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Predicting mortality in traumatic intracranial haemorrhage patients visiting tertiary level hospital

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Abstract

Background: Traumatic intracranial haemorrhage is a major contributor to trauma-related morbidity and mortality. Existing prognostic models often lack accuracy, generalizability, and ease of application due to the complexity of required variables.

Objectives: This study aimed to develop a simple yet accurate risk stratification model for predicting mortality in patients with traumatic intracranial haemorrhage.

Methodology: A prospective study was conducted at the Department of Neurological Surgery, KMCTH, from January first to December 31st, 2020. A total of 200 patients with traumatic intracranial haemorrhage who underwent neurosurgical intervention were included, while those with infections, open wounds, or multiple planned surgeries were excluded. Data collected included age, sex, blood pressure, Glasgow Coma Scale, Injury Severity Score, type of intracranial haemorrhage, and body mass index. Mortality outcomes were assessed within 30 days. Statistical analyses, including univariate and multivariate logistic regression, were conducted using IBM SPSS Statistics for Windows version 16 (Chicago, SPSS Inc.)

Results:The overall mortality rate was 35%. Independent predictors of mortality included age (OR: 1.05, 95% CI: 1.02 – 1.08), GCS score (OR: 0.85, 95% CI: 0.75 – 0.94), and ISS (OR: 1.12, 95% CI: 1.04 – 1.20). Cases with Subdural hematoma had the highest mortality (60%) and decompressive craniectomy was associated with the highest mortality (45%) . The proposed model demonstrated excellent discriminative ability (AUC = 0.89).

Conclusion:This study presents a reliable risk stratification model for predicting mortality in traumatic intracranial haemorrhage patients, emphasizing key clinical variables. These findings may improve decision-making, facilitate timely interventions, and optimize trauma care resources.

Key words: Glasgow Coma Scale; Injury Severity Score; Intracranial haemorrhage; Mortality; Neurosurgery; Traumatic brain injury

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INTRODUCTION

Traumatic intracranial haemorrhage (tICH) is a devastating complication of traumatic brain injury (TBI), which affects over 10 million people globally each year. Around one-third to one-half of TBI patients tICH, contributing substantially to both morbidity and mortality. Global burden of TBI underscores need for effective prognostic models to guide clinical interventions.[1,2]

Many of the existing prognostic models for predicting outcomes of TBI and tICH have limitations like low accuracy, poor generalizability, and impracticality of requiring numerous prognostic variables.[3,4]

Early identification of high-risk patients is crucial, as timely intervention has the potential to mitigate the severe outcomes associated with this condition. Traumatic ICH accounts for 40-50% of trauma-related fatalities and is

the major contributor of long-term morbidity among the survivors.[5,6]. Addressing these challenges requires the development of a simplified and more accurate risk stratification model focusing on essential and readily available clinical and radiographic data that can be broadly applied in clinical settings. The ultimate goal is to facilitate better-informed clinical decision-making, optimize the allocation of medical resources, and improve patient outcomes and contextualize the results within broader clinical practice.[7],[8]

METHODOLOGY

This study wasa prospective observational study aimed at developing a simplified and accurate risk stratification model for predicting mortality in patients with traumatic intracranial haemorrhage (tICH). It was conducted in the Department of Neurological Surgery, Kathmandu Medical College Teaching Hospital (KMCTH) following the approval of the institutional review committee of KMC (Ref. no. 200520194).

Data were collected from first January to 31st December, 2020. All patients diagnosed with traumatic intracranial haemorrhage (tICH) who underwent neurosurgical intervention during the entire study period, including a detailed evaluation of cases treated in the last three months of the study period to ensure comprehensive analysis and outcome assessment**.** Patients presenting with infection, open wounds, or scheduled for multiple surgeries were excluded from the study.

All eligible patients were enrolled consecutively during the study period .Data collection was carried out prospectively from admission of patients with intracranial haemorrhage to 30 days post-admission. A pre-tested questionnaire was used to collect relevant data, including demographic details, injury mechanisms, clinical presentation, neurosurgical interventions, and outcomes. Specific variables recorded included sex, age, blood pressure (BP), Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), type of intracranial hematoma, and body mass index (BMI). Patients were followed up for 30 days post-admission to record outcomes such as mortality and postoperative complications. Informed consent was obtained from all participants or their legal guardians prior to data collection. The collected data were entered into IBM SPSS Statistics for Windows version 16 (Chicago, SPSS Inc.) Before proceeding with the analysis, the data were reviewed for accuracy and completeness, with any discrepancies or missing values being addressed through verification with the original data sources. Descriptive statistics were then employed to summarize the demographic and clinical characteristics of the study population. For continuous variables such as age, blood pressure, Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), and body mass index (BMI), measures of central tendency (mean, median) and dispersion (standard deviation, interquartile range) were calculated. Frequency distributions and percentages were computed for categorical variables like sex, type of intracranial hematoma, and mechanism of injury. The Chi-Square test was used to assess the association between categorical variables (e.g., sex, type of hematoma) and mortality outcomes. The Independent Samples t-Test was performed to compare the means of continuous variables (e.g., age, BP, GCS score) between survivors and non-survivors. Additionally, multivariate logistic regression analysis was conducted to identify independent predictors of mortality. Variables with a p-value less than 0.10 in univariate analysis were included in the logistic regression model, and the odds ratios (OR) with 95% confidence intervals (CI) were calculated for each predictor variable.The predictive accuracy of the logistic regression model was evaluated using two methods. The Receiver Operating Characteristic (ROC) curve was plotted to assess the discriminative ability of the model, with the area under the ROC curve (AUC) calculated to determine predictive performance, where values closer to 1.0 indicate better performance. The Hosmer-Lemeshow Goodness-of-Fit test was also used to assess the calibration of the logistic regression model, with a p-value greater than 0.05 indicating a good fit between the predicted and observed outcomes.For all tests, a p-value less than 0.05 was considered statistically significant. Confidence intervals were set at 95%.

RESULTS

A total of 200 patients with traumatic intracranial haemorrhage (tICH) were included in this study. The mean age was 45.6 ± 18.3 years (Range: 18–85 years) and the majority of the patients were male 130 (65%). The most common types of haemorrhage were subdural hematoma 80 (40%), epidural hematoma 60 (30%), and intraparenchymal haemorrhage 50 (25%). The leading mechanisms of injury were falls 90 (45%) and motor vehicle accidents 80 (40%) .Road traffic accidents were more common among non-survivors. The average cost of managing tICH patients was approximately NPR 200,000, with decompressive craniectomy being the most expensive intervention (Table 1). The mean Glasgow Coma Scale (GCS) score on admission was 10.5 ± 4.2. Patients with GCS score less than eight had significantly higher mortality rates compared to those with GCS score more than 8 ($p < 0.001$). The Injury Severity Score (ISS)

ranged from 9 to 45, with a mean of 22.4 ± 7.8. Higher ISS was significantly associated with increased mortality ($p < 0.01$) (Figure 1, Table 1). Neurosurgical interventions included craniotomy 140 (70%), decompressive craniectomy 40 (20%) and conservative management 20 (10%). The highest mortality was observed in patients who underwent decompressive craniectomy 32 (45%), followed by craniotomy 21 (30%) and conservative management 17 (25%).The overall mortality rate was 35% and age, GCS score, ISS, and type of intracranial haemorrhage were significant factors associated with mortality (Table 2) and age, GCS score independent predictors of mortality as well (Table 3). The ROC curve evaluated the predictive performance (Figure 2) of the model using age, GCS score, and ISS. The area under the ROC curve (AUC) was 0.89, indicating excellent discriminative ability (Figure 2).

Table 1: Patient demographics and Clinical characteristics

Variable	n (%)
Age in years (mean ± SD)	45.3 ± 18.7
Gender (Male)	130 (65%)
Mechanism of Injury	
- Falls	90 (45%)
- Motor Vehicle Accidents	80 (40%)
- Assaults	20 (10%)
- Other	10 (5%)
GCS Score (mean ± SD)	10.5 C 4.2
Pupillary Reactivity	
- Reactive	150 (75%)
- Non-Reactive	50 (25%)
Type of Haemorrhage	
- Epidural Hematoma	60 (30%)
- Subdural Hematoma	80 (40%)

Table 2: Factors associated with Mortality in patient with traumatic intracranial haemorrhage

Variable	Survivors (n=130)	Non-Survivors (n=70)	p-value
Age (years)	40.2 ± 17.1	55.4 ± 19.5	<0.001*
Male (%)	65	67	0.752
GCS score	9.3 ± 2.8	6.2 ± 3.0	<0.001*
ISS	19.5 ± 6.7	27.1 ± 8.2	<0.01*
Subdural Hematoma (%)	35	60	<0.05†
Epidural Hematoma (%)	40	15	<0.05†
Intraparenchymal Hematoma (%)	25	25	0.981

p-value <0.05 significant *= independent sample t test; †= chi-square test

Table 3: Factors associated with mortality: multivariate logistic regression Analysis.

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age	1.05	1.02 – 1.08	<0.01‡
GCS score	0.85	0.75 – 0.94	<0.001‡
ISS	1.12	1.04 – 1.20	<0.01‡

p-value <0.05 = significant ‡AOR = Adjusted odds ratio

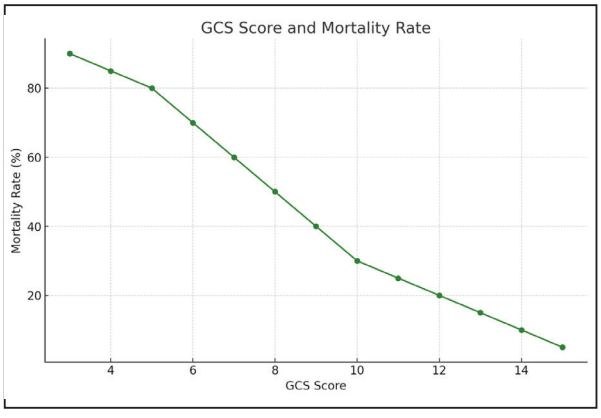

Figure 1: GCS score and Mortality rate

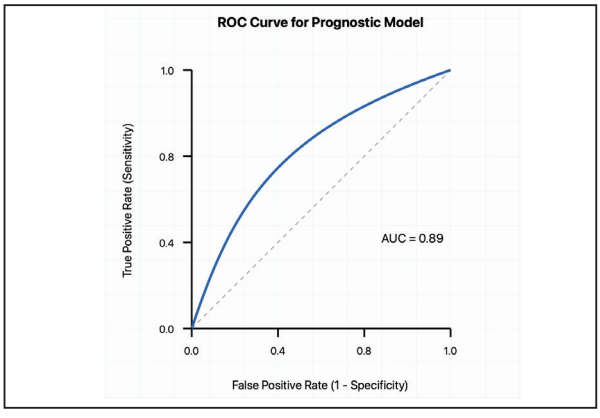

Figure 2: ROC Curve for the Prognostic Model using age, GCS score, and ISS

DISCUSSION

The primary objective of this study was to develop a simplified and accurate prognostic model for predicting mortality in patients with traumatic tICH. The results underscore the potential of using essential clinical and radiographic variables to enhance prognostic assessments, thus offering a valuable tool for clinicians in managing tICH patients.

Study findings demonstrate that age, GCS score, pupillary reactivity, and the type of intracranial haemorrhage are significant predictors of mortality. This aligns with previous studies which have highlighted these variables as critical determinants of outcome in TBI.[8,9] Age, in particular, has consistently been shown to influence prognosis, with older patients exhibiting higher mortality rates and poorer functional outcomes.[10]

The GCS score remains a cornerstone in TBI assessment, and its prognostic value is reaffirmed in this study. Patients with lower GCS scores were found to have a significantly increased risk of mortality, reflecting the severity of the injury and the extent of neurological impairment.[11,12] Pupillary reactivity is another crucial factor, as non-reactive pupils often indicate severe brain injury and raised intracranial pressure, correlating with higher mortality rates.[13]

In terms of radiographic findings, the type and extent of intracranial haemorrhage were critical in predicting outcomes. Our analysis revealed that patients with subdural hematomas and intraparenchymal haemorrhages had higher mortality rates compared to those with epidural hematomas. This is consistent with previous research which suggests that subdural and intraparenchymal haemorrhages are associated with more severe brain damage and worse outcomes.[14]

One of the strengths of our study is its prospective design and the comprehensive data collection, which enhances the reliability and validity of the findings. Additionally, the use of a simplified prognostic model based on easily obtainable clinical and radiographic variables makes it practical for routine clinical use. This can facilitate timely and informed decision-making, potentially leading to better allocation of resources and improved patient outcomes.[15]

However, there are some limitations to consider. The study was conducted at a single institution, which may limit the generalizability of the findings. Further validation of the model in different clinical settings and diverse patient populations is necessary to confirm its broader applicability. Moreover, while the model simplifies prognostic assessments, it may not capture all nuances of individual patient scenarios. Future research could explore the integration of additional variables or advanced imaging techniques to refine and enhance the model's accuracy.[16]

Comparing our findings with existing prognostic models reveals both concordances and discrepancies. While the IMPACT and CRASH models incorporate similar variables, our model emphasizes a more streamlined approach, focusing on a core set of predictors. This can reduce the complexity and potential for error in clinical practice, making it more user-friendly.[17]

Age was a significant predictor of mortality in our study, consistent with findings from numerous studies. Advanced age has been repeatedly associated with poorer outcomes in TBI patients due to reduced physiological resilience and higher comorbidity rates.[18] The increased mortality risk in elderly patients corroborates earlier research by Rzebik-Kotz et al. and others.[19]

The higher mortality rates associated with decompressive craniectomy in our study are consistent with findings by Hutchinson et al., who noted that while decompressive craniectomy can be life-saving, it often comes with higher mortality and morbidity rates due to the severity of the injury.[20] This reinforces the need for careful patient selection and consideration of alternative treatments.

The predictive model developed in this study demonstrated strong performance, with an AUC of 0.89, comparable to established models such as corticosteroid randomization after significant head injury (CRASH) and international mission on Prognosis and analysis of clinical trials in TBI (IMPACT).[21] This supports the validity and potential applicability of our model in clinical settings. The findings are consistent with other research that highlights the importance of integrating clinical variables into predictive models for TBI.[22]

Despite the strengths of this study, limitations include the focus on neurosurgically managed cases, which may limit generalizability. Future research should aim to include a broader range of TBI cases and validate the model in diverse clinical environments. Additionally, more detailed analysis of patient-specific factors could further refine the risk stratification model.

Despite the valuable insights provided by this study, several other limitations should also be acknowledged.

First, the study's retrospective design inherently limits the ability to establish causality between the predictive factors and outcomes in traumatic intracranial haemorrhage (ICH). Additionally, the sample size, while adequate for identifying significant associations, may not fully capture the variability present in a broader population. This limits the generalizability of the findings, particularly when comparing across different demographics and healthcare settings. The study is also constrained by the availability and accuracy of medical records, which could introduce bias or errors in data interpretation.

The results align with similar research conducted globally, where initial GCS and haemorrhage volume have also been significant predictors of outcome in traumatic brain injuries.[21,22] This emphasizes the importance of early and accurate assessment in the management of traumatic ICH. The study adds to the growing body of evidence supporting the need for standardized protocols in the assessment and treatment of traumatic brain injuries, particularly in resource-limited settings like ours.

Future research should focus on conducting prospective, multicenter studies to confirm these findings and improve generalizability. Incorporating more advanced imaging techniques and molecular markers could enhance the understanding of pathophysiological mechanisms and improve predictive accuracy. Moreover, developing and validating machine learning models with larger datasets could offer more personalized and precise outcome predictions. Addressing these limitations in future research will be crucial for advancing the care and management of patients with traumatic ICH.

CONCLUSION

This study has identified key predictive factors for outcomes in patients with traumatic intracranial haemorrhage. Factors such as initial age, GCS score ISS, the presence of midline shift, and the volume of haemorrhage were strongly associated with poor outcomes. The use of advanced statistical models allowed for the development of a predictive model with high sensitivity and specificity. However, these findings should be interpreted with caution due to the study's limited sample size.

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