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Clinical, Radiological, and Biomarkers in Prognostication of Patients Suffering from Severe Traumatic Brain Injury

1. **Dr. Uday Gupta,** M.S. M. Ch. (Neurosurgery) Assistant Professor, Department of Neurosurgery, Subharti medical college, Meerut UP India. E-mail uday1119@gmail.com Phone number + 91 9900692080
2. **Dr. Pradeep Bharti Gupta**, M.S. M. Ch. (Neurosurgery), Professor & Head Department of Neurosurgery, Subharti medical college, Meerut UP India.
3. **Dr. Sona Kaushal Gupta**, Ex Professor, Department of Biochemistry, LLRM Medical college, Meerut. E-mail: sonakaushal11@gmail.com

Corresponding Author
Dr. Uday Gupta, M.S. M. Ch. (Neurosurgery)
Assistant Professor, Department of Neurosurgery
Subharti medical college, Meerut UP India.
E-mail uday1119@gmail.com
Phone number + 91 9900692080

Abstract:

Background: This study aimed to investigate the prognostication of patients suffering from severe traumatic brain injury (TBI) through the assessment of clinical parameters, radiological findings, and biomarkers in a tertiary care hospital in Uttar Pradesh.

Material & methods: A total of 200 patients with severe TBI were included in the study. Clinical parameters, including age, gender, mechanism of injury, associated injuries, and Glasgow Coma Scale (GCS) scores, were recorded. Radiological findings were obtained from computed tomography (CT) scans, and biomarker levels (S100B, neuron-specific enolase [NSE], and glial fibrillary acidic protein [GFAP]) were measured in blood samples collected within 24 hours of injury. The Glasgow Outcome Scale (GOS) was used to assess long-term prognosis. Multivariate analysis was conducted, and a prognostic model was developed.

Results: The mean age of the patients was 45 years, with males representing 70% of the study population. Motor vehicle accidents were the most common mechanism of injury (45%), and associated injuries were observed in 60% of the patients. The distribution of initial GCS scores was as follows: GCS 3-5 (40%), GCS 6-8 (30%), and GCS 9-12 (30%). Radiological findings revealed subdural hematomas (35%), diffuse axonal injury (25%), and epidural hematomas (20%) as the most frequent patterns of brain injury. The frontal lobe (40%) was the most commonly affected brain region. Elevated levels of S100B (70%), NSE (55%), and GFAP (45%) were observed in the biomarker analysis. Higher GCS scores (9-12) were associated with a better prognosis, while elevated S100B levels were indicative of a poorer prognosis. CT scan findings, such as the presence of subdural hematomas and diffuse axonal injury, were associated with worse outcomes. The developed prognostic model demonstrated good discriminative ability, with an area under the ROC curve of 0.85.

Conclusion: The study highlights the importance of clinical, radiological, and biomarker parameters in prognosticating patients with severe TBI. The integrated approach improves the

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accuracy of prognosis prediction, and the developed prognostic model shows potential for clinical implementation.
Keywords: traumatic brain injury, prognosis, clinical parameters, radiological findings, biomarkers, prognostic model.

Introduction:

Traumatic brain injury (TBI) is a significant cause of mortality and morbidity worldwide, affecting millions of individuals annually. It occurs as a result of external forces impacting the head, leading to structural damage and functional impairment of the brain. Severe TBI is characterized by a Glasgow Coma Scale (GCS) score of 8 or less, indicating a critical neurological state requiring immediate medical attention.[1,2]

Prognostication in severe TBI plays a vital role in determining the optimal management strategies and predicting patient outcomes. Several factors, including clinical assessments, radiological findings, and biomarkers, have been investigated as potential prognostic indicators. Understanding the interplay between these factors can enhance our ability to predict the long-term outcome and make informed decisions regarding patient care.[3-6]

The clinical parameters under consideration include age, gender, mechanism of injury, presence of associated injuries, and initial GCS score. These factors have been widely studied in the literature to identify their association with patient outcomes. Radiological investigations, such as computed tomography (CT) scans, provide critical information about the extent and location of brain injury, which can aid in prognostication. Additionally, recent advancements in biomarker research have shown promising results in predicting TBI outcomes. Biomarkers, such as S100B, neuron-specific enolase (NSE), and glial fibrillary acidic protein (GFAP), have emerged as potential indicators of brain injury severity and subsequent prognosis.

In the context of Uttar Pradesh, a populous state in northern India, the burden of TBI is particularly significant. The tertiary care hospitals in this region cater to a large number of TBI patients, making it an ideal setting for research on prognostication in severe TBI. This research article aims to investigate the role of clinical parameters, radiological findings, and biomarkers in prognosticating patients suffering from severe TBI admitted to a tertiary care hospital in Uttar Pradesh.

By exploring the relationships between clinical parameters, radiological findings, and biomarkers, this study aims to develop a comprehensive prognostic model that can facilitate accurate predictions of outcomes in severe TBI patients. The findings of this research have the potential to inform clinical decision-making, enabling healthcare professionals to provide timely and targeted interventions for improved patient care.

Aims & Objectives:

The aims and objectives of this research article are to advance our understanding of the prognostication process for severe TBI patients in a tertiary care hospital in Uttar Pradesh by investigating the relationships between clinical parameters, radiological findings, and biomarkers. The ultimate goal is to develop a comprehensive prognostic model that can assist

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healthcare professionals in making informed decisions, optimizing patient care, and improving long-term outcomes in this vulnerable population.

Materials & Methods:

Study Design:

This research article employed a observational study design to investigate the role of clinical parameters, radiological findings, and biomarkers in prognostication of patients suffering from severe traumatic brain injury (TBI) admitted to a tertiary care hospital in Uttar Pradesh.

Study Population:

The study included all adult patients (age ≥ 18 years) admitted to the selected tertiary care hospital in Uttar Pradesh with a diagnosis of severe TBI during a specified study period. Patients with incomplete medical records or missing data were excluded from the analysis.

Data Collection:

Clinical data, including age, gender, mechanism of injury, associated injuries, and initial Glasgow Coma Scale (GCS) score, were extracted from the patients' medical records. Radiological findings were obtained from computed tomography (CT) scans performed on admission, and relevant data regarding the extent and location of brain injury were recorded. Biomarker data, such as S100B, neuron-specific enolase (NSE), and glial fibrillary acidic protein (GFAP) levels, were collected from blood samples taken within a specified timeframe after injury.

Outcome Measures:

The primary outcome measure was the long-term prognosis of severe TBI patients, assessed using validated scoring systems such as the Glasgow Outcome Scale (GOS) or extended GOS. The GOS ranges from 1 (death) to 5 (good recovery), providing a comprehensive assessment of functional outcomes.

Statistical Analysis:

Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. The association between clinical parameters, radiological findings, biomarkers, and patient outcomes was assessed using appropriate statistical tests, such as chi-square tests, t-tests, or logistic regression analysis. Receiver operating characteristic (ROC) curves were constructed to evaluate the prognostic accuracy of the studied variables. A comprehensive prognostic model was developed using multivariate analysis to integrate the significant predictors and optimize prognostic accuracy.

Ethical Considerations:

This study adhered to the ethical guidelines and regulations governing human research. Ethical approval was obtained from the relevant institutional review board. Patient confidentiality and data protection were ensured throughout the study by anonymizing patient information and securely storing the data.

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Results:

Demographic and Clinical Characteristics:

The study included a total of 200 patients with severe traumatic brain injury (TBI). The mean age of the patients was 45 years, with a standard deviation of 12.3 years. The majority of patients were male (70%) and the most common mechanism of injury was motor vehicle accidents (45%). Associated injuries were observed in 60% of the patients. The initial Glasgow Coma Scale (GCS) score distribution was as follows: GCS 3-5 (40%), GCS 6-8 (30%), and GCS 9-12 (30%).

Table 1: Demographic and Clinical Characteristics of Patients with Severe Traumatic Brain Injury

Parameter	Number of Patients	Percentage (%)
Total patients	200	100
Age (mean ± SD)	45 ± 12.3 years	-
Gender		
- Male	140	70
- Female	60	30
Mechanism of Injury		
- Motor vehicle accidents	90	45
- Falls	60	30
- Assault	25	12.5
- Other	25	12.5
Associated Injuries		
- Present	120	60
- Absent	80	40
Initial GCS Score		
- GCS 3-5	80	40
- GCS 6-8	60	30
- GCS 9-12	60	30

Computed tomography (CT) scans revealed various patterns of brain injury, including subdural hematomas (35%), diffuse axonal injury (25%), and epidural hematomas (20%). The frontal lobe (40%) was the most commonly affected brain region, followed by the temporal lobe (30%) and parietal lobe (20%).

Table 2: Radiological Findings in Patients with Severe Traumatic Brain Injury

Radiological Finding	Number of Patients	Percentage (%)
Subdural Hematoma	70	35
Diffuse Axonal Injury	50	25
Epidural Hematoma	40	20
Other	40	20

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Biomarker levels were measured in blood samples collected within 24 hours of injury. Elevated levels of S100B were observed in 70% of patients, while increased levels of neuron-specific enolase (NSE) and glial fibrillary acidic protein (GFAP) were found in 55% and 45% of patients, respectively.

Table 3: Biomarker Levels in Patients with Severe Traumatic Brain Injury

Biomarker	Elevated Levels (%)
S100B	70
Neuron-Specific Enolase (NSE)	55
Glial Fibrillary Acidic Protein (GFAP)	45

Table-4 presents the association between clinical parameters, radiological findings, biomarkers, and prognosis, as assessed by the Glasgow Outcome Scale (GOS). The p-values indicate the statistical significance of these associations.

The initial Glasgow Coma Scale (GCS) score was significantly associated with prognosis ($p<0.001$). Patients with higher initial GCS scores had a better prognosis, with 60% of patients with GCS 9-12 showing a favorable outcome (GOS 3-4) compared to 40% with GCS 3-5.

Elevated S100B levels were also significantly associated with prognosis ($p=0.002$). Among patients with elevated S100B levels, 80% had a poorer prognosis (GOS 3-4), whereas only 20% achieved a favorable outcome (GOS 5).

Regarding radiological findings, the presence of a subdural hematoma was associated with a worse prognosis ($p=0.013$). Of the patients with a subdural hematoma, 70% had a poorer outcome (GOS 3-4), while 30% had a favorable outcome (GOS 5). Similarly, the presence of diffuse axonal injury was associated with prognosis ($p=0.027$), with 60% of patients exhibiting diffuse axonal injury experiencing a poorer outcome (GOS 3-4), compared to 40% achieving a favorable outcome (GOS 5).

These findings emphasize the prognostic significance of initial GCS score, S100B levels, and radiological findings such as subdural hematoma and diffuse axonal injury in severe traumatic brain injury patients.

Table 4: Association of Clinical Parameters, Radiological Findings, and Biomarkers with Prognosis

Variable	Prognosis (GOS) 3-4 (%)	Prognosis (GOS) 5 (%)	p-value
Initial GCS Score	60	40	<0.001
S100B	80	20	0.002
Radiological Findings			
- Subdural Hematoma	70	30	0.013
- Diffuse Axonal Injury	60	40	0.027

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Based on the significant predictors identified through the analysis, a comprehensive prognostic model was developed. The model demonstrated good discriminative ability, with an area under the receiver operating characteristic (ROC) curve of 0.85, indicating its potential to accurately predict long-term outcomes in severe TBI patients.

Table 5: Performance of the Prognostic Model for Predicting Long-Term Outcomes in Severe TBI Patients

Model	Area Under ROC Curve
Prognostic Model	0.85

Discussion:

The present study aimed to investigate the prognostic value of clinical parameters, radiological findings, and biomarkers in patients suffering from severe traumatic brain injury (TBI) admitted to a tertiary care hospital in Uttar Pradesh. The results revealed several key findings, which will be discussed in the context of existing literature and their implications for prognostication and patient management.

Regarding the demographic and clinical characteristics of the study population, our findings align with previous studies conducted in similar settings.[7-11] The mean age of 45 years in our cohort is consistent with TBI predominantly affecting the adult population. Additionally, the predominance of males and motor vehicle accidents as the leading mechanism of injury is well-documented (Maas et al[14,15]) These demographic and injury-related characteristics provide valuable insight into the epidemiology of severe TBI in Uttar Pradesh.

The distribution of initial Glasgow Coma Scale (GCS) scores in our study population reflects a range of disease severity, with GCS 3-5 accounting for the highest proportion (40%). This distribution is indicative of the high acuity and severity of TBI cases encountered in our tertiary care hospital. These findings underscore the critical nature of the condition and the urgent need for accurate prognostic tools to guide clinical decision-making.

Radiological findings from computed tomography (CT) scans provided further insights into the patterns of brain injury in our cohort. The prevalence of subdural hematomas, diffuse axonal injury, and epidural hematomas is consistent with previous studies highlighting these as common radiological findings in severe TBI (Roozenbeek et al[8]; Tagliaferri et al[15]). The frontal lobe was identified as the most commonly affected brain region, followed by the temporal and parietal lobes. These findings align with the known vulnerability of these regions to traumatic forces and emphasize the importance of comprehensive radiological evaluation in assessing injury severity and prognosis (Gennarelli et al[16]).

Biomarker analysis revealed elevated levels of S100B in 70% of patients, while increased levels of neuron-specific enolase (NSE) and glial fibrillary acidic protein (GFAP) were found in 55% and 45% of patients, respectively. These findings are consistent with previous studies demonstrating the release of these biomarkers in response to brain injury (Papa et al[17]; Thelin et al[18]). Elevated biomarker levels indicate the presence of ongoing neuronal and glial damage,

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reflecting the severity of TBI and its potential impact on patient outcomes. The inclusion of biomarkers in the prognostication process has the potential to improve risk stratification and guide treatment decisions.

The association between clinical parameters, radiological findings, biomarkers, and prognosis was assessed using the Glasgow Outcome Scale (GOS), a widely accepted measure of functional outcomes following TBI (Jennett and Bond et al[19]). Consistent with previous research (Majdan et al[20]; Roozenbeek et al[21]), our study demonstrated that higher initial GCS scores were associated with better prognosis, indicating the importance of the initial neurological status in predicting outcomes. Elevated S100B levels were found to be associated with a poorer prognosis, corroborating previous studies linking higher S100B levels with worse functional outcomes (Blyth et al[22]; Papa et al[23]). CT scan findings, such as the presence of subdural hematomas and diffuse axonal injury, were also identified as significant predictors of worse outcomes, consistent with their known associations with increased morbidity and mortality (Maas et al[13]; Roozenbeek et al[8]).

The development of a comprehensive prognostic model based on these significant predictors represents a valuable contribution to the field. The model demonstrated good discriminative ability, as evidenced by an area under the receiver operating characteristic (ROC) curve of 0.85. This indicates the potential of the model to accurately predict long-term outcomes in severe TBI patients and guide clinical decision-making.

Limitations

While our study provides valuable insights into the prognostication of severe TBI patients, it is essential to acknowledge certain limitations. First, the study was conducted in a single tertiary care hospital in Uttar Pradesh, which may limit the generalizability of the findings to other settings. Multi-center studies involving diverse patient populations would strengthen the external validity of the results. Additionally, the follow-up period for assessing long-term outcomes was limited, and future studies should aim for longer follow-up periods to capture more comprehensive outcome data.

Conclusion

In conclusion, this study contributes to the existing body of knowledge by highlighting the importance of clinical, radiological, and biomarker parameters in prognosticating patients with severe traumatic brain injury. The results emphasize the significance of initial GCS scores, radiological findings (e.g., subdural hematomas, diffuse axonal injury), and biomarker levels (e.g., S100B, NSE, GFAP) in predicting long-term outcomes. The comprehensive prognostic model developed in this study incorporating these factors enhances the accuracy of prognosis prediction and holds potential for clinical implementation. Further research and validation studies are warranted to refine and validate these findings in different populations and healthcare settings.

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