North Clin Istanb 2024;11(4):353–358
doi: 10.14744/nci.2024.67434

Original Article NEUROLOGY

Assessing the efficacy of the shock index in predicting mortality in patients with intracerebral hemorrhage

Aysenur Onalan,[1] Bengu Mutlu Saricicek[2]

[1]Department of Neurology, University of Health Sciences, Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Turkiye
[2]Department of Emergency Medicine, University of Health Sciences, Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Turkiye

ABSTRACT

OBJECTIVE: It has been reported that the shock index assists in the prediction of poor prognosis in stroke patients. However, the role of this index in predicting mortality and prognosis in patients with intracerebral hemorrhage has not been sufficiently investigated. The objective is to examine the correlation between the shock index and mortality and unfavorable clinical outcomes in individuals with intracerebral hemorrhage.

METHODS: 110 consecutive cases of intracerebral hemorrhage were evaluated in the emergency department. The shock index values of the patients were calculated using their initial blood pressures and HR. For descriptive purposes, the shock index values were categorized into three groups: <0.50, 0.50–0.70, and >0.70. The relationships of these three values and the mean shock index with hematoma volume, hematoma rupturing into the ventricle, length of hospital stay, complications during this period, and in-hospital and three-month mortality were examined.

RESULTS: There were 58 male patients in this study, with a mean age of 62.66±13.64 years. The mean baseline Glasgow Coma Scale score was 13.78±2.37, and the mean baseline shock index value was 0.51±0.13. The mean time of hospitalization was estimated to be 17.01±14.02 days. The mean in-hospital mortality rate was 19%, and the mean three-month mortality rate was 23%. No statistically significant differences were found in hematoma volume, hematoma rupturing into the ventricle, length of hospital stay, complications during this period, or in-hospital and three-month mortality according to the mean shock index value or shock index categories (<0.50, 0.50–0.70, and >0.70).

CONCLUSION: The shock index evaluated in the emergency department in patients with intracerebral hemorrhage is not related to mortality or morbidity.

Keywords: Intracerebral hemorrhage; mortality; shock index; stroke.

Cite this article as: *Onalan A, Mutlu Saricicek B. Assessing the efficacy of the shock index in predicting mortality in patients with intracerebral hemorrhage. North Clin Istanb 2024;11(4):353–358.*

Intracerebral hemorrhage (ICH) constitutes approximately 10% to 15% of all stroke cases. In comparison to ischemic stroke, it has a greater risk of morbidity and mortality [1]. Despite the significant progress made in intravenous and endovascular therapies for ischemic stroke, the efficacy of any medical intervention for patients with intracerebral hemorrhage (ICH) remains unverified [2]. Several prognostic models are available for predicting mortality and functional outcome following ICH [3, 4]. These models often incorporate criteria related to neurological status, various clinical and laboratory parameters, or neuroimaging findings. Therefore, while these models can accurately predict the outcome, practical and reliable predictors are needed in the emergency department to facilitate prompt decision-making in acute situations and provide consistent communication with patients' families.

Received: March 18, 2024 *Revised:* July 01, 2024 *Accepted:* July 24, 2024 *Online:* August 07, 2024

Correspondence: Aysenur ONALAN, MD. Saglik Bilimleri Universitesi, Kartal Dr. Lutfi Kirdar Sehir Hastanesi, Noroloji Klinigi, Istanbul, Turkiye.
Tel: +90 216 458 30 00 e-mail: draysenurkaymaz@gmail.com

Istanbul Provincial Directorate of Health - Available online at www.northclinist.com

The shock index (SI) is defined as the ratio between heart rate (HR) and systolic blood pressure (SBP) and has been investigated as a surrogate measure of hemodynamic status that can enhance the prognostic value of (HR) or SBP alone [5].

SI, the ratio of HR to SBP, has been identified as a potential indicator of hemodynamic status that can improve the predictive value of HR or SBP alone. The SI was originally proposed as an indicator of the severity of hypovolemic shock. It was subsequently shown that early sepsis was a useful bedside indicator with prognostic importance in community-acquired pneumonia, pulmonary embolism, trauma, and myocardial infarction [6–8]. However, there is very limited literature on the use of the SI in the evaluation of stroke patients [9].

The objective of this study was to investigate the correlation between SI and post-ICH outcomes, which, we consider, can be promptly and accurately assessed at the time of presentation and can help predict short- and long-term prognosis. Therefore, the primary objective of this study is to examine the relationship between mortality and shock index. The secondary aim is to investigate the relationship between SI and poor neurological outcomes.

MATERIALS AND METHODS

This study is a retrospective, observational cohort study. The present investigation was carried out in adherence to the principles outlined in the 1964 Declaration of Helsinki. Patients over 18 years who were detected to have ICH on cranial computed tomography (CT) within the first six hours of their presentation to the emergency department between November 2022 and January 2023 were included in the study. The study obtained approval from the Kartal Dr. Lutfi Kirdar City Hospital Clinical Research Ethics Committee (Decision no: 010.99/25, date: 28.02.2024). The mean baseline hematoma volume on cranial CT was calculated according to the ABC/2 formula (1), and whether it ruptured into the ventricle was noted. Brainstem and posterior system hematoma volumes were excluded from the study due to the small volume and number of patients. For patients with remaining anterior system hemorrhages, parameters such as age, sex, comorbidities, antiplatelet treatments used, baseline Glasgow Coma Scale (GCS) score, length of hospital stay, in-hospital complications and mortality, need for surgical treatment, and third-month Modified Rankin Scale (mRS) scores were recorded.

Highlight key points

- The shock index is a crucial indicator used to assess tissue perfusion by calculating the ratio of heart rate to systolic blood pressure.
- Effective prognostic indicators are crucial in the management of intracerebral hemorrhage due to its high morbidity and death rates. These indicators are crucial for expeditious decision-making and ongoing communication with the relatives of patients.
- The association between shock index and poor outcomes or mortality has been demonstrated in diseases such as trauma, septic shock, pneumonia, and myocardial infarction (MI).
- The evaluation of shock index in relation to hemorrhagic stroke has not been sufficiently conducted.

Patients over the age of 18, regardless of gender, with a baseline mRS score ≤2 and diagnosed with intracerebral hemorrhage after clinical and radiological imaging were included in the study. The exclusion criteria of the study were as follows:

- Administration of intravenous or oral antihypertensive or antiarrhythmic medication while being transferred to the hospital by the 112 ambulance service
- Atrial fibrillation at baseline
- mRS score ≥3 before ICH
- ICH caused by trauma
- ICH caused by vascular malformation
- Aneurysmal subarachnoid hemorrhage
- Bleeding due to hemorrhagic transformation after ischemic stroke
- Missing data or CT images
- Decompensated heart failure
- Severe liver or renal failure

Figure 1 presents the flow chart of the study population.

First described in 1967, the calculation of the baseline SI was conducted by the division of the HR value obtained in the emergency department by the systolic blood pressure (SBP) value (SI=HR/systolic BP (mmHg). The patients were categorized into three distinct groups: those with a SI value of less than 0.5, those with a SI value between 0.5 and 0.7 (reference category), and those with a SI value greater than 0.7 [8]. Values nearing 1.0 indicate a deterioration in hemodynamic condition and the presence of shock [9].

Outcome

The primary outcome was mortality, and the secondary outcomes were functional status evaluated by mRS 90 days after ICH and major complications (major cardio-

TABLE 1. Demographic data and descriptive characteristics of the patients

	nMean±SD	n	%
Sex			
Male	58		
Female	33		
Baseline SBP	174.63±38.39		
Baseline DBP	100.22±25.84		
Length of hospital stay (day)	17.01±14.02		
Hematoma volume (ml)	12.88±13.47		
Comorbidities		63	69.23
Hypertension		46	50.55
Diabetes		17	18.68
Hyperlipidemia		4	4.40
Coronary artery disease		20	21.98
Chronic heart failure		2	2.20
History of stroke		8	8.79
COPD		1	1.10
Chronic renal failure		4	4.40
Malignancy		4	4.40
Dementia		5	5.49
Antiaggregant use		22	24.18
Anticoagulant use		10	10.99

nMean±SD: Numerical mean±standard deviation; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; COPD: Chronic obstructive pulmonary disease.

vascular events, such as myocardial infarction, cardiogenic shock, pneumonia, and deep vein thrombosis) during hospital stay.

Statistical Analysis

The data analysis was conducted using SPSS version v25, a software application developed by IBM Inc. in Chicago, IL, USA. The normality of the variables was assessed by analyzing histogram images and conducting the Kolmogorov-Smirnov test. Mean, standard deviation, median, and minimum-maximum values were used when presenting descriptive analyses. The chi-square test was used for 2x2 table comparisons. In the evaluation of non-parametric variables with a normal distribution between groups, the Mann-Whitney U test was employed, while groups with more than two groups were evaluated with the Kruskal-Wallis test. The Spearman correlation test was performed to analyze the relationship between the measurement data. Results were deemed statistically significant when the p-value was less than 0.05.

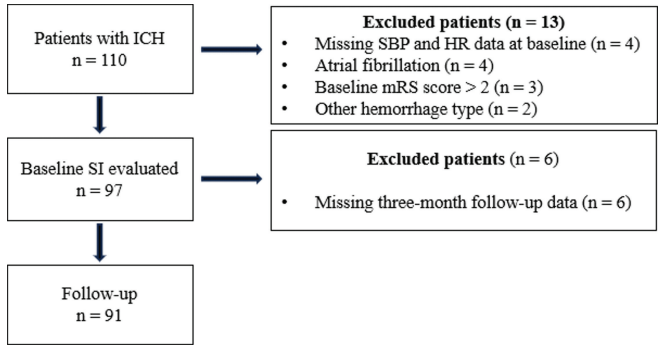

FIGURE 1. Patient flow chart of the study.

ICH: Intracerebral hemorrhage; SBP: Systolic blood pressure; HR: Heart rate; mRS: Modified Rankin Scale; SI: Shock index.

RESULTS

The study included a total of 91 patients, including 58 men and 33 women. The mean age of the patients was 62.66±13.64 years. The median of admission GCS was 15 (3–15). The mean SI value was 0.51±0.13, and there were 47 (52%) patients with an SI of <0.5, 35 (39%) with an SI of 0.5–0.7, and eight (9%) with an SI of >0.7. No statistically significant differences were found between the SI groups in terms of age or sex. The mortality rate during hospital stay was 19% (n=17), and the total mortality rate was 23% (n=21), including four individuals who died within three months after discharge. In-hospital complications developed in 29 (32%) patients, of whom 21 (23%) had pneumonia, five (5%) had urinary tract infections, and three (3%) had cardiovascular events. There were eight (9%) individuals required a surgical operation during their hospital stays and 13 (14%) had hematoma rupture into the ventricle. Table 1 summarizes the demographic data and descriptive characteristics of the patients.

Sex, age, comorbidities, medication use, in-hospital complications, right-left hemisphere localization, and hematoma rupture into the ventricle were compared between the mRS score groups. Accordingly, the mean age of the patients with an mRS score of 3–6 (65.97±13.45) was higher than that of those with an mRS score of 0–2 (56.85±12.1) (p<0.001). The rate of patients using medication was higher in the mRS 0–2 group (72.73%) than in the mRS 3–6 (60.34%) group (p=0.041). The rates of comorbidities and in-hospital complications (pneumonia, urinary tract infection, and cardiovascular events) were higher in the mRS 3–6 group (77.59% and 44.83%, respectively) compared to the mRS 0–2 group (54.55% and 9.09%, respectively) (p=0.022 and p<0.001, respectively).

Table 2. Statistical analysis of demographic data, mortality, and morbidity according to shock index categories

	Shock index category			
	n=47, <0.5 %	n=35, 0.5–0.7 %	n=8, >0.7 %	p
Sex				0.670
Male	65.96	65.71	50.00	
Female	34.04	34.29	50.00	
Comorbidity				0.883
Absent	29.79	28.57	37.50	
Present	70.21	71.43	62.50	
Medication use				0.092
Absent	65.96	57.14	87.50	
Antiaggregant	29.79	22.86	0.00	
Anticoagulant	4.26	20.00	12.50	
Hematoma rupture into the ventricle				0.765
Absent	82.98	88.57	87.50	
Present	17.02	11.43	12.50	
In-hospital mortality				0.317
Absent	80.85	85.71	62.50	
Present	19.15	14.29	37.50	
Three-month mortality				0.412
Absent	74.47	82.86	62.50	
Present	25.53	17.14	37.50	
mRS score				0.726
0–2	36.17	40.00	25.00	
3–6	63.83	60.00	75.00	
In-hospital complications				0.603
None	63.83	71.43	75.00	
Pneumonia	25.53	22.86	12.50	
Urinary tract infection	6.38	5.71	0.00	
Cardiovascular event	4.26	0.00	12.50	

mRS: Modified Rankin Scale.

The mean SI was compared according to sex, comorbidities, medication use, hematoma rupture into the ventricle, in-hospital mortality, three-month mortality, mRS 0–2 and 3–6, and in-hospital complications (pneumonia, urinary tract infection, and cardiovascular events), and no statistical significance was found (p>0.05).

The patients were divided into three groups according to their SI values: <0.5, 0.5–0.7, and >0.7. Sex, comorbidities, medication use, hematoma volume, hematoma rupture into the ventricle, in-hospital mortality, three-month mortality, mRS 0–2 and 3–6, and in-hospital complications did not statistically significantly differ between these groups (p>0.05) (Table 2, 3).

DISCUSSION

In this study conducted with patients who had ICH, it was observed that the SI was insufficient to determine mortality and poor prognosis. Furthermore, no significant results were observed concerning in-hospital complications or mortality evaluated according to SI categories.

Wilson et al. [10] examined a 5-point scoring system to determine variables associated with in-patient mortality in patients over 90 years of age. In multivariate analysis, SI was shown to be an independent predictor (Shock index >1.0, OR 2.65, CI 1.20–5.86, p=0.016). Another

Table 3. Statistical analysis of age, baseline GCS score, length of hospital stay and hematoma volumes according to shock index categories

	Shock index category						p
	<0.5		0.5–0.7		>0.7		
	Mean±SD	Med. (Min–Max)	Mean±SD	Med. (Min–Max)	Mean±SD	Med. (Min–Max)	
Age	63.66±12.76	65 (36–91)	63.26±13.84	62 (35–89)	53.87±17.18	54.5 (27–77)	0.300
Baseline GCS score		15 (5–15)		15 (3–15)		15 (10–15)	0.947
Length of hospital stay	19±14.05	13 (5–68)	15.2±15.26	10 (5–84)	14.63±5.5	14 (8–24)	0.135
Hematoma volume (ml)	14.58±14.66	9.5 (0.6–63.9)	9.92±9.89	5.2 (0.5–32.4)	16.96±18.69	8.9 (4.2–58.6)	0.106

GCS: Glasgow Coma Scale, SD: Standard deviation; Med: Median.

study has indicated that individuals over the age of 80 who have acute coronary syndrome are more likely to have a higher risk of death if they have low blood pressure and a fast heart rate [11]. Older age and comorbidities that increase with age increase the risk of both hemorrhagic and ischemic strokes and negatively affect the long-term outcomes of these patients [10–13]. At the third-month follow-up, the mean age of patients with an mRS score of 3–6 was determined to be higher than that of those with an mRS score of 0–2 (65.97±13.45 and 56.85±12.1 years, respectively, p<0.001). However, in our study, no significant relationship was found between older age and SI.

The SI has been investigated as a possible predictor of poor outcomes in several situations, including hypovolemia, cardiovascular events, community-acquired pneumonia and sepsis [14–17]. It has previously been shown to predict adverse outcomes in stroke [5, 6]. Evaluating hemorrhagic stroke patients, Pana et al. [7] examined the relationship between third-day, seventh-day, and 90th-day mortality rates between different SI groups and found no significant difference (p=0.432, p=0.871, and p=0.522, respectively). The authors also noted that there were no significant differences between the SI groups in terms of the need for surgical treatment or in-hospital complications. In a large study consisting of ischemic and hemorrhagic stroke cases, SI groups were compared in relation to in-hospital mortality, three-month mortality, mRS scores, and in-hospital complications, and no statistical significance was found. In the same study, in the evaluation of the prognostic value of clinical outcomes other than mortality, in-hospital mortality and mRS score >2 were found to be at higher rates in the group with an SI value of >0.7 compared to the remaining SI groups [5]. In the current study, sex, comorbidities, medication use, hematoma rupture into the ventricle, in-hospital mortality, three-month mortality, mRS score, and in-hospital complications were compared according to the mean SI value and three SI categories, but no statistical significance was detected. We considered that this result might be related to the measurements performed only once and the small number of patients.

The 2022 AHA/ASA guideline references the INTERACT-2 and ATACH-2 studies, emphasizing the importance of keeping the target systolic pressure at 140 mmHg for a better prognosis [18–20] Intervention for hypertension or tachycardia during hospitalization and use of medications with different side effects may affect the SI value. Therefore, in our study, only the SI value at the time of admission was discussed to predict mortality [21]. Pana et al. [7] found that high initial, 24th-hour, 48th-hour, and 72nd-hour SI values increased the risk of three-month mortality two to four times. However, the authors did not provide any information regarding the specific medical treatments administered, their dosages, or the target range for blood pressure management in patients presenting with high blood pressure during the follow-up. Therefore, this data is open to debate, given that only SBP may be affected by intravenous antihypertensive treatment, while HR would also be affected by the use of beta-blockers.

Conclusion

The SI may not be adequate for accurately predicting the mortality and morbidity in patients with ICH. It is needed to conduct prospective research including a larger sample size of patients in order to validate our preliminary findings.

Ethics Committee Approval: The Kartal Dr. Lutfi Kirdar City Hospital University Clinical Research Ethics Committee granted approval for this study (date: 28.02.2024, number: 010.99/25).

Authorship Contributions: Concept – AO; Design – AO; Supervision – AO, BMS; Fundings – BMS; Materials – AO, BMS; Data collection and/or processing – AO, BMS; Analysis and/or interpretation – AO; Literature review – AO; Writing – AO; Critical review – AO, BMS.

Conflict of Interest: No conflict of interest was declared by the authors.

Use of AI for Writing Assistance: Not declared.

Financial Disclosure: The authors declared that this study has received no financial support.

Peer-review: Externally peer-reviewed.

REFERENCES

1. Hemphill JC 3rd, Bonovich DC, Besmertis L, Manley GT, Johnston SC. The ICH score: a simple, reliable grading scale for intracerebral hemorrhage. Stroke 2001;32:891–7. [CrossRef]
2. Poungvarin N, Bhoopat W, Viriyavejakul A, Rodprasert P, Buranasiri P, Sukondhabhant S, et al. Effects of dexamethasone in primary supratentorial intracerebral hemorrhage. N Engl J Med 1987;316:1229–33. [CrossRef]
3. Italian Acute Stroke Study Group. Haemodilution in acute stroke: results of the Italian haemodilution trial. Lancet 1988;1:318–21. [CrossRef]
4. Yu YL, Kumana CR, Lauder IJ, Cheung YK, Chan FL, Kou M, et al. Treatment of acute cerebral hemorrhage with intravenous glycerol: a double-blind, placebo-controlled, randomized trial. Stroke 1992;23:967–91. [CrossRef]
5. Myint PK, Musonda P, Sankaran P, Subramanian DN, Ruffell H, Smith AC, et al. Confusion, Urea, Respiratory Rate and Shock Index or Adjusted Shock Index (CURSI or CURASI) criteria predict mortality in community-acquired pneumonia. Eur J Intern Med 2010;21:429–33. [CrossRef]
6. McCall SJ, Musgrave SD, Potter JF, Hale R, Clark AB, Mamas MA, et al; Anglia Stroke Clinical Network Evaluation Study (ASCNES) Group. The shock index predicts acute mortality outcomes in stroke. Int J Cardiol 2015;182:523–7. [CrossRef]
7. Pana TA, Quinn TJ, Perdomo-Lampignano JA, Szlachetka WA, Knoery C, Mamas MA, et al; VISTA-ICH Collaborators. Shock index predicts up to 90-day mortality risk after intracerebral haemorrhage. Clin Neurol Neurosurg 2021;210:106994. [CrossRef]
8. Pandit V, Rhee P, Hashmi A, Kulvatunyou N, Tang A, Khalil M, et al. Shock index predicts mortality in geriatric trauma patients: an analysis of the National Trauma Data Bank. J Trauma Acute Care Surg 2014;76:1111–5. [CrossRef]
9. Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: utility and limitations. Open Access Emerg Med 2019;11:179–99. [CrossRef]
10. Wilson AH, Kidd AC, Skinner J, Musonda P, Pai Y, Lunt CJ, et al. A simple 5-point scoring system, NaURSE (Na+, urea, respiratory rate and shock index in the elderly), predicts in-hospital mortality in oldest old. Age Ageing 2014;43:352–7. [CrossRef]
11. Austruy J, El Bayomy M, Baixas C, Elbaz M, Lairez O, Dumonteil N, et al. Are there specific prognostic factors for acute coronary syndrome in patients over 80 years of age? Arch Cardiovasc Dis 2008;101:449–58. [CrossRef]
12. Myint PK, Sheng S, Xian Y, Matsouaka RA, Reeves MJ, Saver JL, et al. shock index predicts patient-related clinical outcomes in stroke. J Am Heart Assoc 2018;7:e007581. [CrossRef]
13. Qureshi AI, Tuhrim S, Broderick JP, Batjer HH, Hondo H, Hanley DF. Spontaneous intracerebral hemorrhage. N Engl J Med 2001;344:1450–60. [CrossRef]
14. Aiyagari V. The clinical management of acute intracerebral hemorrhage. Expert Rev Neurother 2015;15:1421–32. [CrossRef]
15. Chung JY, Hsu CC, Chen JH, Chen WL, Lin HJ, Guo HR, et al. Shock index predicted mortality in geriatric patients with influenza in the emergency department. Am J Emerg Med 2019;37:391–4. [CrossRef]
16. Huang B, Yang Y, Zhu J, Liang Y, Tan H, Yu L, et al. Usefulness of the admission shock index for predicting short-term outcomes in patients with ST-segment elevation myocardial infarction. Am J Cardiol 2014;114:1315–21. [CrossRef]
17. Sankaran P, Kamath AV, Tariq SM, Ruffell H, Smith AC, Prentice P, et al. Are shock index and adjusted shock index useful in predicting mortality and length of stay in community-acquired pneumonia? Eur J Intern Med 2011;22:282–5. [CrossRef]
18. Greenberg SM, Ziai WC, Cordonnier C, Dowlatshahi D, Francis B, Goldstein JN, et al; American Heart Association/American Stroke Association. 2022 Guideline for the Management of Patients with Spontaneous Intracerebral Hemorrhage: A Guideline from the American Heart Association/American Stroke Association. Stroke 2022;53:e282–361. [CrossRef]
19. Anderson CS, Heeley E, Huang Y, Wang J, Stapf C, Delcourt C, et al; INTERACT2 Investigators. Rapid blood-pressure lowering in patients with acute intracerebral hemorrhage. N Engl J Med 2013;368:2355–65. [CrossRef]
20. Qureshi AI, Palesch YY, Barsan WG, Hanley DF, Hsu CY, Martin RL, et al; ATACH-2 Trial Investigators and the Neurological Emergency Treatment Trials Network. Intensive blood-pressure lowering in patients with acute cerebral hemorrhage. N Engl J Med 2016;375:1033–43. [CrossRef]
21. Onalan A. Butterfly effect on shock index. Clin Neurol Neurosurg 2024;241:108294. [CrossRef]