J Biochem Tech (2019) Special Issue (2): 163-170
ISSN: 0974-2328

Investigating the Diagnostic Value of Shock Index in Early Recognition and Clinical Outcomes of Sepsis

Vahid Vahedian, Negar Ahmadi*, Saeed Abbasi, Davood Farsi, Mohammad Amin Zare

Received: 20 September 2018 / Received in revised form: 10 March 2019, Accepted: 21 March 2019, Published online: 25 April 2019

Abstract

Introduction: Sepsis is a prevalent condition threatening the emergency department of hospitals with its role in mortality. The present study intended to investigate the diagnostic value of shock index in early recognition and clinical outcomes of sepsis. Methodology: The current cross-sectional study was conducted on patients having severe sepsis and shock septic. To this end, the patients were clinically screened for sepsis symptoms by the means of checking their vital signs upon arrival to triage, basic laboratory tests, serum lactate level, central venous pressure, arterial blood gases, and shock index upon arrival and after 2 hours of fluid therapy (resuscitation). Data were analyzed using SPSS, version 22, software. Results: The results of Chi-square test indicated that there was a statistically significant correlation between the status of shock index upon arrival and after 2 hours of fluid therapy and the status of serum lactate in patients hospitalized in the emergency department with the early recognition of sepsis (P=0.0001). About % 60.7 of patients with SI>0.7 showed a mortality rate of %78.7 in compared with %21.3 of patients with SI<0.7 (P=0.0001). Moreover, the 28-day interval outcome caused % 15.7 of patients to die, whereas %83.3 of them were fully recovered from the hospital. Patients with SI>0.7 had a hyperlactatemia incidence of % 84.4. On the contrary, patients with SI<0.7 only showed a hyperlactatemia incidence of % 15.6. Conclusion: The shock index can be used as a tool in prioritization of patients and the emergency departments

Keywords: Diagnostic Value, Shock Index, Sepsis, Hyperlactatemia

Introduction

Sepsis is a serious life-threatening disease caused by a wide range of gram-negative and gram-positive bacteria. It has variable signs and symptoms that varies depending on the patient's age, background and type of organism. (Hall et al., 2011) Studies have shown that patients with sepsis have nearly doubled in number over the past decade suggesting the use of appropriate and accurate tools for the early recognition of sepsis in patients. The reason is that early diagnosis and treatment will certainly reduce the mortality rate amongst patents in hospitals. (Osborn et al., 2005; Shapiro et al., 2005) Hyperlactatemia (serum lactate 4 mmol/l) is one of the physiological and rapid signs of severe sepsis occurring in the human body due to hypoxia caused by anaerobic metabolism and increased lactate level. (Mikkelsen et al., 2009; Howell et al., 2007)

Nowadays, septic patients are clinically screened based on the criteria of systematic inflammatory response syndrome (SIRS). Sepsis is diagnosed if the screening results, together with positive blood culture test, suggests two or more SIRS criteria. (American College of Chest Physicians and Society of Critical Care Medicine Consensus Conference Committee, 1992) Research has shown that although the clinical criteria of SIRS have appropriate sensitivity, (Dellinger and Bone, 1998) they lack the necessary attribute for diagnosing the infection agent of the disease and its clinical outcomes. (Sibbald et al., 1995; Vincent, 1997)

Shapiro et al. found that infection-susceptible patients with two or more clinical criteria of SIRS are less prone to the mortality risk than those with less than two SIRS clinical criteria. (Shapiro et al., 2006) Therefore, the lack of SIRS specificity indicated that it cannot be a useful clinical criterion for screening septic patients. This finding has led the practitioners to focus on an appropriate clinical criterion, namely Shock Index (SI). Shock Index is an appropriate and effective bedside assessment tool defined as heart rate (HR) divided by systolic blood pressure (SBP) with a normal range of 0.5 to 0.7. (Berger et al., 2013)

Vahid Vahedian
DVM., Ph.D. Rofeydeh Rehabilitation Hospital, Diagnostic Laboratory Medicine Department, University of Social Welfare and Rehabilitation Sciences(USWR), Tehran, Iran.

Negar Ahmadi*
Emergency Medicine Specialist, Department of Emergency Medicine, Faculty of Medicine, Iran University of Medical Sciences, Tehran, Iran.

Saeed Abbasi, Davood Farsi, Mohammad Amin Zare
Assistant professor of Emergency Medicine , Emergency Medicine Management Research Center, Iran University of Medical Sciences, Tehran, Iran.

***Email:** Ahmadi_negar_271@yahoo.com

Berger et al. (2012) investigated the diagnostic value of shock index in early recognition of sepsis. They performed a retrospective analysis on 2,824 infection-susceptible patients with random visits to the ED of Queen Hospital, New York from February 2007 to May 2008. They found that about %11.5 (290 patients) out of %89 of patients (2,524), included in the analysis, had hyperlactatemia while %14 (361 patients) died within 28 days. The results also indicated that patients with SI ≥0.7 were three times more likely to present hyperlactatemia than those with a normal SI. This could be notably generalized to patients with both a normal SI and SI≥1.0. The negative predictive value of patients with SI≥0.7 was %95 and identical to the SIRS patients, which was an appropriate criterion. There was not any statistically significant difference between the sensitivity of SIRS patients and the sensitivity of patients with SI≥0.7. However, patients with SI≥0.7 were more likely to present hyperlactatemia and 28-day mortality. (Berger et al., 2013)

Allgower and Buri (1967) pioneered a study on SI as a simple and effective index to measure hypovolemia in septic and hemorrhagic shock. Rady et al. (1994) found that SI could be considered as a valuable tool only in case HR or BP level of patients, upon arrival to triage, could not individually be an indicator of the risk of sepsis. Moreover, their results showed that SI≥0.9 was associated with a significant increase in hospitalization. (Rady et al., 1994, 1992) Finally, Hass (2005) introduced SI as an ideal, usable, accurate, expeditious and generalizable index for all patients.

The purpose of the present study was to compare the ability of patient's shock index, vital signs and SIRS clinical criteria in predicting hyperlactatemia as a surrogate for assessing the disease severity as a primary outcome and the 28-day mortality rate as the secondary outcome. (Shapiro et al., 2005; Howell et al., 2007) The present study intended to investigate the diagnostic value of shock index in early recognition and clinical outcomes of sepsis in patients referring to the emergency department of Rasul-e Akram and Firoozgar hospitals within 2014-2015.

Materials and Methods

The current cross-sectional study was conducted on patients with severe sepsis and septic shock hospitalized in the emergency department of Rasul-e Akram and Firoozgar hospitals in 2014 and 2015.

To calculate the sample size, the Buderer Formula (Rady et al., 1992) was used:

$$\text{Sample size } (n) \text{ based on sensitivity} = \frac{Z^2_{1-\alpha/2} \times S_N \times (1-S_N)}{L^2 \times Prevalence}$$

n = required sample size
S_N = anticipated sensitivity
α = size of the critical region (1 − α is the confidence level)
$Z^2_{1-\alpha/2}$ = standard normal deviate corresponding to the specified size of the critical region (α)
L = absolute precision desired on either side (half-width of the confidence interval) of sensitivity or specificity

Based on the formula above, the sample size was estimated about 300 subjects. The inclusion criteria were ages over 18 years, the presence of two or more SIRS criteria (body temperature <36˚C or >38˚C, heart rate >90 beats/min, respiratory rate >20/min, P_aCO_2<32 mmHg, WBC<4000 or >12000, immature neutrophil >%10) that assigned the patients to severe sepsis or septic shock group, and evidences of end organ damage such as high creatinine or low GCS (<14), serum lactate >4 mg/dl and blood pressure <90/60 irresponsive to initial fluid therapy (resuscitation). The severe sepsis criteria included the presence of two or more SIRS criteria and a possible source of infection in the body. The septic shock criteria included the presence of two or more SIRS criteria, a possible source of infection in the body and blood pressure <90/60 irresponsive to initial fluid therapy. The exclusion criteria were ages below 18 years, patients receiving BP medication (B-blocker, CCB, Digoxin etc.), patients with advanced cancer, patients with atrial fibrillation heart rhythm, patients with acute gastrointestinal bleeding, patients with a low immune system such as corticosteroid users and patients who received immediate vasopressor after arrival (before 2 hours).
The sample size of the current study included initially 430 subjects, some of whom were excluded due to taking antihypertensive medicines, atrial fibrillation heart rhythm or other exclusion criteria. Patients were clinically screened for sepsis symptoms by the means of checking their vital signs upon arrival to triage, basic laboratory tests, serum lactate level, central venous pressure, arterial blood gases, shock index upon arrival and after 2 hours of fluid therapy (resuscitation). The screening results were used for calculating the primary and secondary outcomes. The used lactate kit in the present study was prepared by Hayyan Mod Company in Iran, whose level of >4 mmol/l was an indicator of hyperlactatemia. The 28-day mortality rate was referred to as the secondary outcome and an indicator of mortality. To determine the secondary outcome, patients who died within the first 28 days were evaluated. To this end, the 28-day death of patients who were already discharged was noticed by a phone call. Data collection form was completed for each individual patient. That is, each patient with sepsis or septic shock completed a form including information about their age, sex, vital signs upon arrival (heart rate, respiratory rate, blood pressure, body temperature), initial laboratory test such as serum lactate, ABG and WBC based on which the intended data and parameters were analyzed. Data were analyzed using SPSS, version 22, software. The numerical/quantitative variables were reported as mean ± SD while the qualitative variables were reported as frequency and percentage.

Results

Table (1) demonstrates the clinical and demographic characteristics of patients with early diagnosis of sepsis upon arrival to the ED of Rasul-e Akram (PBUH) and Firoozgar hospitals.

Table 1: Clinical and demographic characteristics of patients with early diagnosis of sepsis upon arrival to the ED of Rasul-E Akram (Pbuh) and Firoozgar hospitals (300 patients).

Variable	Status	No.	Percentage
Sex	Male	183	61
	Female	117	39
Age Range	Below 40	52	17.3
	41-60	93	31
	61-80	109	36.3
	Over 80	46	15.3
Age (Mean ± SD) (Years)		60.03±19.05	
Heart Rate (Mean ± SD) (beat/min)		94.46±14.32	
Respiratory Rate (Mean ± SD) (per min)		19.37±19.05	
Body Temperature (Mean ± SD) (˚C)		37.8±0.79	
WBC (Mean ± SD) (per ml of blood)		11519±5443	
Systolic Blood Pressure (Mean ± SD) (mmHg)		114.4±24.5	

Table (2) shows the shock index upon arrival and after 2 hours of fluid therapy for patients with early diagnosis of sepsis upon arrival to the emergency department.

Table 2: Shock index upon arrival and after 2 hours of fluid therapy for patients with early diagnosis of sepsis upon arrival to the ED (300 patients).

Variable		No.	Percentage	Statistical Estimate (P-value)
SI upon arrival	> 1	68	22.7	P=0.0001
	0.7-1	114	38	
	< 0.7	118	39.3	
Total		300	100	
SI after 2 hours of fluid therapy	> 1	24	8	P=0.0001
	0.7-1	91	30.3	
	< 0.7	185	60.7	
Total		300	100	

Using McNemar Test, it was determined that there was a statistically significant relationship between the status of SI upon arrival and the status of SI after 2 hours of fluid therapy (P=0.0001) (Table 3).

Table 3: Clinical and demographic characteristics of patients with early diagnosis of sepsis and different shock index upon arrival to the ED pf Rasul-E Akram (Pbuh) and Firoozgar Hospitals (300 patients)

Variable	SI<0.7	SI≥0.7	SI≥1
Age (Mean ± SD) (Years)	60.01 ± 15.09	60.09 ± 18.02	61.05 ± 17.07
Male Sex	(%22.7) 67	(%38.6) 116	(%13.3) 40
Systolic Blood Pressure (Mean ± SD) (mmHg)	110.1 ± 11.5	11.5 ± 24.6	117.6 ± 27.1
Respiratory Rate (Mean ± SD) (per min)	18 ± 10.12	19.36 ± 19.05	22 ± 19.02
Heart Rate (Mean ± SD) (beat/min)	90.03 ± 13.01	95.46 ± 14.12	99.01 ± 12.01
Body Temperature (Mean ± SD) (˚C)	37.3 ± 0.65	37.8 ± 0.79	37.9 ± 0.45
WBC (Mean ± SD) (per ml of blood)	10421 ± 3652	11092 ± 4432	12114 ± 22672
CVP ± SD (cmH_2O)	6.71 ± 3.32	5.21 ± 3.45	4.32 ± 4.1
pH ± SD	7.35 ± 0.42	7.3 ± 0.62	7.25 ± 0.51
Hyperlactatemia	(%15.6) 10	(%84.3) 54	(%59.3) 38

SIRS Criteria*	Median 2, IQR (2-3)	Median 3, IQR (2-3)	Median 3, IQR (3-4)
28-day Mortality	(%29.7) 14	(%70.2) 33	18

*: Sirs Criteria Have 4 Items. Each Item Receives 1 Score.

Table (4) shows the comparison of some clinical and laboratory indices upon arrival and 2 hours after fluid therapy in patients with early sepsis diagnosis. The results of paired t-test determined that there was a statistically significant difference between the CVP value upon arrival and its value after 2 hours of fluid therapy (P=0.0001). Furthermore, Wilcoxon test showed a statistically significant difference between the values of pH and P_aO_2 upon arrival and the values after 2 hours of fluid therapy (P=0.0001 & P=0.0001). Nonetheless, there was not any statistically significant difference between the values of HCO_3 and PCO_2 upon arrival and the values after 2 hours of fluid therapy (P=0.246 & P=0.541).

Table 4: Comparison of some clinical and laboratory indices upon arrival and 2 hours after fluid therapy in patients with early sepsis diagnosis (300 patients)

Variable	Time	No.	Mean ± SD	P-value
CVP	Upon Arrival	91	5.21 ± 3.45	P=0.0001
	2 hrs. after Fluid Therapy	91	7.17 ± 2.78	
PH	Upon Arrival	300	7.3 ± 0.62	P=0.0001
	2 hrs. after Fluid Therapy	300	7.34 ± 0.38	
PCO_2	Upon Arrival	300	42.54 ± 12.19	P=0.246
	2 hrs. after Fluid Therapy	300	42.71 ± 19.5	
P_aO_2	Upon Arrival	300	71.88 ± 13.8	P=0.0001
	2 hrs. after Fluid Therapy	300	75.3 ± 16.98	
HCO_3	Upon Arrival	300	23. 5 ± 5.87	P=0.541
	2 hrs. after Fluid Therapy	300	23.5 ± 6.75	

Table (5) demonstrates the frequency distribution of serum lactate, infection site, 28-day outcome, CRP status as well as SIRS clinical criteria including and excluding WBC upon arrival in patients (300) with early sepsis diagnosis. The 28-day outcome of patients with early sepsis diagnosis had finally led to their death by %15.7 while %84.3 of patients were fully recovered.

Table 5: Frequency distribution of serum lactate, infection site, 28-day outcome, CRP status as well as SIRS clinical criteria including and excluding WBC upon arrival in patients (300) with early sepsis diagnosis.

Variable		No.	Percentage
Serum Lactate	Normal (4.5-20 mg/dl)	236	78.7
	Hyperlactatemia	64	21.3
	Total	300	100
Infection Site	Respiratory System	105	35
	Gastrointestinal Tract	69	20.3
	Musculoskeletal	11	3.6
	Kidney and Urinary Tract	62	20.7
	Liver and Biliary Tract	19	6.3
	Nervous System	20	6.6
	Other	14	4.6
	Total	300	100
28-day Outcome	Recovery	253	84.3
	Mortality	47	15.7
	Total	300	100
CRP Status	Negative	134	44.7
	Positive	166	55.3
	Total	300	100
SIRS Clinical Criteria including WBC	Negative	293	97.7
	Positive	7	2.3
	Total	300	100
SIRS Clinical Criteria excluding WBC	Negative	186	62
	Positive	114	38
	Total	300	100

Table (6) shows the frequency distribution of SI upon arrival as well as SI after 2 hours of fluid therapy based on the status of serum lactate and mortality rate in patients hospitalized in ED. According to the Chi-Square test, there was a statistically significant relationship between

the SI upon arrival and SI after 2 hours of fluid therapy based on serum lactate (P=0.0001 & P=0.0001) and mortality rate (P=0.0023 & P=0.0012) in patients with early sepsis diagnosis in ED.

Table 6: Frequency distribution of SI upon arrival as well as SI after 2 hours of fluid therapy based on the status of Serum lactate and mortality rate in hospitalized patients in ED.

Variable	Serum Lactate Status	Hyperlactatemia		Normal Lactate Status		P-value
		No.	**Percentage**	**No.**	**Percentage**	
SI Upon Arrival	> 1	38	55.9	30	44.1	P=0.0001
	0.7-1	16	14	98	86	
	< 0.7	10	8.5	108	91.5	
Total		64	21.3	236	78.7	
SI after 2 hrs. of Fluid Therapy	> 1	13	54.2	11	45.8	P=0.0001
	0.7-1	40	44	51	56	
	< 0.7	11	5.9	174	94.1	
Total		252	84.3	47	15.7	
Variable	**Serum Lactate Status**	**Recovery**		**Mortality**		**P-value**
		No.	**Percentage**	**No.**	**Percentage**	
SI Upon Arrival	> 1	50	19.7	18	38.2	P=0.0023
	0.7-1	99	39.1	15	31.9	
	< 0.7	104	41.2	14	29.7	
Total		64	21.3	236	78.7	
SI after 2 hrs. of Fluid Therapy	> 1	13	5.1	11	23.4	P=0.0012
	0.7-1	79	31.2	12	25.3	
	< 0.7	161	63.6	24	51.06	
Total		253	84.3	47	15.7	

Table (7) demonstrates the comparison of the intended shock indices in predicting hyperlactatemia and 28-day mortality. Using Chi-square test, it was determined that there was a statistically significant relationship between hyperlactatemia and 28-day mortality in the SI>0.7 and SI>1 in patients hospitalized in ED with early sepsis diagnosis (P=0.0001 & P=0.0001).

Table 7: Comparison of the intended shock indices in predicting Hyperlactatemia and 28-day morality

SI Status	SI≥0.7		SI<0.7		SI≥1		SI<1		P-value
Outcomes	**Percentage**	**No.**	**Percentage**	**No.**	**Percentage**	**No.**	**Percentage**	**No.**	
Hyperlactatemia	84.4	54	15.6	10	59.3	38	40.7	26	P=0.0001
28-day Mortality	29.8	14	70.2	33	38.3	18	61.7	29	

Table (8) shows the frequency distribution of SI upon arrival and SI after 2 hours of fluid therapy based on the SIRS clinical criteria including and excluding WBC in hospitalized patients in ED with early sepsis diagnosis. According to the results of Chi-Square test, there was not any statistically significant relationship between the SI upon arrival and the SI after 2 hours of fluid therapy based on SIRS clinical criteria including WBC (P=0.57 & P=0.39). However, while there was a statistically significant relationship between the SI upon arrival and the SI after 2 hours of fluid therapy based on SIRS clinical criteria excluding WBC (P=0.0001 & P=0.014).

Table 8: Frequency distribution of SI upon arrival and SI after 2 hours of fluid therapy based on the SIRS clinical criteria including and excluding WBC in hospitalized patients in ED with early sepsis diagnosis.

Variable	**SIRS Clinical Criteria with WBC**	**Positive**		**Negative**		**P-value**
		No.	**Percentage**	**No.**	**Percentage**	
SI Upon Arrival	> 1	67	98.5	1	1.5	P=0.57
	0.7-1	110	96.5	4	3.5	
	< 0.7	116	98.3	2	1.7	
Total		293	97.7	7	2.3	
SI after 2 hrs. of Fluid Therapy	> 1	24	100	0	0	P=0.39
	0.7-1	90	98.9	1	1.1	
	< 0.7	179	96.8	6	3.2	
Total		293	97.7	7	2.3	
Variable	**SIRS Clinical Criteria without WBC**	**Positive**		**Negative**		**P-value**
		No.	**Percentage**	**No.**	**Percentage**	
SI Upon Arrival	> 1	44	64.7	24	35.3	P=0.0001
	0.7-1	27	23.7	87	76.3	

	< 0.7	115	97.5	3	2.5	
Total		186	62	114	38	
SI after 2 hrs. of Fluid Therapy	> 1	21	87.5	3	12.5	P=0.014
	0.7-1	50	54.9	41	45.1	
	< 0.7	115	62.2	70	37.8	
Total		186	62	114	38	

Discussion and Conclusion

Sepsis is a serious life-threatening disease that can lead to a long-term hospitalization in intensive care units and ultimately death. Thus, early diagnosis and interventions are necessary in order to reduce the mortality rate and complications of sepsis. The use of specific scales is one of the interventions to highlight the severity of injury, acuteness, dynamicity and resistance of patients, which has a significant role in determining the type of required treatment and cares as well as reducing the mortality rate. (Rady et al., 1994) Shock index is known as an instance of such specific scale. Therefore, with regard to the significance of this issue, it is highly important and practical to evaluate the ability of shock index and other clinical criteria. Sepsis is a disease with a high risk of mortality rate. It seems that the early diagnosis of sepsis and expeditious treatment can be effective in the treatment and recovery of patients and the reduction of mortality due to its high prevalence in the ICUs and ORs of hospitals. One of the helpful and caring ways for the early diagnosis of sepsis is to recognize the underlying causes of the disease. (Mikkelsen et al., 2009) One of such underlying factors is old age. Ages over 70 years in Allgower, Buri's et al. study (1967) and over 65 years in Rady's et al. study (1992) were considered as a risk factor to the disease.

In the present study, the first riskiest age group ranged between 61-80 years (%36.3) while the second riskiest group aged between 41-60 years (%31), which was consistent with the findings of other reviewed studies. The present study also showed that about %61 of patients consisted of male while female were %39 of the subjects. Some studies reported that the male sex was a risk factor to sepsis. Similarly, Berger et al. (2012) found that about %66.5 of septic patients were men while the remaining were women, which was in line with the findings of the current study.

Any case of infection site may cause sepsis. Common infection sites include abdominal infections (peritonitis, cholangitis, abscess), urinary tract infections (pyelonephritis), respiratory tract infections (pneumonia) and soft issue infections (abscess and cellulitis). In the present study, the frequency of infection sites upon arrival was respectively observed as the source of sepsis in the lungs (%35), kidney and urinary tract (%20.7) and gastrointestinal tract (%20.3) of patients with early sepsis diagnosis. Other studies such as Ray's et al. found that digestive and pulmonary disease were the most common causes of sepsis. (Rady et al., 1994) In the present study, it was recognized that there was a statistically significant relationship between the status of SI upon arrival and SI after 2 hours of fluid therapy so that all the vital signs returned to the stable condition after 2 hours of fluid therapy in patients. It indicated that the shock index can be used as a simple and effective index to measure hypovolemia in septic shock. (Allgöwer and Buri, 1967) Furthermore, Hass (2005) introduced SI as an ideal, usable, accurate, expeditious and generalizable index for all patients, consistent with the results of other studies. (Berger et al., 2013; Rady et al., 1994, 1992) It was also found that there was a negative correlation between the index of shock and the index of pH and P_aO_2 after 2 hours of fluid therapy i.e. the higher the SI after 2 hours of fluid therapy, the lower the index of pH and P_aO_2 after 2 hours of fluid therapy; which was consistent with the strong ability of SI in patients' recovery.

With regard to the intensity of emergency conditions and the critical situation of sepsis that caused such intensive conditions as septic shock or even mortality, the necessity of using a more appropriate and applicable tool for optimizing care is clearly felt in emergency conditions. (American College of Chest Physicians and Society of Critical Care Medicine Consensus Conference Committee, 1992)

The present study indicated that the 28-day outcome of patients with early sepsis diagnosis finally led %15.7 of them to death, while %84.3 of patients were fully recovered. Moreover, the examination of subjects (patients) showed that about %60.7 of patients had SI>0.7 amongst which %78.8 accounted for mortality rate. In contrast, Patients with SI<0.7 covered only %21.3 of the mortality rate, which was in line with the findings of other studies. Sankaran's et al. (2011)`s study on 190 patients indicated that the shock index had the ability to predict septic patients within 6 weeks since hospitalization. Canon et al. (2009) studied the application of SI in predicting the mortality of severely ill patients on 1,166 dossiers. They found that %25 of the patients with SI>0.9 had a mortality rate of %15.9 compared with %6.3 of patients with normal SI. (Canon et al., 2009) Berger et al. (2012) investigated the diagnostic value of SI in the early sepsis recognition. Accordingly, about 2524 patients (%89) presented SI>0.7 while 361 patients (%14) died within the first 28 days of the disease. (Berger et al., 2013)

The present study showed that there was a statistically significant relationship between the SI upon arrival and the SI after 2 hours of fluid therapy with regard to the serum lactate status in patients hospitalized in the ED with early sepsis diagnosis. Moreover, the results of determining the diagnostic value of SI after 2 hours of fluid therapy in predicting hyperlactatemia in septic patients indicated that about %38.3 of patients with SI>0.7 enclosed %82.8 of hyperlactatemia while those with SI<0.7 covered %17.2 of hyperlactatemia cases. It was consistent with other findings. Similarly, Berger et al. (2012) conducted a retrospective study on 2824 infection-susceptible patients with random visits to the emergency department of hospital in 2008 in order to investigate the diagnostic value of SI in predicting early sepsis

recognition. They found that about %11.5 (290 patients) out of %89 of patients (2,524) with SI>0.7 had hyperlactatemia. The results also showed that patients with SI ≥0.7 were three times more likely to present hyperlactatemia than those with a normal SI. (Berger et al., 2013)

Rady et al. compared the ability of patients' SI and vital signs in recognizing the acute and critical diseases in ED. The results showed that SI had a higher ability to determine hyperlactatemia i.e. about %81 of patients with SI>0.7 covered %53 of hyperlactatemia cases, (Rady et al., 1994, 1992) which was consistent with the findings of the current study. In multivariable regression analysis, that investigated the relationship between 28-day mortality rate and other variables (such as age, sex, SI>0.7, SI>1, serum lactate status as well as SIRS criteria with/without WBC etc.), the odd ratio of 1.6 (CI 2.8 – 10.8) showed that hyperlactatemia was highly associated with 28-day mortality.

The present study suggested that the shock index can present the homodynamic condition of patients more precisely than the vital signs in solitude. The reason is that SI not only included heart rate and blood pressure but also it was a factor that reflected the changes in the patient's vital signs. Therefore, SI can be effectively used in the emergency departments and hospitals. Additionally, the present study advised that given the ease of use of SI, the ED staff would be able to determine the shock index of patients and predict possible risks and outcomes after controlling their heart rate and blood pressure.

According to the findings of the current study, it can be concluded that patients with SI>0.7 experienced higher risk of mortality rate compared with patients with SI<0.7. SI was a helpful and efficient tool in the classification and prediction of mortality in septic patients particularly when optimal use of emergency resources was sought. In other words, SI could be applicable as a triage tool for the prediction and prioritization of patient cares especially when they lacked emergency resources and facilities. However, it should be used together with other tools to maximize its efficient diagnosis and prevent any possible potential errors. Besides, patients with SI>0.7 were more likely to hyperlactatemia i.e. they were 5 times more likely to present hyperlactatemia than patients with a normal SI.

References

Allgöwer M, & Buri C. (1967). Schockindex. Deutsche Medizinische Wodenschrift. 6:1–10.

American College of Chest Physicians, & Society of Critical Care Medicine Consensus Conference Committee. (1992). American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference: definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Crit Care Med*, *20*, 864-874.

Berger, T., Green, J., Horeczko, T., Hagar, Y., Garg, N., Suarez, A., ... & Shapiro, N. (2013). Shock index and early recognition of sepsis in the emergency department: pilot study. *Western Journal of Emergency Medicine*, *14*(2), 168.

Cannon, C. M., Braxton, C. C., Kling-Smith, M., Mahnken, J. D., Carlton, E., & Moncure, M. (2009). Utility of the shock index in predicting mortality in traumatically injured patients. *Journal of Trauma and Acute Care Surgery*, *67*(6), 1426-1430.

Dellinger P, Bone R. (1998). To SIRS with Love. Crit Care Med.26:178–179.

Haas, H. (2005). Outils de triage aux urgences pédiatriques. *Archives de pédiatrie*, *6*(12), 703-705.

Hall, M. J., Williams, S. N., DeFrances, C. J., & Golosinskiy, A. (2011). Inpatient Care for Septicemia or Sepsis: A Challenge for Patients and Hospitals. U.S. Department of Health and Human Services - National Center for Health Statistics.62:1–7.

Howell, M. D., Donnino, M., Clardy, P., Talmor, D., & Shapiro, N. I. (2007). Occult hypoperfusion and mortality in patients with suspected infection. *Intensive care medicine*, *33*(11), 1892-1899.

Mikkelsen, M. E., Miltiades, A. N., Gaieski, D. F., Goyal, M., Fuchs, B. D., Shah, C. V., ... & Christie, J. D. (2009). Serum lactate is associated with mortality in severe sepsis independent of organ failure and shock. *Critical care medicine*, *37*(5), 1670-1677.

Osborn, T. M., Nguyen, H. B., & Rivers, E. P. (2005). Emergency medicine and the surviving sepsis campaign: an international approach to managing severe sepsis and septic shock. *Annals of emergency medicine*, *46*(3), 228-231.

Rady, M. Y., Rivers, E. P., Martin, G. B., Smithline, H., Appelton, T., & Nowak, R. M. (1992). Continuous central venous oximetry and shock index in the emergency department: use in the evaluation of clinical shock. *The American journal of emergency medicine*, *10*(6), 538-541.

Rady, M. Y., Smithline, H. A., Blake, H., Nowak, R., & Rivers, E. (1994). A comparison of the shock index and conventional vital signs to identify acute, critical illness in the emergency department. *Annals of emergency medicine*, *24*(4), 685-690.

Sankaran P, Kamath AV, Tariq SM, Prentice P, Smith AC, & Subramanian DN. (2011). Are ShockIndex and Adjusted Shock Index are Useful in Predicting Mortality and Length of Stayin Community Acquired Pneumonia? *Eur J Intern Med*, *22*(3):283-5.

Shapiro, N. I., Howell, M. D., Talmor, D., Nathanson, L. A., Lisbon, A., Wolfe, R. E., & Weiss, J. W. (2005). Serum lactate as a predictor of mortality in emergency department patients with infection. *Annals of emergency medicine*, *45*(5), 524-528.

Shapiro, N., Howell, M. D., Bates, D. W., Angus, D. C., Ngo, L., & Talmor, D. (2006). The association of sepsis syndrome and organ dysfunction with mortality in emergency department patients with suspected infection. *Annals of emergency medicine*, *48*(5), 583-590.

Sibbald, W. J., Doig, G., & Inman, K. J. (1995). Sepsis, SIRS and infection. *Intensive care medicine*, *21*(4), 299-301.

Vincent, J. L. (1997). Dear SIRS, I'm sorry to say that I don't like you. *Critical care medicine*, *25*(2), 372-374.