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Original Research Paper

Radio-Diagnosis

"ROLE OF COMPUTED TOMOGRAPHY IN CRANIOCEREBRAL TRAUMA"

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ABSTRACT

Background: Traumatic brain injury (TBI) remains a significant cause of morbidity and mortality worldwide, especially in low- and middle-income countries. With the rise in road traffic accidents (RTAs), TBI incidence is increasing, affecting predominantly young and middle-aged individuals. Early diagnosis using clinical and radiological tools is essential for effective management and outcome prediction. This study aimed to evaluate the clinical presentations, CT imaging findings, and Glasgow Coma Scale (GCS) scores in TBI patients, and to assess their prognostic value, particularly the impact of midline shift on outcomes. **Materials And Methods:** A prospective observational study was conducted at the Department of Radiodiagnosis, Sri Aurobindo Medical College & PG Institute, Indore, over 18 months. Two hundred patients with head trauma who underwent CT imaging were included. Data regarding demographics, clinical features, GCS scores, and CT findings were analyzed. Associations between midline shift, GCS, and outcomes were assessed using statistical tests. **Results:** Most patients were males (80%) aged 31–50 years. RTAs were the most common cause (59.5%). Frequent CT abnormalities included skull fractures (42%), cerebral edema (38%), and epidural hemorrhage (35%). A strong negative correlation was observed between GCS scores and midline shift ($r = -0.800$; $p < 0.001$). Severe midline shift (>5 mm), low GCS, and diffuse axonal injury were significantly associated with poor outcomes and higher mortality. **Conclusion:** GCS scores and CT-based parameters, especially midline shift and diffuse axonal injury, are critical prognostic indicators in TBI. Early clinical and radiological assessment can optimize management and improve patient outcomes.

KEYWORDS : Traumatic Brain Injury, Glasgow Coma Scale, Midline Shift, Computed Tomography, Prognosis

INTRODUCTION

Traumatic brain injury (TBI) has emerged as a major public health concern globally, particularly in rapidly developing nations where industrialization and urbanization have increased the incidence of road traffic accidents (RTAs)-a leading cause of head injuries. As Hippocrates aptly stated, "No head injury is so minor as to be neglected, nor so serious as to be disregarded." Most victims of TBI are young, economically productive individuals, which amplifies both the emotional toll on families and the economic burden on society [1].

TBI refers to brain dysfunction caused by an external mechanical force, such as a blow or jolt to the head. It is classified into primary injuries—resulting directly from trauma—and secondary injuries—arising from complications such as edema, hemorrhage, or ischemia [3]. Despite global advancements in medical care, TBI remains a leading cause of morbidity and mortality in individuals under 40 years of age and is projected to become one of the top causes of death and disability by 2030 [4,5]. The World Health Organization reports that nearly 90% of injury-related deaths occur in low- and middle-income countries (LAMICs), where prehospital care and rehabilitation services are often inadequate [6,7]. India alone accounts for 1.5 to 2 million TBI cases and 1 million deaths annually [8,9].

In the last decade, the role of rapid neuroimaging, particularly Computed Tomography (CT), has gained prominence in the evaluation and management of craniocerebral trauma. CT is crucial not only for initial diagnosis but also for grading injury severity and monitoring complications [10,11]. The Glasgow Coma Scale (GCS), though essential for clinical assessment, may fail to detect subtle intracranial injuries, necessitating adjunctive imaging [12–14]. CT remains the gold standard due to its speed, accessibility, and capacity to detect acute hemorrhages, skull fractures, and mass effects [15].

Despite its limitations in identifying diffuse axonal injuries or early ischemic changes, CT has revolutionized emergency TBI care, with newer-generation scanners offering faster acquisition and better image resolution [16,18]. This study aims to explore CT's diagnostic and prognostic value in acute head injury patients, its correlation with GCS, and its impact on surgical decision-making.

MATERIAL AND METHODS

After approval from the Institutional Ethics Committee, a cross-sectional observational study was conducted in the Department of Radiodiagnosis at Sri Aurobindo Medical College & Postgraduate Institute (SAMC & PGI), Indore. The study spanned 18 months, from June 1, 2023, to November 30, 2024, and included patients presenting twith head trauma who underwent CT imaging.

A total of 200 patients were enrolled, based on a calculated sample size using an effect size of 0.40, 95% confidence level, and 80% power. The estimated number was feasible given the department's consistent trauma caseload of approximately 15–16 patients per month requiring CT head scans. Written informed consent was obtained from all participants or their legal guardians prior to inclusion in the study.

Inclusion Criteria

All patients presenting with craniocerebral trauma and undergoing CT head imaging during the study period.

Exclusion Criteria

- Patients unwilling to give informed consent.
- Patients for whom CT imaging was contraindicated.

Imaging Methodology

All included patients underwent non-contrast computed tomography (CT) of the head using a Philips 128 slice CECT scanner (Incisive CT). Scans were performed with patients in the supine position, ensuring proper immobilization for optimal imaging. Bone window algorithms and wide window settings were employed for detailed evaluation of:

- Skull fractures
- Intracranial hemorrhages (epidural, subdural, subarachnoid, and intracerebral)
- Cerebral edema
- Midline shift

Clinical Assessment And Data Collection

At the time of presentation, each patient's clinical profile was documented using a structured proforma. Relevant data collected included demographics (age and gender), clinical history, Glasgow Coma Scale (GCS) score, and CT findings. Particular emphasis was placed on identifying the presence and degree of midline shift on CT, which was then correlated with the GCS score to assess the severity of the brain injury. This comprehensive data collection facilitated both clinical and radiological evaluation.

Statistical Analysis

Data were compiled using Microsoft Excel 2010 and analyzed with SPSS 26.0 software. Descriptive statistics were applied to summarize the data, with mean and standard deviation (SD) calculated for continuous variables, and frequencies and percentages for categorical variables. For inferential analysis, the Chi-square test was employed to assess associations between categorical variables. The correlation between quantitative variables such as GCS score and degree of midline shift was evaluated using Pearson's or Spearman's correlation coefficient, depending on the normality of data distribution. The findings were graphically represented using scatter plots, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

The study population consisted of 200 patients with craniocerebral trauma. The majority were middle-aged, particularly within the 31–50 years age group, which accounted for approximately 50% of the sample. Males predominated, forming 80% of the cohort, likely reflecting greater exposure to outdoor or occupational hazards.

Among clinical complications, headache (50.5%) and loss of consciousness (48.5%) were the most common, indicating significant neurological impact in nearly half the cases. Vomiting (21%), seizures (7.5%), and ear bleeding (2%) were less frequently observed.

Road traffic accidents (RTA) emerged as the leading mode of injury, responsible for 59.5% of cases, followed by falls from height (21.5%) and assaults (14%), highlighting the need for preventive strategies in traffic safety and trauma care.

On CT evaluation, the most prevalent findings were fractures (42%), edema (38%), and epidural hemorrhage (35%). Subdural hemorrhage, contusions, and intracerebral bleeds were also notable. Less common but severe findings included diffuse axonal injury (9%), intraventricular hemorrhage (8.5%), and infarcts (3%), suggesting diverse injury patterns.

Only 23% of patients required surgical intervention, indicating that most injuries were managed conservatively. Despite the severity of presentations, the outcome was favorable in most cases-with 69% achieving complete recovery and 17% showing improvement. However, 14% mortality reflects the critical nature of head injuries and underscores the importance of early diagnosis and prompt intervention.

Overall, the findings emphasize that middle-aged males involved in RTAs are most at risk, and that CT imaging plays a crucial role in diagnosis, prognosis, and guiding management decisions in craniocerebral trauma.

Table 1: Distribution Of Study Population Based On Demographic, Clinical, And Radiological Parameters (N = 200)

Parameter	Category	Frequency	Percentage (%)
Age Group (Years)	1–10	4	2.0
	11–20	10	5.0
	21–30	44	22.0
	31–40	49	24.5
	41–50	51	25.5
	51–60	21	10.5
	61–70	17	8.5
	71–80	4	2.0
Gender	Male	160	80.0
	Female	40	20.0
Complications	Headache	101	50.5
	Loss of Consciousness	97	48.5
	Vomiting	42	21.0
	Seizures	15	7.5
	Ear Bleed	4	2.0
Mode of Injury	Road Traffic Accident	119	59.5
	Fall from Height	43	21.5
	Blunt/Assault	28	14.0
	Other	10	5.0
CT Findings	Fracture	84	42.0
	Edema	76	38.0
	Epidural Hemorrhage (EDH)	70	35.0
	Subdural Hemorrhage (SDH)	42	21.0
	Contusion	42	21.0
	Intracerebral Hemorrhage	41	20.5
	Subarachnoid Hemorrhage	24	12.0
	Diffuse Axonal Injury	18	9.0
	Intraventricular Hemorrhage	17	8.5
	Infarcts	6	3.0
Surgical Intervention	Not Required	154	77.0
	Required	46	23.0
Outcome	Complete Recovery	138	69.0
	Improved	34	17.0
	Death	28	14.0

The correlation analysis demonstrated a **strong, statistically significant negative relationship** between **Glasgow Coma Scale (GCS) scores** and **midline shift** measured on CT scans. A **Pearson correlation coefficient of -0.800** indicates that patients with **lower GCS scores** (indicating more severe neurological impairment) tend to have **greater midline shifts**, reflecting more severe intracranial pathology.

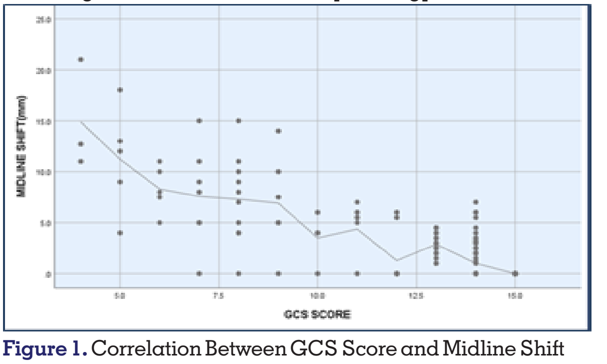

Figure 1. Correlation Between GCS Score and Midline Shift

The analysis revealed a significant association between midline shift severity and both age and GCS score. Patients aged ≥60 years had a higher incidence of >5 mm midline shift, indicating more severe brain injury compared to younger individuals (p = 0.000). Similarly, lower GCS scores were strongly associated with greater midline shifts, with 70% of severely injured patients (GCS 3–8) exhibiting >5 mm shift (p = 0.000). In contrast, no significant association was found between gender and midline shift grade (p = 0.390). Overall, increasing age and worsening neurological status were linked to more pronounced midline shifts on CT imaging.

Table 2 : Association Between Midline Shift Grade and Demographic & Clinical Variables (N = 200)

Variable	Category	No Shift	≤5 mm Shift	>5 mm Shift	Total	p-value
Age Group	< 60 years	108 (60.7%)	43 (24.2%)	27 (15.2%)	178	0.000 (Sig)
	≥ 60 years	3 (13.6%)	10 (45.5%)	9 (40.9%)	22	
	Total	111 (55.5%)	53 (26.5%)	36 (18.0%)	200	
Gender	Female	20 (50.0%)	14 (35.0%)	6 (15.0%)	40	0.390 (NS)
	Male	91 (56.9%)	39 (24.4%)	30 (18.8%)	160	
	Total	111 (55.5%)	53 (26.5%)	36 (18.0%)	200	
GCS Score	Mild (13–15)	98 (68.5%)	41 (28.7%)	4 (2.8%)	143	0.000 (Highly Sig)
	Moderate (9–12)	11 (40.7%)	5 (18.5%)	11 (40.7%)	27	
	Severe (3–8)	2 (6.7%)	7 (23.3%)	21 (70.0%)	30	
	Total	111 (55.5%)	53 (26.5%)	36 (18.0%)	20	

***Chi square test; P value<0.05 was considered statistically significant**

Variable		Complete Recovery (%)	Improved (%)	Death (%)	p-value
Demographic Variables					
Age	< 60 years	77.5	10.7	11.8	0.000
	≥ 60 years	0.0	68.2	31.8	0.000
Gender	Female	82.5	2.5	15.0	0.023
	Male	65.6	20.6	13.8	0.023
Clinical Severity					
GCS Score	Mild (13–15)	90.9	9.1	0.0	0.000
	Moderate (9–12)	25.9	63.0	11.1	0.000
	Moderate (9–12)	25.9	63.0	11.1	0.000
	Severe (3–8)	3.3	13.3	83.3	0.000
Radiological Parameters – Midline Shift					
Midline Shift	No Shift	94.6	3.6	1.8	0.000
	≤5 mm Shift	60.4	32.1	7.5	0.000
	>5 mm Shift	2.8	36.1	61.1	0.000
CT Findings					
Finding	Fracture – Absent	81.9	12.9	5.2	0.000
	Fracture – Present	51.2	22.6	26.2	0.000
	Contusion – Absent	77.8	12.0	10.1	0.000
	Contusion – Present	35.7	35.7	28.6	0.000
	SDH – Absent	77.8	12.7	9.5	0.000
	SDH – Present	35.7	33.3	31.0	0.000
	EDH – Absent	81.5	13.1	5.4	0.000
	EDH – Present	45.7	24.3	30.0	0.000
	SAH – Absent	74.4	11.9	13.6	0.000
	SAH – Present	29.2	54.2	16.7	0.000
	DAI – Absent	73.6	18.1	8.2	0.000
	DAI – Present	22.2	5.6	72.2	0.000
	IVH – Absent	71.6	15.3	13.1	0.031
	IVH – Present	41.2	35.3	23.5	0.031
	Edema – Absent	91.1	6.5	2.4	0.000
	Edema – Present	32.9	34.2	32.9	0.000
	ICH – Absent	77.4	10.7	11.9	0.000
	ICH – Present	36.6	41.5	22.0	0.000
	Infarcts – Absent	69.6	16.0	14.4	0.076
	Infarcts – Present	50.0	50.0	0.0	0.076

The study found that younger age (<60 years), female gender, higher GCS scores, and absence of midline shift were significantly associated with better outcomes in craniocerebral trauma (p<0.05). Patients with mild GCS had a 90.9% recovery rate, while those with severe GCS had an 83.3% mortality rate. Increasing midline shift strongly predicted poor prognosis, with >5 mm shift linked to 61.1% mortality. CT findings such as fractures, contusions, SDH, EDH, SAH, DAI, edema, IVH, and ICH were all significantly associated with increased mortality and reduced recovery (p < 0.05), particularly DAI and cerebral edema. Infarcts showed no significant association (p=0.076). Overall, clinical severity and radiological findings were strong predictors of outcome. [Table 3]

DISCUSSION

Traumatic Brain Injury (TBI) continues to pose a major global public health burden, particularly among young and middle-aged individuals who form the most economically productive segment of society. The present study conducted at the Department of Radiology, SAIMS & PG Institute, Indore, offers crucial insights into the clinical and radiological profiles of TBI patients and reinforces the prognostic value of CT imaging and Glasgow Coma Scale (GCS) scoring in evaluating injury severity and guiding management.

The demographic distribution in this study revealed a mean patient age of 39.54 ± 14.66 years, with the majority of TBI cases occurring in the 21–40-year age group (50%). This finding reflects the vulnerability of this age group due to increased exposure to occupational hazards, road traffic, and risk-prone activities. Similar observations have been made in studies by Kirankumar MR et al. [16], Yattoo GH et al. [17], Bhole AM et al. [18], Shivakumar BC et al. [19], and Arvind K et al. [20], all of which reported a peak incidence of TBI between the ages of 20 and 50 years. Furthermore, our findings align with Chaurasia AK et al. [21] and Agrawal et al. [22], who reported the highest frequency of head injuries in the 31–40 and 21–30-year groups, respectively.

Gender analysis showed a marked male predominance, with a male-to-female ratio of 4:1, reflecting regional and global trends in TBI demographics. This pattern is attributed to the higher likelihood of males being engaged in driving, occupational work, and riskier behaviors such as alcohol consumption and traffic violations. Comparable gender disparities were reported by Chaurasia AK et al. [21] and Emejulu et al. [23], with male representation exceeding 70% in their respective cohorts.

Clinically, the most frequent presenting features in our study included headache (50.5%) and loss of consciousness (48.5%). These symptoms are characteristic of both mild and moderate TBI and have been widely documented in the literature. Kirankumar MR et al. [16] and Gupta P et al. [24] similarly observed LOC and vomiting as dominant early manifestations. Bhole et al. [18] also reported headache and vomiting as primary complaints. The incidence of post-traumatic seizures was 8.9%, comparable to Bhole et al.'s [18] 8.5% and Gupta P et al.'s [24] 16.46%, highlighting the importance of neurological monitoring even in less severe cases.

Road traffic accidents (RTAs) emerged as the predominant etiology (59.5%), followed by falls from height (21.5%), a pattern mirrored in numerous Indian and international studies. Krishnakumar MR et al. [16], Yattoo GH et al. [17], Bhole AM et al. [18], Rahman MA et al. [25], and Kumar NB et al. [26] consistently emphasized RTAs—particularly involving two-wheelers—as a leading cause of TBI. The high incidence of RTAs reinforces the necessity for stringent traffic regulations and improved infrastructure. Findings from Chaurasia AK et al. [21] and Agrawal et al. [22] similarly highlighted RTAs as responsible for over 65% of TBI cases.

Radiologically, CT scan findings in this study identified cranial fractures (42%), cerebral edema (38%), and epidural hemorrhage (35%) as the most common abnormalities. These results align with Krishnakumar MR et al. [16], who noted contusions and fractures as the leading CT findings. Other corroborative studies by Yattoo GH et al. [17], Bhole AM et al. [18], and Arvind K et al. [20] reported similar imaging profiles. While contusions were predominant in some studies, scalp injuries were most frequent in the series by Tandle RM et al. [27], indicating slight variations based on patient demographics and injury mechanisms.

Management was largely conservative (77%), with surgical intervention required in 23% of cases. This approach is consistent with Krishnakumar MR et al. [16] and others, where non-operative treatment was preferred for mild injuries. Surgical options were reserved for cases with space-occupying hematomas or raised intracranial pressure. Analysis showed that 93% of mild TBI cases were treated conservatively, while 36% of moderate-to-severe cases required surgical management, a pattern similarly observed by Yattoo et al. [17], Bhole et al. [18], and Gupta P et al. [24].

Regarding outcomes, 69% of patients in this study achieved complete recovery, 17% showed improvement, and 14% succumbed to their injuries. These trends correlate well with those reported by Krishnakumar MR et al. [16], Bhole et al. [18], and Munakomi et al. [28], who found mortality closely linked with TBI severity. Ting TW et al. [29] observed that patients with GCS <5 had a mortality rate exceeding 50%, underscoring the prognostic significance of GCS.

A statistically significant association ($p < 0.000$) was observed between GCS scores and midline shift, with greater shift correlating with lower GCS and worse outcomes. Patients with a midline shift >5 mm had a mortality rate of 61.1%, while 94.6% of those without a shift made a full recovery. These results affirm the conclusions of Chaurasia AK et al. [21] and Chiewvit P et al. [22], who noted a direct correlation between midline shift and poor prognosis. Similarly, diffuse axonal injury and subdural hemorrhage were associated with the highest mortality rates.

This study underscores the combined utility of CT imaging and GCS scoring in triaging TBI patients, predicting outcomes, and guiding management strategies. These findings reaffirm conclusions from earlier studies and support the integration of clinical-radiological data to enhance patient care. However, limitations such as single-center design, modest sample size, reliance on CT alone, and lack of long-term follow-up must be acknowledged. Future multicentric studies with extended outcome assessment and multimodal imaging could offer broader generalizability and deeper insights into TBI management and prognosis.

CONCLUSION

This study highlights the pivotal role of integrated clinical and radiological assessment in the management of traumatic brain injury (TBI). The strong correlation between Glasgow Coma Scale (GCS) scores, midline shift, and patient outcomes underscores the importance of early neurological grading and CT imaging. High-risk features such as diffuse axonal injury, significant midline shift (>5 mm), and low GCS scores were powerful predictors of mortality. Conversely, patients with mild TBI and no shift demonstrated excellent recovery. These findings advocate for timely diagnosis, risk stratification, and personalized management strategies to enhance survival and functional outcomes in TBI patients.

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