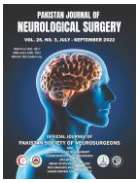

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Original Article

Midline Shift as a Predictor of Outcome in Head Trauma Patients managed Conservatively

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ABSTRACT

Objective: To evaluate the role of the degree of midline shift on CT scans in predicting clinical outcomes in traumatic brain injury (TBI).

Materials and Methods: A prospective observational study was conducted at the Department of Neurosurgery of a tertiary care hospital. We included 148 patients. After fulfilling the inclusion criteria, the patient's baseline data, including the patient's age, gender, and CT scan findings with the degree of midline shift, was noted. The patients were monitored for three months to evaluate the outcome. The collected data was analyzed using SPSS version 22.0.

Results: Our study showed that 105 (70.9%) patients showed satisfactory outcomes while 43 (29.1%) showed unsatisfactory outcomes. Patients with no midline shift were 70, out of which 55 (78.6%) showed satisfactory outcomes. Similarly, patients with 1-2 mm midline shifts showed satisfactory outcomes in 39 (69.6%) while 3-5 mm midline shifts showed 11 (50%) satisfactory outcomes. In our study, the degree of brain midline shift on CT scan was a statistically significant outcome factor ($p = 0.035$).

Conclusion: Patients with TBI who had an increasing degree of midline shift on brain CT scans had considerably worse clinical outcomes.

Keywords: Midline shift, CT scan, Glasgow Coma Score, Head Injury.

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INTRODUCTION

Traumatic brain injury (TBI) is a grave epidemic that is an important cause of death and disability worldwide.[1] Around fifty percent of the world's population is expected to suffer from one or more traumatic brain injuries (TBI) during their lifetime, with more than 50 million individuals suffering from TBI each year.[2] The Centers for Disease Control report that between 2001 and 2010 there was an increase in the overall combined rates of emergency room visits,

hospitalizations, and fatalities linked to TBI.[3] It impacts roughly 1.7 million individuals in the United States each year, making up at least 30% of all injury-related fatalities and costing approximately $60 billion per year.[4] TBI is most common in children under the age of four, as well as adolescents and young adults (15 – 24 years).[5]

TBI commonly causes a rise in intracranial pressure that can lead to a certain amount of midline shift. The more the midline shift, the worse the outcome becomes for the patient. Prediction of outcomes in TBI patients is of significant importance to take useful therapeutic decisions and evaluating their effectiveness, plan rehabilitation goals, and providing informed expectations to the family of the patient.[6-7] Therefore, a system that reliably predicts outcomes is required to correctly distribute already limited resources, especially in developing countries.

One of the most commonly used methods of classifying the severity of TBI is using the Glasgow Coma Scale (GCS).[13] GCS score enables the clinical categorization of TBI into mild, moderate, and severe categories, with associated rates of lifelong disability of 10% for mild, 60% for moderate, and 100% for severe TBI, and overall mortalities of 20 – 30%.[8] However, its use is limited in patients who are under the influence of sedation, psychoactive drugs, or alcohol, or are intubated.[16]

Classifying TBI according to morphology based on radiological findings is an alternative in such patients. Computed tomography (CT) continues to be the gold standard for diagnosing, treating, and determining the prognosis of traumatic brain injury despite recent advancements in imaging techniques.[9] Outcome of TBI patients has been linked to compression of the basal cisterns, midline shift, traumatic subarachnoid hemorrhage (tSAH), and intraventricular hemorrhage.[10-11]

One of the measures used to determine the severity of TBI is midline shift (MLS), which represents the greatest degree of horizontal brain displacement and indicates elevated ICP. Several reports have linked a large midline shift (usually greater than 5 mm) with the unfavorable outcome or with other dire consequences of TBI.[12-13]

The goal of this study was to evaluate the role of the degree of midline shift on the CT scan brain in predicting the clinical course of traumatic brain injury and to further analyze the relationship of age, gender, type of injury, pupillary size, and reactivity as drivers of the outcome.

MATERIAL AND METHODS

Study Design and Setting

This is a prospective observational study conducted from 01-01-2021 to 30-06-2021, at the department of Neurosurgery of a tertiary care hospital.

Inclusion Criteria

We included 148 adult TBI patients presenting within 24 hours of injury, who were managed conservatively.

Exclusion Criteria

Patients with penetrating head injury, bilateral fixed and dilated pupils, impending death, on anticoagulant therapy, or any other pre-existing intracranial lesion or chronic debilitating illness were excluded from the study. Patients with midline shifts of > 5mm on the CT scan or those operated upon were also excluded from our study.

Data Collection & Management

All patients underwent a CT scan utilizing a 16-slice CT scanner within 24 hours of suffering a head injury following initial resuscitation. The CT abnormalities of midline shift, epidural, subdural, intracerebral collection, and diffuse axonal injury were noted. Midline shift was measured in

millimeters and was defined as the distance between the septum pellucidum at the level of the foramina of Monro and the skull midline (the line between the anterior and posterior attachment of the falx to the skull). The degree of midline shift was divided into 3 categories i.e. no shifting, 1 – 2 mm, and 3 – 5 mm. Three subgroups were used to categorize the severity of head injuries: Mild (GCS = 13 – 15), Moderate (GCS = 9–12), and Severe (GCS = 3-8). Clinical data including mean age of the subjects, gender, cause of head injury (road traffic accident, fall, assault), GCS, pupil size and responsiveness, and final clinical status were all recorded. Following discharge, patients were tracked for up to three months in the outpatient department for clinical assessment, and the Glasgow Outcome Scale (GOS) was used to classify their outcomes as satisfactory or unsatisfactory. The GOS scores of 4 – 5 were taken as a "Satisfactory" outcome while scores from 1 – 3 were taken as an "Unsatisfactory" outcome. All patients were managed according to the latest brain trauma foundation guidelines.[26]

Data Analysis

To determine the mean, frequencies, and p values, data was analyzed using SPSS. In our research, a P value of less than 0.05 was considered significant.

RESULTS

Age & Gender Distribution

Our research showed that males made up the bulk of the head injury patients (n = 107; 72.3%), while females made up only 41 instances (27.7%), with a male: female ratio of 2.6:1. Majority of the patients in the study fell into the age group of 36 to 50 years (n = 63; 42.6%), followed by 18 to 35 years (n = 45; 30.4%) and rest (n = 40; 27%) greater than 50 years with the mean age being 41 ± 12.9 years as shown in Table I.

Table 1: Patients Demographics, Injury Characteristics, Patients Characteristics, and Study Outcome.

	Frequency (Percentage)
Patients Demographic	
Age (Mean 41.047, S.D ± 12.884)	
18-35	45 (30.4%)
36-50	63 (42.6%)
>50	40 (27%)
Gender	
Male	107 (72.3%)
Female	41 (27.7%)
Characteristics of Injury	
Mode of Injury	
Road Traffic Accident (RTA)	84 (56.8%)
Fall	37 (25.0%)
Others	27 (18.2%)
Severity of Injury	
Mild	65 (43.9%)
Moderate	52 (35.1%)
Severe	31 (20.9%)
Midline shift	
No shift	70 (47.3%)
1-2mm	56 (37.8%)
3-5mm	22 (14.9%)
CT Characteristics	
Extra Dural Hematoma (EDH)	
Present	40 (27%)
Absent	108 (73%)
Contusion	
Present	49 (33.1%)
Absent	99 (66.9%)
Subdural Hematoma (SDH)	
Present	21 (14.2%)
Absent	127 (85.8%)
Subarachnoid Hemorrhage (SAH)	
Present	44 (29.7%)
Absent	104 (70.3%)
Intraventricular Hemorrhage (IVH)	
Present	10 (6.8%)
Absent	138 (93.2%)
Skull Fracture (SF)	
Present	28 (18.9%)
Absent	120 (81.1%)
Pupils	
BERL	90 (60.8%)
Anisocoric	34 (23%)
Nonreactive (non-dilated)	24 (16.2%)
Follow up Outcome	
Satisfactory Outcome	105 (70.9%)
Unsatisfactory Outcome	43 (29.1%)

Mode of Injury

There was a preponderance of road traffic accidents (n = 84; 56.8%) as the mode of head injury, followed by falls (n = 37; 25%) and others (n = 27; 9%).

The severity of Head Injury

65 (43.9%) patients came to us with mild traumatic brain injury, 52 (35.1%) with moderate, and 31 (20.9%) with severe traumatic brain injury.

Type of Injury

CT scan of the brain revealed no intracranial abnormality in 35 (24%) patients whereas the remaining demonstrated common intracranial lesions linked to head trauma, such as contusion (n = 49; 33%), subarachnoid hemorrhage (n = 44; 30%), extradural hematoma (n = 40; 27%), skull fracture (n = 28; 19%), subdural hematoma (n = 21; 14%) and intraventricular hemorrhage (n = 10; 7%).

Midline Shift

Among these, 70 (47.3%) patients had no midline shift, while 78 (52.7%) patients had a midline shift. Out of these 78 patients, 56 (37.8%) had a midline shift of 1 – 2 mm, whereas 22 (14.9%) patients had a midline shift of 3-5 mm as demonstrated in Table 1.

Pupillary Reactivity

It was observed that 90 (60.8%) patients presented with equally reacting pupils, 34 (23%) patients had anisocoria and 24 (16.2%) patients had nonreactive (non-dilated) pupils.

Outcome

105 (71%) patients with head injuries had satisfactory outcomes (GOS 4 and 5) as opposed to 43 (29%) patients who had unsatisfactory outcomes (GOS 1, 2, and 3). Mortality in our study was 12%.

Comparison

Out of the total of 105 patients in the satisfactory outcome group, only 11 (10.5%) patients had a midline shift of 3 – 5 mm, while 55 (52.4%) patients had no shift and 39 (37.1%) patients had a shift of 1 – 2 mm. Therefore, increasing the degree of midline shift was associated with a poor outcome with P-value = 0.035. When considering patients with no midline shift, 15 out of 70 (21.4%) showed unsatisfactory outcomes as compared to 28 out of 78 (35.9%) with midline shifts with a P value of 0.052. Therefore, the increasing amount of midline shift was associated with worse outcomes but the presence or absence of midline shift, although showed worse outcomes, this, however, was statistically insignificant.

Patients with mild injury (GCS 13 – 15) at presentation had 80% (n = 52) satisfactory outcomes (GOS 4 and 5), compared to 20% (n = 13) unsatisfactory outcomes (GOS 1, 2, and 3), while patients with severe injury (GCS 3-8) experienced 64.5% (n = 20) satisfactory outcomes and 35.5% (n = 11) unsatisfactory outcomes. 63.5% (n = 33) of patients with moderate injury had a satisfactory outcome, while 36.5% (n = 19) patients had an unsatisfactory outcome. However, at the time of admission, the severity of the head injury was not significantly linked with poor outcomes (p-value = 0.099).

In the satisfactory outcome group, 68 (64.8%) patients had equally reacting pupils, 25 (23.8%) patients presented with anisocoria, and 12 (11.4%) patients presented with non-reacting pupils. Also, when taking pupillary reaction into account, 68 (75.6%) patients presenting with equally reacting pupils had satisfactory outcomes while 22 (24.4%) patients had unsatisfactory outcomes, 25 (73.5%) patients with anisocoria had satisfactory outcomes and 9 (26.5%) patients had

Table 2: Statistical Stratification of Variables with Study Outcomes with Cross Tabulation (Chi-Square).

	Outcome		Total (%)	P Value
	Satisfactory n=105 (70.9%)	Unsatisfactory n = 43 (29.1%)		
Age				
18-35	37 (82.2%)	8 (17.8%)	45 (30.4%)	0.131
36-50	41 (65.1%)	22 (34.9%)	63 (42.6%)	
>50	27 (67.5%)	13 (32.5%)	40 (27%)	
Gender				
Male	76 (71%)	31 (29%)	107 (72.3%)	0.972
Female	29 (70.7%)	12 (29.3%)	41 (27.7%)	
Mode of Injury				
RTA	63 (75%)	21 (25%)	84 (56.8%)	0.087
Fall	21 (56.76%)	16 (%)	37 (25.0%)	
Others	21 (77.8%)	6 (22.2%)	27 (18.2%)	
Severity of Injury				
Mild	52 (80.0%)	13 (20.0%)	65 (43.9%)	0.099
Moderate	33 (63.5%)	19 (36.5%)	52 (35.1%)	
Severe	20 (64.5%)	11 (35.5%)	31 (20.9%)	
Midline Shift (MLS)				
No shift	55 (78.6%)	15 (21.4%)	70 (47.3%)	0.035 (significant result)
1-2mm	39 (69.6%)	17 (30.4%)	56 (37.8%)	
3-5mm	11 (50.0%)	11 (50.0%)	22 (14.9%)	
Pupils				
BERL	68 (75.6%)	22 (24.4%)	90 (60.8%)	0.046 (significant result)
Anisocoric	25 (73.5%)	9 (26.5%)	34 (23%)	
Nonreactive	12 (50.0%)	12 (50.0%)	24 (16.2%)	

an unsatisfactory outcome. 12 (50.0%) patients presenting with non-reacting pupils had a satisfactory outcome while 12 (50.0%) patients had an unsatisfactory outcome. This was statistically significant (p-value = 0.046).

When taking age and gender into consideration, no significant association was found with the outcome with P values = 0.131 and 0.972 respectively.

DISCUSSION

TBI is a worldwide health and socioeconomic concern that is a significant cause of death and disability.[14] Combination of the clinical condition of the patient, GCS on arrival, and CT scan findings are used to make emergent decisions for proper allocation of already scarce resources. It is commonly acknowledged that the magnitude of midline displacement following traumatic brain injury is an important indicator of severe injury. Numerous studies have shown that a substantial midline shift on a CT scan is linked to a bad clinical outcome as it denotes impending herniation and brain tissue compression.[13]

In our study, the most common age group involved was the middle ages i.e., 36-50 years (42.6%) which is slightly older than other literature. Research by Chiewvit et al. indicated that in the adult population, people between 21 and 40 years are most commonly affected by head injuries with a mean age of 35.7 years.[13] Likewise Kraus demonstrated that the age group most frequently afflicted by head injuries is between 20 – 40 years. Our mean came out to be 41 years.[15]

Kraus' study reported that the prevalence of head trauma is higher in men compared to

women.[15] In another study by Palekar SG et al, the male: female ratio was 4:1 with males more commonly being affected by head trauma.[16] Similarly in our study males were more commonly affected with male to female ratio of 2.6:1.

Age and gender are important predictors of the outcome as denoted by Gan et al, who mentioned that the mortality of elderly patients was almost double that of younger ones.[17] The reason for this might lie in the fact that old aged patients already have different comorbidities apart from the already injured brain, this in addition to senile changes like decreased elasticity and atrophic changes in the brain parenchyma can cause increased mortality in the elderly group.[16] However, Fabbri et al. found no evidence that age was significantly related to the prognosis of the patients with head trauma.[18] Slewa-Younan et al, stated that the severity of TBI in males was greater than that of females.[19] In our study, however, age and gender were not significant predictors of the outcome of head injury with p-values of 0.131 and 0.972 respectively.

There is strong evidence that increasing the amount of midline shift is associated with worse outcomes.[11] A study by Jacobs et al, which included a total of 605 patients, concluded that midline shift is a significant outcome predictor in head trauma patients. He pointed out that no threshold value for the degree of midline shift concerning outcome could be found, rather it was a continuous variable.[21] However, different research done by Selladurai et al, stated that the degree of midline shift does not offer any useful prognostic data.[22] According to the results of our study, the degree of midline shift in patients with head trauma at the time of presentation was a statistically significant predictor of outcome (p = 0.035), but again no cut-off value was determined. A total of 105 (70.9%) patients showed satisfactory outcomes while 43 (29.1%) showed unsatisfactory outcomes. Patients with no midline shift were 70, out of which 55 (78.6%) showed satisfactory outcomes. Similarly, patients with 1-2 mm midline shifts showed satisfactory outcomes in 39 (69.6%) while 3-5 mm midline shifts showed 11 (50%) satisfactory outcomes.

According to the literature, the GCS score on admission has strong prognostic significance. Lower admission GCS scores are associated with worse outcomes.[16] According to a study by Selladurai et al, more than 95% of patients are likely to suffer a worse outcome if their score is 4 or lower in comparison to individuals with a score of 8 or more.[22]According to a study by Chiewvit et al, out of 46 patients with a GCS of 15, 2 cases (13.3%) and 33 patients with a GCS of 13 – 14, 1 case (3.0%), respectively, had poor outcomes, while out of 136 patients with a GCS score of 12, 46 cases (33.8%) had poor outcomes.[13] To the contrary, Lipper KH et al. found that a significant proportion of patients had Glasgow outcome scores from 5 – 7, and that it was not very useful in anticipating prognosis.[24] Similar frequency was observed in our study population, with increasing severity associated with a worse prognosis, however, this was not statistically significant (p-value = 0.099).

The abnormal pupillary reaction is associated with poor outcomes, as described in the literature.[20,23] Different intracranial lesions, midline shifts, and compressed cisterns are more common in patients with pupillary abnormalities.[25] In a study by Palekar et al, the abnormal pupillary response came out to be statistically significant in relation to outcome.[16] In our study, patients having satisfactory outcomes, 68 (64.8%) patients had equally reacting pupils, while only 37 (35.2%) patients had abnormal pupillary reactivities. This association was shown to be statistically significant in our study (p-value = 0.046).

CONCLUSION

Increased midline shift following TBI on CT scan is linked to worse clinical outcomes. Also, clinically,

abnormal pupillary reaction signifies poor outcomes. In an already resource-deficient country, these two parameters can be used to accurately predict the outcome of patients and guide clinical decision-making, providing family members with realistic expectations and assessing the efficacy of treatment.

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Additional Information

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In compliance with the ICMJE uniform disclosure form, all authors declare the following:
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AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Arfa Qasim	1. Study design and methodology.
2.	Farrukh Javeed	2. Paper writing.
3.	Raheel Gohar	3. Data collection and calculations.
4.	Rubab Qadir	4. Analysis of data and interpretation of results.
5.	Anas Ahmed	5. Literature review and referencing.
6.	Lal Rehman	6. Editing and quality insurer.