

# Early risk stratification in traumatic brain injury: An analysis of MEWS and rSIG scores in patients with isolated head trauma

Ekim Sağlam Gürmen,<sup>1</sup> Mustafa Yorgancıoğlu,<sup>2</sup> Hakan İğdeli<sup>1</sup>

<sup>1</sup>Department of Emergency, Manisa Celal Bayar University School of Medicine, Manisa-Türkiye

<sup>2</sup>Department of Emergency, İzmir Torbalı State Hospital, İzmir-Türkiye

## ABSTRACT

**BACKGROUND:** Traumatic brain injury (TBI) is a major cause of trauma-related morbidity and mortality worldwide. Early identification of patients at risk of clinical deterioration is essential for optimizing emergency management. The Modified Early Warning Score (MEWS) and the reverse Shock Index multiplied by the Glasgow Coma Scale (rSIG) are simple, rapidly calculable tools that may assist clinicians in early prognostic assessment. This study aimed to evaluate the prognostic performance of MEWS and rSIG in predicting poor outcomes among patients with isolated head trauma.

**METHODS:** This retrospective observational study included patients presenting to the emergency department of Manisa Celal Bayar University Hospital between June 2021 and June 2024 with isolated head trauma. Demographic, clinical, and laboratory data were retrieved from the hospital information system. MEWS, Shock Index (SI), reverse Shock Index (rSI), and rSIG values were calculated for each patient. Group comparisons were performed using nonparametric tests. Correlations were analyzed using Spearman coefficients. Receiver operating characteristic (ROC) curves were constructed to assess discriminative power, and binary logistic regression was used to identify independent predictors of poor outcomes, defined as intensive care unit admission and/or in-hospital mortality.

**RESULTS:** A total of 705 patients (65.7% male; mean age 37.2±27.0 years) were analyzed. Pathological cranial CT findings were present in 24.7%, and the overall mortality rate was 2.7%. Patients with poor outcomes exhibited significantly higher MEWS and SI values, whereas GCS, rSI, and rSIG were markedly lower (all  $p < 0.001$ ). ROC analysis showed moderate predictive ability for rSIG (AUC=0.701) and limited discriminative power for MEWS (AUC=0.610), with optimal cut-offs of  $\leq 21.35$  and  $\geq 0.5$ , respectively. In multivariate analyses, MEWS and rSIG demonstrated independent prognostic significance for poor outcomes in separate models, with rSIG remaining significant in models excluding GCS. MEWS correlated positively with hospital stay ( $r=0.385$ ,  $p<0.001$ ), while rSIG showed a negative correlation ( $r=-0.252$ ,  $p<0.001$ ).

**CONCLUSION:** MEWS and rSIG are practical bedside tools that may support early risk stratification in patients with isolated head trauma. MEWS reflects early physiological deterioration, while rSIG provides complementary hemodynamic–neurological information and should be interpreted as an adjunct rather than a standalone triage instrument. Routine use of these scores may support early clinical decision-making and patient monitoring in the emergency setting when interpreted as adjuncts to standard clinical assessment.

**Keywords:** Traumatic Brain Injury, Head Trauma, Modified Early Warning Score (MEWS), Reverse Shock Index multiplied by GCS (rSIG), Shock Index.

Cite this article as: Sağlam Gürmen E, Yorgancıoğlu M, İğdeli H. Early risk stratification in traumatic brain injury: An analysis of MEWS and rSIG scores in patients with isolated head trauma. *Ulus Travma Acil Cerrahi Derg* 2026;32:159-166.

Address for correspondence: Mustafa Yorgancıoğlu

Department of Emergency, İzmir Torbalı State Hospital, İzmir, Türkiye

E-mail: mustafaayorgancioglu@gmail.com

*Ulus Travma Acil Cerrahi Derg* 2026;32(2):159-166 DOI: 10.14744/tjtes.2026.57167

Submitted: 23.10.2025 Revised: 10.01.2026 Accepted: 15.01.2026 Published: 09.02.2026

OPEN ACCESS This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).



## INTRODUCTION

Head trauma occurs when mechanical forces, either direct or indirect, cause injury to the cranial region.<sup>[1]</sup> The rising prevalence of motor vehicle use, urban development, and industrialization has led to a marked increase in head trauma cases, which now constitute a leading cause of trauma-related deaths in many developed countries.<sup>[2]</sup> Traumatic brain injury (TBI) continues to be a significant public health challenge globally, contributing heavily to mortality and long-term disability, particularly among patients experiencing multiple trauma.<sup>[3]</sup> Falls and traffic accidents are the most common causes of TBI, whereas assaults, firearm injuries, and blunt trauma to the head are less frequent but clinically relevant etiologies.<sup>[4]</sup> In Türkiye, traffic accidents account for 60–68% of multiple trauma cases, and head injuries rank third among trauma-related fatalities.<sup>[5,6]</sup>

The Glasgow Coma Scale (GCS) remains the standard tool for assessing head injury severity. According to the GCS, injuries are classified as mild (14–15), moderate (9–13), or severe ( $\leq 8$ ).<sup>[7]</sup> Approximately 80% of TBI cases are mild, 10% moderate, and the remainder severe, with moderate and severe injuries carrying a significantly higher risk of long-term disability and death.<sup>[8,9]</sup>

While GCS provides critical information about consciousness, it does not fully capture systemic physiological changes following trauma. Consequently, scoring systems such as the Modified Early Warning Score (MEWS), Revised Trauma Score (RTS), quick Sequential Organ Failure Assessment (qSOFA), and Shock Index (SI) have been developed. Among these, MEWS has shown strong predictive performance for mortality, ICU admission, and early death in TBI patients.<sup>[10]</sup>

The Shock Index (SI), calculated as the ratio of heart rate (HR) to systolic blood pressure (SBP), is a simple tool for evaluating hypovolemic shock severity.<sup>[11]</sup> SI values above 0.9 have been associated with increased mortality.<sup>[12]</sup> Recognizing that hemodynamic instability may result from low SBP as well as elevated HR, the reverse Shock Index (rSI = SBP/HR) was introduced. Values of rSI below 1 have been linked to adverse outcomes, even in the absence of hypotension.<sup>[13–15]</sup>

Given the strong correlation between GCS and mortality,<sup>[16,17]</sup> a composite score, rSIG (rSI  $\times$  GCS), has been proposed. While this measure has been reported to demonstrate high discriminative ability in predicting in-hospital mortality in broad trauma populations,<sup>[18]</sup> its specific prognostic value in isolated head trauma remains to be further validated, as these patients may present with unique physiological challenges where neurological deterioration can occur independently of systemic hemodynamic changes.

This study aimed to evaluate the prognostic performance of MEWS and rSIG in patients presenting with isolated head trauma. Furthermore, we examined whether these scores can serve as rapid, reliable, and practical tools for early risk stratification in emergency care, acknowledging their potential role alongside established clinical assessments.

## MATERIALS AND METHODS

### Study Design and Ethical Approval

This retrospective descriptive study received approval from the Ethics Committee (Approval No: 20.478.486/2589, Date: September 4, 2024). This study was conducted in accordance with the Declaration of Helsinki and relevant institutional regulations. Patient data were collected from the hospital information management system (HIMS) and archived records of the Emergency Department of Manisa Celal Bayar University Faculty of Medicine, Hafsa Sultan Hospital. All personal data were anonymized to ensure confidentiality.

### Study Period

Patients presenting with isolated head trauma between June 1, 2021, and June 1, 2024, were included. The study analysis was conducted between September 1, 2024, and September 1, 2025.

### Inclusion Criteria

- Confirmed isolated head trauma
- No pre-existing organ dysfunction
- No systemic infection or sepsis prior to trauma

### Exclusion Criteria

- Incomplete clinical or laboratory data

### Data Collection

Demographic data (age, gender), vital signs (systolic and diastolic blood pressure, heart rate), laboratory values (glucose, phosphorus, glucose/phosphorus ratio), imaging results, and triage codes were recorded. The glucose/phosphorus ratio was calculated by dividing serum glucose by serum phosphorus at admission.

MEWS, SI, rSI, and rSIG scores were calculated for each patient using standard formulas.

### Variables

The main parameters evaluated in the study are:

- Independent variables: Age, gender, vital signs, laboratory parameters, MEWS, GCS, SI, rSI, rSIG scores.
- Dependent variables: Brain CT result, intubation status, triage category, hospital stay, and clinical outcome (discharge, ward/ICU admission, mortality).
- Poor outcome was defined as admission to the intensive care unit and/or in-hospital mortality.

### Statistical Analysis

All analyses were performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics included:

- Categorical variables as n (%)
- Continuous variables as mean  $\pm$  SD or median (min–max)

Normality was tested using the Kolmogorov–Smirnov meth-

od. Group comparisons were conducted with the Mann–Whitney U or Kruskal–Wallis tests as appropriate. Spearman correlation evaluated relationships between continuous variables. Receiver operating characteristic (ROC) curve analysis was conducted to assess the discriminatory power of MEWS, rSIG, and biochemical parameters for predicting poor outcomes. The Youden index was used to determine optimal cut-off values, sensitivity, and specificity. Variables with statistical significance in univariate analyses were included in a binary logistic regression model to identify independent predictors of intensive care unit admission and in-hospital mortality. Considering the substantial overlap between GCS and rSIG, separate multivariate logistic regression models were constructed to prevent multicollinearity. The model's fit was evaluated using the Hosmer–Lemeshow test and Nagelkerke R<sup>2</sup>. A p-value < 0.05 was considered statistically significant.

## RESULTS

A total of 705 patients who presented to the emergency department with isolated head trauma between June 1, 2021, and June 1, 2024, were included in the study. Of the participants, 65.7% (n=463) were male, and 34.3% (n=242) were female. The mean age was 37.2±27.0 (range, 1–98) years (Table 1).

The proportion of patients with trauma-related pathology detected on brain CT was 24.7% (n=174). The intubation rate was 4.0% (n=28). 16.3% (n=115) of patients received a red triage code, and 83.7% (n=590) received a yellow triage code. Based on outcome, 74.6% (n=526) of patients were discharged, 13.9% (n=98) were admitted to the ward, 8.8% (n=62) were admitted to the intensive care unit, and 2.7% (n=19) died (Figure 1).

In patients with trauma-related pathological findings on brain

CT, diastolic blood pressure (p=0.033), pulse (p<0.001), MEWS (p<0.001), shock index (p<0.001), and length of stay (p<0.001) were significantly higher, while GCS (p<0.001), reverse shock index (p<0.001), and rSIG (p<0.001) values were significantly lower (Table 2).

In patients who underwent intubation, diastolic blood pres-

**Table 1.** Patients' Sociodemographic Characteristics, Some Health Data, and Trauma Scores

Variables	n	%
Sex		
Female	242	34.3
Male	463	65.7
	Mean±SD	Median (Min- Max)
Age	37.2±27.0	31 (1-98)
Systolic Blood Pressure	126.2±19.7	124 (85-200)
Diastolic Blood Pressure	67.7±11.3	67 (43-138)
Heart Rate	93.9±20.9	90 (49-164)
Glucose	125.2±51.3	111 (32-493)
Phosphate	3.4±1.1	3,3 (0.7-11.6)
Glucose/Phosphate Ratio	41.3±25.5	35,1 (7.7-295.0)
Scores		
GCS	14.6±1.8	15 (2-15)
MEWS	1.0±1.5	0 (0-8)
Shock Index (SI)	0.7±0.2	0.7 (0.3-1.6)
Reverse Shock Index (rSI)	1.4±0.4	1.4 (0.1-3.1)
rSIG	20.6±6.0	20.9 (1.5-46.7)

**Table 2.** Comparison of patients' brain CT results with vitals, glucose/phosphorus ratio, scores, and length of stay

	Brain CT Results		p*
	Presence of pathology (n=174)	No pathology (n=531)	
	Mean±SD	Mean±SD	
Systolic Blood Pressure	127.0±22.1	125.9±18.8	0.956
Diastolic Blood Pressure	69.9±13.4	67.0±13.4	0.033
Pulse Rate	103.3±23.8	90.9±18.9	<0.001
Glucose/Phosphorus Ratio	43.3±23.7	40.7±26.0	0.098
GCS	13.6±3.3	15.0±0.3	<0.001
MEWS	1.9±2.0	0.7±1.2	<0.001
Shock Index	0.8±0.3	0.7±0.2	<0.001
Reverse Shock Index	1.3±0.4	1.4±0.4	<0.001
rSIG	17.6±7.0	21.6±5.3	<0.001
Length of Stay	6.2±3.1	4.2±1.5	<0.001

\* Mann-Whitney U Test

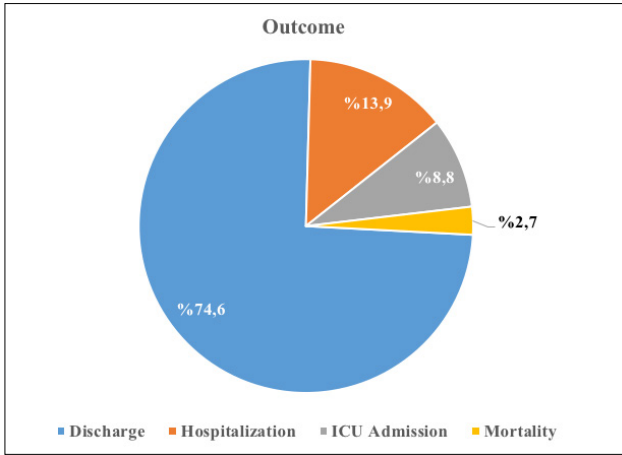


Figure 1. Outcome Distributions of Patients.

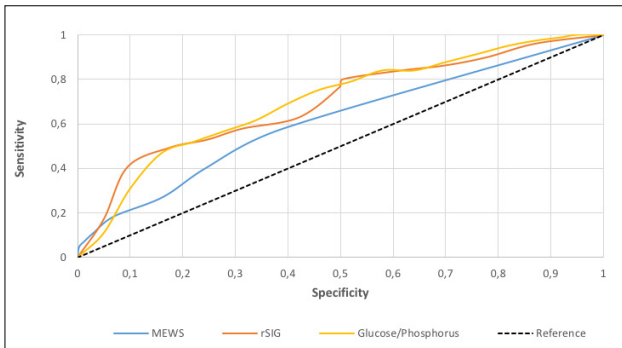


Figure 2. ROC curves of MEWS, rSIG, and glucose/phosphorus ratio for predicting poor outcomes in isolated head trauma.

sure ( $p<0.001$ ), pulse rate ( $p=0.045$ ), glucose/phosphorus ratio ( $p<0.001$ ), and MEWS ( $p=0.002$ ) were higher, whereas GCS ( $p<0.001$ ) and rSIG ( $p<0.001$ ) were lower (Table 3).

Patients in the red triage group exhibited significantly higher diastolic blood pressure ( $p=0.001$ ), heart rate ( $p<0.001$ ), glucose/phosphate ratio ( $p<0.001$ ), MEWS ( $p<0.001$ ), shock index ( $p=0.005$ ), and length of hospital stay ( $p<0.001$ ). In contrast, GCS ( $p<0.001$ ), reverse shock index ( $p=0.010$ ), and rSIG ( $p<0.001$ ) were significantly lower (Table 4).

Analysis according to patient outcomes revealed that GCS ( $p<0.001$ ) and rSIG ( $p<0.001$ ) were highest in discharged patients and lowest in those who died. In contrast, MEWS, shock index, glucose/phosphate ratio, and length of stay were significantly elevated in patients with a fatal course ( $p<0.001$ , Table 5).

ROC analysis was performed to evaluate the discriminative performance of MEWS, rSIG, and the glucose/phosphorus ratio in predicting poor clinical outcomes, defined as intensive care unit admission and/or in-hospital mortality (Figure 2). The area under the curve (AUC) for MEWS was 0.610 (95% CI: 0.542–0.679;  $p=0.001$ ), indicating limited discriminative ability. The AUC for rSIG was 0.701 (95% CI: 0.636–0.767;  $p<0.001$ ), reflecting moderate discriminative performance. The glucose/phosphorus ratio demonstrated a statistically significant but limited discriminative ability, with an AUC of 0.697 (95% CI: 0.637–0.757;  $p=0.031$ ). Optimal cut-off values were determined using the Youden index. The optimal threshold for MEWS was  $\geq 0.5$  (sensitivity: 58.0%, specificity: 60.9%), while the optimal cut-off for rSIG was  $\leq 21.35$  (sensitivity: 80.2%, specificity: 49.5%).

Table 3. Association of intubation status with vital signs, glucose/phosphate ratio, clinical scores, and hospital stay

	Intubation		p*
	Present (n=28) Mean±SD	Absent (n=677) Mean±SD	
Systolic Blood Pressure	137.5±28.8	125.7±19.1	0.068
Diastolic Blood Pressure	79.1±18.9	67.2±10.6	<0.001
Pulse Rate	102.3±23.1	93.6±20.7	0.045
Glucose/Phosphorus Ratio	58.8±22.3	40.6±25.3	<0.001
GCS	7.0±4.0	14.9±0.4	<0.001
MEWS	2.0±2.1	1.0±1.5	0.002
Shock Index	0.8±0.3	0.7±0.2	0.975
Reverse Shock Index	1.4±0.4	1.4±0.4	0.952
rSIG	10.2±6.4	21.0±5.6	<0.001
Length of Stay	4.3±1.8	4.7±2.2	0.373

\* Mann-Whitney U Test.

**Table 4.** Comparison of patients' triage status with vitals, glucose/phosphorus ratio, scores, and length of stay

	Triage		p*
	Red (n=115)	Yellow (n=590)	
	Mean±SD	Mean±SD	
Systolic Blood Pressure	128.2±22.8	125.8±19.0	0.667
Diastolic Blood Pressure	71.4±13.6	69.0±10.6	0.001
Pulse Rate	102.8±23.8	92.2±19.8	<0.001
Glucose/Phosphorus Ratio	48.9±25.1	39.8±25.3	<0.001
GCS	12.8±3.9	15.0±0.2	<0.001
MEWS	1.8±2.0	0.9±1.4	<0.001
Shock Index	0.8±0.3	0.7±0.2	0.005
Reverse Shock Index	1.3±0.4	1.4±0.4	0.010
rSIG	16.8±7.2	21.3±5.5	<0.001
Length of Stay	6.1±3.1	4.4±1.9	<0.001

\* Mann-Whitney U Test.

**Table 5.** Comparison of patients' outcomes with vital signs, glucose/phosphate ratio, clinical scores, and length of stay

	Outcome				p*
	Discharge Mean±SD	Hospitalization Mean±SD	ICU Admission Mean±SD	Mortality Mean±SD	
Systolic Blood Pressure	125.9±18.8	125.2±20.1	130.8±24.3	124.3±24.9	0.608
Diastolic Blood Pressure	67.0±10.4 <sup>a</sup>	67.0±10.7 <sup>a,b</sup>	73.5±16.7 <sup>b</sup>	71.8±10.3 <sup>a,b</sup>	0.006
Pulse Rate	90.6±18.7 <sup>a</sup>	105.6±24.1 <sup>b</sup>	101.9±21.8 <sup>b</sup>	98.3±28.4 <sup>a,b</sup>	<0.001
Glucose/Phosphorus Ratio	40.8±26.1 <sup>a</sup>	34.7±19.0 <sup>b</sup>	52.2±23.3 <sup>c</sup>	55.0±30.5 <sup>c</sup>	<0.001
GCS	15.0±0.2 <sup>a</sup>	14.9±0.5 <sup>a</sup>	12.3±4.2 <sup>b</sup>	10.7±4.8 <sup>c</sup>	<0.001
MEWS	0.7±1.2 <sup>a</sup>	2.0±2.0 <sup>b</sup>	1.5±1.9 <sup>b</sup>	2.4±2.4 <sup>b</sup>	<0.001
Shock Index	0.7±0.2 <sup>a</sup>	0.9±0.3 <sup>b</sup>	0.8±0.3 <sup>a,b</sup>	0.8±0.3 <sup>a,b</sup>	<0.001
Reverse Shock Index	1.4±0.4 <sup>a</sup>	1.2±0.4 <sup>b</sup>	1.3±0.4 <sup>a,b</sup>	1.3±0.5 <sup>a,b</sup>	<0.001
rSIG	21.6±5.3 <sup>a</sup>	18.8±6.4 <sup>b</sup>	16.4±7.1 <sup>b</sup>	15.0±8.2 <sup>b</sup>	<0.001
Length of Stay	4.2±1.5 <sup>a</sup>	6.8±3.2 <sup>b</sup>	5.1±2.4 <sup>a,c</sup>	6.4±3.4 <sup>b,c</sup>	<0.001

\*Kruskal Wallis Test.

In multivariate logistic regression analyses performed to identify independent predictors of intensive care unit admission and/or in-hospital mortality, two separate models were constructed to avoid multicollinearity between GCS and rSIG. In Model 1, which included GCS, MEWS, and age, lower GCS values and higher MEWS values were independently associated with an increased risk of poor outcome, whereas age was not a significant predictor. This model demonstrated higher explanatory power (Nagelkerke  $R^2=0.372$ ) and acceptable calibration (Hosmer–Lemeshow  $p=0.209$ ). In Model 2, which included rSIG, MEWS, and age, lower rSIG values were independently associated with poor outcome,

whereas MEWS and age were not independently associated. Compared to Model 1, this model showed lower explanatory power (Nagelkerke  $R^2=0.179$ ) with acceptable model fit (Hosmer–Lemeshow  $p=0.097$ ) (Table 6).

Correlation analysis between length of stay and scoring systems revealed a moderate positive correlation with MEWS ( $r=0.385$ ;  $p<0.001$ ) and a weak positive correlation with shock index ( $r=0.238$ ;  $p<0.001$ ). In contrast, rSIG ( $r=-0.252$ ;  $p<0.001$ ) and reverse shock index ( $r=-0.240$ ;  $p<0.001$ ) showed a weak negative correlation with length of stay. Notably, although GCS scores significantly differed between patients with and without CT pathologies (as shown in Table 2,

**Table 6.** Multivariate logistic regression models for predicting poor outcome

Variable	Model 1 (GCS-based) OR (95% CI)	p*	Model 2 (rSIG-based) OR (95% CI)	p*
Age	1.005 (0.983-1.028)	0.664	1.028 (1.014-1.043)	<0.001
MEWS	1.279 (1.056-1.550)	0.012	1.004 (0.897-1.124)	0.943
GCS	0.304 (0.187-0.494)	<0.001	–	–
rSIG	–	–	0.825 (0.775-0.878)	<0.001

Model characteristics: Model 1-Nagelkerke  $R^2=0.372$ , Hosmer–Lemeshow  $p=0.209$ ; Model 2-Nagelkerke  $R^2=0.179$ , Hosmer–Lemeshow  $p=0.097$ . Statistical significance was set at  $p<0.05$ . Due to the substantial overlap between GCS and rSIG, these variables were not included in the same model to avoid multicollinearity and the potential masking effect of GCS on rSIG.

**Table 7.** Correlation between patients' length of stay and clinical scores

	Length of Stay	
	r	p*
GCS	-0,067	0,076
MEWS	0,385	<0,001
Shock Index	0,238	<0,001
Reverse Shock Index	-0,240	<0,001
rSIG	-0,252	<0,001

\*Spearman Correlation Test.

$p<0.001$ ), GCS did not demonstrate a significant linear correlation with the length of hospital stay ( $r=-0.067$ ;  $p=0.076$ ) (Table 7).

## DISCUSSION

This study assessed the prognostic utility of the Modified Early Warning Score (MEWS) and the reverse Shock Index multiplied by Glasgow Coma Scale (rSIG) for predicting poor outcomes, defined as intensive care unit admission and/or in-hospital mortality in patients presenting to the Emergency Department with isolated head injuries.

Our results demonstrated that patients with unfavorable or fatal outcomes exhibited higher MEWS and shock index, while lower GCS, reverse shock index, and rSIG scores were associated with poor outcomes. The glucose/phosphate ratio was also higher in patients with adverse outcomes.

Traumatic brain injury (TBI) remains a major contributor to trauma-related death and long-term disability. Early risk stratification in patients with head trauma is essential for guiding treatment and monitoring strategies.<sup>[3]</sup> Although the Glasgow Coma Scale (GCS) is widely used to evaluate consciousness, it does not fully account for hemodynamic instability or systemic physiological alterations. Therefore, integrating physiological early warning scores with GCS has become increas-

ingly valuable in recent years.<sup>[18]</sup>

Our findings align with prior studies. Dündar et al.<sup>[10]</sup> (2016) reported that MEWS effectively predicts mortality in trauma patients and can identify elderly patients who may require intensive care. Similarly, Gardner-Thorpe et al. found that  $MEWS \geq 4$  was linked to significantly higher mortality.<sup>[19]</sup> In our cohort, MEWS was higher among patients with pathological findings on brain CT and in those with fatal outcomes, supporting its prognostic relevance in head trauma.

The rSIG score, which combines hemodynamic and neurological assessment, has emerged as a novel tool in trauma care. Using data from the Japan Trauma Data Bank, Kimura and Tanaka demonstrated that rSIG outperforms SI or GCS alone in mortality prediction in broad trauma populations.<sup>[18]</sup> Lai et al.<sup>[4]</sup> also showed that patients with  $rSIG < 10$  had markedly increased mortality. In our cohort, rSIG had a moderately high discriminative ability in univariate ROC analysis ( $AUC=0.701$ ), indicating a statistically significant but moderate discriminative performance. This finding aligns with the understanding that in isolated head trauma, neurological status can deteriorate independently of systemic physiological changes. Therefore, while rSIG provides valuable clinical context, it should be interpreted as an auxiliary tool rather than a definitive triage instrument.

Shock index (SI) and reverse shock index (rSI) also showed prognostic significance. Literature suggests that  $SI \geq 0.9$  correlates with higher mortality,<sup>[12]</sup> which aligns with our results. Patients with lower rSI and consequently lower rSIG scores demonstrated closer associations with poor outcomes, highlighting the advantage of combining hemodynamic and neurological evaluation for more precise risk stratification.

While comprehensive models such as IMPACT and CRASH can predict long-term outcomes, they require advanced imaging and laboratory data, limiting rapid clinical decision-making.<sup>[20]</sup> In contrast, MEWS and rSIG rely on readily available vital signs and GCS, allowing early bedside risk assessment. Our comparison of MEWS and rSIG indicates that MEWS may reflect overall clinical trajectory, including length of stay and morbidity, whereas rSIG provides additional discriminatory information for poor outcomes.

These findings are consistent with previous literature. Kim et al.<sup>[21]</sup> found that MEWS predicted in-hospital mortality in head trauma patients, and Kimura et al.<sup>[18]</sup> reported that rSIG surpassed GCS and SI in mortality prediction. Wan-Ting et al.<sup>[22]</sup> demonstrated an AUC of 0.76 for rSIG, supporting its role in trauma risk stratification. In our cohort, rSIG had the highest discriminative ability in univariate ROC analysis (AUC=0.701), indicating a moderate but statistically significant discriminative performance. Conversely, although the glucose/phosphate ratio demonstrated a statistically significant AUC (0.697) in univariate ROC analysis, this finding reflects a limited discriminative ability and should be interpreted with caution, as the parameter was not incorporated into multivariate prognostic models.

Logistic regression analyses demonstrated that lower Glasgow Coma Scale (GCS) scores and higher Modified Early Warning Score (MEWS) values were independently associated with poor outcomes, underscoring the combined prognostic impact of neurological status and early physiological deterioration.<sup>[23]</sup> When rSIG was evaluated in multivariate analyses excluding GCS, it showed independent prognostic significance, supporting its role as a composite parameter integrating hemodynamic and neurological information. However, when GCS and rSIG were considered simultaneously, the well-established prognostic value of GCS in traumatic brain injury appeared to attenuate the independent contribution of rSIG. This finding suggests that rSIG should not be viewed as an alternative to GCS, but rather as a complementary tool that may provide additional clinical context, particularly in patients with preserved consciousness but concomitant hemodynamic instability.

Elevated glucose/phosphate ratios in patients with severe or fatal courses may reflect systemic metabolic stress following TBI. Mechanisms such as catecholamine surge, cortisol increase, insulin resistance, intracellular phosphate depletion, and renal phosphate excretion may contribute to elevated ratios, reflecting tissue energy imbalance. Prior studies also link high glucose/phosphate ratios to worse neurological outcomes.<sup>[24]</sup> However, in the present study, the glucose/phosphate ratio demonstrated limited discriminative performance and did not show independent prognostic value. Therefore, this parameter should be interpreted with caution in the context of early risk stratification.

This study has limitations due to its retrospective, single-center design. Data from archived records may be incomplete or inaccurate. Chronic or systemic comorbidities affecting outcomes were not included. Glucose and phosphate were measured only at admission, without longitudinal follow-up. Long-term neurological recovery was not assessed. The study focused solely on isolated head trauma, which may limit generalizability. Nevertheless, the relatively large sample size and the combined evaluation of MEWS and rSIG strengthen the descriptive findings of this study, and future multicenter prospective studies are needed to further validate these results.

## CONCLUSION

In conclusion, MEWS and rSIG demonstrated statistically significant but moderate prognostic performance for predicting intensive care unit admission and/or in-hospital mortality in patients with isolated head trauma. MEWS appears to reflect overall physiological deterioration, whereas rSIG should be regarded as a complementary parameter rather than an alternative to the Glasgow Coma Scale. In contrast, the glucose/phosphate ratio showed limited discriminative ability and did not demonstrate robust prognostic value in this cohort. Therefore, these parameters should be considered adjunctive tools to support early clinical assessment rather than stand-alone triage instruments. Further prospective studies are warranted to clarify their role in emergency care.

**Ethics Committee Approval:** This study was approved by the Manisa Celal Bayar University Ethics Committee (Date: 04.09.2024, Decision No: 20.478.486/2589).

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: M.Y., H.İ., E.S.G.; Design: E.S.G., M.Y.; Supervision: E.S.G., M.Y.; Resource: E.S.G., M.Y., H.İ.; Materials: E.S.G., M.Y.; Data collection and/or processing: H.İ., E.S.G., M.Y.; Analysis and/or interpretation: H.İ., E.S.G., M.Y.; Literature review: E.S.G., M.Y.; Writing: H.İ., E.S.G., M.Y.; Critical review: E.S.G., M.Y.

**Conflict of Interest:** None declared.

**Financial Disclosure:** The author declared that this study has received no financial support.

## REFERENCES

1. Walls RM, Hockberger RS, Gausche-Hill M. Rosen's Emergency Medicine: Concepts and Clinical Practice. 9th ed. Amsterdam: Elsevier; 2017. [\[CrossRef\]](#)
2. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. *Neuro-Rehabilitation* 2007;22:341–53. [\[CrossRef\]](#)
3. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, et al. Estimating the global incidence of traumatic brain injury. *J Neurosurg* 2018;130:1080–97. [\[CrossRef\]](#)
4. Hilmer LV, Park KB, Vyetheth I, Wirsching M. Cerebral contusion: An investigation of etiology, risk factors, related diagnoses, and the surgical management at a major government hospital in Cambodia. *Asian J Neurosurg* 2018;13:23–30. [\[CrossRef\]](#)
5. Akkose S, Armağan E, Bulut M, Tokyay R. Trauma care system in Turkey and the approach to patients suffering head trauma. *Ulus Travma Acil Cerrahi Derg* 2002;8:1–2.
6. Karasu A, Sabanci PA, Cansever T, Hepgül KT, Imer M, Dolaş I, et al. Epidemiological study in head injury patients. *Ulus Travma Acil Cerrahi Derg* 2009;15:159–63. [In Turkish].
7. Tintinalli JE, Stapczynski JS, Ma OJ, Yealy D M, Meckler GD, Cline DM. Tintinalli's Emergency Medicine: A Comprehensive Study Guide. New York, NY, USA: McGraw-Hill Education; 2016: pp. 340–4.
8. Langlois JA, Rutland-Brown W, Thomas KE. Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths. Bethesda, MD: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004.
9. Thurman D. The epidemiology and economics of head trauma. In: Miller L, editor. *Head Trauma: Basic, Preclinical, and Clinical Directions*. New

- York, NY: Wiley; 2001.
10. Dunder ZD, Ergin M, Karamercan MA, Ayranci K, Colak T, Tuncar A, et al. Modified Early Warning Score and VitalPac Early Warning Score in geriatric patients admitted to emergency department. *Eur J Emerg Med* 2016;23:406–12. [CrossRef]
  11. Mutschler M, Nienaber U, Münzberg M, Wöfl C, Schoechl H, Paffrath T, et al; TraumaRegister DGU. The Shock Index revisited - a fast guide to transfusion requirement? A retrospective analysis on 21,853 patients derived from the TraumaRegister DGU. *Crit Care* 2013;17:R172. [Cross-Ref]
  12. Cannon CM, Braxton CC, Kling-Smith M, Mahnken JD, Carlton E, Moncure M. Utility of the shock index in predicting mortality in traumatically injured patients. *J Trauma* 2009;67:1426–30. [CrossRef]
  13. Chuang JF, Rau CS, Wu SC, Liu HT, Hsu SY, Hsieh HY, et al. Use of the reverse shock index for identifying high-risk patients in a five-level triage system. *Scand J Trauma Resusc Emerg Med* 2016;24:12. [CrossRef]
  14. Lai WH, Rau CS, Hsu SY, Wu SC, Kuo PJ, Hsieh HY, et al. Using the reverse shock index at the injury scene and in the emergency department to identify high-risk patients: a cross-sectional retrospective study. *Int J Environ Res Public Health* 2016;13:357. [CrossRef]
  15. Lai WH, Wu SC, Rau CS, Kuo PJ, Hsu SY, Chen YC, et al. Systolic blood pressure lower than heart rate upon arrival at and departure from the emergency department indicates a poor outcome for adult trauma patients. *Int J Environ Res Public Health* 2016;13:528. [CrossRef]
  16. Emami P, Czorlich P, Fritzsche FS, Westphal M, Rueger JM, Lefering R, et al. Impact of Glasgow Coma Scale score and pupil parameters on mortality rate and outcome in pediatric and adult severe traumatic brain injury: a retrospective, multicenter cohort study. *J Neurosurg* 2017;126:760–7. [CrossRef]
  17. Nik A, Sheikh Andalibi MS, Ehsaei MR, Zarifian A, Ghayoor Karimi-ani E, Bahadoorkhan G. The Efficacy of Glasgow Coma Scale (GCS) Score and Acute Physiology and Chronic Health Evaluation (APACHE) II for Predicting Hospital Mortality of ICU Patients with Acute Traumatic Brain Injury. *Bull Emerg Trauma* 2018;6:141–5. [CrossRef]
  18. Kimura A, Tanaka N. Reverse shock index multiplied by Glasgow Coma Scale score (rSIG) is a simple measure with high discriminant ability for mortality risk in trauma patients: an analysis of the Japan Trauma Data Bank. *Crit Care* 2018;22:87. [CrossRef]
  19. Gardner-Thorpe J, Love N, Wrightson J, Walsh S, Keeling N. The value of Modified Early Warning Score (MEWS) in surgical in-patients: a prospective observational study. *Ann R Coll Surg Engl* 2006;88:571–5. [CrossRef]
  20. Eagle SR, Nwachuku E, Elmer J, Deng H, Okonkwo DO, Pease M. Performance of CRASH and IMPACT prognostic models for traumatic brain injury at 12 and 24 months post-injury. *Neurotrauma Rep* 2023;4:118–23. [CrossRef]
  21. Kim DK, Lee DH, Lee BK, Cho YS, Ryu SJ, Jung YH, et al. Performance of Modified Early Warning Score (MEWS) for Predicting In-Hospital Mortality in Traumatic Brain Injury Patients. *J Clin Med* 2021;10:1915. [CrossRef]
  22. Wan-Ting C, Chin-Hsien L, Cheng-Yu L, Cheng-Yu C, Chi-Chun L, Keng-Wei C, et al. Reverse shock index multiplied by Glasgow Coma Scale (rSIG) predicts mortality in severe trauma patients with head injury. *Sci Rep* 2020;10:2095. [CrossRef]
  23. Yu Z, Xu F, Chen D. Predictive value of Modified Early Warning Score (MEWS) and Revised Trauma Score (RTS) for the short-term prognosis of emergency trauma patients: a retrospective study. *BMJ Open* 2021;11:e041882. [CrossRef]
  24. Li J, Ma W, Tang W, Yang K, Gu H, Shi J, et al. Serum Glucose-Phosphate Ratio on Admission as a Potential Biomarker for Severity, Functional Outcome, and Recurrence in Acute Ischemic Stroke. *Int J Gen Med* 2024;17:5825–36. [CrossRef]

## ORIJİNAL ÇALIŞMA - ÖZ

### Travmatik beyin hasarında erken risk sınıflandırması: izole kafa travmalı hastalarda MEWS ve rSIG skorlarının analizi

**AMAÇ:** Travmatik beyin hasarı (TBH), dünya genelinde travmaya bağlı morbidite ve mortalitenin başlıca nedenlerinden biridir. Klinik kötüleşme riski taşıyan hastaların erken dönemde tanınması, acil yönetimin optimize edilmesi açısından kritik öneme sahiptir. Modifiye Erken Uyarı Skoru (MEWS) ve Glasgow Koma Skalası ile çarpılmış ters Şok İndeksi (rSIG), erken prognostik değerlendirmede klinisyenlere yardımcı olabilecek, basit ve hızlı hesaplanabilen araçlardır. Bu çalışmanın amacı, izole kafa travması olan hastalarda MEWS ve rSIG'nin kötü sonlanımı öngörmedeki prognostik performansını değerlendirmektir.

**GEREÇ VE YÖNTEM:** Bu retrospektif gözlemsel çalışmaya, Haziran 2021-Haziran 2024 tarihleri arasında Manisa Celal Bayar Üniversitesi Hastanesi Acil Servisi'ne izole kafa travması ile başvuran hastalar dâhil edildi. Demografik, klinik ve laboratuvar verileri hastane bilgi yönetim sisteminden elde edildi. Tüm hastalar için MEWS, Şok İndeksi (SI), ters Şok İndeksi (rSI) ve rSIG değerleri hesaplandı. Grup karşılaştırmaları parametrik olmayan testlerle yapıldı. Korelasyonlar Spearman katsayıları kullanılarak analiz edildi. Skorların ayırt edici gücünü değerlendirmek amacıyla alıcı işletim karakteristiği (ROC) eğrileri oluşturuldu ve kötü sonlanımın (yoğun bakım yatışı ve/veya hastane içi mortalite) bağımsız belirleyicilerini saptamak için ikili lojistik regresyon analizi uygulandı.

**BULGULAR:** Toplam 705 hasta (%65.7 erkek; ortalama yaş 37.2±27.0 yıl) analiz edildi. Hastaların %24.7'sinde kranial BT'de patolojik bulgu saptandı ve genel mortalite oranı %2.7 idi. Kötü sonlanımı olan hastalarda MEWS ve SI değerleri anlamlı olarak daha yüksek bulunurken; GKS, rSI ve rSIG değerleri belirgin şekilde daha düşüktü (tümü için p<0.001). ROC analizinde rSIG için orta düzeyde ayırt edici performans (AUC=0.701), MEWS için ise sınırlı ayırt edici güç (AUC=0.610) saptandı; optimal kesme değerleri sırasıyla ≤21.35 ve ≥0.5 idi. Çok değişkenli analizlerde, MEWS ve rSIG kötü sonlanımı öngörmede ayrı modellerde bağımsız prognostik anlamlılık gösterdi; GKS'nin dışlandığı modellerde rSIG anlamlılığını korudu. MEWS, hastanede kalış süresi ile pozitif yönde korelasyon gösterirken (r=0.385; p<0.001), rSIG ile negatif yönde korelasyon saptandı (r=-0.252; p<0.001).

**SONUÇ:** MEWS ve rSIG, izole kafa travması olan hastalarda erken risk sınıflamasını destekleyebilecek pratik yatak başı araçlardır. MEWS erken fizyolojik bozulmayı yansıtırken, rSIG tamamlayıcı hemodinamik-nörolojik bilgi sağlamaktadır ve tek başına bir triyaj aracı olarak değil, destekleyici bir parametre olarak yorumlanmalıdır. Bu skorların rutin kullanımı, standart klinik değerlendirmeye ek olarak acil serviste erken klinik karar verme ve hasta izlemine katkı sağlayabilir.

**Anahtar sözcükler:** Glasgow koma skoru ile çarpılmış ters şok indeksi (rSIG); kafa travması; modifiye erken uyarı skoru (MEWS); şok indeksi; travmatik beyin hasarı.