mid line shift, signs of edema, presence of cranial fractures, intracranial hemorrhage, diffuse axonal injury (DAI) [10]Traumatic Brain Injury (TBIs) are of two types namely primary, secondary. Primary injury occurs after the initial trauma and may include intracranial haemorrhage and skull fractures that can damage the brain or it may leads to infection. Primary injuries can be diffuse or localized.

Secondary injuries develop gradually over days or even weeks and results from subsequent alterations in micro-environment and cellular mechanism.[11]In most of the studies, they included that when any abnormality was found on the non-contrast CT scan, most probably the patho-anatomic lesion types were skull fractures, contusions and acute subdural hemorrhage. [12]

MATERIAL AND METHODS: This study was performed on CT SIEMENS HEALTHNEERS SOMATOM GO TOP 128 slices CT scanner. Non contrast axial images reconstructed by standard algorithm like iterative reconstruction from brain CT scans. Slice thickness in soft tissue 2-3 mm and bony window with 1mm. Images are reconstructed by multi-planar reconstruction (MPR) techniques. Patients were positioned supine with head immobilized. This is a Cross sectional study done in NIMS University, Rajasthan, Jaipur. This study includes patients undergoing for non contrast CT head scan with traumatic brain injury, over 71 patients. Patients of all gender and all age groups who undergone head trauma. Data were analyzed using SPSS version 26.0. Descriptive statistics were expressed as frequencies (n) and percentages (%) for categorical variables, and mean ± standard deviation for continuous variables. Associations were assessed using Pearson's Chi-square test or Fisher's Exact test where appropriate. An independent-samples t-test compared the mean age between outcome groups. Logistic regression identified independent predictors of poor outcome. A two-tailed p-value <0.05 was considered statistically significant.

SELECTION OF PATIENTS:

A study on 71 patients from Radiology Department of NIMS Hospital, Rajasthan, Jaipur with traumatic brain injury (TBI) to correlate with clinical outcomes. The patients who undergone traumatic brain injury with road traffic accidents, falls, physical assaults and others who undergone non contrast CT scan after injury. All NCCT scans were performed on Siemens Somatom go Top expandible upto 128 slices. All examinations were performed using the NIMS institution standardized imaging protocol for NCCT head scans.

RESULT

A total of 71 traumatic brain injury patients undergoing a non-contrast CT head scan were included. Demographic, clinical, radiological, and outcome data were analyzed.

Age Group	Frequency (n)	Percentage (%)
≤24 years	18	25.35
25-44 years	30	42.25
45-64 years	17	23.94
≥65 years	6	8.45
Total	**71**	**100.00**

TABLE 1: AGE DISTRIBUTION OF STUDY POPULATION (N=71)

Mean Age ± SD: 35.21 ± 16.84 years. The highest proportion of traumatic brain injury cases occurred in the 25-44 years age group (42.25%), representing the economically productive segment of the population. Combined with the ≤24 years group (25.35%), young and middle-aged adults (≤44 years) constitute 67.60% of all cases. The mean age of 35.21 ± 16.84 years confirms that TBI predominantly affects younger individuals, with a progressive decline in frequency among older age groups (Table 1, Figure 1).

Gender	Frequency (n)	Percentage (%)
Male	56	78.87
Female	15	21.13
Total	**71**	**100.00**

TABLE 2: GENDER DISTRIBUTION OF STUDY POPULATION (N=71)

A marked male predominance is observed, with males accounting for 78.87% of traumatic brain injury cases compared to 21.13% for females. The male-to-female ratio of approximately 3.73:1 reflects greater male exposure to high-risk activities, occupational hazards, and road traffic scenarios. This gender disparity is consistent with established epidemiological patterns in trauma literature.

Mechanism of Injury	Frequency (n)	Percentage (%)
Road Traffic Accident	50	70.42
Fall	15	21.13
Physical Assault	5	7.04
Other	1	1.41
Total	**71**	**100.00**

TABLE 3: MECHANISM OF INJURY DISTRIBUTION (N=71)

Road Traffic Accidents (RTA) represent the overwhelming majority of traumatic brain injuries, accounting for 70.42% of all cases. Falls constitute the second most common mechanism (21.13%), while physical assault contributes to 7.04% of injuries. The predominance of RTA underscores the critical need for enhanced road safety interventions and preventive strategies targeting vehicular trauma (Table 3, Figure 3).

Common Symptoms*	Frequency (n)	Percentage (%)
Headache	62	87.32
Dizziness	42	59.15
Vomiting	22	30.99
Loss of Consciousness (LOC)	14	19.72
Confusion	14	19.72
Seizures	8	11.27

TABLE 4: DISTRIBUTION OF CLINICAL SYMPTOMS (N=71)

Multiple symptoms per patient; percentages calculated from total N=71Headache emerged as the most prevalent symptom, reported by 87.32% of patients, serving as a near-universal indicator of traumatic brain injury. Dizziness (59.15%) and vomiting (30.99%) represent important clinical markers of vestibular dysfunction and elevated intracranial pressure. Neurological red flag symptoms including loss of consciousness (19.72%), confusion (19.72%), and seizures (11.27%) were observed in a substantial minority, identifying patients at higher risk for significant intracranial pathology requiring urgent CT evaluation.

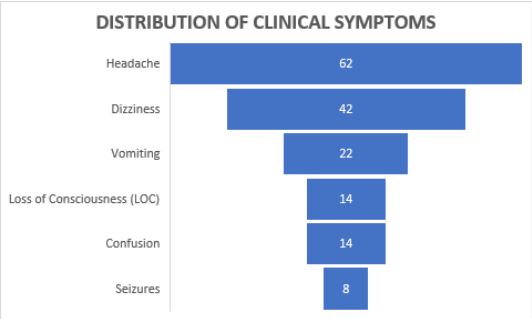

Figure 4: DISTRIBUTION OF CLINICAL SYMPTOM

Major CT Findings	Frequency (n)	Percentage (%)
Skull Fracture	40	56.34
Hemorrhagic Contusion	27	38.03
Subdural Hematoma	11	15.49
Subarachnoid Hemorrhage	11	15.49
Midline Shift	8	11.27
Epidural Hematoma	5	7.04
Intraparenchymal Hemorrhage	5	7.04
No Abnormality	10	14.08

TABLE 5: DISTRIBUTION OF MAJOR CT FINDINGS (N=71)

Skull fractures were the most frequent radiological finding, present in 56.34% of patients. Among intracranial hemorrhages, hemorrhagic contusions predominated (38.03%), followed by subdural hematoma and subarachnoid hemorrhage (each 15.49%). Midline shift, a critical indicator of mass effect and elevated intracranial pressure, was noted in 11.27% of cases. Notably, 14.08% of patients with clinical suspicion of TBI demonstrated no significant CT abnormality, consistent with mild traumatic brain injury or concussion syndromes without structural damage.

CASE STUDY

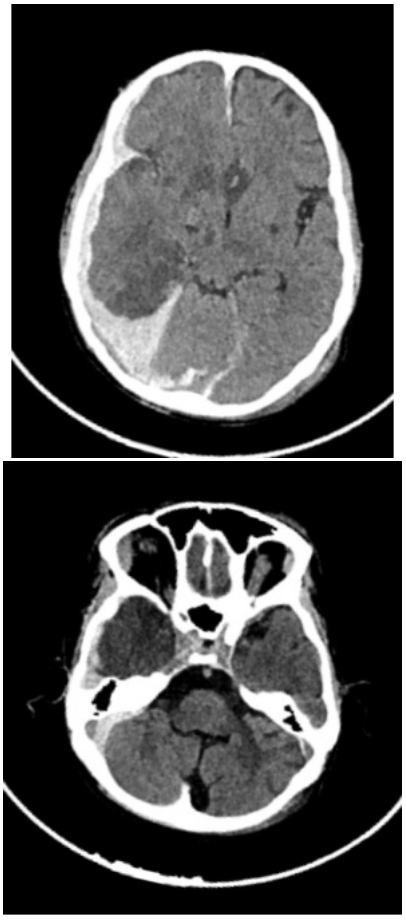

Figure : A 14-yr old male patient who fall from height undergone head trauma and have symptoms like severe headache, altered mental status and nausea undergone non contrast CT scan of brain which showed findings like SDH in right frontal, parietal and temporal lobe and SAH in falx cerebri and falx tentorium.

DISCUSSION:

Traumatic brain injury (TBI) is a major cause of morbidity and mortality worldwide, with computed tomography (CT) playing a major role in its early evaluation and management. In the present study, a total of 71 patients were analyzed to assess the correlation between CT findings and clinical outcomes. The majority of the patients belonging to the 25–44 years age group (42.25%), indicating that TBI predominantly affects the middle aged group. Similar findings have been reported and also observed a higher incidence of TBI in young adults due to over speeding, distracted driving activities, so that road traffic accidents are common in young adults in which similar study done by **Anand et al.** and **Ramanana Rao DV et al**..[7,1]A marked male predominance (78.87%) was observed in this study, which is consistent with previous studies and it reflects men are more exposed to outdoor because of family responsibilities compared to women similar study done by **Rathaur SK et al**. and **Kajoak et al**.[2,9]Road traffic accidents (70.42%) were identified as the most common mechanism of injury, followed by falls. There are some studies in which they highlighted the road traffic accidents as the main cause of TBI, particularly in developing countries, similar study done by **Patil NJ et al.** and **Munakomi S et al**.[5,8]Among clinical features, headache (87.32%) was the most common symptom, followed by dizziness and vomiting. These findings are comparable to some studies, in which they concluded that these symptoms are common indicators prompting CT evaluation, similar study done by **Anand A et al**.[7]In CT findings, skull fractures (56.34%) were the most frequent, followed by hemorrhagic contusions (38.03%) and subdural/subarachnoid hemorrhages. Similar patterns have been reported by **Lolli V et al**.[3] which emphasized the utility of CT in detecting fractures and intracranial hemorrhages. Notably, 14.08% of patients had normal CT findings, which correlates with mild TBI cases as described in the TRACK-TBI (Transforming Research and Clinical Knowledge in Traumatic Brain Injury) investigators study.

CONCLUSION

This study demonstrates that computed tomography (CT) is an essential and reliable tool in the evaluation of traumatic brain injury, providing rapid and accurate detection of skull fractures, contusions, intracranial hemorrhage and midline shift. Traumatic brain injury predominantly affects young adult males, with

road traffic accidents being the leading cause. Among radiological findings, skull fractures seen in 40 patients (56.34%), hemorrhagic contusions seen in 27 patients (38.03%), subdural hematoma seen in 11 patients (15.49%), subarachnoid hemorrhage seen in 11 patients (15.49%), midline shift seen in 8 patients (11.27%), epidural hematoma seen in 5 patients (7.04%) and intraparenchymal hemorrhage seen in 5 patients (7.04%)were the most common radiological findings, midline shift and specific intracranial hemorrhagic patterns were the strongest predictors of patient outcome and no significant abnormalities seen in 10 patients (14.08%). Thus, in cases of traumatic brain injury, CT imaging helps doctors diagnose problems quickly, determine the level of risk and predict recovery, leading to better, faster management of the patient.

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