



Utilization and Limitations of the Shock Index in the Emergency Settings

**Amal Saleh Akeel ^{a*}, Awad Hassan Alamri ^b, Nada Ayed Alayed ^c,
Abdulkarim Hamzah Alraddadi ^d, Yasser Mansour Aljufan ^e,
Mohammed Yousef Alnazzal ^f, Nidal Abdullah Al Mutaileq ^g,
Saba Saeed Baskran ^h, Hadeel Mohammed Alrowaily ^c,
Abdulrhman Ebrahim Mughallis ⁱ and Mohammed Saeed Alamri ^j**

^a Department of Emergency Medicine, King Fahad General Hospital, Jeddah, Saudi Arabia .

^b Department of Emergency Medicine, Ajjad Emergency Hospital, Mecca, Saudi Arabia.

^c College of Dentistry, Princess Nourah Bint Abdul Rahman University, Riyadh, Saudi Arabia.

^d Department of General Surgery, King Fahad Hospital, Medina, Saudi Arabia.

^e College of Medicine, Alfaisal University, Riyadh, Saudi Arabia.

^f Department of Emergency Medicine, Dammam Medical Complex, Dammam, Saudi Arabia .

^g Department of Emergency Medicine, Qatif Central Hospital, Qatif, Saudi Arabia.

^h Emergency Medical Services, Ajjad Emergency Hospital, Mecca, Saudi Arabia.

ⁱ Department of Intensive Care Unit, King Fahad Central Hospital, Jazan, Saudi Arabia.

^j Department of Emergency Medicine, Aseer Central Hospital, Abha, Saudi Arabia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

It is widely known that evaluation and prediction tools play an essential role in diagnosing and managing patients admitted to the emergency department. For example, evaluating patients by shock index can diagnose an underlying shock, indicating the need for resuscitation. Evidence shows that the shock index has been used in the emergency department to evaluate different cases. Due to various conditions, it can predict different clinical outcomes and mortality among patients presenting to the emergency department. In the present literature review, we have

discussed the utilization and limitations of the modality in these settings. Our findings indicate that the shock index is a valuable tool that can effectively predict the need for blood transfusion and mortality among patients with traumatic injuries and other conditions, including sepsis and cardiovascular diseases. However, many factors can limit the efficacy of this tool in these settings. For instance, age, some conditions, and specific medication use might reduce the sensitivity of shock index in predicting mortality. In addition, some studies reported that the SIPA score could be better used for pediatric patients. Besides, most of the current studies are retrospective, limiting the quality of evidence in these studies. Accordingly, further studies are needed.

Keywords: Shock index; shock; emergency; hemodynamics; evaluation; efficacy; limitations.

1. INTRODUCTION

Evidence shows that the shock index has been used in the emergency department to evaluate different cases. It was first introduced to the literature in 1967, providing an approximate estimation of the vital signs and hemodynamic status [1]. It has been defined as the patient's heart rate ratio per systolic blood pressure [2]. It is widely known that evaluation and prediction tools play an essential role in diagnosing and managing patients admitted to the emergency department. In addition, evaluating patients by shock index can diagnose an underlying shock, indicating the need for resuscitation [1].

Although the shock index has been validated across various reports, some limitations were reported in some settings [3,4]. For instance, it has been demonstrated that its efficacy in predicting mortality in older patients reduced. Therefore, the age shock index was proposed with the better predictive ability of severe adverse events for this population in the emergency department [5]. The present literature review aims to discuss the utilization and efficacy of shock index and the potential limitations among the different investigations conducted in the emergency department.

2. LITERATURE REVIEW

Pre-hospital trauma resuscitation is usually performed using whole blood and synthetic hemoglobins and packed red blood cells (intravenous oxygen carriers). Evidence shows that patients with shock usually have higher morbidities and an increased risk of mortality. They might also require remarkable amounts of blood transfusion to manage their cases and reduce the risk of developing secondary complications. This section discusses the applications of shock index in the different emergency settings and the reported limitations among the various relevant studies in the

literature. Again, different settings were reported, of which we will discuss the commonest and the most important based on clinical perspectives. A previous investigation by Mitra et al. [6] studied the utility of shock index after major trauma to indicate the administration of pre-hospital oxygen carrier. In their retrospective investigation, the authors demonstrated that shock index ≥ 1 was a significant predictor for ≥ 1 of crystalloid transfusion. In addition, it has been shown that identifying patients who received blood transfusion by four hours from hospital arrival was associated with an estimated specificity rate of 93.5%.

Another retrospective investigation by scroll et al. [7] also aimed to assess the need for massive transfusion for patients with significant traumas using the shock index. It has been estimated that predicting Massive Transfusion Protocol activation was significantly associated with a shock index score of ≥ 1 . The estimated specificity and sensitivity for this correlation were 81.3% and 67.7%, respectively. The authors compared the outcomes with the ABC score, which also showed statistical significance. However, the authors concluded that the shock index is more favorable because it can be more easily conducted and has a higher sensitivity than the ABC score. On the other hand, another study by Rau et al. [8] reported that the shock index had a moderate predicting power. Moreover, it has been reported that the presence of comorbidities as coronary artery disease, diabetes mellitus, and hypertension can compromise the predictive power of the shock index. However, it should be noted that the authors compared the predictive abilities of the shock index, age shock index, and modified shock index. It has been reported that the predictive power of the shock index was significantly better than the other two indices, which were also reported to be more complex in their calculation, adding to the advantages of the shock index. Based on the findings of a previous

systematic review, which included five articles, the optimal cutoff score of the shock index to have acceptable predicting abilities is ≥ 0.9 [9]. In addition, evidence demonstrates that the high shock index scores can significantly predict bleeding, whereas higher scores are more associated with bleeding. Accordingly, it is suggested that pre-hospital evaluation of patients should be performed using the shock index to predict better excessive bleeding and the subsequent need to perform blood transfusion and establish proper management modalities.

Shock index was also reported among various investigations that included patients with cardiovascular diseases. For example, a previous study compared the utility of predicting 30-day mortality using shock index with Simplified Pulmonary Embolism Severity Index (sPESI) for patients with pulmonary embolism. The authors reported that the reliability of the shock index was significantly lower than the other score as more mortality rates were recorded among patients with low shock index than other patients with low sPESI scores. Therefore, it has been concluded that the shock index cannot be reliably used to predict severe cases and mortality among patients with pulmonary embolism [10]. On the other hand, another study reported that in-hospital mortality of patients with pulmonary embolism was significantly associated with having a shock index score ≥ 1 . It was further reported that moderate-to-severe right ventricular hypokinesia was significantly associated with higher mortality rates regardless of the shock index score [11]. Moreover, it has been reported that cardiogenic shock has been associated with high scores of shock index among patients with ST-segment elevation myocardial infarction. Evidence shows that a cutoff score of ≥ 0.8 among these patients can significantly predict in-hospital mortality in these events [12]. Although the findings of these studies are encouraging and support the use of the shock index in these settings, it should be noted that the sample size and design of these studies might limit these results. Therefore, validation by further future investigations is encouraged.

As an effective modality to predict rupture, shock index has been used in obstetric settings for patients with an ectopic pregnancy to achieve an adequate diagnosis. A previous case-control study showed that elevated shock index scores and heart rate were significant among patients suffering from ruptured ectopic pregnancies [13].

Therefore, this study also aimed to estimate the cutoff point for predicting rupture of ectopic pregnancies for patients presenting to the emergency department during the first trimester. Estimated specificity and sensitivity rates were 70% and 76%, respectively, for a cutoff of 0.7. However, the authors reported that the sensitivity and specificity rates were 40% and 97%, respectively, when the estimated shock index score was ≥ 0.85 . Accordingly, increased risk of rupture of ectopic pregnancies can be significantly predicted by increased shock index score. Moreover, evidence shows that shock index can be used as a valid screening tool that is more productive than heart rate and systolic blood pressure. This was further indicated in a previous cohort investigation that included patients with ectopic pregnancies presenting to the emergency department. In addition, it has been shown that the shock index scores for patients with ruptured pregnancies were higher than other patients with unruptured events. However, this difference was not statistically significant, and therefore, it was not clinically relevant. However, the authors also reported an increased risk of rupture was significantly associated with a shock index score of ≥ 0.81 [14]. However, it should be noted that as a result of the reduced sensitivity rates, transvaginal ultrasound should still be considered as the most superior tool to all of these modalities. Further research is also needed in this context before making conclusions about using shock index to predict emergency interventions.

The Systemic Inflammatory Response (SIRS) criteria have been used to assess and screen patients with sepsis presenting to the emergency department. Previous studies have evaluated the efficacy of shock index in assessing patients with sepsis by comparing it with SIRS criteria. However, evidence comparing shock index and Sequential Organ Failure Assessment (SOFA) is lacking. In addition, evidence shows that sustained elevation in the shock index significantly predicts the need to administer vasopressin. For example, Wira et al. [15] reported that only 11.6% of patients who did not have sustained shock index levels required vasopressin administration within three days following admission compared to 38.6% of patients with sustained shock index >0.8 . In addition, a previous study compared the validity of shock index in predicting serum lactate ≥ 4 mmol/L among included patients that had modified SIRS (SIRS without white blood count) and ≥ 2 SIRS criteria. The authors reported that

the risk of developing hyperlactatemia was significantly increased by three times among patients that had shock index >0.7 . However, it has been reported that the shock index had a poor positive predictive value in predicting 28-day mortality and hyperlactatemia. On the other hand, the estimated negative predictive value was 97% [16]. Evidence shows that using shock index trends might be more specific in detecting septic shock and mortality cases than using a single-point measurement [15]. These findings indicate that shock index can be used in combination with SIRS criteria for better prediction and accurate diagnosis of patients present to the emergency department to enhance their outcomes. The hemodynamic response was also evaluated using shock index following fluid resuscitation. This has been shown in a previous prospective study that reported that responding to volume expansion was unlikely among patients with shock index ≤ 1 and central venous pressure ≥ 8 . The estimated negative predictive value for this correlation was 93%. On the other hand, the enhanced fluid response was associated with having a shock index >1 [17]. This might evidence the combined use of central venous pressure measurement and shock index in evaluating response to fluid administration. Therefore, clinicians can intervene against fluid overload for severely ill patients in a more enhanced approach than using either of the modalities alone.

3. OBSERVATIONS

It should be noted that all of the cited investigations did not study the association between shock index, sepsis, and secondary mortality in old patients. Using shock index was also used to predict mortality among geriatric patients suffering from different systemic conditions. It has been well-established that the presence of these chronic disorders might mask the severity of the vital signs necessary to predict mortality and severe morbidity. A previous retrospective investigation aimed to identify whether old age (>65 years old), diabetes, hypertension, and the administration of beta-blockers and calcium channel blockers can significantly impair the ability of shock index to predict mortality among 111,019 included patients. It has been reported that 30-day mortality was associated with shock index ≥ 1 and old age (65 years old) [18]. However, this correlation was affected by hypertension, calcium channel blockers, or beta-blockers, but not with diabetes. Another investigation also assessed

the ability of the shock index to predict mortality among patients with influenza. High negative predictive value and specificity were associated with the ability of shock index ≥ 1 in predicting 30-day mortality in these patients [5]. These findings are promising and indicate the validity of the shock index. However, further studies are still needed to comprehend the association between shock index and age in predicting the different parameters based on other disorders. The impact of age on the values of shock index was also studied in the pediatric population. Therefore, studies have suggested that pediatric age-adjusted shock index (SIPA) might better predict outcomes. SIPA has been defined as minimum normal systolic blood pressure and maximum average heart rate [3,4,19,20]. Many of these studies indicated that SIPA is a better predictor for the different outcomes, including hospital and intensive care unit admission, intubation, all-cause mortality, and need for operation [21,22]. However, not all resuscitation measures were included in such comparisons, and the current evidence is mainly based on retrospective investigations. Thus, further prospective studies are encouraged.

4. CONCLUSION

The shock index can predict different clinical outcomes and mortality among patients presenting to the emergency department due to various conditions. In the present literature review, we have discussed the utilization and limitations of the modality in these settings. Our findings indicate that the shock index is a valuable tool that can effectively predict the need for blood transfusion and mortality among patients with traumatic injuries and other conditions, including sepsis and cardiovascular diseases. However, many factors can limit the efficacy of this tool in these settings. For instance, age, some conditions, and specific medication use might reduce the sensitivity of shock index in predicting mortality. In addition, some studies reported that the SIPA score could be better used for pediatric patients. Besides, most of the current studies are retrospective, limiting the quality of evidence in these studies. Accordingly, further studies are needed.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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