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Prognostic Value of APACHE II, SAPS II, and SOFA Scores in Critically Ill Hematologic Patients: A Single-Center, Retrospective Analysis

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Abstract

Aim: Critically ill hematologic patients (CIHPs) represent a distinct population in the intensive care unit (ICU), characterized by complex pathophysiology and high mortality rates. Prognostic assessment in this group remains challenging. This study aimed to evaluate the utility of acute illness severity and organ dysfunction scores in predicting ICU outcomes in CIHPs.

Study Design: This retrospective, single-center study was conducted in a dedicated hematology ICU. The prognostic performance of commonly used acute illness severity and organ dysfunction scores (APACHE II, SAPS II, and SOFA) was evaluated in CIHPs. ICU mortality was assessed as the primary outcome. Additionally, early trajectories of these scores—particularly changes by ICU day 3—were analyzed for their association with prognosis.

Results: A total of 107 patients were included. The median age of the patients was 62 (range: 53–70), and 69 (64.5%) were male. The ICU mortality rate was 40.2%. The most frequent underlying diagnoses were multiple myeloma (31.8%) and non-Hodgkin lymphoma (20.6%). Respiratory failure (68.2%) and sepsis (54.2%) were the leading reasons for ICU admission. Non-survivors had significantly higher APACHE II, SAPS II, and SOFA scores on both day 1 and day 3. Furthermore, non-survivors demonstrated a significant increase in all three scores over the first three ICU days. Among these parameters, the day 3 SOFA score was the strongest independent predictor of ICU mortality (OR 2.042, 95% CI 1.407–2.962; p = 0.001), suggesting that early organ dysfunction and its progression during the ICU stay are critical determinants of ICU mortality.

Conclusions: Acute illness severity and organ dysfunction scores are valuable tools for predicting ICU outcomes in CIHPs. In particular, early SOFA score trajectories—especially the day 3 SOFA score—provide superior prognostic information and may support clinical decision-making in this high-risk population.

Keywords: APACHE II; Critically ill hematologic patients; Intensive care unit mortality; SAPS II; SOFA.

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Introduction

The prognosis of patients admitted to intensive care units (ICUs) is primarily determined by the severity of acute illness and the degree of organ dysfunction. To quantify these parameters and facilitate prognostic assessment, several scoring systems have been developed and widely implemented in critical care practice. Acute illness severity scores—such as the Acute Physiology and Chronic Health Evaluation (APACHE II, III, and IV), the Simplified Acute Physiology Score (SAPS II and SAPS 3), and the Mortality Probability Model (MPM II and III)—are typically calculated upon ICU admission to estimate baseline mortality risk. In contrast, organ dysfunction scores, including the Sequential Organ Failure Assessment (SOFA), Multiple Organ Dysfunction Score (MODS), and Logistic Organ Dysfunction System (LODS), are designed for serial assessment, allowing for the evaluation of the progression of organ failure during the ICU stay.[1]

Several studies have investigated the performance of general ICU severity and organ dysfunction scores in patients with hematologic diseases, particularly hematologic malignancies, yielding heterogeneous results. While some studies have demonstrated acceptable discrimination of APACHE II, SAPS II, and SOFA scores in this population, others have reported reduced predictive accuracy compared to mixed ICU cohorts. Importantly, most prognostic models were developed and validated in general ICU populations, where hematologic patients are often underrepresented, and disease-specific factors—such as immunosuppression, treatment-related toxicity, and prolonged organ dysfunction—are not adequately captured. Consequently, the applicability and reliability of these models in critically ill hematologic patients remain uncertain.[2-5]

Moreover, most available data originate from general ICUs in high-income countries, with limited evidence from dedicated hematology ICUs or from low- and middle-income healthcare settings.[3,4] Dedicated hematology ICUs may differ substantially from general ICUs in terms of admission criteria, patient case-mix, timing of ICU referral, and intensity of hematologic support, all of which may influence the performance of prognostic scoring systems. The scarcity of data from such specialized units represents a relevant gap in the literature.

In recent years, increasing attention has been directed toward the prognostic value of dynamic changes in organ dysfunction scores. In particular, trends in SOFA scores during the first days of ICU admission have been shown to outperform single admission values in predicting mortality in heterogeneous ICU populations. However, data specifically evaluating early SOFA trajectories in critically ill hematologic patients remain limited.[3,5] Given the high prevalence of evolving multiorgan failure and the complexity of treatment decisions in this population, understanding whether early changes in SOFA scores provide meaningful prognostic information is of considerable clinical importance.

Therefore, in the present study, we aimed to address these gaps by evaluating prognostic factors associated with ICU mortality in critically ill hematologic patients admitted to a dedicated hematology ICU at a university hospital. Specifically, we assessed the predictive performance of APACHE II, SAPS II, and SOFA scores and investigated the prognostic significance of early changes in these scores between ICU day 1 and day 3.

Materials and Methods

Study Design and Setting

This retrospective study was conducted in the hematology ICU of Gazi Hospital, a tertiary care referral center in Ankara. This unit, exclusively dedicated to patients with hematologic diseases requiring intensive care support, has a capacity of 4 beds and admits approximately 100-150 patients annually.

Patient Population

Adult patients (≥18 years) with hematologic diseases admitted to the hematology ICU between January 1, 2018, and December 31, 2019, were eligible for inclusion. Patients with an ICU stay of less than 24 hours or with missing data were excluded. For patients with multiple ICU admissions, only the data from the first admission were analyzed.

Data Collection

Demographic characteristics, underlying hematologic diagnoses, disease status (newly diagnosed, remission, relapsed or progressive disease, or terminal stage), history of hematopoietic stem cell transplantation (HSCT), and recent chemotherapy were recorded. Reasons for ICU admission, source of admission, laboratory variables required to calculate severity scores, and clinical outcomes were extracted from electronic medical records. APACHE II, SAPS II, and SOFA scores were calculated at 24 and 72 hours after ICU admission, and changes in scores over time were analyzed.

Ethical Consideration

This study was approved by the Gazi University Faculty of Medicine Clinical Research Ethics Committee (Approval Number: 545, Date: 14.06.2021).

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as medians and interquartile ranges (1st-3rd quartiles), and categorical variables as counts and percentages. Patients were categorized as survivors or non-survivors based on ICU outcome. Continuous variables were compared using the Mann–Whitney U test, and categorical variables using the chi-square or Fisher's exact test, as appropriate. Variables significant in univariate analyses were entered into multivariate logistic regression models to identify independent predictors of ICU mortality. Receiver operating characteristic (ROC) curve analysis was used to evaluate the prognostic performance of scoring systems, with area under the curve (AUC), optimal cut-off values, sensitivity, and specificity reported. A p-value <0.05 was considered statistically significant.

Results

Study Population

During the study period, 187 patients were admitted to the hematology ICU. After excluding repeated admissions (n=48), ICU stays shorter than 24 hours (n=28), and cases with missing data (n=4), a total of 107 patients were included in the final analysis. The ICU mortality rate was 40.2% (n=43).

Baseline demographic characteristics, hematologic diagnoses, comorbidities, and admission features are summarized in Table 1. Survivors and non-survivors did not differ significantly in terms of age, sex, or comorbidity burden. However, non-survivors had a significantly longer interval between hospital admission and ICU transfer (p=0.001). Additionally, non-survivors were more frequently admitted from the hematology ward (p=0.001), had a higher prevalence of allogeneic hematopoietic stem cell transplantation (HSCT) (p=0.024), and were more commonly admitted due to respiratory failure (p=0.016) and neurological deterioration (p=0.013).

Acute Illness Severity and Organ Dysfunction Scores at Day 1 and Day 3 in the ICU

APACHE II, SAPS II, and SOFA scores calculated at 24 and 72 hours after ICU admission are presented in Table 2. At both time points, non-survivors had significantly higher scores across all three scoring systems compared to survivors (all p<0.001).

Dynamic Changes in Acute Illness Severity and Organ Dysfunction Scores

Dynamic changes in severity scores between ICU day 1 and day 3 were analyzed in 75 patients who survived beyond 72 hours. An increase in APACHE II, SAPS II, or SOFA scores during this period was significantly associated with ICU mortality. Survivors demonstrated a significant reduction in all three scores, whereas non-survivors exhibited persistently elevated or increasing scores. Median changes in APACHE II, SAPS II, and SOFA scores differed significantly between the two groups (Table 2), indicating that early score trajectories provided additional prognostic information beyond baseline values.

Prognostic Performance of Acute Illness Severity and Organ Dysfunction Scores

Receiver operating characteristic (ROC) curve analyses demonstrated good discriminatory performance of APACHE II, SAPS II, and SOFA scores at both ICU day 1 and day 3 (Figs. 1–3). For all scoring systems, day 3 values showed higher predictive accuracy than admission values. Cut-off values, sensitivities, specificities, and area under the curve (AUC) are summarized in Table 3. Among all evaluated parameters, the SOFA score at day 3 demonstrated the highest prognostic accuracy for ICU mortality.

Dynamic changes in severity scores between day 1 and day 3 were also prognostically relevant. Failure to de-

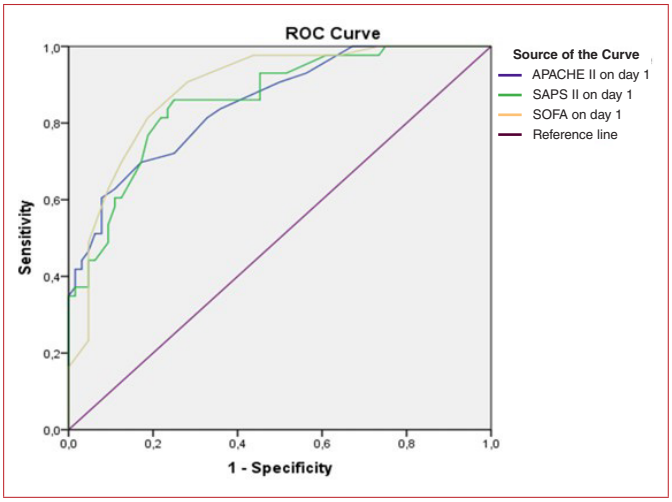

Figure 1. ROC curves for APACHE II, SAPS II, and SOFA scores on Day 1.

Table 1. Baseline characteristics of critically Ill hematologic patients

Characteristics	All patients (n=107)	Survivors (n=64)	Non-Survivors (n=43)	p
Age (years)*	62 (53-70)	62 (55-69.75)	61 (42-70)	0.442
Gender, male, n (%)	69 (64.5)	42 (65.6)	27 (62.8)	0.764
Days from hospital to ICU admission*	5 (0-18)	1 (0-15)	14 (4-28)	0.001
ICU length of stay (days)*	4 (2-7)	4 (2.25-6)	4 (2-9)	0.895
Hospital length of stay (days)*	21 (14-42)	21 (14-41.5)	23 (12-42)	0.824
Comorbidities, n (%)				
Hypertension	35 (32.7)	18 (28.1)	17 (39.5)	0.217
Diabetes mellitus	22 (20.6)	15 (23.4)	7 (16.3)	0.369
Cardiovascular disease	18 (16.8)	11 (17.2)	7 (16.3)	0.902
Chronic Kidney disease	18 (16.8)	11 (17.2)	7 (16.3)	0.902
COPD/Asthma	11 (10.3)	6 (9.4)	5 (11.6)	0.753
Solid cancer	9 (8.4)	4 (6.3)	5 (11.6)	0.480
Hematologic disease, n (%)				
Multiple myeloma	34 (31.8)	27 (42.2)	7 (16.3)	0.005
Non-Hodgkin lymphoma	22 (20.6)	10 (15.6)	12 (27.9)	0.123
Acute myeloid leukemia	20 (18.7)	9 (14.1)	11 (25.6)	0.134
Acute lymphoblastic leukemia	9 (8.4)	4 (6.3)	5 (11.6)	0.480
Other hematologic diseases**	22 (20.6)	15 (23.4)	7 (16.3)	0.10
Disease status, n (%)				
Relapse/Progressive	43 (40.2)	21 (32.8)	22 (51.2)	0.058
Newly diagnosed	37 (34.6)	26 (40.6)	11 (25.6)	0.109
Complete/Partial response	25 (23.4)	16 (25)	9 (20.9)	0.626
Terminal stage	2 (1.9)	1 (1.6)	1 (2.3)	0.563
Chemotherapy in the Last 30 days	77 (72)	48 (75)	29 (67.4)	0.393
Hematopoietic stem cell transplantation (HSCT), n (%)				
All HSCT	47 (43.9)	25 (39.1)	22 (51.2)	0.216
Allogeneic HSCT	30 (28)	13 (20.3)	17 (39.5)	0.024
Autologous HSCT	22 (20.6)	14 (21.9)	8 (18.6)	0.682
Graft versus host disease, n (%)	17 (15.9)	7 (10.9)	10 (23.3)	0.087
Admission from, n (%)				
Admission from the hematology ward	61 (57)	28 (43.8)	33 (76.7)	0.001
Admission from the emergency room	30 (28)	27 (42.2)	3 (7)	0.0001
Admission from the bone marrow transplant unit	13 (12.1)	6 (9.4)	7 (16.3)	0.284
Other clinics	3 (2.7)	3 (4.8)	0	1.00
Reasons for admission, n (%)				
Respiratory failure	73 (68.2)	38 (59.4)	35 (81.4)	0.016
Sepsis	58 (54.2)	33 (51.6)	25 (58.1)	0.503
Hemodynamic instability	36 (33.6)	24 (37.5)	12 (27.9)	0.303
Neurological deterioration	12 (11.2)	3 (4.7)	9 (20.9)	0.013
Post-Arrest care	11 (10.3)	3 (4.7)	8 (18.6)	0.026
Postoperative monitoring	2 (1.9)	2 (3.1)	0	0.515
Metabolic	3 (2.8)	2 (3.1)	1 (2.3)	1.00
GI/Hepatic	2 (1.9)	2 (3.1)	0	1.00
Other	4 (3.6)	3 (4.8)	1 (2.3)	0.425

Median (1st-3rd quartiles), n = number, % = percentage. **Other Hematological Diseases: essential thrombocytosis (4), aplastic anemia (5), myelofibrosis (4), immune thrombocytopenic purpura (3), autoimmune hemolytic anemia (4), and polycythemia vera (2).

Table 2. Acute illness severity and organ dysfunction scores on day 1 and day 3, and change in scores between day 1 and day 3 in critically Ill hematologic patients

Scores	All patients (n=107)	Survivors (n=64)	Non-Survivors (n=43)	p
Day 1 APACHE II	23 (19-29)	20.5 (17-23.75)	30 (23-40)	0.0001
Day 1 SAPS II	49 (40-69)	42 (37.25-49.75)	68 (54-94)	0.0001
Day 1 SOFA	8 (6-11)	6 (4-8)	11 (9-14)	0.0001
Scores	**All Patients (n=75)**	**Survivors (n=48)**	**Non-Survivors (n=27)**	
Day 3 APACHE II	21 (15-27)	17 (13.25-20.75)	31 (25-37)	0.0001
Day 3 SAPS II	49 (36-62)	39.5 (34-48.5)	70 (56-84)	0.0001
Day 3 SOFA	7 (4-12)	5 (4-6.75)	14 (10-15)	0.0001
Change in scores between day 1 and day 3				
APACHE II decreased, n (%)	45 (60)	34 (70.8)	11 (40.7)	0.003
APACHE II increased, n (%)	21 (28)	7 (14.6)	14 (51.8)	
APACHE II unchanged, n (%)	9 (12)	7 (14.6)	2 (7.4)	
Δ APACHE II*	-2.0 (-5.0-2.0)	-2.0 (-5.0-0.0)	0.0 (-4.0-5.0)	0.006
SAPS II decreased, n (%)	36 (48)	31 (64.5)	5 (18.5)	0.0001
SAPS II increased, n (%)	23 (30.6)	5 (10.4)	18 (66.6)	
SAPS II unchanged, n (%)	16 (21.3)	12 (25)	4 (14.8)	
Δ SAPS II*	0.0 (-8.0-3.0)	-5.5 (-8.0-0.0)	3.0 (0.0-12.0)	0.0001
SOFA decreased, n (%)	35 (46.6)	32 (66.6)	3 (11)	0.0001
SOFA increased, n (%)	23 (30.6)	6 (12.5)	17 (62.9)	
SOFA unchanged, n (%)	17 (22.6)	10 (20.8)	7 (25.9)	
Δ SOFA*	0.0 (-1.0-1.0)	-1.0 (-2.0-0.0)	1.0 (0.0-4.0)	0.0001

Median (1st-3rd quartiles), n = number, % = percentage. APACHE II: Acute Physiology and Chronic Health Evaluation II, SAPS II: Simplified Acute Physiology Score II, SOFA: Sequential Organ Failure Assessment, Δ: Difference between day 3 score and day 1 score.

Table 3. AUC, Cut-off, sensitivity, and specificity values of ROC curves for APACHE II, SAPS II, and SOFA scores on Day 1, Day 3, and changes between these days

Variable	Cut-off	AUC	p	95% CI (Lower)	95% CI (Upper)	Sensitivity (%)	Specificity (%)
Day 1 APACHE II	22.5	0.850	0.0001	0.779	0.922	81.4	67.2
Day 1 SAPS II	52.5	0.859	0.0001	0.789	0.929	81.4	78.1
Day 1 SOFA	8.5	0.888	0.0001	0.826	0.950	81.4	81.2
Day 3 APACHE II	22.5	0.946	0.0001	0.894	0.997	92.6	89.6
Day 3 SAPS II	49.5	0.946	0.0001	0.899	0.992	92.6	81.2
Day 3 SOFA	8.5	0.958	0.0001	0.910	1.000	96.3	93.7
Δ APACHE II	-1.5	0.692	0.006	0.562	0.822	63.0	62.5
Δ SAPS II	-0.5	0.800	0.0001	0.683	0.916	81.5	64.6
Δ SOFA	-0.5	0.845	0.0001	0.750	0.941	88.9	66.7

AUC: Area Under the Curve, CI: Confidence Interval, APACHE II: Acute Physiology and Chronic Health Evaluation II, SAPS II: Simplified Acute Physiology Score II, SOFA: Sequential Organ Failure Assessment, Δ: Difference between day 3 score and day 1 score.

crease APACHE II, SAPS II, or SOFA scores was associated with increased mortality, with changes in SOFA score providing the strongest discrimination.

Multivariate Analysis

In multivariate logistic regression analysis incorporating clinically relevant variables and severity scores, the

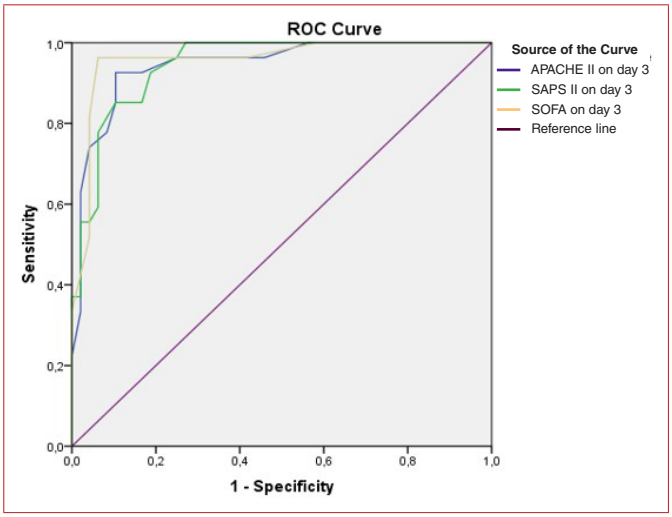

Figure 2. ROC curves for APACHE II, SAPS II, and SOFA scores on day 3.

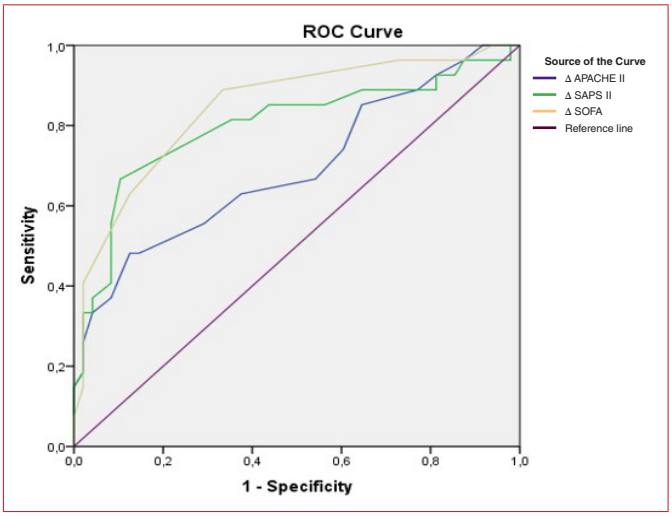

Figure 3. ROC curves of changes between day 1 and day 3 in APACHE II, SAPS II, and SOFA scores.

Table 4. Independent risk factors for ICU mortality in critically ill hematologic patients

Variable	Wald	p	OR	95% CI (Lower)	95% CI (Upper)
Pre-ICU hospital stay	1.080	0.299	1.049	0.959	1.148
Admission from the hematology ward	2.258	0.133	5.512	0.595	51.083
Presence of allogeneic HSCT	0.799	0.372	2.719	0.303	24.378
Day 3 SOFA	14.121	0.001	2.042	1.407	2.962
Respiratory failure on admission	1.008	0.315	3.017	0.349	26.049

ICU: Intensive Care Unit, HSCT: Hematopoietic Stem Cell Transplantation, SOFA: Sequential Organ Failure Assessment, MV: Mechanical Ventilation, OR: Odds Ratio, CI: Confidence Interval.

SOFA score at ICU day 3 emerged as the strongest independent predictor of ICU mortality (OR 2.042, 95% CI 1.407-2.962, p=0.001) (Table 4).

Discussion

Historically, ICU admission of patients with hematologic diseases, particularly those with hematologic malignancies, was approached with caution due to poor reported outcomes. However, advances in hematologic-oncologic therapies, supportive care, and critical care practices have led to increased ICU utilization and improved survival in this population. Nevertheless, mortality rates among critically ill hematologic patients remain substantially higher than those observed in the general ICU population, particularly among patients with hematologic malignancies who require invasive mechanical ventilation, vasopressor support, renal replacement therapy, or those with allogeneic hematopoietic stem cell transplantation (HSCT).[6-9] In this context, accurate and dynamic prognostic assessment remains essential to guide clinical decision-making.

Previous studies have identified numerous factors associated with mortality in critically ill hematologic patients, including disease-related characteristics, treatment history, organ support requirements, and laboratory abnormalities.[10-15] However, the prognostic relevance of several of these variables—such as age, neutropenia, disease type, and disease status—has been shown to vary over time.[16,17] In contrast, the severity of acute illness, the extent of organ dysfunction at ICU admission, and, importantly, their evolution during the ICU stay have consistently remained robust predictors of outcome.[18-21]

Acute illness severity and organ dysfunction scores have been extensively studied in both general ICU and hematologic populations. Higher APACHE II, SAPS II, and SOFA scores at ICU admission are associated with increased mortality in both populations. Numerous

studies in general ICU cohorts have also demonstrated that serial SOFA measurements and early score trajectories outperform single admission values in predicting mortality. Similar findings have been reported in hematologic populations, where persistent or worsening organ dysfunction is strongly associated with poor outcomes.[21-31]

Our results align with this body of evidence. In the present study, higher APACHE II, SAPS II, and SOFA scores at ICU admission and on day 3 were significantly associated with ICU mortality. More importantly, early dynamic changes in these scores—particularly between day 1 and day 3—provided additional prognostic information. Survivors demonstrated significant reductions in severity scores, whereas non-survivors exhibited persistently elevated or worsening scores, highlighting the clinical relevance of early responses to intensive care support.

Among all evaluated parameters, the SOFA score on ICU day 3 emerged as the strongest independent predictor of ICU mortality in multivariate analysis, demonstrating excellent discriminatory performance. This finding underscores that ongoing organ dysfunction and its reversibility, rather than baseline disease characteristics or admission severity alone, are the principal drivers of outcomes in critically ill hematologic patients. Compared with APACHE II and SAPS II, the SOFA score showed superior prognostic accuracy, likely because it captures the dynamic burden of organ failure and response to therapy over time.

These findings have important clinical implications. Dynamic SOFA assessment may support early identification of high-risk patients, facilitate timely reassessment of treatment goals, and aid in shared decision-making with patients and families. Rather than using admission scores as a basis for ICU triage or treatment limitations, an approach that incorporates short-term ICU trials with serial reassessments of organ dysfunction may be more appropriate for this complex population.

An additional strength of this study lies in its setting. Most data on prognostic scoring systems in critically ill hematologic patients originate from general ICUs in high-income countries. Our results from a dedicated hematology ICU in a university hospital provide valuable insights into the performance of these scores in a specialized care environment, where admission practices, supportive strategies, and hematologic management may differ substantially from those in general ICUs.

Several limitations should be acknowledged. This was a single-center study with a relatively small sample size, which may limit generalizability. The retrospective design precludes the assessment of how real-time use of severity scores influenced clinical decision-making. Additionally, disease-specific and treatment-related factors were not incorporated into the prognostic models. Despite these limitations, the study provides valuable data from a dedicated hematology ICU and reinforces the prognostic importance of dynamic organ dysfunction assessment.

In conclusion, although APACHE II, SAPS II, and SOFA scores are all useful for prognostication in critically ill hematologic patients, dynamic evaluation—particularly the SOFA score on ICU day 3—offers the most accurate prediction of ICU mortality. These findings support routine serial assessment of organ dysfunction and emphasize that ICU outcomes in this population are primarily driven by the severity and reversibility of organ failure rather than by underlying hematologic disease characteristics.

Ethics Committee Approval: Ethics committee approval was obtained from Gazi University Faculty of Medicine Clinical Research Ethics Committee (Approval Number: 545, Date: 14.06.2021).

Informed Consent: Written informed consent was not required due to the retrospective nature of this study.

Conflict of Interest: The authors have no conflicts of interest to declare.

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