

## ***Value of Nonspecific Severity Scores in Predicting Mortality in Severe Traumatic Brain Injury***

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### **Abstract**

**Introduction:** Severe traumatic brain injury (sTBI) is a leading cause of mortality in young adults. Neurological scores alone, such as the Glasgow Coma Scale (GCS), may be insufficient due to associated organ dysfunction. This study evaluated the predictive value of nonspecific severity scores (APACHE II, SAPS II) and organ dysfunction scores (SOFA, LODS, and MODS) for mortality in ICU patients with sTBI.

**Methods:** Prospective descriptive and analytical study over 10 months in a 22-bed multidisciplinary ICU at Habib Bourguiba University Hospital, Sfax. We included adult patients ( $\geq 18$  years) admitted to the ICU with both isolated severe traumatic brain injury and polytrauma patients with severe traumatic brain injury (Glasgow Coma Scale  $\leq 8$  after initial resuscitation). Patients who died before day 5 were excluded, and organ dysfunction scores were calculated whenever data were available on days 1, 3, and 5. Data collected included demographics, neurological and biological status, imaging, interventions, initial severity scores, and organ dysfunction scores on days 1, 3, and 5. Univariate and multivariate analyses were performed to identify factors associated with mortality. Predictive performance was assessed using ROC curves (AUC, sensitivity, specificity).

**Results:** Thirty-seven patients were included, with a median age of 40 years and 86% male. Road traffic accidents accounted for 86%. ICU mortality was 16.2%. Non-survivors had higher SAPS II and APACHE II scores ( $p < 0.01$ ). LODS and MODS scores on days 1, 3, and 5 were significantly associated with mortality. ROC analyses showed excellent discrimination, particularly for LODS on day 5 (AUC 0.911). Multivariate analysis revealed MODS day 1, LODS day 3, and LODS day 5 as autonomous predictors of mortality.

**Conclusion:** Nonspecific severity scores and serial organ dysfunction scores are reliable tools for predicting ICU mortality in sTBI. Dynamic assessment enhances prognostic accuracy and may guide clinical decision-making.

**Keywords:** Severe traumatic brain injury, mortality prediction, APACHE II, SAPS II, SOFA, LODS, MODS, intensive care unit

## INTRODUCTION

Trauma represents the leading cause of mortality before the age of 45 years(1). Approximately half of trauma-related deaths are due to traumatic brain injuries (TBI)(1). Every day, intensivists face difficulties in the management of severe traumatic brain injury (sTBI) patients (2) and must decide which patients should be admitted to the intensive care unit. Although TBI-specific prognostic models, particularly IMPACT and CRASH, demonstrate good discriminatory ability, they primarily predict long-term neurological outcomes and inadequately account for extracranial organ dysfunction or the dynamic course of critical illness. Therefore, routinely used nonspecific ICU severity scores may provide a more comprehensive assessment of mortality risk in patients with severe TBI(3). Patients with severe TBI admitted to the ICU often present not only with neurological dysfunction, assessed by specific scores such as the Glasgow Coma Scale (GCS) and the Glasgow Outcome Scale (GOS) (4), but also with dysfunction of at least one other major organ system. Therefore, predicting outcomes and mortality in severe TBI patients admitted to the ICU based on the number, severity, and duration of organ failures has become increasingly relevant (5). Several scoring systems have been developed, among the most recent being the Multiple Organ Dysfunction Score (MODS) (6), the Logistic Organ Dysfunction Score (LODS) (7), and the Sequential Organ Failure Assessment (SOFA) score (8). The main objective of our study was to evaluate the predictive value of two antiepileptic drugs, anti-edema therapy, and surgery), imaging findings, biological data at admission, systemic secondary brain insults at admission, initial severity scores at admission (GCS (9), SAPS II(10), and APACHE II (11)), and organ dysfunction scores (SOFA (8), MODS (6), and LODS (7)) calculated on day 1, day 3, and day 5. Additional variables included the need for tracheostomy, length of ICU stay, duration of mechanical ventilation, and mortality.

types of nonspecific severity scores—initial severity scores (APACHE II and SAPS II) and organ dysfunction scores (SOFA, LODS, and MODS) in predicting mortality after severe traumatic brain injury.

## METHODS

**Study Design:** This was a prospective descriptive and analytical study conducted over 10 months (from November 1, 2024, to August 31, 2025) in the multidisciplinary intensive care unit of the Habib Bourguiba University Hospital in Sfax, which has 22 beds. We included adult patients ( $\geq 18$  years) admitted to the ICU with both isolated severe traumatic brain injury and polytrauma patients with severe traumatic brain injury (Glasgow Coma Scale  $\leq 8$  after initial resuscitation). Patients who died before day 5 were excluded, and organ dysfunction scores were calculated whenever data were available on days 1, 3, and 5. We included all consecutive eligible patients admitted during the study period; no formal sample size calculation was performed. The requirement for informed consent was waived because of the anonymized data collection. All medical records of patients admitted during the study period were reviewed. Data were collected using a standardized file including: age, sex, medical history, mechanism of injury, neurological examination at admission (pupillary status and presence or absence of motor deficit), treatments used at admission (mechanical ventilation, catecholamine, fluid resuscitation, sedation,

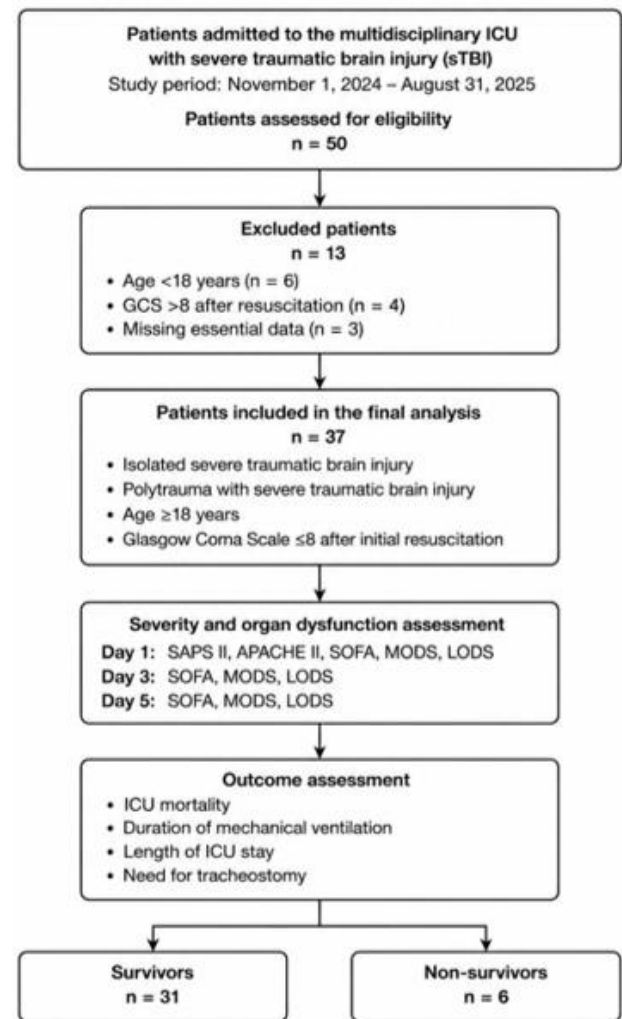
**Statistical Analysis:** Data were entered and analyzed using SPSS software version 22. Results were presented as a descriptive study. Quantitative variables were expressed as mean  $\pm$  standard deviation or median (IQR) depending on their distribution, while qualitative variables were expressed as number (percentage). For the analytical study, factors associated with mortality were evaluated. Comparisons of proportions

were performed using the Pearson Chi-square test or Fisher's exact test when appropriate. Comparisons of means were performed using the nonparametric Mann–Whitney U test. The level of statistical significance was set at  $p < 0.05$ . Multivariate analysis was performed using a stepwise ascending multiple logistic regression model, including variables with  $p < 0.05$  in the univariate analysis. The optimal cut-off values were determined using receiver operating characteristic (ROC) curve analysis.

## RESULTS

**Descriptive Study:** Patients assessed for eligibility were 50. Thirty-seven patients were included in our study (Figure 1). The median age was 40 years, with extremes ranging from 19 to 73 years. A male predominance was observed, with a sex ratio of 6. Most patients had no prior medical history (76%). The most frequent mechanism of injury was road traffic accident (86%). All included patients had a Glasgow Coma Scale (GCS) score  $\leq 8$  after initial resuscitation, with a median admission GCS of 6. The median SAPS II (IGS II) was 39, and the median APACHE II score was 17. The median SOFA score was 7, LODS was 5, and MODS was 5. Thirteen patients (35%) presented with motor deficits. Thirteen patients exhibited anisocoria (45%), and one patient had mydriasis. Twenty-one patients (56%) developed shock at admission, requiring catecholamine. Volume resuscitation was performed in 28 patients (75%), and all patients (100%) required mechanical ventilation from admission. Organ dysfunction scores were available for all 37 patients at each assessment time point (Day 1, Day 3, and Day 5), as no deaths occurred before Day 5. Table 1 details the severity and organ dysfunction scores on Day 3 and Day 5. All patients underwent a cranial CT scan on admission. The most common lesions were subdural hematoma ( $n=21$ ; 56%) and epidural

hematoma ( $n=12$ ; 32%). All patients received sedation (100%).



**Figure 1: Flow chart of patient selection**

Osmotherapy with 20% mannitol was indicated in 24 patients (64%), and antiepileptic treatment in 21 patients (56%). Tracheostomy was performed in 19 patients (51%) at a median of 10 days. Surgical decompressive craniectomy was performed in 10 patients (27%). Blood transfusion was indicated in 20 patients. The median duration of mechanical ventilation was 10 days, and the median ICU stay was 18 days. Overall mortality was 16% (6 patients).

**Analytical Study:** The median age of nonsurvivors was slightly higher than that of survivors (43 vs. 41 years;  $p = 0.84$ ). The median SAPS II (IGS II) score was higher in nonsurvivor patients than in survivors (58 vs. 37;  $p = 0.004$ ).

**Table 1: Severity scores during ICU stay**

|          | Median [IQR] |
|----------|--------------|
| SOFA d 3 | 7 [5–9]      |
| LODS d 3 | 4 [3–7]      |
| MODS d 3 | 5 [4–8]      |
| SOFA d 5 | 5 [3–8]      |
| LODS d 5 | 4 [2–6]      |
| MODS d 5 | 4 [2–7]      |

SOFA: Sequential Organ Failure Assessment Score, LODS: Logistic Organ Dysfunction System, MOD: Multiple Organ Dysfunction Score, d: day, IQR:interquartile

The median APACHE II score was also higher among nonsurvivors patients (24 vs. 16;  $p = 0.001$ ). LODS and MODS scores on day 1 were higher in nonsurvivors compared to survivors, with significant differences ( $p = 0.034$  for both). LODS and MODS on day 3, and SOFA, LODS, and MODS on day 5 were also significantly associated with mortality (Table 2).

ROC curve analysis showed that: SAPS II (IGS II)  $> 53.5$  had an AUC of 0.823, with a sensitivity of 83% and specificity of 93% ( $p = 0.013$ ) (Figure 2, curve A). APACHE II  $> 20.5$  had an AUC of 0.836, with a sensitivity of 83% and specificity of 87% ( $p = 0.01$ ) (Figure 2, curve B). LODS on day 1  $> 6.5$  had an AUC of 0.847, with a sensitivity of 83% and specificity of 87% ( $p = 0.008$ ) (Figure 2, curve C). MODS on day 1  $> 5.5$  had an AUC of 0.815, with a sensitivity of 83% and specificity of 67% ( $p = 0.016$ ) (Figure 2, curve D). MODS on day 3  $> 6.5$  had an AUC of 0.863, with a sensitivity of 83% and specificity of 90% ( $p = 0.005$ ) (Figure 3, curve E).

LODS on day 3  $> 6.5$  had an AUC of 0.883, with a sensitivity of 83% and specificity of 93% ( $p = 0.003$ ) (Figure 3, curve F). SOFA on day 5  $> 6.5$  had an AUC of 0.819, with a sensitivity of 83% and specificity of 79% ( $p = 0.015$ ) (Figure 3, curve G).

**Table 2: Univariate analysis of factors associated with mortality**

| Variables    | Survivors (n=31) | Nonsurvivors (n=6) | <i>p</i> |
|--------------|------------------|--------------------|----------|
| Age (median) | 41               | 43                 | 0.84     |
| Sex ; n(%)   |                  |                    |          |
| Male         | 26 (83)          | 6(100)             | 0.29     |
| Female       | 5 (16)           | 0 (0)              |          |

#### **Factors associated with mortality in univariate analysis**

|                       |    |    |              |
|-----------------------|----|----|--------------|
| GCS (median)          | 7  | 5  | 0.108        |
| IGSII d1 (median)     | 37 | 58 | <b>0.004</b> |
| APACHE II d1 (median) | 16 | 24 | <b>0.001</b> |
| SOFA d1 (median)      | 7  | 11 | 0.076        |
| LODS d1 (median)      | 5  | 10 | <b>0.034</b> |
| MODS d1 (median)      | 5  | 10 | <b>0.034</b> |

#### **Systemic secondary brain insults (SBI) at admission**

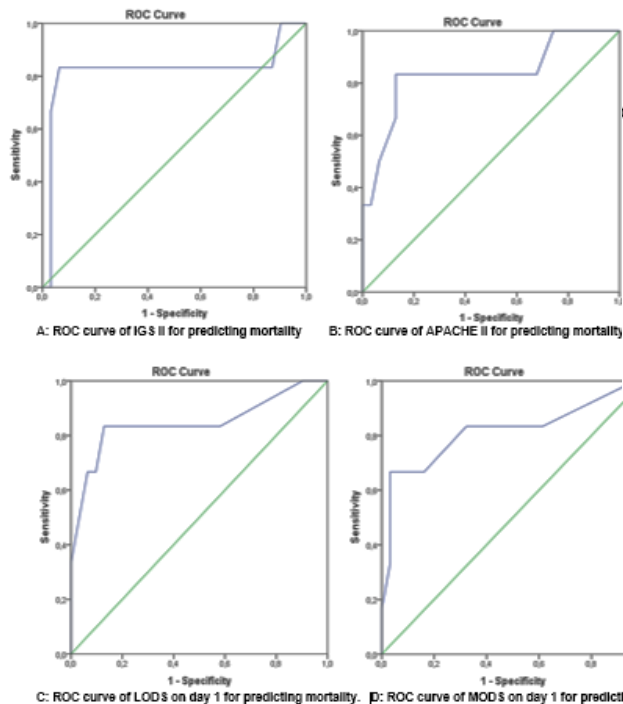
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|--------------------------------------|--------|-------|-----|
| Shock (n ;%)                         | 17(46) | 4(66) | 0.6 |
| Anemia (n ;%)                        | 8(25)  | 1(16) | 0.6 |
| Hypoxemia (n ;%)                     | 16(51) | 4(66) | 0.6 |
| Hypercapnia (n ;%)                   | 12(38) | 2(33) | 0.8 |
| Hyponatremia<135 mmol/l (n ;%)       | 1(3)   | 1(16) | 0.3 |
| Hyperglycemia $\geq$ 8 mmol/l (n ;%) | 10(32) | 2(33) | 1   |

#### **Severity scores and organ dysfunction scores during the ICU stay**

|                   |   |    |              |
|-------------------|---|----|--------------|
| SOFA d3 (median)  | 6 | 10 | 0.053        |
| LODS d3 (median)  | 4 | 9  | <b>0.037</b> |
| MODS d3 (median)  | 4 | 10 | <b>0.05</b>  |
| SOFA d 5 (median) | 5 | 11 | <b>0.048</b> |
| LODS d 5 (median) | 3 | 9  | <b>0.02</b>  |
| MODS d 5 (median) | 4 | 10 | <b>0.032</b> |

GCS: Glasgow coma score, IGSII: Indice de Gravité Simplifié II, APACHE: Acute Physiology and Chronic Health Evaluation, SOFA: Sequential Organ Failure Assessment Score, LODS: Logistic Organ Dysfunction System, MOD: Multiple Organ Dysfunction Score, d: day, ACSOS: agressions cérébrales secondaires d'origine systémiques, CIVD: coagulation intra vasculaire disséminée, pH: potentiel Hydrogène

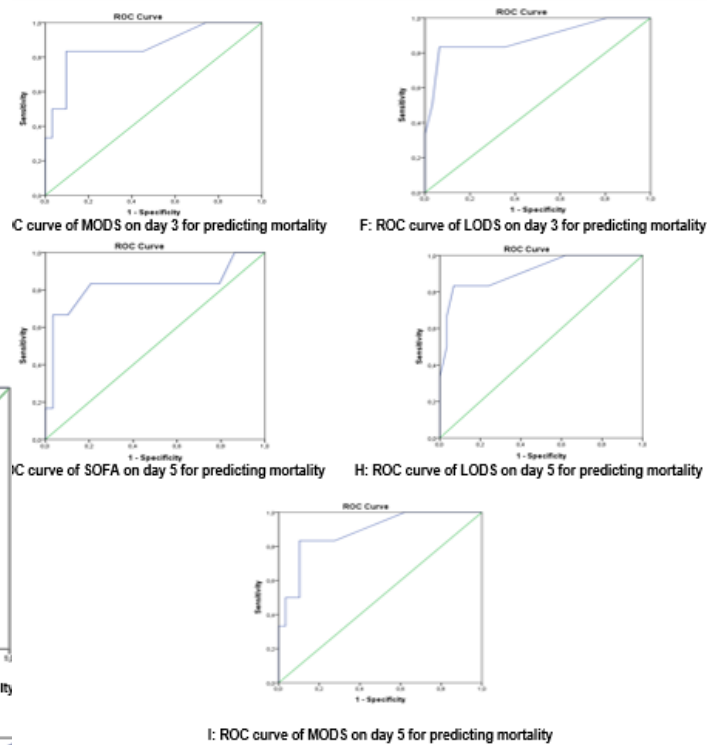
LODS on day 5 > 6.5 had an AUC of 0.911, with a sensitivity of 83% and specificity of 93% ( $p = 0.002$ ) (Figure 3, curve H). MODS on day 5 > 6.5 had an AUC of 0.855, with a sensitivity of 83% and specificity of 89% ( $p = 0.003$ ) (Figure 3, curve I). Table 3 details the prognostic accuracy of severity scores for predicting ICU mortality.



**Figure 2: ROC curves of IGS II, APACHE II, and LODS (day 1), and MODS (day 1) for predicting mortality.**

## DISCUSSION

Severe traumatic brain injury (TBI) remains a leading cause of critical illness and mortality worldwide, particularly among young adults (12). Despite advancements in prehospital care and intensive care unit (ICU) management, predicting outcomes after severe TBI continues to be a clinical challenge(13). Early prognostication is essential for guiding therapeutic decisions, allocating resources, and informing families, yet reliance solely on neurological scores such as the Glasgow Coma Scale (GCS) may be insufficient given the systemic impact of severe TBI (12).



**Figure 3: ROC curves of MODS (day 3), LODS (day 3), SOFA (day 5), LODS (day 5), and MODS (day 5) for predicting mortality.**

Multivariate Analysis identified MODS on day 1, LODS on day 3, and LODS on day 5 as independent factors associated with mortality (Table 4).

In our cohort of 37 patients with severe sTBI, we observed an ICU mortality of 16.2%. Median admission severity scores (APACHE II: 17; SAPS II: 39) and organ dysfunction scores (SOFA: 7; LODS: 5; MODS: 5) were elevated, reflecting significant physiological disturbances. These findings corroborate prior studies demonstrating that severe TBI frequently results in multisystem dysfunction, which has a substantial influence on patient outcomes (14,15).

Our analyses indicate that both nonspecific severity scores (APACHE II, SAPS II) and organ dysfunction scores (SOFA, LODS, MODS) are significantly associated with mortality in severe TBI.

**Table 3: Prognostic accuracy of severity scores for predicting ICU mortality**

| Severity score | Cut-off | AUC (95% CI)     | Sensitivity (%) | Specificity (%) | P value |
|----------------|---------|------------------|-----------------|-----------------|---------|
| SAPS II        | >53.5   | 0.823(0.66–0.98) | 83              | 93              | 0.013   |
| APACHE II      | >20.5   | 0.836(0.68–0.99) | 83              | 87              | 0.010   |
| LODS Day 1     | >6.5    | 0.847(0.70–0.99) | 83              | 87              | 0.008   |
| MODS Day 1     | >5.5    | 0.815(0.65–0.98) | 83              | 67              | 0.016   |
| MODS Day 3     | >6.5    | 0.863(0.73–0.99) | 83              | 90              | 0.005   |
| LODS Day 3     | >6.5    | 0.883(0.75–1.00) | 83              | 93              | 0.003   |
| SOFA Day 5     | >6.5    | 0.819(0.66–0.98) | 83              | 79              | 0.015   |
| LODS Day 5     | >6.5    | 0.911(0.80–1.00) | 83              | 93              | 0.002   |
| MODS Day 5     | >6.5    | 0.855(0.71–1.00) | 83              | 89              | 0.003   |

*AUC, area under the receiver operating characteristic (ROC) curve; SAPS II, Simplified Acute Physiology Score II; APACHE II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment; MODS, Multiple Organ Dysfunction Score; LODS, Logistic Organ Dysfunction System; CI, confidence interval.*

**Table 4: Multivariate analysis of severity and organ dysfunction scores associated with mortality**

| Variables | <i>p</i> | OR   | Confidence Interval 95% |
|-----------|----------|------|-------------------------|
| MODS D1   | 0.004    | 2.5  | 2.24-10.80              |
| LODS D3   | 0.013    | 4.5  | 3.53-12.77              |
| LODS D5   | 0.011    | 6.33 | 4.33-15.43              |

Univariate comparisons showed higher median values of these scores among nonsurvivors, and ROC curve analysis demonstrated excellent discriminative performance. Notably, LODS at day 5 yielded an AUC of 0.911, with high sensitivity and specificity, while scores such as MODS at day 3 (AUC 0.863) and SOFA at day 5 (AUC 0.819) also showed robust predictive value.

These results align with contemporary literature (15,16). Prior research has shown that commonly used ICU scoring systems traditionally developed for general critical illness can reliably predict mortality in TBI populations when applied dynamically (14,15). For example, recent comparative analyses indicate that APACHE II and SAPS II outperform GCS alone (17) in prognostic accuracy when predicting short- and medium-term mortality after TBI (14). In addition, the predictive validity of organ dysfunction scores such as SOFA, MODS, and LODS has been increasingly recognized, reflecting the systemic inflammatory response and secondary organ failures that commonly complicate severe TBI (15,18).

The selection of days 1, 3, and 5 for organ dysfunction assessment was intended to capture the dynamic evolution of multiple organ dysfunction during the early phase of critical illness. Day 1 reflects the initial physiological derangement at ICU admission, whereas day 3 corresponds to the period when secondary brain injury and systemic inflammatory responses may lead to the development or worsening of organ dysfunction. Day 5 allows evaluation of the persistence or resolution of organ failure following initial resuscitation and intensive care management. Serial assessment at these predefined time points provides a more comprehensive evaluation of disease progression than a single measurement and may improve the prognostic performance of organ dysfunction scores (19–21).

Our findings confirm that serial measurements of organ dysfunction scores provide additional prognostic value beyond initial admission scores. Several authors have emphasized that evaluating trends in organ failure over the early ICU period better captures the evolving pathophysiology after TBI and improves outcome prediction (18). This temporal dimension allows clinicians to detect progressive organ dysfunction and identify high-risk patients who may benefit from

intensified monitoring and tailored supportive therapies.

Multivariate analysis in our study identified MODS at day 1, LODS at day 3, and LODS at day 5 as independent predictors of mortality, underscoring the relevance of dynamic organ dysfunction assessment. These results are consistent with prior evidence suggesting that early and sustained organ failure represents a significant contributor to adverse outcomes in critically ill TBI patients (18). Whereas initial neurological severity provides important information about primary brain injury, systemic scores capture the cumulative burden of secondary insults such as shock, hypoxia, sepsis, and metabolic dysfunction that often determine survival.

Clinically, incorporating both nonspecific ICU severity scores and organ dysfunction scales into routine TBI assessment can enhance prognostic precision. Such integration can support multidisciplinary decision-making regarding escalation of care, resource utilization, and goals of treatment. For instance, high APACHE II or SAPS II scores combined with increasing LODS or MODS trajectories may indicate a poor prognosis, warranting early palliative care involvement or discussion of withdrawal of aggressive treatment modalities (15). Conversely, patients with stable organ function scores over the first ICU week may have better recovery potential.

Nevertheless, our study has limitations. The sample size is modest and derived from a single tertiary center, potentially limiting external validity. Additionally, although nonspecific severity and organ dysfunction scores provide valuable prognostic information, these tools should be interpreted within the broader clinical context including neuroimaging, comorbidities, and complications such as intracranial hypertension (13). Another important limitation of this study is the small number of deaths (6 events), which may have limited the robustness of the multivariable logistic regression analysis.

Future research should pursue larger, multicenter cohorts to validate prognostic models that combine neurological and systemic variables, potentially enhanced by advanced machine learning techniques (18).

## CONCLUSION

Our findings support the use of nonspecific severity scores (APACHE II, SAPS II) and serial organ dysfunction scores (SOFA, LODS, MODS) as effective predictors of ICU mortality in severe TBI. Dynamic assessment over the first week after injury offers superior discrimination compared with single-time-point measurements. Integrating these scoring systems into clinical practice could improve prognostication, optimize care strategies, and facilitate informed decision-making in the management of severe TBI.

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**Conflict of Interest:** All authors certify that they have no affiliations

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