European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 09, Issue 04, 2022

Original Research Article

Shock index as a predictor of vasopressin use in sepsis

[1]Dr. Sujith MS, [2]Dr. Harsha V Patel, [3]Dr. Mohan CN, [4]Dr. Arvind MN

[1]Resident, Department of Internal Medicine, KIMS, Bengaluru, Karnataka, India.
[2,3]Assistant Professor, Department of Internal Medicine, Shri Atal Bihari Vajpayee Medical College & Research Institute, Bengaluru, Karnataka, India
[4]Professor, Department of Internal Medicine, Shri Atal Bihari Vajpayee Medical College & Research Institute, Bengaluru, Karnataka, India.

Corresponding Author:
Dr. Mohan CN

Abstract

Background: Currently for physicians, there are limited parameters to stratify patients at risk for short term cardiovascular collapse (i.e. vasopressor dependence). The shock index (SI, heart rate divided by systolic blood pressure) is a simple formula useful for detecting changes in cardiovascular performance before the onset of systemic hypotension. It is an easily accessible, non-invasive, and non-costly risk stratification tool that may enhance current methods for differentiating severe sepsis patients at risk for imminent cardiovascular collapse.
Materials: In this study, we have taken patients who are above 18 years diagnosed to have sepsis were followed up and shock index was calculated every 6th hour. In 50 such patients who required vasopressor use within 72 hours of admission, percentage of SI elevation for each patient was determined by taking the total number of SI values greater than 0.8 and dividing this number by the total number of vital signs taken. The patients were divided into Sustained SI elevation (i.e. >or=80%) group and non-sustained SI elevation group (i.e. < 80%) and comparison was done.
Results: 80 patients were followed up, out of which 50 patient's required vasopressor use with in 72 hours of admission. Among them 41 patients had sustained shock index elevation and 9 patients had non sustained SI elevation. It is found that sustained shock index was statistically significant in predicting vasopressor use in sepsis patients. Sustained SI had sensitivity of 82%, specificity of 83.3%, PPV of 89.13%, NPV of 73.55% and Diagnostic accuracy of 82.5% in predicting vasopressor use.
Conclusion: Patients with sepsis and a sustained SI elevation appear to have higher rates of vasopressor use short term after admission contrasted to patients without a sustained SI Elevation. A sustained SI elevation may be a promising simple, cost-efficient, and non-invasive measurement to help risk stratify patients who present with sepsis, and may complement other predictors of disease progression. A sustained SI elevation may be a useful modality to identify patients with severe sepsis at risk for disease progression.

Keywords: Shock, predictor, sepsis, cardiovascular

Introduction

The global burden of sepsis is difficult to ascertain, although a recent scientific publication estimated that in 2017 there were 48.9 million cases and 11 million sepsis-related deaths

ISSN 2515-8260 Volume 09, Issue 04, 2022

worldwide, which accounted for almost 20% of all global deaths [1]. The largest contributors to sepsis cases and sepsis-related mortality across all ages are diarrheal diseases (9.2 to 15 million annual cases) and lower respiratory infections (1.8-2.8) million annually [2]. One-third of sepsis cases and nearly half of all sepsis related deaths (2017) are due to an underlying injury or chronic disease [2]. Maternal disorders were one of the most common non-communicable diseases complicated by sepsis. The striking increase is largely attributable to the far higher burden among people living in areas with a lower Socio-Economic status, for whom data had previously been lacking. Nearly half of all the sepsis-related deaths occur secondary to sepsis complicating an underlying injury or non-communicable disease [2]. The host's ability to resist as well as tolerate both direct and immune-pathologic damage will determine whether uncomplicated infection becomes sepsis [3]. One of the most common and important causes of septic shock is gram-positive bacteria, followed by gram-negative organisms and fungi. Although it was previously thought that infections had to be disseminated to the systemic circulation to cause septic shock. The infections which are localized to a specific tissue can also trigger sepsis, even without detectable spread to the bloodstream. The ability of diverse organisms to precipitate septic shock in patients is consistent with the idea that several different microbial constituents can initiate the process. The most notable factors are immune mediators such as macrophages, neutrophils, dendritic cells, endothelial cells, as well as soluble components of the innate immune system such as complement system recognize and are also activated by a variety of substances derived from pathogenic microorganisms. Once these factors are activated, these 8 cells and soluble factors initiate several inflammatory responses that interact in a complex, incompletely understood mechanism to produce septic shock [4]. Shock index (SI) provided an approximation of hemodynamic status in addition to traditional vital signs [5]. SHOCK INDEX (SI), can be defined as the ratio of heart rate (HR) to systolic blood pressure (SBP). The normal range for this measure is currently accepted as 0.5-0.7, though some evidence suggests that up to 0.9 is acceptable Values approaching 1.0 are indicative of worsening hemodynamic status and Shock. Elevation in SI values has been correlated with reduced left ventricular end-diastolic pressure and circulatory volume, even when HR and SBP are within normal limits Modified SI (MSI) [HR/mean arterial pressure (MAP)] and age SI (age × SI) have been proposed in continued efforts to improve the prognostic value. MSI was developed to incorporate the MAP rather than only SBP, as DBP is also used to determine the clinical severity of illness Age × SI is more indicative of mortality in geriatric patients the pediatric adjusted shock index (SIPA) was developed for pediatric populations and has proven to be more reliable than the standard adult cutoffs. This study was done to evaluate the role of sustained Shock index elevation as a predictor of vasopressor dependence within 72 hours of initial presentation in sepsis patients and to compare sustained shock index elevation group with non-sustained Shock index elevation group among sepsis patients on vasopressor use within 72 hours of admission.

Materials and Methods

50 sepsis patients were taken up for the study after considering the inclusion and exclusion criteria. After obtaining approval and clearance from the institutional ethics committee, the patients fulfilling the inclusion criteria were enrolled for the study after obtaining informed consent. Baseline data regarding age, sex and medical history of patients was collected and clinical examination was done and relevant investigations were done. A pre-structured and pretested proforma was used to collect the data. Shock index was measured at 6-hour interval every day for 72 hours during stay in hospital. Patients were followed up till 72 hours after admission and patients not on any vasopressor within 72 hours of admission were excluded from study. The percentage of Shock index elevation for each patient was determined by

ISSN 2515-8260 Volume 09, Issue 04, 2022

taking the total number of Shock index values greater than 0.8 and dividing this number by the total number of times shock index measured. This calculation was used to estimate the total percentage of time that each patient maintained a Shock index elevation. The sustained Shock index elevation group will be defined as having a Shock index greater than 0.8 for more than or equal to 80% of shock index measurement. The non-sustained SI elevation group was defined as having a SI greater than 0.8 for less than 80% of the shock index measurement. As an alternative analysis, initial Shock index of all study patients was compared and also outcomes of short-term vasopressor use.

Results

In the study out of 50 subjects who were on vasopressors, 82% had sustained Shock index and 18% had a non-sustained shock. It is also observed that other initial vital signs can also aid in the prediction of vasopressor use, the initial systolic blood pressure of patients who had sustained SI elevation was lower than those who had non-sustained SI (115.17 versus 135.56 mm of Hg respectively, P-value 0.004*). However, the mean systolic pressure in both groups is within normal limits suggesting that the patient with normal systolic pressure will also have similar chances of developing cardiovascular collapse. A similar relationship can be observed in initial diastolic pressure (70.98 versus 81.11 respectively, P-value 0.02*). The mean initial heart rate in the sustained SI elevation group (101.29 bpm) and Non sustained SI elevation (99.33bpm), mean temperature rate in the sustained SI elevation group (99.47 F) and Non sustained SI elevation (99.09 F), mean white blood count rate in sustained SI elevation group (21373.66 x103 per mL) and Non sustained SI elevation (23424.44 x103 per mL) was similar in both the groups. In our study out of 50 patients who required vasopressor use within 72 hours. The majority of the patient had respiratory tract infections (58.0%) other system involvement in patients included Urinary tract infection (32.0%), Intra-abdominal infection (24.0%), soft tissue infection (16.0%), others (2.0%). The majority of patients had one i.e. 21(51.2% in sustained SI group and 7(77.8%) in non-sustained SI group or two i.e. 18(43.9%) in sustained SI group and 2(22.2%) in non-sustained SI group organ involvement at admission apart from the increased white blood cell count. Mean organ involvement apart from raised white blood count was similar in both the sustained shock index group (1.54) and non-sustained SI group (1.22). There were no statistically significant differences in APACHE II, the total number of organ failures at admission among both the groups. The distribution of risk factors such as Congestive heart failure, Coronary artery disease, Hypertension, Chronic obstructive pulmonary disease, Asthma, Diabetes (Type 1 or 2), Chronic liver disease, history of end-stage renal disease, HIV infection, history of cancer, History of ischemic stroke or TIA, Chronic altered mental status among both the groups were almost similar and there was no statistically significant difference. Out of 35 patients who had lactate elevation of more than 2.0 mg/dl at the time of admission 31 belonged to the sustained SI elevation group and 8 belonged to non-sustained SI elevation group. There is no statistically significant difference between both groups among factors such as platelet count, elevation of coagulation factors, acute kidney Injury, hypoxemia. In our study, the mean shock index among patients who required vasopressor was 0.87. Among them mean shock index in the sustained shock index group is 0.902 with a standard deviation of about 0.156 and the mean shock index in the non-sustained shock index group is 0.744 with a standard deviation of about 0.148, which is of statistical significance (p-value 0.008*). So the conventionally used shock index at presentation also aids in recognizing the patients with poor prognosis unless intervention is done. The mean modified shock index among patients who required vasopressor was 1.15. The mean modified shock index in the sustained shock index group is 1.18 with a standard deviation of about 0.20 and the mean modified shock index in non-sustained shock index group is 1.03 with a standard deviation of about 0.18, which is of statistical significance (p-

ISSN 2515-8260 Volume 09, Issue 04, 2022

value 0.05*) The mean MAP among patients who required vasopressor is 87.64. Mean Arterial Pressure at presentation in the sustained shock index group is 85.59 (mean) with a standard deviation of 13.45. In the non-sustained shock index group is 96.99 (mean) with a standard deviation of about 11.36. So, mean arterial pressure measurement among both the groups is of statistical significance (p-value 0.022*), Therefore MAP is also a useful tool in the early identification of deterioration of sepsis patients. In the study among subjects with Vasopressor use, 82% had sustained SI and 8% had non-sustained SI. Among subjects without vasopressor use, 83.3% had non-sustained SI and 16.7% had sustained SI. There was a significant association between SI and vasopressor use. Sustained SI had a sensitivity of 82%, specificity of 83.3%, PPV of 89.13%, NPV of 73.55% and diagnostic accuracy of 82.5% in predicting vasopressor use.

		Age		P value
		Mean	SD	
	Sustained SI	54.12	15.03	0.413
Shock Index	Non-Sustained SI	58.56	12.07	
	Total	54.92	14.53	

Table 1: Age distribution of subjects

		Shock Index					
		Sustained SI		Non-Sustained SI		Total	
		Count		Count		Count	
ex	Female	12	29.3%	6	66.7%	18	36.0%
	Male	29	70.7%	3	33.3%	32	64.0%
	Total	41	100.0%	9	100.0%	50	100.0%

X^2 =4.480, DF =1, p=0.034*

Table 2: Sex distribution of subjects

	Shock Index						P value
	Sustained SI		Non-Sustained SI		Total		
	Mean	SD	Mean	SD	Mean	SD	
Initial SBP (mm of hg)	115.17	18.17	135.56	18.10	118.84	19.64	3.004*
Initial DBP (mm of 4)	70.98	11.79	81.11	?.28	72.80	11.96	).02'
Initial heart rate- (beats per minute)	101.29	11.69	99.33	10.63	100.94	11.43	0.646
Temperature - (degrees Fahrenheit)	99.47	1.07	99.09	73	99.40	1.03	).320
Respiratory rate - (breaths per minute)	23.80	6.72	22.89	5.30	23.64	6.45	3.704
White blood cell count - (x103 per mL)	21373.66	5469.25	23424.44	7492.92	21742.80	5849.64	3.346

Table 3: Vital parameter distribution

	Shock Index						P value
	Sustained SI		Non-Sustained SI		Total		
	Mean	SD	Mean	SD	Mean	SD	
Initial SBP (mm of hg)	115.17	18.17	135.56	18.10	118.84	19.64	3.004*
Initial DBP (mm of hg)	70.98	11.79	81.11	?.28	72.80	11.96	3.02*
Initial heart rate- (beats per minute)	101.29	11.69	99.33	10.63	100.94	11.43	3.646
Temperature - (degrees Fahrenheit)	99.47	1.07	99.09	73	99.40	1.03	3.320
Respiratory rate - (breaths per minute)	23.80	6.72	22.89	5.30	23.64	6.45	3.704
White blood cell count - (x103 per mL)	21373.66	5469.25	23424.44	7492.92	21742.80	5849.64	3.346

ISSN 2515-8260 Volume 09, Issue 04, 2022

Table 4: Vasopressor use, 82% had sustained SI and 8% had non-sustained SI. Among subjects without Vasopressor use, 83.3% had non-sustained SI and 16.7% had sustained SI.

	Vasopressor Used		Vasopressor Not Used	
	Count	%	Count	%
Sustained SI	41	82%	5	16.7%
Non-Sustained SI	9	18%	25	83.3%
	50		30	

X^2 =32.75, DF =1, p<0.001*

Discussion

The SI is a simple and clinically identifiable risk stratification tool useful in detecting clinical progression even prior to the onset of hypotension and cardiovascular collapse [6].

Our study showed that among subjects without vasopressor use, 83.3% had non-sustained SI and 16.7% had sustained SI. There was a significant association between SI and vasopressor use. This was similar to the study done by Wira *et al.* [7] showed that sustained SI for longer periods was a better predictor of deterioration and the requirement for vasopressors in patients with severe sepsis. The 295 patients from the study came from an Emergency department sepsis registry maintained over 2 years. For each set of vital signs taken on each patient, the Shock index was calculated until the patient required vasopressors. If the Shock index was greater than 0.8 on at least 80% of the measurements, the patient would be considered to have a sustained SI elevation. The patients with sepsis and a sustained SI had lower initial blood pressures and higher heart rates and they had more organ dysfunction.

It was concluded in our study that sustained SI had a sensitivity of 82%, specificity of 83.3%, PPV of 89.13%, NPV of 73.55%, and diagnostic accuracy of 82.5% in predicting vasopressor use. A similar study done by Mann *et al.* [8] conducted a single-center retrospective review in which subjects were identified by the following: at least 2 SIRS criteria, suspected infection and it was concluded that in patients who presented to the ED with signs concerning sepsis, an elevated shock index of > 1.2 was significantly associated with increased use of vasopressor therapy in the first 24 hours.

Ospina-Tascón, G.A., Teboul, JL., Hernandez, G. *et al.* [9] reported that Loss of vascular tone is a key pathophysiological feature of septic shock. A combination of gradual diastolic hypotension and tachycardia could reflect more serious vasodilatory conditions and sought to evaluate the relationships between heart rate (HR) to diastolic arterial pressure (DAP) ratios and clinical outcomes during early phases of septic shock. Diastolic shock index (DSI) was defined as the ratio between HR and DAP. They concluded that DSI at pre-vasopressor and vasopressor start points might represent a very early identifier of patients at high risk of death. Isolated DAP or HR values do not identify such risk. However, in our study it was shown that the mean systolic pressure in both groups is within normal limits suggesting that the patient with normal systolic pressure will also have similar chances of developing cardiovascular collapse and a similar relationship can be observed in initial diastolic pressure.

This study showed that serial monitoring of shock index in patients with sepsis will aid in predicting cardiovascular collapse. A sustained SI elevation appears to have higher rates of vasopressor use in the short term after admission compared to patients without a sustained SI Elevation. A sustained SI elevation is a simple, economic, and non-invasive measurement to help risk-stratify patients who present with sepsis, and also may complement other predictors of disease progression

Conclusion

In our study, we found that patients with sepsis with sustained SI elevation have higher rates

ISSN 2515-8260 Volume 09, Issue 04, 2022

of vasopressor use within 72 hours of admission compared to patients without a sustained SI Elevation. Hence, A sustained SI elevation is a promising, simple, cost-efficient, and non-invasive measurement to help risk-stratify patients who present with sepsis and may complement other predictors of disease progression. A sustained SI elevation can be a useful modality to identify patients with severe sepsis at risk for disease progression.

References

1. Rudd KE, Johnson SC, Agesa KM, Shackelford KA, Tsoi D, Kievlan DR, *et al*. Global, regional, and national sepsis incidence and mortality, 1990-2017: analysis for the Global Burden of Disease Study. Lancet (London, England). 2020;395(10219):200-11.
2. Lanspa MJ, Brown SM, Hirshberg EL, Jones JP, Grissom CK. Central venous pressure and shock index predict lack of hemodynamic response to volume expansion in septic shock: a prospective, observational study. Journal of critical care. 2012 Dec;27(6):609-15.
3. Harrison's Principles of Internal Medicine. 20th ed. McGraw Hill, 2018. Accessed April 19, 2020.
4. Kumar V, Abbas AK, Aster JC. Robbins Basic Pathology (10th ed.). Elsevier-Health Sciences Division, 2017.
5. Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: utility and limitations. Open Access Emerg Med. 2019 Aug;11:179-199. Doi: 10.2147/OAEM.S178358. PMID: 31616192; PMCID: PMC6698590.
6. Rady MY. The role of central venous oximetry, lactic acid concentration and shock index in the evaluation of clinical shock: a review. Resuscitation. 1992;24:55-60.
7. Wira CR, Francis MW, Bhat S, *et al*. The shock index as a predictor of vasopressor use in emergency department patients with severe sepsis. West J Emerg Med. 2014;15:60-6.
8. Blake Mann MD, Catherine Hough MD, David Carlbom MD. University of Washington, Seattle, WA Shock Index as a Predictor of Hospital.
9. Ospina-Tascón GA, Teboul JL, Hernandez G, *et al*. Diastolic shock index and clinical outcomes in patients with septic shock. Ann. Intensive Care 10, 41, 2020.