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Correlation of C-Reactive Protein–Albumin Ratio, International Normalized Ratio, Platelet-to-Lymphocyte Ratio, Fibrinogen, and Neutrophil-to-Lymphocyte Ratio with Discharge Glasgow Coma Scale in Non-Operative Isolated Traumatic Brain Injury at H. Adam Malik General Hospital in 2025

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ABSTRACT

Introduction: Traumatic brain injury (TBI) remains a major cause of neurological morbidity, and early assessment of neurological outcome is important for clinical evaluation. Prognostic assessment traditionally relies on clinical examination and neuroimaging; however, routinely measured inflammatory and coagulation biomarkers may offer additional information regarding neurological status.
Methods: This retrospective cohort study investigated the correlations between the C-reactive protein-to-albumin ratio (CAR), international normalized ratio (INR), platelet-to-lymphocyte ratio (PLR), fibrinogen concentration, and neutrophil-to-lymphocyte ratio (NLR) and Glasgow Coma Scale (GCS) scores at hospital discharge among adults with isolated TBI managed non-operatively at H. Adam Malik General Hospital during 2025.
Results: A total of 36 patients were included. The median age was 33 years (range, 18–74 years), and 69.4% were male. The median GCS score at discharge was 12 (range, 3–15). Spearman rank correlation analysis demonstrated statistically significant associations between discharge GCS scores and CAR ($r = -0.481$; $p = 0.003$), INR ($r = -0.659$; $p = 0.001$), PLR ($r = 0.401$; $p = 0.015$), fibrinogen ($r = 0.539$; $p < 0.001$), and NLR ($r = 0.373$; $p = 0.025$).
Conclusion: INR showed the strongest correlation, with higher INR values associated with lower discharge GCS scores. These findings suggest that routinely available inflammatory and coagulation biomarkers are associated with short-term neurological status in non-operatively managed isolated TBI, although their prognostic utility requires further evaluation in larger cohorts.

Keywords: Traumatic brain injury; Inflammatory biomarkers; Coagulation biomarkers; Glasgow Coma Scale; Neurological outcome

1. Introduction

Traumatic brain injury (TBI) remains a major cause of morbidity, mortality, and long-term disability worldwide. Its clinical spectrum ranges from mild concussion to severe neurological impairment, and the burden is particularly important in low- and middle-income countries where road traffic injury, falls, and interpersonal violence are frequent causes [1–4]. Prognostic assessment is therefore central to triage, treatment planning, resource allocation, and communication with patients and families.

Common prognostic indicators such as admission Glasgow Coma Scale (GCS), pupillary response, age, and neuroimaging primarily describe the initial severity of injury. They may not fully represent evolving secondary mechanisms, including neuroinflammation, oxidative stress, ischemia, immune dysregulation, and trauma-associated coagulopathy [4–7]. This has stimulated interest in inexpensive blood-based biomarkers that can be obtained from routine laboratory testing.

The C-reactive protein-to-albumin ratio (CAR) integrates a positive acute-phase reactant with a negative acute-phase protein and has been associated with adverse outcomes in TBI [8–10]. The international normalized ratio (INR) reflects the extrinsic coagulation pathway and may capture trauma-induced hypocoagulability; elevated INR has been associated with worse neurological outcomes in isolated TBI [11–13]. Platelet-to-lymphocyte ratio (PLR) and neutrophil-to-lymphocyte ratio (NLR) summarize the balance between cellular inflammatory and immune responses, while fibrinogen contributes to both clot formation and inflammatory signaling [14–18].

Evidence directly comparing these routinely available markers within a single cohort of non-operative isolated TBI remains limited, particularly in Indonesia. The objective of this study was to determine and compare the correlations of admission CAR, INR, PLR, fibrinogen, and NLR with discharge GCS among patients with non-operative isolated TBI treated at H. Adam Malik General Hospital in 2025.

2. Method

2.1. Study design and setting

This was an analytical observational study with a retrospective cohort design conducted at H. Adam Malik General Hospital, Medan, Indonesia. Medical-record data were collected for patients treated from January through December 2025.

2.2. Participants

The target population comprised patients with isolated non-operative TBI. Inclusion criteria were: age 18 years or older; diagnosis of isolated TBI managed without neurosurgical operation; GCS between 3 and 15; and complete medical-record data including CRP, albumin, INR, platelet count, lymphocyte count, neutrophil count, fibrinogen measured within the first 24 hours after emergency-department admission, and discharge GCS. Exclusion criteria were chronic infection, malignancy, immune disorders or immunosuppressive therapy; congenital coagulation disorders or long-term anticoagulant/antiplatelet use; incomplete laboratory data; and extracranial polytrauma requiring orthopedic, abdominal, thoracic, or other surgery.

2.3. Sample size and data collection

The minimum sample size calculated for the correlation analysis was 30 patients. Eligible medical records were reviewed until the available study sample was obtained. Demographic characteristics, laboratory measurements, and discharge GCS were recorded on a structured data-collection form. Thirty-six patients remained for analysis after exclusion of records with incomplete data.

2.4. Biomarker definitions and outcome

CAR was calculated as serum C-reactive protein divided by serum albumin. INR was recorded from the prothrombin-time assay. PLR was calculated as absolute platelet count divided by absolute lymphocyte count, and NLR as absolute neutrophil count divided by absolute lymphocyte count. Fibrinogen was recorded in mg/dL. The dependent outcome was GCS at hospital discharge, ranging from 3 to 15.

2.5. Statistical analysis

Data were analysed using IBM SPSS Statistics version 26.0. Categorical data were summarized as frequency and percentage. Numerical data were summarized as mean ± standard deviation when normally distributed or as median and range when non-normally distributed. Normality was assessed with the Shapiro–Wilk test because the sample size was below 50. All principal biomarkers and discharge GCS were non-normally distributed; therefore, associations between each biomarker and discharge GCS were evaluated using Spearman rank correlation. Statistical significance was defined as a two-tailed p value < 0.05 with a 95% confidence level.

2.6. Ethical considerations

The thesis source supplied for manuscript preparation does not state the ethics committee approval number or waiver/consent details. These items should be inserted before journal submission.

3. Results and Discussion

3.1. Patient characteristics and biomarker distribution

A total of 36 patients with non-operative isolated TBI were analysed. The median age was 33 years (range 18–74), and 25 patients (69.4%) were male. Median discharge GCS was 12 (range 3–15). The demographic distribution, dominated by young adult men, is consistent with the broader epidemiological pattern of TBI in which road traffic and occupational exposures disproportionately affect men of productive age [2,19].

All principal continuous variables were non-normally distributed by Shapiro–Wilk testing. Median CAR was 13.94 (range 0.16–64.35), median INR 1.21 (1.04–2.14), median PLR 16.86 (4.38–59.00), median fibrinogen 218.50 mg/dL (135–255), and median NLR 4.71 (1.38–19.42).

Table 1. Baseline characteristics and discharge neurological status.

Variable	Overall (n = 36)
Age, years, median (range)	33 (18–74)
Male sex, n (%)	25 (69.4)
Female sex, n (%)	11 (30.6)
Discharge GCS, median (range)	12 (3–15)

Table 2. Admission biomarker distribution.

Biomarker	Median	Range
CRP-albumin ratio (CAR)	13.94	0.16–64.35
International normalized ratio (INR)	1.21	1.04–2.14
Platelet-to-lymphocyte ratio (PLR)	16.86	4.38–59.00
Fibrinogen, mg/dL	218.50	135–255
Neutrophil-to-lymphocyte ratio (NLR)	4.71	1.38–19.42

3.2. Correlation of biomarkers with discharge GCS

Spearman analysis demonstrated statistically significant correlations between all five biomarkers and discharge GCS. CAR showed a moderate-to-strong inverse association ($r = -0.481$; $p = 0.003$), while INR demonstrated the strongest inverse association ($r = -0.659$; $p < 0.001$). In contrast, PLR ($r = 0.401$; $p = 0.015$), fibrinogen ($r = 0.539$; $p < 0.001$), and NLR ($r = 0.373$; $p = 0.025$) were positively correlated with discharge GCS.

Table 3. Spearman correlations between admission biomarkers and discharge GCS.

Biomarker	Spearman r	p value	Direction
CAR	−0.481	0.003	Inverse
INR	−0.659	<0.001	Inverse
PLR	0.401	0.015	Positive
Fibrinogen	0.539	<0.001	Positive
NLR	0.373	0.025	Positive

3.3. Interpretation of CAR and INR

The inverse correlation between CAR and discharge GCS supports the concept that a greater systemic inflammatory burden combined with lower albumin is associated with poorer neurological status. CRP rises in response to tissue injury and inflammatory signaling, whereas albumin may decrease during inflammation and catabolic stress. Previous TBI studies have similarly reported an association between higher CAR and adverse clinical outcomes or mortality [8–10,20].

INR had the largest absolute correlation coefficient in this cohort. Trauma-induced coagulopathy after TBI can involve tissue-factor release, consumption of clotting factors, fibrinolytic disturbances, and platelet dysfunction. Elevated INR may therefore mark a systemic hemostatic disturbance accompanying more severe brain injury. Prior work has identified INR as a useful prognostic marker in isolated TBI and as part of models predicting functional outcome [11–13]. The present data reinforce the potential value of early coagulation testing even in patients managed non-operatively.

3.4. Interpretation of PLR, fibrinogen, and NLR

PLR was positively associated with discharge GCS in this dataset. This direction differs from several studies in which higher PLR was associated with worse prognosis [14,17]. The thesis discussion proposes that early consumptive thrombocytopenia during the hyper-acute phase may lower PLR in patients with more severe injury, whereas later reactive thrombocytosis and systemic inflammation may produce the opposite pattern. Because the present study used measurements obtained during the first 24 hours, the timing of sampling is a plausible contributor to this finding, but the retrospective dataset cannot establish this mechanism.

Fibrinogen showed the second strongest positive correlation with discharge GCS. Fibrinogen is central to stable clot formation, but it also participates in neuroinflammatory processes [16,21]. Lower levels in more severe trauma may reflect consumption during trauma-induced coagulopathy, while preserved fibrinogen may indicate more intact hemostatic reserve. The association observed here is compatible with the concept that fibrinogen kinetics after TBI are time-dependent and may have prognostic relevance [16,21,22].

NLR also correlated positively with discharge GCS, which is opposite to the commonly reported association between elevated NLR and poor TBI outcomes [15,18,23]. The thesis proposes a hyper-acute sequestration/extravasation explanation in which circulating neutrophils migrate into injured cerebral tissue early after severe injury, potentially lowering peripheral NLR before a later systemic neutrophilic rebound. This interpretation should be considered hypothesis-generating rather than proven by the current single-time-point retrospective data. Serial measurements would be necessary to test this temporal model.

3.5. Clinical implications and limitations

These findings suggest that routine admission laboratory tests may complement bedside neurological assessment in non-operative isolated TBI. INR, CAR, fibrinogen, PLR, and NLR are inexpensive and widely available, making them potentially useful for early risk stratification where advanced biomarker platforms are unavailable. However, correlation with discharge GCS does not establish independent predictive performance, diagnostic thresholds, sensitivity, specificity, or causality.

Several limitations should be considered. First, the retrospective single-center design limits control of unrecorded confounding factors and external generalizability. Second, biomarker measurements were obtained at only one early time point, preventing assessment of temporal trajectories. Third, GCS at discharge was the sole neurological outcome and may not capture the full spectrum of disability, particularly in mild-to-moderate injury; a broader functional scale such as the Glasgow Outcome Scale–Extended could provide additional information. Fourth, the sample size was modest. Future prospective multicenter studies should use serial biomarker measurements, evaluate multivariable models and clinically meaningful cut-off values, and include longer-term functional outcomes.

4. Conclusion and Future Research

In adults with non-operative isolated TBI, admission CAR, INR, PLR, fibrinogen, and NLR were all significantly correlated with GCS at hospital discharge. Higher CAR and INR were associated with lower discharge GCS, while higher PLR, fibrinogen, and NLR were associated with higher discharge GCS in this cohort. INR showed the strongest correlation, followed by fibrinogen and CAR. These results support further evaluation of routinely available inflammatory and coagulation markers as adjuncts to early prognostic assessment, but they should not yet be interpreted as validated standalone predictors.

Future work should determine sensitivity and specificity, establish clinically useful thresholds, include both operative and non-operative TBI populations, increase sample size, and evaluate serial biomarker trajectories against comprehensive short- and long-term neurological outcomes.

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Conflict of Interest

The source thesis does not provide a conflict-of-interest or funding declaration. Please insert the authors' final declaration before submission.

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