

CT EVALUATION OF MIDLINE SHIFT IN TRAUMATIC BRAIN INJURY AND ITS CORRELATION WITH CLINICAL SEVERITY

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Abstract

Background: Traumatic brain injury (TBI) is an important cause of morbidity and mortality and may result in a wide spectrum of neurological impairment. The Glasgow Coma Scale is commonly used to assess clinical Severity, whereas computed tomography (CT) provides rapid identification of structural intracranial abnormalities. Midline Shift (MLS) is an important CT finding associated with intracranial mass effect. This study evaluates the relationship between CT-measured MLS and Clinical severity in patients with traumatic brain injury.

Methods: A cross-sectional study was conducted among 40 patients with traumatic brain injury presenting to tertiary-care hospitals in Multan. We assessed clinical severity using the Glasgow Coma Scale and categorized it as mild (13-15), moderate (9-12), or severe (<8). All patients had a non-contrast CT scan. We measured midline shift in millimeters on axial CT images at the level of the third ventricle or septum pellucidum using standardized anatomical landmarks. Data were analyzed using SPSS version 26. We used descriptive statistics, chi-square tests, and Spearman's rank correlation coefficient. A p-value <0.05 was considered statistically significant.

Results: Of the 40 patients, 13 (32.5%) were female, and 27 (67.5%) were male. Twenty-three (57.5%) of the patients had mild TBI, six (15.0%) had moderate TBI, and eleven (27.5%) had severe TBI. Twenty-one (52.5%) patients had no MLS, while 19 (47.5%) exhibited midline shift. Eleven (57.9%) of the MLS patients had severe traumatic brain injury (TBI), six (31.6%) had moderate TBI, and two (10.5%) had mild TBI. On the other hand, mild TBI was present in all 21 patients who did not have MLS. The presence of MLS and the severity of TBI were found to be statistically correlated ($\chi^2 = 32.677$, $df = 2$, $p < 0.001$). The degree of MLS and the severity of TBI were found to be strongly positively correlated by Spearman's correlation ($\rho = 0.859$, $p < 0.001$).

Conclusion: In patients with traumatic brain injury, CT-detected midline shift was highly correlated with clinical severity. A higher degree of MLS was linked to a more severe TBI. Therefore, when assessing patients with traumatic brain injury, systematic evaluation of MLS on CT may offer helpful objective radiological information.

Introduction:

Traumatic brain injury can result in significant neurological morbidity and mortality, making it a significant clinical and public health issue. The effects of traumatic brain injury (TBI) can vary from moderate, temporary neurological malfunction to severe neurological impairment necessitating close observation and treatment. Therefore, an essential part of managing acute trauma is assessing the severity of injuries at presentation.

A common clinical tool for evaluating consciousness in traumatic brain injury patients is the Glasgow Coma Scale. It provides a standardized numerical evaluation of neurological status by assessing eye opening, verbal response, and motor response. In the current study, we divided TBI severity into mild, moderate, and severe groups based on GCS.

Neurological examination may not be sufficient to show the underlying structural abnormalities caused by trauma, even when clinical evaluation is crucial. Because computed tomography can quickly show intracranial structural abnormalities, it is a crucial imaging modality in the acute assessment of traumatic brain injury. Hemorrhage, cerebral oedema, mass effect, and displacement of intracranial structures are possible CT findings.

One of the significant radiological indicators of cerebral mass effect is midline shift. It describes the movement of brain structures from their normal anatomical midline and can be brought on by cerebral oedema, intracranial hemorrhage, or other space-occupying pathologies.

Previous studies have shown a correlation between neurological severity and MLS identified by CT. Therefore, the current study was conducted to assess the association between clinical severity and CT-measured MLS in patients with traumatic brain injury who present to Multan's tertiary care facilities.

Aims and Objectives:

The main goal was to look into the relationship between clinical severity and the midline shift shown on CT scan in patients with traumatic brain injury.

- To investigate the relationship between the degree of midline shift and clinical severity assessed using the Glasgow Coma Scale.

- To compare midline shift patterns among patients with mild, moderate, and severe traumatic brain injury.

Methods:

Study design & Settings:

In the radiology departments of tertiary care hospitals in Multan, Pakistan. A cross-sectional correlational study was carried out. Nishtar Hospital, Haq Medicare, Shahbaz Shareef DHQ, Noshahi Hospital, and Al Shifa Medicare were among the participating hospitals. The study was carried out over six months.

Study Population and Sample Size:

Forty traumatic brain injury patients were involved in the study. Fisher's Z transformation correlation was used to estimate the necessary sample size. The final sample was rounded to 40 participants from the computed sample of 38.921.

Sampling Technique:

The method utilised was non-probability sequential sampling. Until the necessary sample size was reached, eligible patients who presented for the CT brain examination throughout the research period were recruited one after the other.

Inclusion and exclusion Criteria:

Individuals with traumatic brain injury who were admitted to the critical care unit or trauma unit were eligible to participate. Patients with coagulopathy, anticoagulant medication, prior brain lesions, pregnancy, or prior neurological impairment unrelated to trauma were not included. Additionally, patients who refused to participate were not included.

Clinical Assessment:

The Glasgow Coma Scale was commonly used to evaluate the clinical severity. Based on their GCS, patients were divided into groups with mild, moderate, and severe TBI. Additionally, the mechanism of injury was noted, as well as vomiting history, pupillary response, and other clinical features.

CT imaging and measurement of Midline Shift:

In accordance with the hospital's imaging procedure, every patient had a non-contrast CT scan. Axial CT scans at the level of the septum pellucidum or third ventricle were used to assess MLS. The hospital PACS workstation was used to measure the intracranial structural displacement from the predicted midline in millimeters. An experienced radiologist took measurements using common anatomical landmarks.

Statistical Analysis:

SPSS version 26 was used to enter, clean, and analyses data. Descriptive statistics were used to summarise quantitative variables, and frequencies and percentages were used to display categorical variables. To evaluate correlations between categorical variables, the chi-square test was employed. The degree of MLS and the

severity of TBI were compared using Spearman's rank correlation coefficient. The threshold for statistical significance was fixed at $p < 0.05$.

Ethical Considerations:

Written informed consent was obtained from participants or, if necessary due to the patients' clinical conditions, from a legally authorized representative. The study was carried out with the approval of the Superior University, Lahore Ethical Committee; patient information was kept private and anonymous.

Results:**Demographic Characteristics:**

There were forty TBI patients. There were 13 (32.5%) females and 27 (67.5%) males. The most common clinical severity group was mild traumatic brain injury. 19 patients (47.5 %) had MLS. While 21 patients (52.5%) did not.

Characteristic	Frequency (n)	Percentage (%)
Male	27	67.5
Female	13	32.5
Mild TBI (GCS 13–15)	23	57.5
Moderate TBI (GCS 9–12)	6	15.0
Severe TBI (<8)	11	27.5
MLS present	19	47.5
MLS absent	21	52.5

Mechanism of Injury:

With 18 (45.0%) instances, automobile accidents were the most common mechanism of

injury. 13 (32.5%) patients reported falls, 4 (10.0%) assaults, and 5 (12.5%) reported blunt force of trauma.

Mechanism of injury	N	%
Road traffic accident	18	45.0
Fall	13	32.5
Assault	4	10.0
Blunt-force trauma	5	12.5

Pupillary response:

In 29 patients (72.5%), both pupils were reactive; in 5 patients (12.5%), one pupil was reactive; and in 6 patients (15.0%), both pupils were non-reactive. Pupillary response and TBI severity were shown to be significantly correlated ($\chi^2 = 40.000$, $df = 4$, $p < 0.001$).

Presence and Degree of Midline Shift:

19 (47.5%) patients had MLS on CT, while 21 (52.5%) had no MLS at all. 29 individuals, or 72.5% of the total, had an MLS measurement between 0 and 4 mm. Three (7.5%) had a midline shift of 15- 18 mm. Four (10.0%) had a displacement of 5-9 mm, and four (10.0%) had a displacement of 10- 14 mm.

Degree of MLS	N	%
0-4 mm	29	72.5
5-9 mm	4	10.0
10-14 mm	4	10.0
15-18 mm	3	7.5

Association between Midline Shift and TBI Severity:

Among patients with MLS, 2 (10.5%) had mild TBI, 6 (31.6%) had moderate TBI, and 11

(57.9%) had severe TBI. Whereas all 21 patients who had no MLS had mild TBI.

Presence of MLS	Mild n (%)	Moderate n (%)	Severe n (%)
Yes	2 (10.5)	6 (31.6)	11 (57.9)
No	21 (100)	0	0

Pearson $\chi^2 = 32.677$, $df = 2$, $p < 0.001$.

Correlation between Degree of MLS and TBI Severity:

Spearman's rank correlation showed a strong positive correlation between the severity of TBI

and the degree of MLS ($\rho = 0.859$, $p < 0.001$, $n = 40$), suggesting that the more MLS as detected by CT, the more severe the TBI.

Variables	Spearman's ρ	p-value	n
Degree of MLS vs. TBI severity	0.859	<0.001	40

Vomiting and TBI Severity:

A history of vomiting was found in 26 (65.0%) of the patients, of which 10, 6 and 10 had mild, moderate, and severe TBI, respectively. In patients without a history of vomiting, 12 had mild TBI and 1 patient had severe TBI, while none had moderate TBI. There was a statistically significant relationship between history of vomiting and TBI severity ($\chi^2 = 11.189$, $p = 0.025$).

Discussion:

This study investigated the association of CT-determined MLS with severity of clinical TBI. The main finding of this study is that there was a significant and strong association found between MLS and severity of clinical TBI. Spearman correlation and categorical analysis revealed a consistent finding of higher radiological displacement in more severe TBIs. Male dominance was observed, with 67.5% of males. Road traffic injuries were the predominant mechanisms of injury [45.0%], followed by falls [32.5%].

Mild TBI was the most common category of clinical severity among the study population (57.5%) while severe TBI was the next most common (27.5%) and moderate TBI the least common (15%). Although mild TBI was more common overall, MLS was disproportionately prevalent among the more severely injured patients.

MLS was seen in 19 patients 10 (57.9%) with severe TBI and 6 (31.6%) with moderate TBI. However, all patients 21 (100%) without MLS had mild TBI. This has significant association (2 32.677; $p < 0.001$). The analysis shows that the primary hypothesis that radiological sign of midline shift was correlated with severity of clinical severity was proved.

The strongest result was Spearman between degree of MLS and TBI severity. The Spearman value was 0.859, with $p < 0.001$. It is a very strong positive correlation according to the coding and categorization within the study.

This study also indicated a significant relationship between pupillary response and TBI severity. All patients with mild and moderate TBI exhibited bilateral pupillary reactivity,

whereas abnormal pupillary findings were predominantly found in patients with severe TBI.

Vomiting was also significantly associated with TBI severity ($\chi^2 = 11.189$, $p = 0.025$). While vomiting is a common sign of life-threatening medical conditions and not specific to structural brain injury, the fact that it was more frequent among patients with moderate and severe TBI in our patient group indicates that it may be valuable in combination with GCS and CT.

The clinical relevance of these results is that neurological examination and CT are complementary. GCS is a rapid clinical assessment of neurological function, whereas CT is an objective structural assessment. MLS may therefore, supplement CT as a radiological marker in the severity assessment of traumatic brain injury.

Limitations:

Limitations of the study included small sample size, limited study locations, study period, and clinical outcome assessment periods. Small sample size is the most obvious limitation, with only 40 patients included. The study was carried out at a few Multan based hospitals over a period of 6 months. Clinical outcome assessment was done only in the short term; therefore, clinical outcome in the long term was not assessed.

Conclusion:

The current study showed a strong and statistically significant correlation between positive MLs on CT scanning with severity of TBI patients. The probability of exhibiting MLS was significantly higher in the patient groups with moderate and severe TBI and 100 % of patients with no MLs were in the mild TBI group. The degree of MLS showed a significant and strong positive correlation with severity of TBI ($P = 0.859$, $p < 0.001$). The results further confirm the usefulness of systematic CT measurement of midline shift as one complementary radiological feature for assessing the severity of traumatic brain injury.

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There was no additional funding reported.

Conflict Of Interest:

There was no conflict of interest in this document.

Ethical Approval:

This research work was performed after getting the Approval from Ethical Committee of The Superior University, Lahore.

Informed Consent:

Where clinical condition precluded direct participation, written informed consent was obtained from the participants or their legally authorized representatives.

REFERENCES:

- Agrawal D, Joshi S, Poonamallee L. Automated midline shift detection and quantification in traumatic brain injury: a comprehensive review. *Indian Journal of Neurotrauma*. 2024 Jun;21(01):006-12.
- Kapoor I, Pandit S, Prabhakar H, Mahajan C. Comparison between transcranial sonography and computerized tomography scans to assess the midline shift in patients with traumatic brain injury. *Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine*. 2023 Jan;27(1):64.
- Palekar SG, Jaiswal M, Patil M, Malpathak V. Outcome prediction in patients of traumatic brain injury based on midline shift on CT scan of brain. *Indian Journal of Neurosurgery*. 2021 Dec;10(03):210-5.
- Chaurasia AK, Dhurve L, Gour R, Kori R, Ahmad AK. A study of correlation of degree of midline shift on computed tomography scan and Glasgow coma scale in patients of acute traumatic head injury. *International Surgery Journal*. 2021 Sep 28;8(10):3075-80.

- Harahap EE, Arsyad AM. ANALYSIS OF GCS AS A PREDICTOR OF MIDLINE SHIFT ON NCCT SCAN IN PATIENTS WITH ACUTE TRAUMATIC SUBDURAL HEMATOMA. MEDALION JOURNAL: Medical Research, Nursing, Health and Midwife Participation. 2025 Aug 10;6(2):277-81.
- Islam MQ, Rahman A, Bahar H, Hossain M, Rabbi AF, Asaduzzaman M. Correlation Between the Degree of Midline Shift in Computed Tomography Scan of Brain and Level of Consciousness of the Patients with Acute Spontaneous Intracerebral Haemorrhage. Sir Salimullah Medical College Journal. 2023 Oct 31;31(2):94-9.
- Kazimierska A, Uryga A, Mataczyński C, Czosnyka M, Lang EW, Kasprowicz M. Relationship between the shape of intracranial pressure pulse waveform and computed tomography characteristics in patients after traumatic brain injury. Critical Care. 2023 Nov 17;27(1):447.
- Wu AR, Hsieh SY, Chou HH, Lai CS, Hung JY, Wang B, Tsai YS. Deep learning-based prediction of mortality using brain midline shift and clinical information. Heliyon. 2025 Jan 30;11(2).
- Agbahovbe E, Akhigbe A, Adeyekun A. Pattern of computed tomographic findings and its correlation with Glasgow Coma Scale in adults with head injury in a tertiary hospital in Benin City. Journal of Medicine and Biomedical Research. 2025 Jun 8;24(1):43-9.
- Rauchman SH, Albert J, Pinkhasov A, Reiss AB. Mild-to-moderate traumatic brain injury: a review with focus on the visual system. Neurology international. 2022 May 30;14(2):453-70.
- Cherian DA, Varghese B, Cherian CG. CT Evaluation of Post-traumatic Extradural Hemorrhage Volume: Correlation with Brain Parenchymal Changes Clinical Outcomes. Nepal Journal of Neuroscience. 2025 Dec 10;22(3):30-6.
- Qasim A, Rehman L, Javeed F, Gohar R, Qadir R. Midline Shift as a Predictor of Outcome in Head Trauma Patients managed Conservatively. Pakistan Journal Of Neurological Surgery. 2022 Dec 23;26(4):597-604.
- Tesfay YG. Pattern and Predictors of Positive Head Computed Tomography Scan in Mild Traumatic Brain Injury at Addis Ababa Burn Emergency and Trauma Hospital. Indian Journal of Clinical Medicine/Sage Journals. 2025 Jan 1.
- Jaiswal P, Sudeep KC, Shrestha S, Dwa Y, Baral S. Correlation of optic nerve sheath diameter (ONSD) assessed by computed tomography (CT) with Glasgow coma scale (GCS) in patients with traumatic brain injury in tertiary care hospital of Nepal. Journal of Patan Academy of Health Sciences. 2025 Oct 30;12(1):12-7.
- Ouyang Q, Zhang W, Ma Y, Zou Y, Sun B, Tang Z, Zhang J, He L. Automated Detection and Quantification of Midline Shift in Traumatic Brain Injury Using CT Images. In 2025 10th International Conference on Communication, Image and Signal Processing (CCISP) 2025 Nov 20 (pp. 99-103). IEEE.
- Abdelhamid FS, Alagamy AE, Rashed MM, Elgouhary MO, Shehata Wahba KA. Comparative Study between Computed Tomography of Brain and Transcranial Ultrasonography in Detecting Midline Shift in Severe Traumatic Brain Injury. QJM: An International Journal of Medicine. 2024 Oct;117(Supplement_2):hcae175-041.
- Müller SJ, Khadhraoui E, Ernst MS, Riedel CH. Prediction of midline shift after media ischemia using computed tomography perfusion. BMC Medical Imaging. 2022 Mar 12;22(1):42.
- Sabbah AE, Nabil A, Taher A, El Gohary T. Monitoring the effect of hyperosmolar solutions on brain midline shift using transcranial ultrasonography in severe traumatic brain injury. Critical Care & Shock. 2025 Jun 1;28(3).

Naeimi A, Aghajanian S, Jafarabady K, Aletaha R, Maroufi SF, Khorasanizadeh M, Stippler M. Prognostic value of computed tomography and magnetic resonance imaging findings in acute traumatic brain injury in prediction of poor neurological outcome and mortality: a systematic review and meta-analysis. *Neurosurgical Review*. 2024 Nov 6;47(1):837.

Gupta H, Patel SK, Bhoraniya AI, Malaviya NB, Parikh R, Pancholi K. Application of Transcranial Sonography for the Assessment of Brain Midline Shift in Patients Presenting With Suspected Intracranial Pathology to the Emergency Department of a Tertiary Care Hospital in Central Gujarat, India. *Cureus*. 2024 Jan 19;16(1).

Ukhale RR, Bhopale S, Kulkarni P. ROLE OF COMPUTED TOMOGRAPHY IN THE EVALUATION OF TRAUMATIC BRAIN INJURIES-AN OBSERVATIONAL STUDY. *Int J Acad Med Pharm*. 2026;8(3):832-7.

