ORIGINAL ARTICLE

The effectiveness of shock indices on prognosis in burn patients admitted to the emergency department

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ABSTRACT

BACKGROUND: Shock index (SI) is the ratio of heart rate (HR) to systolic blood pressure (SBP); modified SI (MSI) is the ratio of HR to mean arterial pressure; age SI (ASI) is age multiplied by SI; reverse SI (rSI) is the ratio of SBP to HR; and rSIG is rSI multiplied by Glasgow Coma Scale Score (rSIG). Studies have proven that shock indices are good tools in predicting mortality. This study aimed to evaluate the sensitivity of the shock indices SI, MSI, ASI, rSI, and rSIG in predicting mortality in burn patients.

METHODS: This is a retrospective cross-sectional study. The vital signs of the patients were recorded and their shock indices were calculated at the time of emergency department admission. The effectiveness of the shock indices SI, MSI, ASI, rSI, and rSIG in predicting mortality was compared in the burn patients included in the study

RESULTS: A total of 913 patients were enrolled. rSIG and MSI were the shock indices with the highest area under the curve (AUC) values in predicting mortality in the burn patients. The AUC values of rSIG and MSI were 0.829 (95% CI: 0.739–0.919, P<0.001) and 0.740 (95% CI: 0.643–0.838, P<0.001), respectively.

CONCLUSION: Vital signs are easily recorded and shock indices are easily calculated at the time of admission of burn patients to the emergency department; they also effectively predict mortality. rSIG and MSI are the best mortality predictors among the shock indices examined in this study.

Keywords: Age shock index;burn; modified shock index; rSIG; shock index.

INTRODUCTION

Burn injury is a common type of traumatic injuries, for which more than 6 million people worldwide receive medical care each year. Mortality rates of hospitalized burn patients range between 1.4% and 34%.[1] Severe burn injuries disrupt the dynamic nature of the endothelial glycocalyx system and cause capillary leak. Fluid extravasation from the intravascular space to the extracellular space first occurs in the burned tissue in the first hour; it continues to increase slowly both in burned tissue and unburned tissue by the first 24–48 h after the systemic inflammatory response develops.[2] Left ventricular systolic dysfunction, a decrease in cardiac output, and an increase in systemic and pulmonary vascular resistance occur within the first few hours after burn injury. This is followed by a hyperdynamic and vasoplegic state within the first 24–48 h due to the release of chemokines, cytokines, and sympathomimetic mediators, which in turn causes an increase in cardiac output and a reduction in systemic and pulmonary vascular resistance.[3]

Shock index (SI) was first defined by Allgower and Burri as the ratio of heart rate (HR) to systolic blood pressure (SBP).[4] Thereafter, many other shock indices have been developed, including modified SI (MSI) defined as the ratio of HR

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to mean arterial pressure (MAP), age SI (ASI) defined as age multiplied by SI, reverse SI (rSI) defined as the ratio of SBP to HR, and rSIG index defined as rSI multiplied by Glasgow Coma Scale (GCS) Score.[5-7] Shock indices have been studied and proven to effectively predict prognosis in trauma, sepsis, pulmonary thromboembolism, determination of massive transfusion need, and obstetric, pediatric, and geriatric patient groups.[5-10]

There is no study in the literature comparing the effectiveness of shock indices on prognosis in burn patients. Herein, we aimed to test the hypothesis that the shock indices calculated at emergency department admission would effectively predict mortality as a result of the hypodynamic state of the cardiovascular system within the 1st h of a burn injury.

MATERIALS AND METHODS

Study Setting and Ethics Statement

This retrospective study included burn patients who were admitted to the emergency department of Dicle University hospital. Approximately 83.000 patients are admitted to our hospital's emergency department each year, and about 26.500 of them are trauma patients. Our hospital contains a 23-bedded burn unit that is managed by plastic and reconstructive surgeons. This study was approved by the Dicle University School of Medicine Ethics Committee for Non-interventional Clinical Research (Session Number March 25, 2021/136). Since the study was a retrospective one, patient consent was not sought.

Study Population and Emergency Department Management

This study evaluated the medical records of 1875 consecutive burn patients who presented to the emergency department between January 2015 and December 2019. It included burn patients who directly presented to our emergency department and were admitted to the burn unit. The following types of burn patients were excluded from the study: Patients who were transferred to our hospital from another emergency department or hospital, who developed cardiac arrest at the time of emergency department admission, whose medical records were incomplete or incorrect, and who lacked an indication for hospitalization were discharged from the emergency department. As a result, 962 patients were excluded from the study, and 913 patients were included. All burn patients who presented to the emergency department were examined in detail and their vital signs were recorded. Total burn surface area (TBSA) was calculated using the Lund-Browder chart. Fluid resuscitation was applied according to the Parkland formula to aim a urine output of 0.5–1 mL/kg/h. The patients were hospitalized according to the hospitalization criteria of the American Burn Association.

Data Collection and Variables

The patient's data were obtained from their medical records in the hospital registry system. Their age, sex, HR, SBP, diastolic blood pressure (DBP), GCS, total body burn percentage, electric burn, inhalation burn, intensive care unit admission status, length of hospitalization, and vital signs were recorded. SI, MSI, ASI, rSI, and rSIG were calculated on the basis of their vital signs at the time of emergency department admission.

The shock indices were calculated with the following formulas:

SI=HR/SBP

MAP= (SBP + 2×DBP)/3

MSI=HR/MAP

ASI=Age×SI

rSI=SBP/HR

rSIG= (SBP/HR)×GCS

Statistical Analyses

Continuous variables showing a numerical distribution were expressed as median and interquartile range (IQR, q1-q3) and analyzed with Mann–Whitney U-test. Categorical variables were expressed as frequency and number and analyzed with Chi-square test ($\chi 2$). The diagnostic discriminatory power of the shock indices SI, MSI, ASI, rSI, and rSIG for mortality prediction in the burn patients was analyzed with the receiver operating characteristic (ROC) curve analysis. The accuracy of a parameter in mortality prediction was defined as the area under the curve (AUC). The best cut-off point, sensitivity, specificity, positive predictive value, and negative predictive value were determined. All tests were two sided. A P <0.05 was considered as statistically significant for all tests. IBM SPSS 21.0 for Windows software package was used for statistical analyses.

RESULTS

Clinical Characteristics and Factors Affecting Mortality

Out of 913 patients enrolled in the study, 876 (95.95%) survived and 37 (4.05%) died. The median age of the overall burn patient group was 4 (2–17); it was 4 (2–17) in the survivors and 3 (1.5–22.5) in the deceased patients. Age was not factor affecting mortality (P=0.985). Four hundred and twenty (46%) patients were female, and 493 (54%) were male. Sex was not a factor affecting mortality (P=0.236). TBSA was significantly greater in the deceased patients. The median TBSA was 12 (7–20) in the whole group, 10 (6–20) in the survivors, and 50 (38–70) in the deceased patients (P<0.001). Electric burn was not a factor affecting mortality (P=0.722). Among patients with inhalation burn, 114 (13%) survived and 8 (21.6%) died. Inhalation burn was a factor affecting mortality (P<0.001). Of those who were admitted to the intensive care unit, 457 (52.2%) survived and 34 (91.9%) died. Intensive care unit admission was a factor affecting mortality (P<0.001). Length of hospitalization was shorter in the deceased patients (P=0.003) (Table 1).

The median (q1-q3) values of DBP, SBP, MAP, GCS, rSI, and

Table 1. Shock indices and factors affecting mortality in burn patients

Variables	Total (n=913)	Survival (n=876)	Mortality (n=37)	P-value
Age, year (median [IQR])	4 (2–17)	4 (2–17)	3 (1.5–22.5)	0.985
Gender n(%)				
Female	420 (46)	407(46.5)	13 (35.1)	0.236
Male	493(54)	469(53.5)	24 (64.9)	
TBSA, (%), (median [IQR])	12 (7–20)	10 (6–20)	50 (38–70)	<0.001
Inhalation burn, n(%)	122 (13.4)	114 (13)	8 (21.6)	<0.001
Electrical burn, n(%)	142 (15.6)	137 (15.6)	5 (13.5)	0.722
ICU admission, n(%)	491 (53.8)	457 (52.2)	34 (91.9)	<0.001
LOS, days (median [IQR])	10 (6–21)	11 (6–21)	6 (5–13)	0.003
Heart rate (beats/min), (median [IQR])	112 (92–126)	112 (92–124)	126 (102–139)	0.010
DBP (mmHg), (median [IQR])	64 (57–74)	65 (57–75)	52 (37.5–61.5)	<0.001
SBP (mmHg), (median [IQR])	108 (95–119)	109 (96–119)	90 (78–106)	<0.001
MAP (mmHg), (median [IQR])	78.3 (70–89.2)	78.7 (70–89.7)	65.3 (51.2–76.3)	<0.001
GCS, (median [IQR])	15 (15–15)	15 (15–15)	12 (8–14)	<0.001
SI, (median [IQR])	1.02 (0.82–1.28)	1 (0.81–1.26)	1.33 (1–1.67)	<0.001
MSI, (median [IQR])	1.39 (1–1.73)	1.38 (1–1.71)	1.95 (1.5–2.46)	<0.001
ASI, (median [IQR])	4.72 (1.90–13.70)	4.74 (1.86–13.55)	4.68 (2–17)	0.302
rSI, (median [IQR])	0.97 (0.78–1.22)	0.98 (0.79–1.23)	0.75 (0.59–0.91)	<0.001
rSIG, (median [IQR])	14.25 (11.55–18.13)	14.51 (11.70–18.21)	8.33 (4.85–12.31)	<0.001

IQR: Interquartile range; TBSA: Total burn surface area; ICU: Intensive care unit stay; LOS: Length of stay; DBP: Diastolic blood pressure; SBP: Systolic blood pressure; MAP: Mean arterial pressure; GCS: Glasgow Coma Scale; SI: Shock index; MSI: Modified shock index; ASI: Age shock index; rSI: Reverse shock ındex; rSIG: Reverse shock index multiplied by Glasgow Coma Scale.

rSIG in the surviving versus deceased patients were 65 (57–75) versus 52 (37.5–61.5), 109 (96–119) versus 90 (78–106), 78.7 (70–89.7) versus 65.3 (51.2–76.3), 15 (15–15) versus 12 (8–14), 0.98 (0.79–1.23) versus 0.75 (0.59–0.91), and 14.51 (11.70–18.21) versus 8.33 (4.85–12.31), respectively; they were lower in the deceased patients and significantly affected mortality (P<0.001). The median (q1-q3) values of SI and MSI in the surviving versus deceased patients were 1 (0.81–1.26) versus 1.33 (1–1.67) and 1.38 (1–1.71) versus 1.95 (1.5–2.46), respectively; they were higher in the deceased patients and significantly affected mortality (P<0.001). However, ASI was not a factor affecting mortality (P=0.302) (Table 1).

ROC Analysis for Predicting Mortality with SI

According to the ROC analysis, the shock indices SI, MSI, rSI, and rSIG had a diagnostic value in predicting mortality. Among the shock indices, rSIG and MSI had the highest AUC values. On the other hand, ASI was the SI among others that had the lowest AUC value, having no diagnostics role in mortality prediction. The AUC, 95% CI: Lower bound-upper bound, P values of the shock indices were as follows: SI (AUC: 0.717, 95% CI: 0.620–0.813; P<0.001), MSI (AUC:

Table 2. Sensitivity, specificity, and optimal cut-point values in predicting mortality for shock indices in burn patients

Predictor	Optimal cut point	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC
SI	1.17	70.27	65.75	7.98	98.13	0.717
MSI	1.81	59.46	81.74	12.09	97.95	0.740
ASI	40.20	21.62	97.26	25	96.71	0.550
rSI	0.85	70.27	65.75	7.98	98.13	0.717
rSIG	10	70.27	90.41	23.64	98.63	0.829

AUC: Area under the curve; PPV: Positive predictive value; NPV: Negative predictive value.

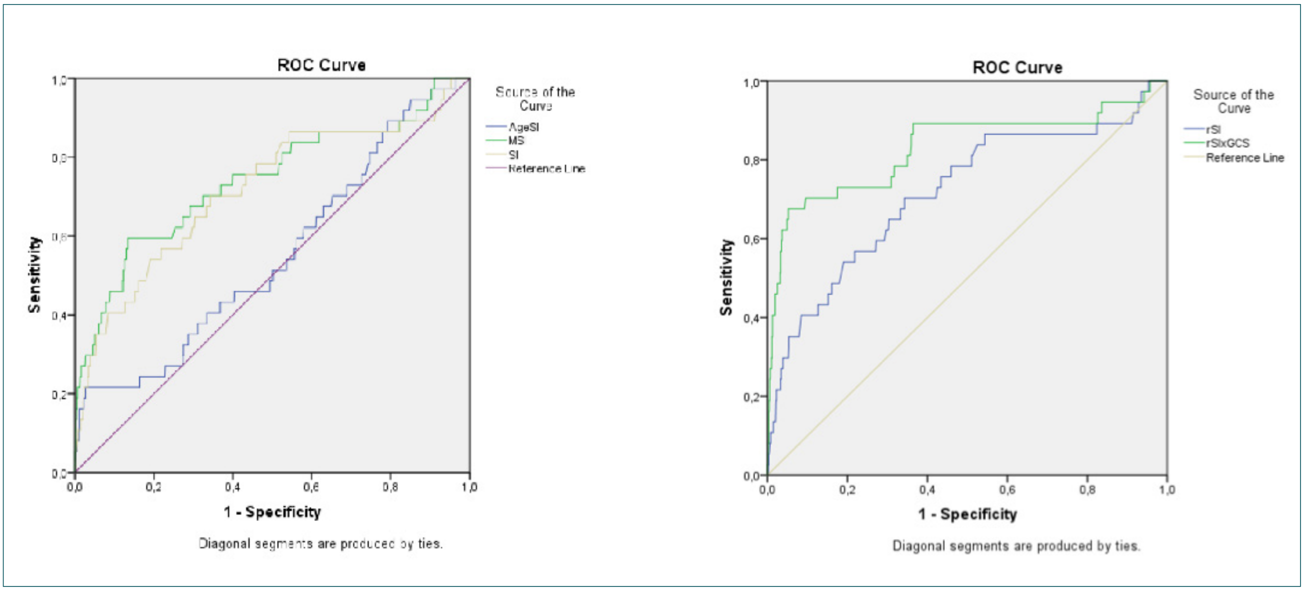

Figure 1. Area under the curve of shock indices in predicting the mortality of burn patients.

0.740, 95% CI: 0.643–0.838; P<0.001), ASI (AUC: 0.550, 95% CI: 0.451–0.649; P=0.302), rSI (AUC: 0. 0.717, 95% CI: 0.620–0.813; P<0.001), and rSIG (AUC: 0.829, 95% CI: 0.739–0.919; P<0.001) (Table 2). The ROC curves of the burn patients are shown in Figure 1.

DISCUSSION

We thought that the shock indices calculated by vital signs taken at the time of emergency department admission would have a prognostic value in mortality prediction in burn patients due to the collapse of the cardiovascular system that develops in the 1st h of burn injury as the pathophysiological mechanism. For this purpose, the shock indices of burn patients were calculated using their vital signs recorded at the first contact with the emergency department, and patients referred from other health-care centers were excluded. This study also compared the abilities of the shock indices SI, ASI, MSI, rSI, and rSIG to predict mortality.

Shock indices can be easily calculated using readily accessible vital parameters to determine the hemodynamic status of burn patients. SI, ASI, MSI, and rSI are calculated using the vital signs SBP and HR, and rSIG is calculated with SBP, HR, and GCS. In this study, the effects of the vital signs such as SBP, HR, and GCS and the shock indices on mortality were statistically significant. When the abilities of the shock indices SI, MSI, rSI, and rSIG to predict mortality in burn patients were compared, rSIG was found superior.

In a previous study, an SI value of >1 significantly predicted hypovolemic shock, transfusion need, and a higher mortality among trauma patients admitted to emergency department.[11] In a recent systematic review, in-hospital mortality increased four folds in adult trauma patients presenting to a trauma center or emergency department when the baseline SI was equal to or greater one.[12] Dai et al.[13] studied the role of SI, MSI, and ASI in predicting in-hospital mortality in trauma patients in the first 7 days; the authors found a mortality rate of 15.19%. For mortality prediction, they reported an AUC value of 0.953 (95% CI: 0.921–0.975), a sensitivity of 100%, and a specificity of 90% for an SI cut off of >0.95; an AUC value of 0.945 (95% CI 0.911–0.968), a sensitivity of 95.35%, and a specificity of 87.08% for an MSI cut off of >1.18; and an AUC value of 0.899 (95% CI 0.858–0.931), a sensitivity of 83.72%, and a specificity of 87.08% for an ASI cut off of >52.7.[13] Lee et al.[14] analyzed SI, ASI, and rSIG for the prediction of hospital mortality among patients presenting to emergency department. They reported an AUC value of 0.578 (0.517–0.638), a sensitivity of 43%, a specificity of 80%, a PPV of 17%, and a NPV of 94% for an SI cut off of 0.81; an AUC value of 0.674 (0.623–0.726), a sensitivity of 54%, a specificity of 77%, a PPV of 18%, and a NPV of 95% for an ASI cut off of 42.34; and an AUC value of 0.812 (0.772–0.852), a sensitivity of 76%, a specificity of 77%, a PPV of 23%, and a NPV of 97% for an rSIG cut off of 10.20.[14] In the study by Dai et al., the AUC values of the shock indices were higher. In a study by Lee et al., on the other hand, rSIG could predict mortality better than SI and ASI. Our study yielded similar results with the study by Lee et al. regarding mortality prediction by the shock indices. In this study, the cut-off values of shock indices in predicting mortality have showed differing from the literature. However, this may be due to these reasons: First, there was no study in the literature comparing shock indices in burn patients; second, the studies we compared were trauma cases; and third, mortality rates in this study were lower than in comparable studies. Therefore, the PPD was lower.

Studies on mortality prediction by ASI in geriatric trauma patients have found an AUC value of 0.69 (95% CI: 0.67–0.72) and 0.83 (95% CI: 0.78–0.88) for 55 years and older and an AUC value of 0.74 (95% CI 0.72–0.76) for 65 years or older.[15-17] ASI is generally a SI with proven diagnostic value in mortality prediction in adult and geriatric patients.[13-17] Since the majority of patients in the present study were children, we thought that the diagnostic value of ASI in mortality prediction in burn patients was limited.

Kuo et al. found that the number of patients with an Injury Severity Score ≥25 and mortality significantly increased among trauma patients with rSI<1.[6] Among adult trauma patients, an rSI smaller than 1 at admission may be an ominous sign even in the absence of hypotension.[18] rSIG had an excellent predictive ability for hospital mortality in trauma patients younger than 55 years of age.[7] In this study, rSIG had a good predictive ability for hospital mortality in burn patients. Accordingly, rSIG seems to be a strong prognostic indicator in burn patients as well as in trauma patients.

Limitations

This study had the following limitations. First, it was a retrospective cross-sectional study. Second, it was a single-center study. Third, the number of cases was small. There is a need for multicenter studies with larger sample size to confirm the results of this study.

Conclusion

Shock indices can be easily calculated with readily available vital signs and used for predicting prognosis in burn patients. This study showed that the shock indices had diagnostic value in mortality prediction in burn patients. Among the shock indices studied, rSIG had the best diagnostic value in mortality prediction.

Ethics Committee Approval: This study was approved by the Dicle University Faculty of Medicine Clinical Research Ethics Committee (Date: 25.03.2021, Decision No: 136).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Acil servise başvuran yanık hastalarında şok indekslerinin prognoz üzerine olan etkinliği

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AMAÇ: Şok indeksi (SI), nabızın (HR) sistolik kan basıncına (SBP) oranı; modifiye şok indeksi (MSI), HR nin ortalama arter basıncına oranı; yaş şok indeksi (ASI), yaşın SI ile çarpımı; rivers şok indeksi (rSI), SBP nin HR ye oranı; rSIG, rSI nın Glasgow Koma Skoru (GCS) ile çarpımıdır. Yapılmış çalışmalarda şok indekslerinin mortaliteyi öngörmede iyi araçlar olduğu kanıtlanmıştır. Bu çalışmanın amacı yanık hastalarında SI, MSI, ASI, rSI, rSIG şok indekslerinin mortaliteyi öngörmedeki duyarlılığını değerlendirmektir.

GEREÇ VE YÖNTEM: Bu çalışma retrospektif kesitsel bir çalışmadır. Hastaların acil servise başvuru anındaki vital bulguları alındı ve şok indeksleri hesaplandı. Çalışmaya alınan yanık hastalarında SI, MSI, ASI, rSI, rSIG şok indekslerinin mortaliteyi öngörmedeki etkinliği karşılaştırıldı.

BULGULAR: Toplam 913 hasta çalışmaya alındı. Yanık hastarında mortaliteyi öngörmede eğri altında kalan alan (AUC) değeri en yüksek olan şok indeksleri rSIG ve MSI idi. Değerleri sırasıyla rSIG (AUC: 0.829, %95 CI: 0.739-0.919, p<0.001) ve MSI (AUC: 0.740, %95 CI: 0.643-0.838, p<0.001) idi.

TARTIŞMA: Yanık hastalarının acil servise başvuru anındaki vital bulguları ile şok indekslerinin hesaplanması basittir ve mortaliteyi öngörmede etkilidirler. Çalışmadaki şok indeksleri içinde mortaliteyi öngörmede en iyisi rSIG ve MSI'dır.

Anahtar sözcükler: Şok indeksi; modifiye şok indeksi; rSIG; yaş şok indeksi; yanık.

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