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Original Research Article

PREDICTIVE VALUE OF SHOCK INDEX, MODIFIED SHOCK INDEX, AND AGE SHOCK INDEX FOR OUTCOMES IN PATIENTS ADMITTED WITH SEPSIS TO THE INTENSIVE CARE UNIT

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Abstract: *Sepsis is a life-threatening multi-organ dysfunction resulting in multiple organ failure. Various indices have been developed to predict outcomes in sepsis.* ***Objective****: The objective of this study is to evaluate the predictive value of the Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI) for determining outcomes in patients admitted to ICU with sepsis.* ***Methods****: It is a retrospective observational study conducted at the intensive care unit of Shifa International Hospital Islamabad from January 2024 to June 2024. The data was collected from hospital medical records. After screening, 162 patients were included in this study. Demographic data and Clinical data such as vital signs, laboratory results, and clinical diagnosis were collected at admission in the ICU. Data was analyzed using SPSS v25.0. The p-value ≤0.05 was considered significant.* **Result:** *The result of the study has shown that 77 patients (47.53%) were male, 85 (52.47%) were female, and 82 (50.62%) had critical outcomes. For critical outcomes, an SI > 0.7 had a sensitivity of 53.9% and a high specificity of 94.3% but a low positive predictive value (PPV). MSI > 1.3 showed a sensitivity of 19.6% and a specificity of 98.1%, with a PPV of 1.6%. ASI > 0.7 had a sensitivity of 15.9% and a specificity of 93.2%, with a PPV of 0.9%.* ***Conclusion:*** *The Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI) are more effective at ruling out critical outcomes than predicting them.*

Keywords: Sepsis, Intensive Care Unit, Critical Outcomes, Predictive Value

Introduction

Sepsis is a life-threatening multi-organ dysfunction caused by a dysregulated host response to an infection, resulting in multiple organ failure. (1). In 2017, an estimated 48.9 million incident cases of sepsis were recorded worldwide, with 11.0 million sepsis-related deaths, representing 19.7% of all global deaths (2). Sepsis is a critical condition associated with high morbidity and mortality rates, necessitating prompt identification and intervention to improve patient outcomes. Various indices have been developed to predict outcomes in sepsis, including the Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI). The Shock Index (SI) is calculated as the heart rate to systolic blood pressure ratio. It has been widely studied as a predictor of mortality and morbidity. Studies have demonstrated that elevated shock index at hospital presentation predicts mortality in patients with sepsis with high specificity, offering potential benefits over existing sepsis scoring systems due to its simplicity (3).

The Modified Shock Index (MSI) incorporates diastolic blood pressure into the calculation (heart rate divided by mean arterial pressure) to enhance predictive accuracy. Research suggests that the modified shock index (MSI) has better predictive validity than the shock index (SI) and age multiplied by SI (ASI) in predicting mechanical ventilation needs in sepsis patients after 24 hours of admission (4). It provides a more refined assessment of hemodynamic instability in septic patients compared to SI as it incorporates diastolic blood pressure measurement, offering a more comprehensive evaluation of cardiovascular function, which is crucial in sepsis management (5). The Age Shock Index (ASI) adjusts the SI by accounting for the patient's age, recognizing that age significantly influences physiological responses and outcomes in sepsis. ASI is calculated as SI multiplied by age. The age-adjusted approach allows for better risk stratification in older populations, particularly vulnerable to poor outcomes in sepsis (6).

Integrating these indices into clinical practice can significantly enhance the early identification and management of sepsis in ICU settings. While SI offers a quick and easy initial assessment, MSI and ASI provide more accurate predictions by incorporating additional factors (7). The comparative analysis of these indices reveals that SI has superior predictive accuracy for mortality compared to MSI and age-SI, with AUC values of 0.802, 0.727, and 0.704, respectively. Additionally, SI outperformed MSI and age-SI in predicting hospital admissions, with AUC values of 0.591 (p=0.029), 0.572 (p=0.059), and 0.580 (p=0.089), respectively (8).

The literature has specific gaps. Research often fails to stratify patients into relevant subgroups based on factors such as age, comorbidities, and the severity of sepsis. Many studies focus on short-term outcomes, such as mortality during ICU stay or within 30 days of admission (10). Studies need to examine the predictive value of these indices for long-term outcomes, including 90-day and 1-year mortality, as well as quality of life and functional status post-discharge (11). There is a gap in research that evaluates these indices across diverse geographic locations and populations with varying demographic characteristics. There is limited evidence on how early interventions based on these indices impact patient outcomes. Much of the existing literature relies on retrospective analyses (12).

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Prospective studies validating the use of SI, MSI, and ASI in real-time clinical settings must confirm their utility and reliability. Addressing these gaps through future research can significantly enhance the understanding and utility of SI, MSI, and ASI in managing sepsis patients in the ICU.
The objective of this study is to evaluate the predictive value of the Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (Age-SI) for determining outcomes in patients admitted to the Intensive Care Unit (ICU) with sepsis.

Methodology

It is a retrospective observational study conducted at the intensive care unit of Shifa International Hospital Islamabad from January 2024 to June 2024 after obtaining approval from the ethical approval letter. The data was collected from hospital medical records. All the patients admitted to the ICU in the selected timeframe were screened for inclusion in the study. A specific criterion of inclusion and exclusion was designed. Adults aged 18 years or older with a diagnosis of sepsis based on Sepsis-3 criteria (suspected or confirmed infection and an acute increase of ≥2 SOFA points) with the availability of complete data for calculating SI, MSI, and ASI. This study did not include patients with incomplete vital signs data at ICU admission and patients with Do-Not-Resuscitate (DNR) orders at the time of ICU admission. Pregnant patients and patients with underlying conditions that could significantly affect vital signs independently of sepsis (e.g., chronic heart failure, significant arrhythmias) were also excluded. Patients who refused treatment or left the ICU against medical advice were also excluded. After screening, 162 patients were included in this study. Demographic data, including age, gender, and co-morbidities, was collected. Clinical data such as vital signs (heart rate, systolic blood pressure, diastolic blood pressure), laboratory results (white blood cell count, etc.), and clinical diagnosis were also gathered at admission in the ICU. Shock Index (SI) was calculated by heart rate divided by systolic blood pressure, with a value more excellent than 0.7 considered abnormal. The Modified Shock Index (MSI) was calculated by heart rate divided by mean arterial pressure with a value greater than 1.3, considered abnormal, and the Age Shock Index (ASI) was calculated by SI multiplied by the patient's age with a value greater than 0.7, considered abnormal. The ICU mortality was also noted. The confidentiality of the information was assured and maintained. Patients were divided into two groups, which were labeled as critical outcomes and those without critical outcomes. The necessary outcome was defined as mortality.
Data was entered and analyzed using SPSS v25.0. Quantitative variables like age by Mean ± S.D and normality of the data were assessed using descriptive statistical analysis on SPSSv27.0. Data was stratified to deal with effect modifiers. The Chi-square test/ Fischer's exact test was applied for post-stratification to determine its significance. The p-value ≤0.05 was considered significant.

Results

The result of the study was that it comprised 162 patients across various age groups. Nine patients were included in the 18-25 group, with six males (66.67%) and three females (33.33%) 4 had a critical outcome. The 25-35 group had 17 patients, ten males (58.82%) and seven females (41.18%), with nine crucial outcomes. For ages 36-45, there were 37 patients, 16 males (43.24%) and 21 females (56.76%), with 17 critical outcomes. The 46-55 group included 34 patients, 15 males (44.11%) and 19 females (55.89%), with 21 crucial outcomes. Ages 56-65 had 29 patients, 11 males (37.93%) and 18 females (62.07%), with 15 essential outcomes. In the 66-75 group, 23 patients were included, 14 males (60.87%) and nine females (39.13%), with 11 critical outcomes. Over 75, there were 13 patients, five males (38.46%) and eight females (61.53%), with five crucial outcomes. Overall, 77 patients (47.53%) were male, 85 (52.47%) were female, and 82 (50.62%) had critical outcomes (Table 1).

Table 1: demographic characteristics of the study population

Age (years)	Total (n=162)	Male	Female	Critical outcome
18-25	9	6(66.67%)	3 (33.33%)	4
25-35	17	10(58.82%)	7 (41.18%)	9
36-45	37	16(43.24%)	21 (56.76%)	17
46-55	34	15(44.11%)	19 (55.89%)	21
56-65	29	11(37.93%)	18 (62.07%)	15
66-75	23	14(60.87%)	9 (39.13%)	11
>75	13	5(38.46%)	8 (61.53%)	5
Total	162	77(47.53%)	85 (52.47%)	82 (50.62%)

The study analyzed patients' average vital signs and shock indices with and without critical outcomes. Average respiratory rate, heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were observed. Regarding shock indices, the average Shock Index for patients with critical outcomes was 0.77, compared to 0.67 for those without. The Modified Shock Index was higher in patients with critical outcomes at 1.23, while it was 0.90 in patients without. The Age Shock Index was significantly higher in patients with critical outcomes at 1.73, compared to 0.69 in those without (Table 2).

For critical outcomes, an SI > 0.7 had a sensitivity of 53.9% and a high specificity of 94.3% but a low positive predictive value (PPV) of 1.8% and a high negative predictive value (NPV) of 99.1%. MSI > 1.3 showed a sensitivity of 19.6% and a specificity of 98.1%, with a PPV of 1.6% and an NPV of 98.9%. ASI > 0.7 had a sensitivity of 15.9% and a specificity of 93.2%, with a PPV of 0.9% and an NPV of 99.4%. For ruling out non-critical outcomes, SI > 0.7 had a low sensitivity of 3.8% but a high specificity of 97.5%, with a PPV of 67.2% and an NPV of 54.6%. MSI > 1.3 had a sensitivity of 63.5% and specificity of 86.5%, with a PPV

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of 54.8% and an NPV of 51.7%. ASI > 0.7 had a sensitivity of 17.5% and specificity of 93.0%, with a PPV of 57.3% and an NPV of 61.6%. These indices are more effective at ruling out critical outcomes than predicting them (Table 3, Figure 1).

Table 2: Vital signs and indices of the study population

Average	Critical outcome	No critical outcome
Respiratory rate (breaths/minute)	21.3	18.7
Heart rate (beats/ minute)	99.5	88.8
Systolic blood pressure (mm HG)	116.53	130.69
Diastolic blood pressure (mm HG)	64.17	77.62
Mean arterial pressure	93.21	97.43
Shock index	0.77	0.67
Modified shock index	1.23	0.90
Age shock index	1.73	0.69

Table 3: predictive accuracy of shock index, modified shock index, and age-specific shock index

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Critical outcome				
SI>0.7	53.9%	94.3%	1.8%	99.1%
MSI> 1.3	19.6%	98.1%	1.6%	98.9%
ASI> 0.7	15.9%	93.2%	0.9%	99.4%
No critical outcome				
SI>0.7				
MSI> 1.3	3.8%	97.5%	67.2%	54.6%
ASI> 0.7	63.5%	86.5%	54.8%	51.7%
	17.5%	93.0%	57.3%	61.6%

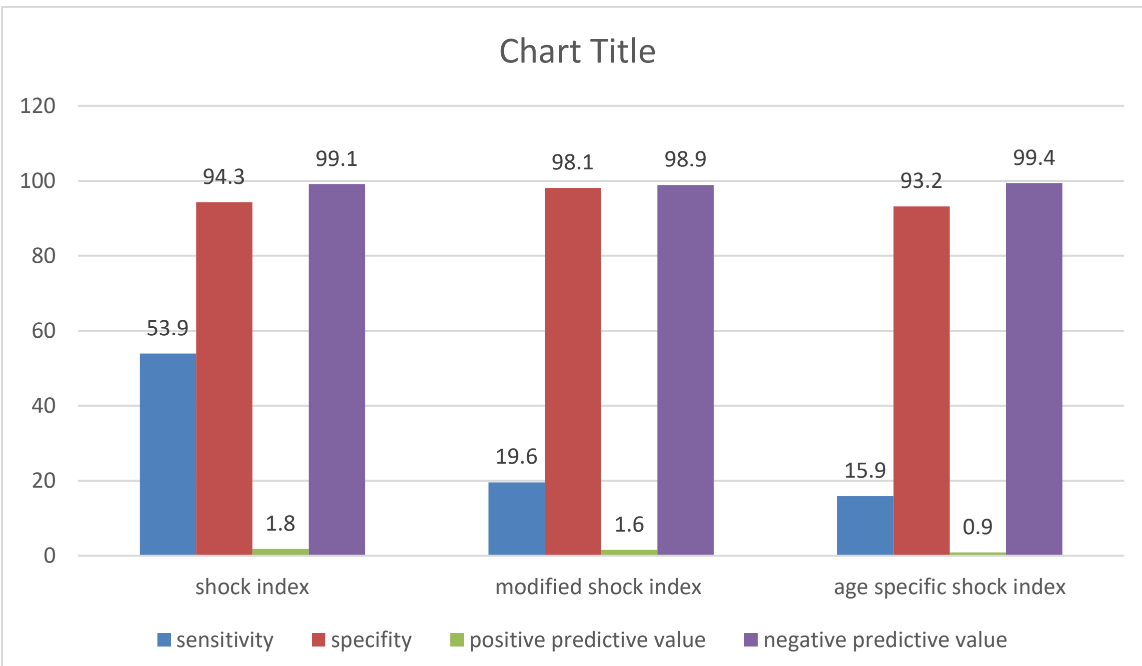

Figure 1: predictive accuracy of indices in patients with critical outcomes

Discussion

This study has analyzed the diagnostic performance of the Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI) for predicting critical outcomes and ruling out non-critical outcomes were analyzed. For predicting critical outcomes, an SI > 0.7 had a sensitivity of 53.9%, indicating a moderate ability to detect essential cases, and a high specificity of 94.3%, which shows its effectiveness in confirming the absence of crucial outcomes. The positive predictive value (PPV) was low at 1.8%, suggesting that when the SI is above 0.7, the likelihood of a critical outcome is minimal. Still, the negative predictive value (NPV) was high at 99.1%, demonstrating its reliability in ruling out critical cases. An MSI > 1.3 had a sensitivity of 19.6% and a high specificity of 98.1%, reflecting its limited ability to predict essential outcomes but high efficacy in ruling them out. The PPV was

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1.6%, and the NPV was 98.9%, indicating that while MSI is effective in ruling out critical outcomes, it is not very predictive of them. For an ASI > 0.7, the sensitivity was 15.9%, with a specificity of 93.2%. This index showed a very low PPV of 0.9% and a high NPV of 99.4%, indicating that while it is effective in ruling out critical outcomes, it has a poor capacity for predicting them. These findings correlate with existing literature that found high specificity of shock index in predicting sepsis or community acquires pneumonia (13). On the other hand, some studies have also suggested the shock index should be used as a screening tool for predicting postpartum hemorrhage (PPH); however, there is little comprehensive evidence regarding its predictive accuracy (14).

In ruling out non-critical outcomes, an SI > 0.7 had a low sensitivity of 3.8% and a high specificity of 97.5%. The PPV was 67.2%, showing that it can effectively predict non-critical cases when positive, but the NPV was 54.6%, indicating some limitations in ruling out non-critical cases completely. An MSI > 1.3 demonstrated a sensitivity of 63.5% and a specificity of 86.5%. Its PPV was 54.8%, and NPV was 51.7%, reflecting a moderate ability to predict non-critical outcomes and rule out critical cases, but with some limitations in accuracy. An ASI > 0.7 had a sensitivity of 17.5% and a specificity of 93.0%. The PPV was 57.3%, and the NPV was 61.6%, showing that it is moderately effective in predicting non-critical outcomes and ruling out critical cases. Overall, these indices are more effective at ruling out critical outcomes than predicting them, with varying degrees of accuracy in predicting and ruling out non-critical outcomes. Modern literature has revealed that the predictive accuracy of Glasgow Coma Scale (rSIG) is significantly higher than those of SI, MSI, and ASI with area under the receiver operating characteristic curve (AUROC), 0.710 vs. 0.495 vs. 0.527 vs. 0.598), especially in the moderate/severe TBI (AUROC, 0.625 vs. 0.450 vs. 0.476 vs. 0.529) and isolated head injury populations (AUROC 0.689 vs. 0.472 vs. 0.504 vs. 0.587). In the subgroup analysis, the prediction accuracy of mortality of rSIG was better in TBI with significant trauma (Injury Severity Score (ISS) ≥ 16), motor vehicle collisions, fall injury, and healthy and cardiovascular disease populations in all age groups (15). These indices' high specificity and negative predictive values make them helpful in ruling out critical conditions in sepsis patients, aiding clinicians in identifying patients who are less likely to experience severe outcomes (16). It can help prioritize ICU resources and interventions, ensuring that patients who are more likely to need intensive care receive timely attention. These indices can be used as part of the initial for faster decision-making and triage. This study has provided local insight into the predictive accuracy of these indices. However, it has certain limitations. It has a small sample size and is performed over a shorter period, limiting the generalizability of the data.

Conclusion

The Shock Index (SI), Modified Shock Index (MSI), and Age Shock Index (ASI) are more effective at ruling out critical outcomes than predicting them. SI and MSI exhibit high specificity and negative predictive values, making them reliable for confirming the absence of essential conditions. These indices should be used primarily for ruling out critical outcomes rather than for prediction, ensuring appropriate resource allocation and management in clinical settings.

Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRB-SIHISB-0037/22)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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Conception of Study, Development of Research Methodology Design, Study Design, manuscript Review, and final approval of manuscript.

AFTAB AKHTER (Consultant)

Coordination of collaborative efforts.

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Study Design, Review of Literature.

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Conception of Study, Final approval of manuscript.

WASIB ISHTIAQ (Consultant)

Data entry and data analysis, as well as drafting the article.

ZAIN SADIQ (Medical Officer)

Manuscript drafting.

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