DOI: https://doi.org/10.70749/ijbr.v3i3.995

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

# Assessment of the Ability of Shock Index to Predict Early Hemodynamic Collapse in Hypotensive Sepsis Patient in Emergency Department

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## ARTICLE INFO

**Keywords**

Diabetes Mellitus, Hypotension, Sepsis, Shock.

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**Declaration**

**Authors' Contribution:** All authors equally contributed to the study and approved the final manuscript.
**Conflict of Interest:** No conflict of interest.
**Funding:** No funding received by the authors.

**Article History**

Received: 04-11-2024, Revised: 26-02-2025
Accepted: 19-03-2025, Published: 31-03-2025

## ABSTRACT

**Background:** Shock is defined as a state of decreased perfusion and oxygenation to distant tissues. There are multiple types of shock depending on its underlying cause. **Objective:** To determine the accuracy of the Shock Index in predicting the early hemodynamic collapse in hypotensive sepsis patients. **Methodology:** This Cross-sectional study was conducted at the Accident and Emergency Department, Mayo Hospital Lahore, from November 2023 to May 2024. In this study, 150 patients, of either gender with ages between 18-75 years, presenting to the accident and emergency department diagnosed with sepsis, were included. Employing non-probability consecutive sampling, patients were divided into Group A with shock index >0.87 and Group B with shock index <0.87. After initial resuscitation, patients were admitted to intensive care units and followed up for 05 days. Demographic characteristics, comorbidity, and hemodynamic collapse during the follow-up period were recorded. **Results:** In our study, 83 (55.3%) were males and 67 (44.6%) were females with a median (IQR) age of 45 (31.75-60.25) years. In patients from Group A, median duration of sepsis was 06 (3-8) days as compared to 5.50 (3-8) days in Group B. The majority of patients in Group A, i.e. 80 (53.3%) , were diabetic as compared to 70 patients (46.6%) with shock index <0.87. When the shock index was used as a predictor of hemodynamic collapse the sensitivity of the shock index was 77%, the specificity was 69.23%, and a diagnostic accuracy of 73.33% (p <0.001). **Conclusion:** The Shock Index is an accurate, easy-to-calculate, and interpretable tool for predicting early hemodynamic collapse in sepsis patients. In the future, it can serve as a valuable bedside tool for identifying sepsis patients at risk of hemodynamic deterioration.

## INTRODUCTION

Shock is defined as a state of decreased perfusion and oxygenation to distant tissues. There are multiple types of shock depending on its underlying cause (i.e., hypovolemic, cardiogenic, distributive, or obstructive). Early recognition is one of the most important steps in the management of shock and is associated with improving the resulting mortality rate.[1]

Screening tools have been developed to identify patients with sepsis, most notably the systemic inflammatory response syndrome (SIRS) and quick sequential organ failure assessment (qSOFA), both of which are used to screen for sepsis cases but also have prognostic roles.[2] Prognostic tools in sepsis have also been developed using multivariable models, and they are likely to have complex applicability at the bedside and during initial resuscitation.

Several trials have been conducted for early recognition of sepsis, however, research gaps still exist due to the scarcity of research on predictive tools that may lead to hypovolemic shock after sepsis. The shock index (SI) is a commonly used perfusion index because it is easily calculated at the bedside. It is defined as the heart rate (HR) over the systolic blood pressure (SBP) (SI = HR/SBP), with a normal range from 0.5 to 0.7 bpm/mmHg. The SI has been studied extensively in acute hypovolemia, hemorrhage, and trauma. In two prospective observational studies with blood bank donors, the SI was shown to have better diagnostic value than traditional vital signs alone in the detection of acute hypovolemia.[3] In a population-based cohort study, SI was shown to be as good as the base deficit (BD) for the recognition of hypovolemic shock patients and their hemostatic resuscitation requirements. Sepsis and septic shock are common presentations in emergency departments (EDs). The morbidity and mortality rates of sepsis are high, with early recognition and prompt management being crucial to decreasing these rates.[4,5]

### Objective

This research aims to assess the accuracy of the shock index in the early prediction of hypovolemic shock in patients presenting to the emergency department.

## METHODOLOGY

The cross-sectional study was conducted at the Accident and Emergency Department, Mayo Hospital Lahore, from November 2023 to May 2024 after approval of the ethical committee of the hospital.

### Sample Size

Sample size calculation was done using a sensitivity and specificity calculator available on www.statulator.com with a 95% confidence level, and the percentage of hemodynamic collapse.

51.5%, sensitivity of shock index 81%6 % with 9% margin of error, and specificity of shock index 72%[6] with 10.5% margin of error. Using a non-probability consecutive sampling technique, n=150 participants were recruited in the study and divided into Group A with a shock index >0.87 and Group B with a shock index <0.87.

### Inclusion Criteria

Patients of either gender with age from 18-75 years presenting to accident and emergency department and diagnosed with sepsis were included in the trial.

### Exclusion Criteria

Patients with atrioventricular block secondary to beta-blockers, calcium channel blockers, digoxin, or amiodarone, and patients with a history of metastatic carcinoma were excluded from the study.

### Data Collection

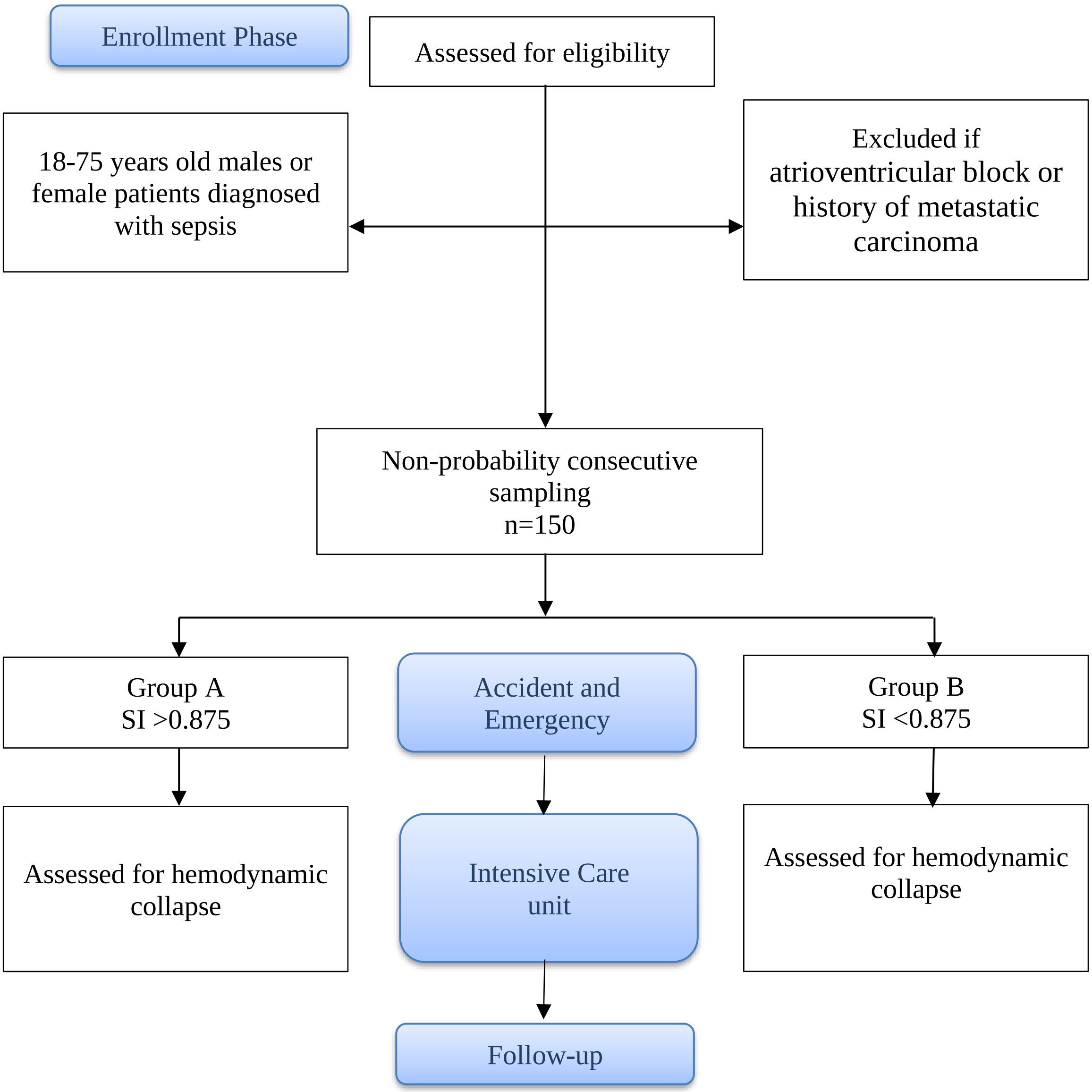
Patients received in the accident and emergency department of Mayo Hospital with suspicion of sepsis or septic shock underwent a detailed history, examination, and initial laboratory investigations. As per the emergency protocol, noninvasive monitoring was done in all patients including non-invasive blood pressure, pulse oximetry, temperature, and electrocardiography monitoring. Using an aseptic technique, a large bore intravenous line was secured in the peripheral venous line and initial fluid therapy commenced with crystalloids 20ml/kg using the sepsis guideline. The Shock Index was calculated for all patients recruited in the study by using the formula Shock Index = Heart Rate / Systolic blood pressure. Patients with a shock index value of <0.87 were assigned to Group A, while patients were assigned to Group B if a shock index was >0.875. Concurrent treatment of all the patients was started using the sepsis six care bundle including high flow oxygen, obtaining blood cultures, administering intravenous antibiotics, intravenous fluid resuscitation, hemoglobin, and serial lactate measurements, and recording hourly urine output. Patients were labeled as cases of sepsis if the infection was confirmed on blood culture, the body had a temperature of $36^0$C (96.8ºF) or temperature ≥38ºC (100.4ºF), heart rate >90 bpm, respiratory rate >20 bpm, PaCO2 <4.3 kPa, WBC count <4000 cells/mm3 or > 12,000 cells/mm3 accompanied by at least 2 out of 4 SIRS criteria:

- Evidence of end-organ dysfunction
- Elevated creatinine or altered mental status, GCS < 14)
- Serum lactate levels of equal or > 4mg/dL
- Episode of hypotension (<90/60 mmHg), which responds to initial fluid resuscitation

All patients were admitted to the intensive care unit as per hospital protocol and followed up for a period of 5 days. Early hemodynamic collapse was documented as YES for each patient who failed to respond to fluid resuscitation requiring vasopressor support for maintaining a mean arterial pressure of >65 mm hg during the follow-up period.

Data recording was maintained using a predesigned Performa and data analysis was conducted using a statistical package for the social sciences version 23 (SPSS 23). Categorical frequencies were computed by analyzing frequencies and percentages and using the Chi-square test for analysis of significance. For scale variables following a non-normal distribution median and interquartile range were calculated and the Whitney U Test was used for analysis of significance. The p-value of <0.05 was considered as significant. The methodology of the analysis is illustrated in figure 1.

**Figure 1**
*Flow diagram of the analysis of selected patients*




## RESULTS

In our study, 150 patients were recruited out of which 83 (55.3%) were males and 67 (44.6%) were females with a median (IQR) age of 45 (31.75-60.25) years. In patients from Group A median duration of sepsis was 06 (3-8) days as compared to 5.50 (3-8) days in Group B. Majority of patients 80 (53.3%) (with shock index of >0.87) in Group A were diabetic as compared to patients with shock index <0.87 in 70 (46.6%) patients. Hypertensive patients in Group A were 26 (32.5%) versus 23 (32.9%) in Group B while patients with a history of smoking were 29 (36.3%) in Group A as compared to 23 (32.9%) patients in Group B. Demographic and clinical characteristics of patients are shown in Table I.

**Table I**
*Demographic characteristics between groups (n=150)*

| **Variables** | | **Group A Shock index > 0.87 (n = 80)** | **Group B Shock index < 0.87 (n = 70)** | **p-value** |
|---|---|---|---|---|
| Gender n (%) | Male | 40 (50%) | 43 (61.4%) | 0.160 |
| | Female | 40 (50%) | 27 (38.6%) | |
| Age in years Median (IQR) | | 48.50 (28.25-61.75) | 44 (36.75-57) | 0.941 |
| Duration of sepsis in days Median (IQR) | | 06 (3-8) | 5.50 (3-8) | 0.604 |
| Diabetes mellitus N (%) | Yes | 37 (46.3%) | 35 (50%) | 0.647 |
| | No | 43 (53.8%) | 35(50%) | |
| Hypertension n(%) | Yes | 26 (32.5%) | 23 (32.9%) | 0.963 |
| | No | 54 (67.5%) | 47 (67.1%) | |
| Smoking n(%) | Yes | 29 (36.3%) | 23 (32.9%) | 0.663 |
| | No | 51 (63.7%) | 47 (67.1%) | |

When the shock index was used as a predictor of hemodynamic collapse the sensitivity of the shock index was 77%, specificity was 69.23% and a diagnostic accuracy of 73.33% was recorded (p <0.001). Table II shows the ability of the shock index to predict hemodynamic collapse.

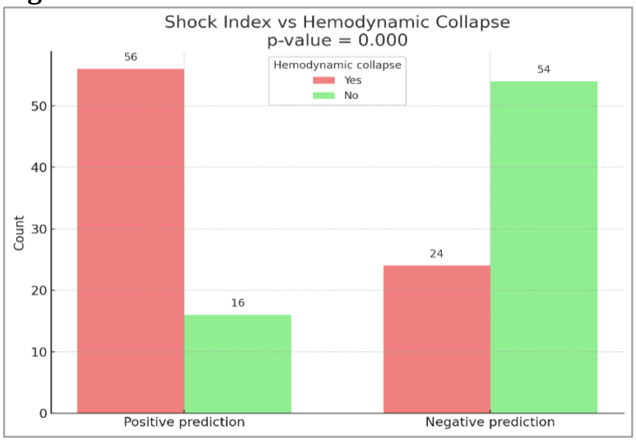
**Table II**

*Predictive ability of hemodynamic collapse by Shock Index (n=150)*

| Shock Index | Hemodynamic Collapse | | p-value |
|---|---|---|---|
| | Yes | No | |
| Positive prediction | 56 (70%) | 16 (22.9%) | 0.000 |
| Negative prediction | 24 (30%) | 54 (77.1%) | |

Sensitivity:77.78%
Specificity: 69.23%
Positive Predictive Value: 70%
Negative Predictive Value: 77.14%
Diagnostic Accuracy: 73.33%
Likelihood Ratio: 2.53

**Figure 1**




Diabetes mellitus, hypertension, smoking, chronic kidney disease, and cardiovascular disease were more prevalent in patients who experienced hemodynamic collapse, with p-values of 0.003, 0.018, 0.004, 0.011, and 0.025, respectively. These findings suggest that these comorbid conditions may contribute to an increased risk of hemodynamic instability in sepsis patients.

**Table III**

*Comorbidities and their association with hemodynamic collapse (n=150)*

| Comorbidity | Hemodynamic Collapse (Yes) (n = 56) | Hemodynamic Collapse (No) (n = 94) | p-value |
|---|---|---|---|
| Diabetes Mellitus | 37 (66.1%) | 35 (37.2%) | 0.003 |
| Hypertension | 26 (46.4%) | 23 (24.5%) | 0.018 |
| Smoking | 29 (51.8%) | 23 (24.5%) | 0.004 |
| Chronic Kidney Disease | 15 (26.8%) | 8 (8.5%) | 0.011 |
| Cardiovascular Disease | 18 (32.1%) | 9 (9.6%) | 0.025 |

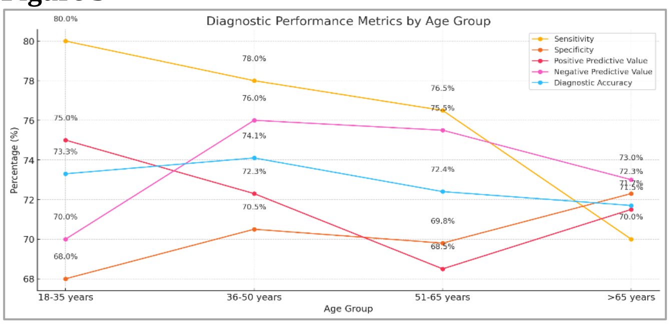
In patients aged 18-35 years, the Shock Index demonstrated the highest sensitivity (80.0%) and specificity (68.0%), with a diagnostic accuracy of 73.3% (p = 0.036). In the 36-50 years group, sensitivity decreased to 78.0%, but specificity improved to 70.5%, with an overall diagnostic accuracy of 74.1% (p = 0.078). In the 51-65 years and >65 years groups, the sensitivity and specificity were lower, with the diagnostic accuracy ranging from 72.4% to 71.7%, indicating a less robust performance in older patients.

**Table IV**

Predictive ability of Shock Index across age groups (n=150)

| Age Group | Sensitivity | Specificity | Positive Predictive Value | Negative Predictive Value | Diagnostic Accuracy | p-value |
|---|---|---|---|---|---|---|
| 18-35 years | 80.0% | 68.0% | 75.0% | 70.0% | 73.3% | 0.036 |
| 36-50 years | 78.0% | 70.5% | 72.3% | 76.0% | 74.1% | 0.078 |
| 51-65 years | 76.5% | 69.8% | 68.5% | 75.5% | 72.4% | 0.215 |
| >65 years | 70.0% | 72.3% | 71.5% | 73.0% | 71.7% | 0.124 |

**Figure 3**




## DISCUSSION

In our resource-stressed settings, even the tertiary care public hospitals lack ample facilities that could help our healthcare professionals make a quick diagnosis and initiate timely intervention. Lab investigations hold a cardinal value in the diagnosis of sepsis and septic shock. However, results take time, and often the hospital does not have resources to perform those tests such as lactate levels.[7] Therefore, it is paramount that bedside assessment is improved by using quick assessment tools to systematically stratify patients according to the risk of deterioration. Shock Index is a simplistic bedside tool that could be readily used in this regard. So even while a patient with sepsis is maintaining vital signs within normal ranges, the shock index can help alert the clinician to escalate care to mitigate the systemic effects of sepsis before the hemodynamic collapse ensues.

In our study sensitivity of the shock index for detection of early hemodynamic collapse was calculated as 77.78%, specificity was 69.23%, positive predictive value was 70%, negative predictive value was 77.14% and diagnostic accuracy was 73.33% revealing its importance in early detection of sepsis and requirement of intensive care. The use of shock index has been widely used in sepsis and the prognosis of sepsis has also been validated by using shock index. A recent trial revealed that when a modified shock index was used in patients presenting to emergencies it predicted the requirement of mechanical ventilation with a sensitivity of 68.75% in patients with comorbidity.[8] Serum lactate which is the end product of anaerobic metabolism has been widely used in the diagnosis of sepsis and mortality in patients.[9] In a similar study, using shock index as a bedside tool, it was concluded that shock index was moderately correlated with serum lactate levels in patients ($r^2 = 0.434$) therefore it may be used as an alternative in setups with diagnostic limitations.[10] We did not incorporate laboratory indices in our study in combination with shock index for the prediction of sepsis however previous studies have concluded that high lactate levels (>2.5) and shock index values of > 2 predicted early requirement of vasopressor support in septic patients with AUC of 0.715 (95% CI, 0.683–0.748) for lactate, 0.688 (95% CI, 0.655–0.722) for DSI.[11]

Apart from the utility of the shock index in sepsis, it has been widely used in trauma patients for the prediction of mortality.[12] A recent mental analysis concluded that in-hospital mortality was increased up to 4 folds in patients with an initial shock index of greater than 1.[13] Similarly another study revealed that the combination of shock index times the AVPU score when used as a triage scoring in trauma patients predicted mortality, intensive care unit stay and total length of hospital stay with an accuracy of 88.56%, 79.84%, and 78.62%, respectively.[14,15]

In our study, the frequency of diabetes in patients with a higher shock index (>0.87) was 80 (53.3%) which revealed that diabetes may be a precipitating factor in sepsis. We could not follow up with the patients for a longer period to assess the mortality rate however another study revealed that diabetic patients presenting with sepsis do not have an increased rate of 28 days mortality as compared to nondiabetic septic.[16,17] Several trials have been conducted to assess the utility of shock index as a bedside tool. In another study performed on patients with covid the use of shock index proved useful in deciding the admission of patients as higher shock index values >0.93 had a significant correlation with mortality in covid.[18]

Although the shock index is readily available, easily calculable, and accurate, it has some limitations (i.e., extremes of age, some chronic illnesses, and medications). It has been noted that normal SI values differ among age groups and between sexes, which is rarely considered when it is studied. To the best of our knowledge, this is the first study to assess the triage shock index as a screening tool for the estimation of hemodynamic collapse and fluid non-responsiveness. This study adds to the literature on shock index in that it tests the accuracy of the shock index as an initial screening tool for the identification of hypotensive septicemic patients in the ED.

### Limitations of the Study

This study is limited by a lack of retrospective data extraction and a relatively small sample size. In addition, the inherent weakness of cross-sectional design means that causality cannot be determined, only associations. We could not determine whether patients had received appropriate fluid resuscitation and whether the administration of fluids adhered to the current guideline recommendation of 30 ml/kg, which may have affected the appropriateness of vasopressor initiation.

## CONCLUSION

Shock Index is an accurate tool in predicting the early hemodynamic collapse in sepsis patients which is easy to calculate and interpret. In the future, it can serve as a valuable bedside tool to identify sepsis patients who are at risk of hemodynamic deterioration.

### Acknowledgements

We are thankful to our seniors who supported us throughout the research and the emergency staff who were very helpful throughout the journey. All praises to Allah for bestowing us the capacity to carry out the research.

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