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# PROGNOSTIC VALUE OF SHOCK INDEX, MODIFIED SHOCK INDEX, AND AGE SHOCK INDEX IN PATIENTS WITH SEPSIS IN THE INTENSIVE CARE UNIT

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## Abstract

**Objective:** We aimed to evaluate the usability of the Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI) in predicting clinical outcomes and mortality in sepsis patients followed in the intensive care unit.

**Methods:** Records of patients admitted to the intensive care unit of Muş State Hospital between January 2022, and April 2024, who developed sepsis were retrospectively recorded from the hospital data system.

**Results:** A total of 127 patients were included in the study. The average age of these patients was found to be 50.83±12.01 years. The average age of discharged patients was 46.14±10.12 years, while the average age of deceased patients was 58.54±10.89 years. In the gender distribution, 63.78% of all patients were male and 36.22% were female ($p$=0.028). SI was determined as 0.88±0.33 in discharged patients and 1.11±0.32 in deceased patients ($p$=0.0002). MSI was found to be 1.45±0.33 in discharged patients and 1.68±0.32 in deceased patients ($p$=0.00001). ASI was determined as 40.73±18.41 in discharged patients and 64.94±22.85 in deceased patients ($p$=0.0001). The cut-off value for SI was found to be 0.76, with an AUC value of 0.69. The cut-off value for the MSI was determined to be 1.35, with an AUC value of 0.72. The cut-off value for the ASI was found to be 38.76, with an AUC value of 0.85.

**Conclusion:** All three shock indices were statistically significant in predicting mortality in sepsis patients. We believe they are valuable indices that can be used bedside and non-invasively in intensive care units.

***Keywords:*** *Intensive care unit, shock index, modified shock index, age shock index, prognosis.*

## Introduction

Organ dysfunction brought on by a dysregulated immunological response to infection is known as sepsis. The most severe kind of this illness is called septic shock, which is defined by a reduction in blood pressure that lowers tissue perfusion pressure and causes hypoxia. One of the biggest causes of death in the world today is still sepsis. Prognosis depends on early diagnosis and treatment.[1]

The Shock Index (SI) was initially introduced in 1967 by Allgöwer and Burri in order to assess the circulatory condition of patients in critical condition.[2] SI is obtained by dividing the heart rate (HR) by the systolic blood pressure (SBP), offering crucial details on the patient's hemodynamic condition. It is utilized to forecast death rates in trauma, sepsis, and critically ill patients in the ICU. Both blood pressure (BP) and HR are not as effective individually as systemic impairment in predicting the severity of hemodynamic impairment.[3-6] The Modified Shock Index (MSI) is calculated by dividing the HR by the mean arterial pressure (MAP).[3,7] The Age Shock Index (ASI) is calculated by multiplying the SI by the patient's age. Both have been shown to be associated with mortality.[8]

There is a significant risk of death for critically sick patients who have high MSI within the first 24 hours after ICU admission. Clinicians might possibly lower mortality and morbidity rates by intervening early thanks to the practical bedside calculation of MSI.[9] In critically sick patients monitored in the intensive care unit, the purpose of this study was to assess the predictive power of SI, MSI, and ASI in terms of clinical outcomes and death.

## Methods

The Health Sciences University Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee granted ethical approval for this retrospective study (No: 76; Date: 24.05.2024). The Helsinki Declaration was followed in the conduct of the research. Patients admitted to the ICU of Muş State Hospital between January 1, 2022, and April 1, 2024, were included in our study. Patient information was retrospectively entered from patient files and the hospital data system. This information included age, gender, length of stay in the intensive care unit (ICU), Glasgow Coma Scale (GCS), Charlson Comorbidity Index (CCI), Acute Physiology and Chronic Health Evaluation II (APACHE II) score, Sepsis-related Organ Failure Assessment (SOFA) score, hemoglobin, albumin, platelet, C-reactive protein , and procalcitonin values, as well as SI, MSI, and ASI.

### Inclusion Criteria

This study included patients aged 18 years or older who had clinically, laboratory, and radiologically confirmed sepsis and stayed in the ICU longer than 24 hours.

### Exclusion Criteria

The patients under 18 years old, immunocompromised and at terminal stage of malignancy and the patients having pacemaker and stayed at ICU less than 24 hrs.

### Statistical Analysis

The Shapiro-Wilk test was used to determine if the laboratory values and other scores were within the normal range. The results were presented as mean±standard deviation. To analyze continuous variables, either the Mann-Whitney U test or T-test was used. For nominal variables, the Fisher's exact test or the Chi-square test was used. We used Receiver Operating Characteristic (ROC) analysis to assess the usefulness of all parameters in predicting mortality. A *p*-value less than 0.05 was considered statistically significant. All calculations were performed using SPSS software (Version 22, SPSS Inc., Chicago, IL, USA).

## Results

The study included 127 patients in total. The mean age of these individuals was 50.83 years with a standard deviation of 12.01 years. The mean age of patients who were discharged was 46.14 years with a standard deviation of 10.12, whereas the mean age of patients who passed away was 58.54 years with a standard deviation of 10.89. The gender breakdown revealed that 63.78% of patients were male and 36.22% were female, showing a statistically significant variance ($p$=0.028) (Table 1).

The average length of ICU stay for all patients was 19.53±15.06 days. Discharged patients had an average stay of 17.81±14.82 days, while deceased patients had an average stay of 22.35±15.18 days ($p$=0.00001) (Table 1).

**Table 1.** Demographic characteristics of the patients

| | All patients (mean ± SD) | Survivors (mean ± SD) | Non-survivors (mean ± SD) | *p* value |
|---|---|---|---|---|
| **Age (years)** | 50.83 ± 12.01 | 46.14 ± 10.12 | 58.54 ± 10.89 | 0.00001 |
| **Gender (n %)** | 127 (63.78% Male, 36.22% Female) | 79 (51.90% Male, 48.10% Female) | 48 (83.33% Male, 16.67% Female) | 0.028 |
| **LOS ICU** | 19.53 ± 15.06 | 17.81 ± 14.82 | 22.35 ± 15.18 | 0.00001 |
| **Hemoglobin(g/dl)** | 9.45 ± 2.06 | 9.99 ± 1.56 | 8.58 ± 2.45 | 0.0001 |
| **Platelet ($10^9$/l)** | 234.09 ± 142.73 | 253.99 ± 153.81 | 201.35 ± 116.59 | 0.043 |
| **Albumin (g/dl)** | 2.76 ± 0.67 | 3.04 ± 0.61 | 2.30 ± 0.46 | 0.00001 |
| **C-Reactive protein(mg/dl)** | 118.42 ± 80.95 | 91.81 ± 70.49 | 162.21 ± 78.58 | 0.00001 |
| **Procalcitonin(ng/ml)** | 6.40 ± 15.50 | 5.24 ± 14.34 | 8.30 ± 17.23 | 0.00001 |
| **SOFA** | 8.00 ± 3.54 | 5.87 ± 2.49 | 11.50 ± 1.80 | 0.00001 |
| **APACHE II** | 24.67 ± 9.23 | 20.33 ± 6.70 | 31.81 ± 8.37 | 0.00001 |
| **GCS** | 8.97 ± 3.30 | 10.22 ± 3.19 | 6.92 ± 2.33 | 0.00001 |
| **CCI** | 7.83 ± 1.64 | 7.49 ± 1.58 | 8.38 ± 1.59 | 0.00001 |
| **Shock Index(SI)** | 0.97 ± 0.34 | 0.88 ± 0.33 | 1.11 ± 0.32 | 0.0002 |
| **Modified Shock Index(MSI)** | 1.54 ± 0.34 | 1.45 ± 0.33 | 1.68 ± 0.32 | 0.00001 |
| **Age Shock Index(ASI)** | 49.88 ± 23.31 | 40.73 ± 18.41 | 64.94 ± 22.85 | 0.0001 |

n: Number of patients, %: Percentage, SOFA: Sequential Organ Failure Assessment, APACHE II: Acute Physiology and Chronic Health Evaluation II, GCS: Glasgow Coma Scale, CCI: Charlson comorbidity index, LOS: Length of stay, ICU: Intensive care unit

Laboratory and clinical values showed that the average hemoglobin level was 9.99±1.56 in discharged patients and 8.58±2.45 in deceased patients ($p$=0.0001). Platelet values were 253.99±153.81 in discharged patients and 201.35 ± 116.59 in deceased patients ($p$=0.043). Albumin levels were 3.04±0.61 in discharged patients and 2.30±0.46 in deceased patients ($p$=0.00001). C-reactive protein levels were 91.81±70.49 in discharged patients and 162.21±78.58 in deceased patients ($p$=0.00001). Procalcitonin levels were 5.24±14.34 in discharged patients and 8.30±17.23 in deceased patients ($p$=0.00001). The SOFA score was 5.87±2.49 in discharged patients and 11.50±1.80 in deceased patients ($p$=0.00001). The APACHE II score was 20.33±6.70 in discharged patients and 31.81±8.37 in deceased patients ($p$=0.00001). GCS scores were 10.22±3.19 in discharged patients and 6.92±2.33 in deceased patients ($p$=0.00001). The CCI score was 7.49±1.58 in discharged patients and 8.38±1.59 in deceased patients ($p$=0.00001) (Table 1).

The Shock Index (SI) was 0.88±0.33 among discharged patients and 1.11±0.32 among patients who died ($p$=0.0002). In discharged patients, the Modified Shock Index (MSI) was recorded at 1.45±0.33, while in deceased patients it was 1.68± 0.32 ($p$=0.00001). In discharged patients, the Age Shock Index (ASI) was recorded at 40.73±18.41, while in deceased patients it was higher at 64.94±22.85 ($p$=0.0001) (Table 1).

The cut-off value for the Shock Index was found to be 0.76, with an AUC value of 0.69. The cut-off value for the Modified Shock Index was 1.35, with an AUC value of 0.72. The cut-off value for the Age Shock Index was found to be 38.76, with an AUC value of 0.85 (Table 2).

**Table 2.** Cut-off and AUC values for Shock Index, Modified Shock Index and Age Shock Index

| Index | Cut-off Value | AUC Value |
|---|---|---|
| **Shock Index(SI)** | 0.76 | 0.69 |
| **Modified Shock Index(MSI)** | 1.35 | 0.72 |
| **Age Shock Index(ASI)** | 38.76 | 0.85 |

ROC curves and AUC values for the Shock Index, Modified Shock Index, and Age Shock Index, as well as comparisons of various biomarkers and clinical scores for predicting mortality, are shown in Figures 1 and 2.

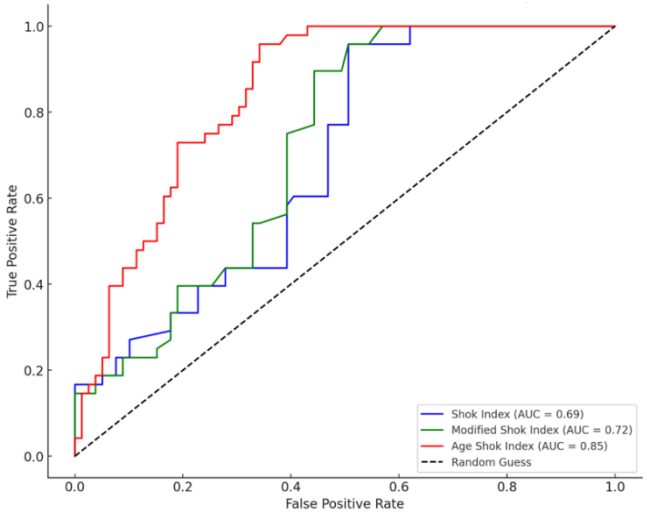


**Figure 1.** Comparison of ROC Curves and AUC Values for Shock Index, Modified Shock Index and Age Shock Index

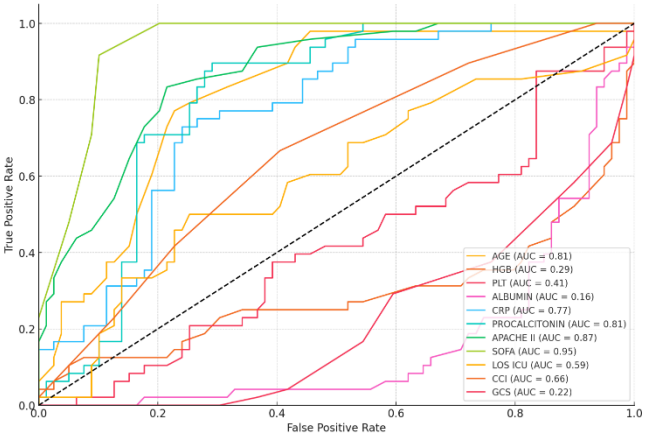


**Figure 2.** Comparison of Various Biomarkers and Clinical Scores on Mortality with ROC Curves and AUC Values

## Discussion

In our study, we found that the SI, MSI, and ASI values at the time of ICU admission for sepsis patients were significant in predicting mortality. In addition to various scoring systems indicating mortality in the intensive care unit, shock indices can provide valuable information to clinicians in predicting the mortality of patients with sepsis. Therefore, shock indices can be used not only in the emergency department to determine the patient's clinical outcome or the need for ICU admission but also as a valuable parameter in predicting mortality at the time of ICU admission for sepsis patients. Unlike other scoring systems, the components of shock indices can be routinely measured at the bedside and easily calculated. This allows for the rapid recognition of severe diseases and the timely application of appropriate treatments.[9]

The Shock Index (SI) is frequently used to evaluate hemodynamic instability and predict outcomes. Introduced for the first time in 1967, it has been shown to be more sensitive in detecting hemodynamic deterioration compared to heart rate or systolic blood pressure alone.[2,10]

Initially, the Shock Index was accepted between 0.5 and 0.7. Later, different threshold values such as 0.9, 1.0, and higher values were used.[10-12] A higher SI value gains specificity while losing sensitivity. Thus, a cutoff value of 1.0 has been accepted in studies as a limit for both sensitivity and specificity, suggesting its effectiveness in predicting mortality.[13] In our study, we found the cutoff value for the Shock Index to be 0.76 and the AUC value to be 0.69. We determined the cutoff value for the ASI to be 38.76 with an AUC value of 0.85. Yu et al. discovered that ASI was more effective than SI and MSI in identifying high-risk patients during acute myocardial infarction.[14]

Ajai et al. research considered an MSI below 0.7 or above 1.3 as important indicators of mortality. They demonstrated that MSI was better at predicting mortality compared to SI and ASI.[15]

In their research on 2524 sepsis patients, Berger and colleagues discovered that an SI ≥ 0.7 had a sensitivity of 0.71 and a specificity of 0.41 in forecasting 28-day mortality.[16] Praveenkumar et al. study reported SI and MSI values of 1.2±0.5 and 1.5±0.6, respectively. The hospital mortality predictive value of MSI was assessed, with a sensitivity of 0.750 and specificity of 0.454 being determined on the curve. These values emphasize the importance of MSI in predicting mortality in hospitals.[17]

In Surendhar et al. research, mortality rates rose significantly from 19% to 90% with an elevation in SI from 0.9 to 1.8. An MSI greater than 1.7 was also linked to higher mortality rates.[18] A research conducted by Romain et al. with 530 participants found a mortality rate of 31% within 28 days, showing a clear connection between mortality and SI, MSI, and ASI.[19]

Esra et al. conducted a study using ROC analysis to assess how effective SI, MSI, and ASI levels are for predicting mortality in septic shock patients. An ROC curve analysis revealed an area of 0.649 for the Shock Index. The mortality threshold value for SI was 1.06. An ROC curve was used to determine that MSI had an area of 0.585, with a mortality threshold of 1.69. The ROC curve for Age SI yielded an area of 0.613, with a mortality threshold value of 87.42 determined for Age SI.[20] Our research identified the threshold value for MSI as 1.35 and the AUC value as 0.72.

Mean arterial pressure is the most reliable indicator of tissue perfusion status. MSI is indicative of stroke volume and systemic vascular resistance. A high MSI implies decreased systemic vascular resistance and increased stroke volume, indicating hypodynamic circulation. On the other hand, a low MSI signifies a hyperactive condition. Hence, both elevated and reduced MSI levels demonstrate a serious status in emergency cases. MSI has been recognized as a more accurate indicator of mortality rates.[3]

In a study by Bruijns et al. involving a large number of patients in a trauma center, the threshold value for Age SI for 48-hour mortality was found to be ≥55 with a specificity of 95%. They also noted that having an Age SI ≥55 increased 48-hour mortality by 8.4 times. This study showed that Age SI was more effective than SI in predicting mortality in trauma patients.[21] Ben et al. found SI and ASI to be similar in predicting mortality.[22] Esra et al. found SI and Age SI values to be similarly effective (AUC: 0.649 and 0.613) in predicting mortality in sepsis patients.[20]

## Limitations

Our study has some limitations; it is a single-center and retrospective study. We believe that multicenter, prospective, and larger studies are needed to reach more definitive conclusions.

## Conclusion

In conclusion, the advantages of shock indices include low calculation costs and immediate calculation compared to other hematological or serological parameters. They are also non-invasive parameters that do not require a blood sample. These indices are important parameters that should be increasingly used in emergency departments and ICUs due to their predictive value and simplicity in critically ill patients, providing clinicians with a perspective on mortality prediction in septic patients.

## Conflict of Interest

There are no disclosed conflicts of interest for the author.

## Compliance with Ethical Statement

The Health Sciences University Diyarbakır Gazi Yaşargil Training and Research Hospital Ethics Committee gave its approval for the study to be conducted (Date: 24.05.2024, Decision No: 76).

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