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ORIGINAL

Shock index and modified shock index as a predictor of mortality in shock sepsis admitted to the critical care unit

Índice de choque e índice de choque modificado, como predictor de mortalidad en choque sepsis que ingresan a unidad de cuidados críticos

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ABSTRACT

Introduction: septic shock is characterized by microvascular endothelial dysfunction, dysregulated immune response, and coagulation disorders. Mortality in this state can reach up to 50 %. The shock index (SI) is the integration of two physiological variables (heart rate/systolic blood pressure) and modified shock index (MSI) (heart rate/mean arterial pressure); several studies demonstrate it as a predictor of mortality in septic shock. The objective was to determine the prognostic value of the shock index and the modified shock index in patients with septic shock.
Method: this was an observational, prospective, and longitudinal study with 176 patients admitted to the critical care unit of Hospital Obrero No. 2, Cochabamba, Bolivia.
Results: the study documented that having a SI > 1,1 and an MSI cut-off point of > 1,7 at admission to the critical care unit, presents higher mortality, with a sensitivity CI of 86 % (CI: 95 %: 0,714-0,869; p = 0,0001), for the MSI a sensitivity of 87 % (CI: 95 %: 0,722-0,874; p = 0,0001).
Discussion: the shock index and modified shock index are moderately accurate predictors of mortality in patients with septic shock admitted to the critical care unit, which could be useful as a reference tool to identify high-risk patients.

Keywords: Modified Shock Index; Mortality Septic Shock; Shock Index; Prediction.

RESUMEN

Introducción: el choque séptico se caracteriza por disfunción endotelial microvascular, respuesta inmunológica desregulada y alteración de la coagulación. La mortalidad en este estado puede llegar cerca del 50 %. El índice de choque (IC) es la integración de dos variables fisiológicas (frecuencia cardíaca / presión arterial sistólica) e índice de choque modificado (ICM), (frecuencia cardiaca / presión arterial media); hay varios estudios que lo demuestran como predictor de mortalidad en choque séptico. El objetivo fue determinar el valor pronóstico de índice de choque y el índice de choque modificado en pacientes con choque séptico.
Método: es un estudio observacional, prospectivo y longitudinal, con 176 pacientes, que ingresan a la unidad de cuidados críticos del Hospital Obrero Nro. 2, de la ciudad de Cochabamba, Bolivia.
Resultados: el estudio documentó que tener un IC > 1,1 y un ICM con punto de corte de > 1,7 al ingreso a unidad de cuidados críticos, presenta mayor mortalidad, con una sensibilidad IC de 86 % (IC: 95 %: 0,714-0,869; p=0,0001), para la ICM una sensibilidad de 87 % (IC: 95 %: 0,722-0,874; p=0,0001).
Discusión: el índice de choque e índice de choque modificado son predictores moderadamente preciso de

mortalidad en pacientes con choque séptico que ingresan a la unidad de cuidados críticos, lo que podrían ser útil como herramienta de referencia para identificar a pacientes de alto riesgo.

Palabras clave: Choque Séptico; Indicie de Choque; Índice de Choque Modificado; Mortalidad; Predicción.

INTRODUCTION

Sepsis is a global problem and is responsible for high morbidity and mortality and high medical costs worldwide; between 1990 and 2017, although the age-specific incidence of sepsis decreased by 37 % and mortality by 52,8 %, it remains a pressing problem in 2017 alone, the global incidence of sepsis worldwide was 48,9 million cases and was associated with 11 million deaths, accounting for 19,7 % of all deaths globally. Data recorded by the National Health Service (NHS) showed 244,158 cases of sepsis with 48,000 deaths in the UK in the same period. From another perspective, the annual financial burden is estimated to be £7,42 billion.[1,2,3]

In the United States, sepsis affects 750,000 patients each year and is the leading cause of death for 210 000 people each year. About 15 % of patients with sepsis progress to septic shock, and 10 % are admitted to intensive care, with a mortality rate of more than 50 %.[4] Approximately 85 % of sepsis cases and deaths occur in low- and middle-income countries, with a higher age-standardized incidence in areas with greater social vulnerability. In Latin America, sepsis is a health problem, with high mortality rates from septic shock in countries such as Brazil, Colombia, and Argentina, where approximately 31 million people suffer from sepsis each year, of whom approximately 6 million die each year from sepsis.[3,5,6]

In 2001, the surviving sepsis campaign (SSC) was formed by the Society of Critical Care Medicine (SCCM), the European Society of Intensive Care Medicine (ESICM), and the International Sepsis Forum. The primary objective was to develop evidence-based guidelines and recommendations for the resuscitation and management of patients with sepsis.[7]

The definition of sepsis has evolved from the first, identified in 1992, where it was described as an exaggerated inflammatory response to infection, recognized by the presence of systemic inflammatory response syndrome (SIRS), which is defined by two or more criteria, such as temperature, heart rate, respiratory rate or white blood cell count; Sepsis was subsequently reconceptualized in 2024 as acute life-threatening organ dysfunction due to a dysregulated host response to infection; septic shock, on the other hand, is defined as sepsis with cardiovascular organ dysfunction such as severe hypotension for age; venous or arterial blood lactate level > 5 mmol/liter (>45,05 mg/dl), or need for vasoactive medication.[5,8]

The most common infections are located in the lungs, accounting for 40-60 % of cases; abdomen 15-30 %; genitourinary tract 15-30 %; bloodstream, skin, or soft tissues 5-10 %. A pathogen is identified in 60-70 % of cases.[9,10] Gram-positive or gram-negative bacterial infections are most common, followed by fungal or viral infections.[5,9] Community-acquired pneumonia (CAP) is the most frequent with sepsis, accounting for more than 40 % of cases, and is responsible for high morbidity and mortality. On the other hand, early and protocolized resuscitation of patients with sepsis improves outcomes, while the prognosis is poor in those with delayed diagnosis and management.[11]

Since the publication of the article by Rivers et al. in 2001, the importance of early identification of patients with sepsis at high risk of morbidity and mortality has been established since when numerous prognostic and diagnostic scales have been used to classify patients with sepsis or septic shock;[12] such as the NEWS (National Early Warning Score) criteria, they have limited prognostic utility due to insufficient specificity; the SOFA (Sepsis-related Organ Failure Assessment) score is an objective scoring system to determine central organ dysfunction, based on oxygen levels (partial pressure of oxygen and fraction of inspired oxygen), platelet count, Glasgow Coma Scale score, bilirubin level, creatinine level (or urine output) and mean arterial pressure (or whether vasoactive agents are required).[11,13,14]

The primary purpose of the SOFA score is to objectively describe organ dysfunction rather than predict outcomes, so an associated equation for predicting mortality was not developed. Furthermore, calculating this score requires training and can be pretty laborious.[11,13]

The shock index (CI) is related to two physiological variables presenting the functioning of the cardiovascular system; systolic blood pressure is a result of cardiac function (preload, afterload, and contractility) as well as arterial vascular function which is present in a physiological regulation through baroreceptors, which respond to altered intravascular volume, heart rate is the result of multiple factors affecting the autonomic nervous system and which determine a balance between the sympathetic and parasympathetic systems of the pathophysiological response of septic shock.[12,15,16]

The hyperdynamic state of septic shock is driven by a combination of tachycardia and increased cardiac output, along with low systemic vascular resistance; tachycardia is a compensatory response to a combination of cardiac underfilling; as cardiac output decreases, additional changes in heart rate act as an important compensatory mechanism for the cardiovascular system.[17,18] In recent years, new studies have been published

that continue to highlight the importance of multiple indices or scores, such as CI, modified shock index (MCI), and diastolic CI (DCI), taking into account the pathophysiological basis of sepsis, with results suggesting benefit as prognostic and management tools in patients with sepsis.[19]

HF is an easy and simple tool to measure at the bedside. It is calculated by dividing heart rate (HR) by systolic blood pressure (SBP), and MCI is calculated by dividing heart rate by mean arterial pressure (MAP) (normal ranges 0,5 to 0,7).[20,21] The present study aims to study the prognostic value of mortality with HF and MCI in patients with septic shock admitted to the intensive care unit.

METHOD

This is an observational, prospective, and longitudinal study, which was carried out in the city of Cochabamba-Cercado, Bolivia, in patients admitted to the intensive care unit (ICU) of the Hospital Obrero No. 2. With the diagnosis of septic shock in August 2022 to December 2024, a population of 176 patients was analyzed, who were chosen according to the type of sample; probabilistic (simple random), with a confidence level of 95 % and a margin of error of 5 %.

Inclusion criteria: Patients over 18 years of age, patients admitted to the Intensive Care Unit with a diagnosis of septic shock, arterial hypotension, and requirement of noradrenaline, in addition to mechanical ventilation.

Exclusion criteria: patients under 18 years of age and pregnant women.

All data were collected on a data registration form, which was entered into SPSS (Statistical Package for the Social Sciences) statistical software to analyze the data, with measures of central tendency and dispersion, as well as the ROC curve for sensitivity and specificity and the Kaplan-Meier curve for survival.

This work was presented and approved by the teaching department of the Hospital Obrero Nro. 2 of the National Health Fund of Cochabamba, Bolivia; being prospective and analytical research, observational in nature, which does not contemplate any direct intervention on patients or modification in the diagnostic or therapeutic procedures established as part of routine medical care; In short, the data collection was carried out from routine clinical sources, without violating the privacy or confidentiality of the users, and without generating any physical, psychological or social risk; in this way, it is considered that this type of research, as it does not involve intervention or manipulation of variables in the participating subjects, does not require evaluation by a Research Ethics Committee. However, compliance with the principles of respect, beneficence, non-maleficence, and justice is ensured throughout the research process.

RESULTS

A population of 176 patients was obtained, of which 108 patients died; the most affected age was greater or equal to 60 years old. Within the population studied, there was a higher mortality rate in the male sex with 66 patients (61,1 %) compared to the female sex with 42 patients (61,8 %). Most of the patients had no relevant pathological history of systemic arterial hypertension or type 2 diabetes mellitus. Among the diagnoses of septic shock, there were different causes, such as community-acquired pneumonia, with 82 patients, of whom 49 patients died (59,8 %). Regarding the surgical cause, the majority represented postoperative exploratory laparotomy with a total of 30 patients, of whom 15 patients died (50 %), as shown in table 1.

Table 1. Description of characteristics of the study population

Features			Live N=68	Deceased N=108	Total N=176
Gender	Female		26 (38,2 %)	42 (61,8 %)	68 (100 %)
	Male		42 (38,9 %)	66 (61,1 %)	108 (100 %)
Background	Hypertension systemic arterial	Yes	26 (41,9 %)	36 (58,1 %)	62 (100 %)
		No	42 (36,8 %)	72 (63,2 %)	114 (100 %)
	Diabetes mellitus type 2	Yes	22 (46,8 %)	25 (53,2 %)	47 (100 %)
		No	46 (35,7 %)	83 (64,3 %)	129 (100 %)
Diagnostics	Pneumological	Community-acquired pneumonia	33 (40,2 %)	49 (59,8 %)	82 (100 %)
		Community-acquired pneumonia	15 (28,8 %)	37 (71,2 %)	52 (100 %)
		Tuberculosis	1 (100 %)	0 (0 %)	1 (100 %)
	Surgical or Post-Operative (PO) and others	PO necrotising pancreatitis	1 (100 %)	0 (0 %)	1 (100 %)
		PO exploratory laparotomy (perforated appendicitis, intestinal obstruction, mesenteric thrombosis)	15 (50 %)	15 (50 %)	30 (100 %)
		PO oesophageal perforation	1 (50 %)	1 (50 %)	2 (100 %)
		Brain Abscess	4 (75 %)	1 (25 %)	5 (100 %)
		Endocarditis	0 (0 %)	2 (100 %)	2 (100 %)
		Pancreatitis	0 (0 %)	2 (100 %)	2 (100 %)

According to the ROC curve analysis, the discharge shock index (0,869) better classifies deceased patients, as it has higher sensitivity and specificity values, as shown in figure 1. The area of classification is significant (p-value = 0,0001).

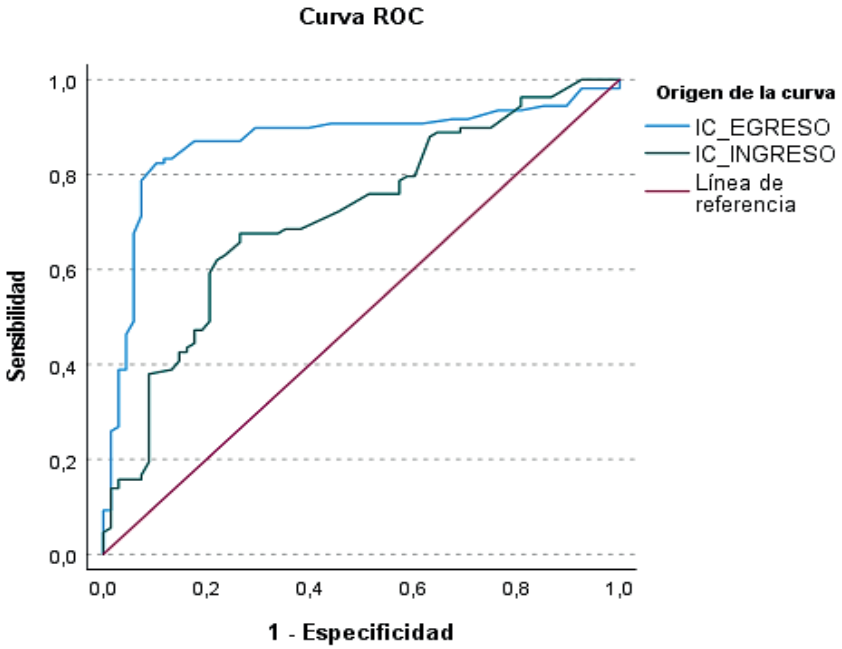

Figure 1. ROC curve for the shock index

The time of hospitalization in the ICU is longer for a CI value greater than 1 (green line) and with a lower probability of survival than when the CI value is less than 1; in association, the Log Rank value indicates that these survival curves are different (p-value = 0,001), with a confidence level of 95 % (figure 2).

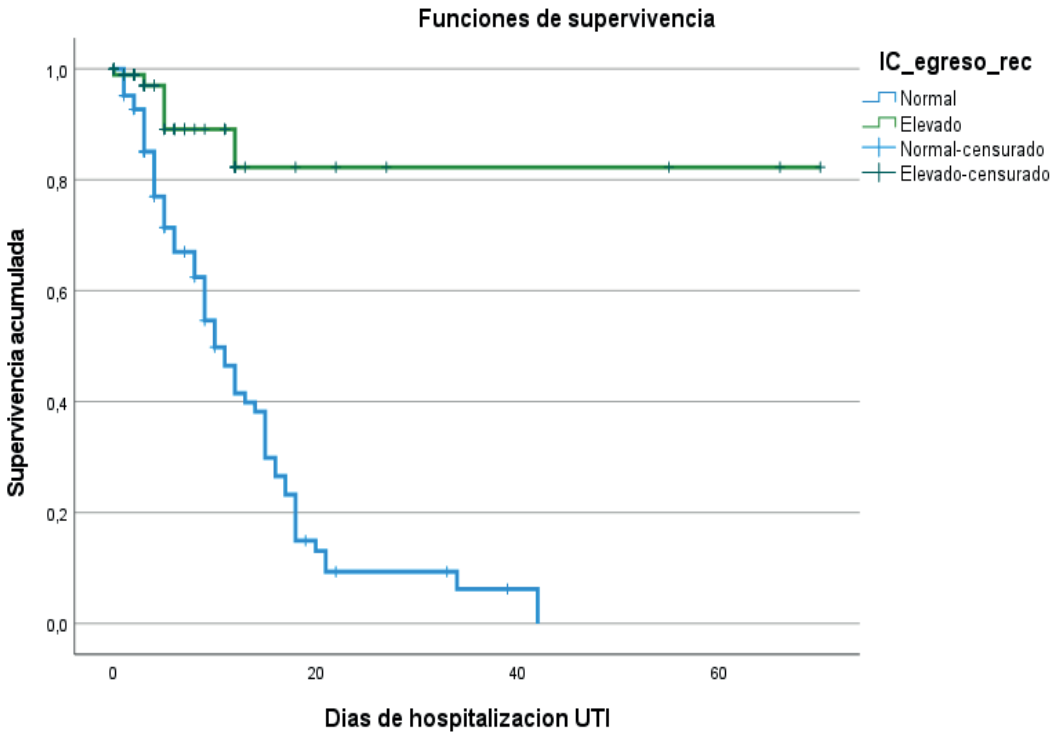

Figure 2. Kaplan Meier curve of the crash index

Similarly, the ROC curve analysis of the modified shock index at discharge (0,874) better classifies deceased patients, as it presents higher sensitivity and specificity values, as shown in figure 3. The area of classification is significant (p-value = 0,0001).

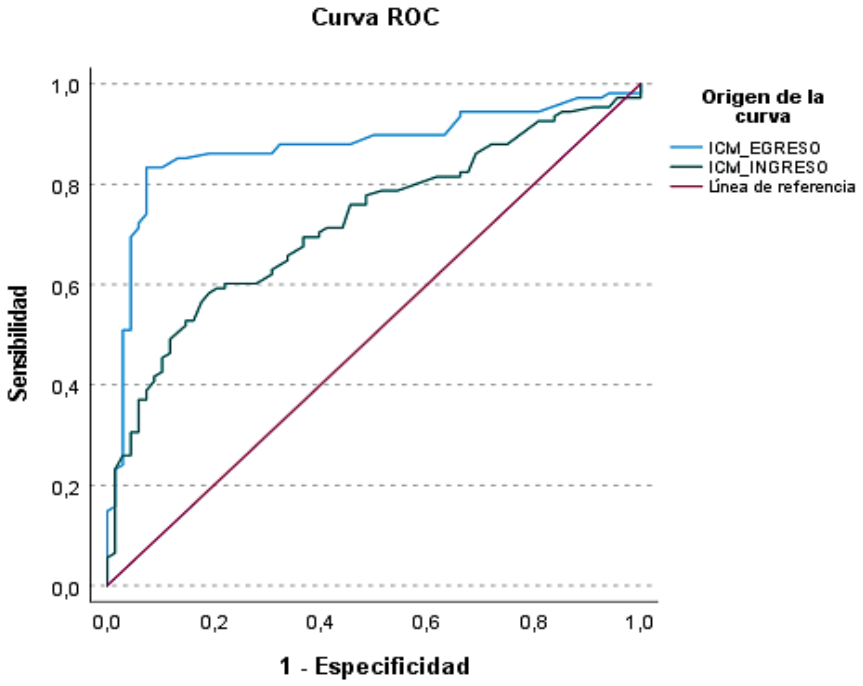

Figure 3. ROC curve of the modified shock index

The time of hospitalization in the ICU is longer in the case of a modified CI value greater than 1,2 (green line) and with a lower probability of survival than when the modified CI value is less than 1,2. In sum, the Log Rank value indicates that these survival curves are different (p-value = 0,001), with a confidence level of 95 % (figure 4).

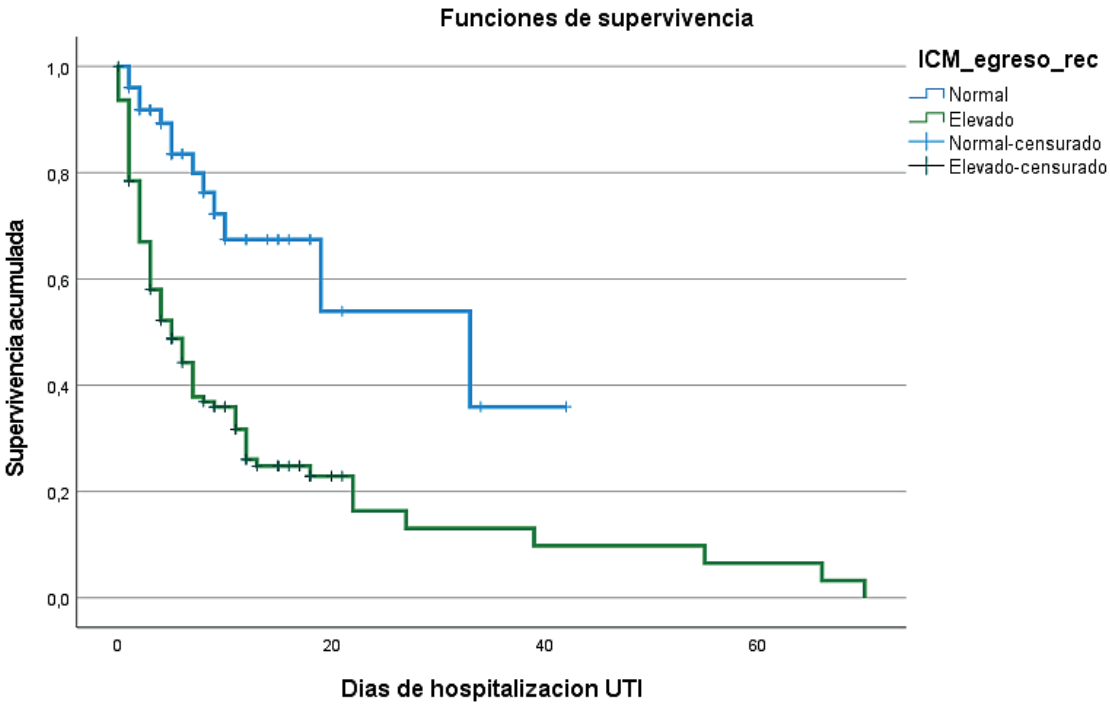

Figure 4. Kaplan Meier curve of the modified shock index

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In the correlation analysis between the SOFA score and the CI at discharge, the Pearson correlation was 0,287, with a weak statistical relationship since the significance level is less than 5 % (p-value = 0,0001), with a confidence level of 95 % (figure 5).

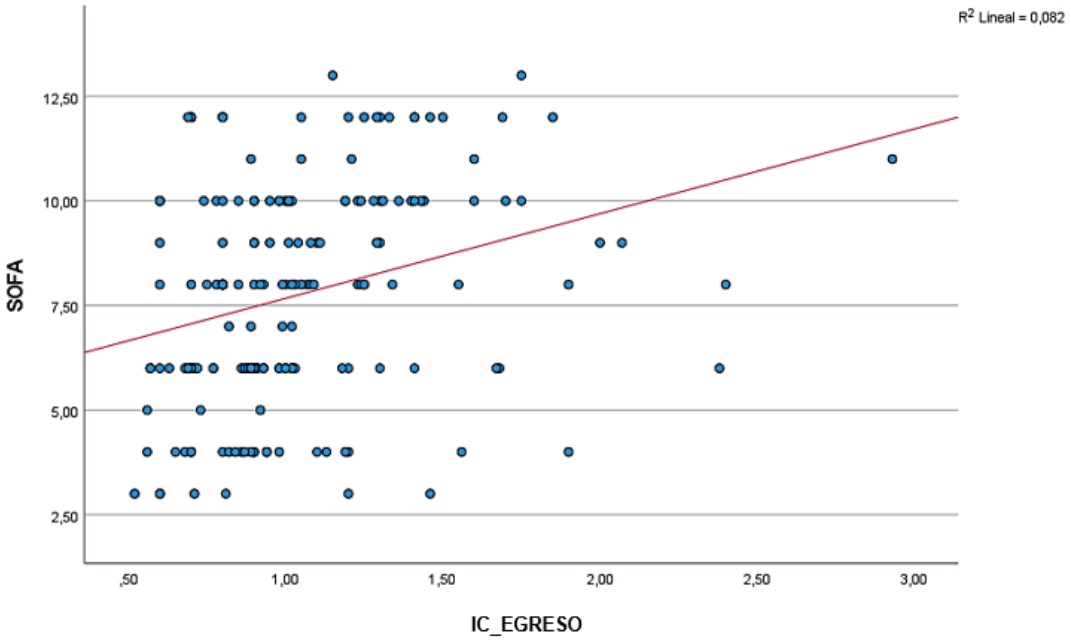

Figure 5. Correlation of shock index with SOFA score at exit

In the correlation analysis between the SOFA score and the MCI value at discharge, the Pearson correlation was 0,348, with a moderate statistical relationship, since the significance level is less than 5 % (p-value = 0,0001), with a confidence level of 95 %. We should also mention that a higher correlation is observed than the CI (figure 6).

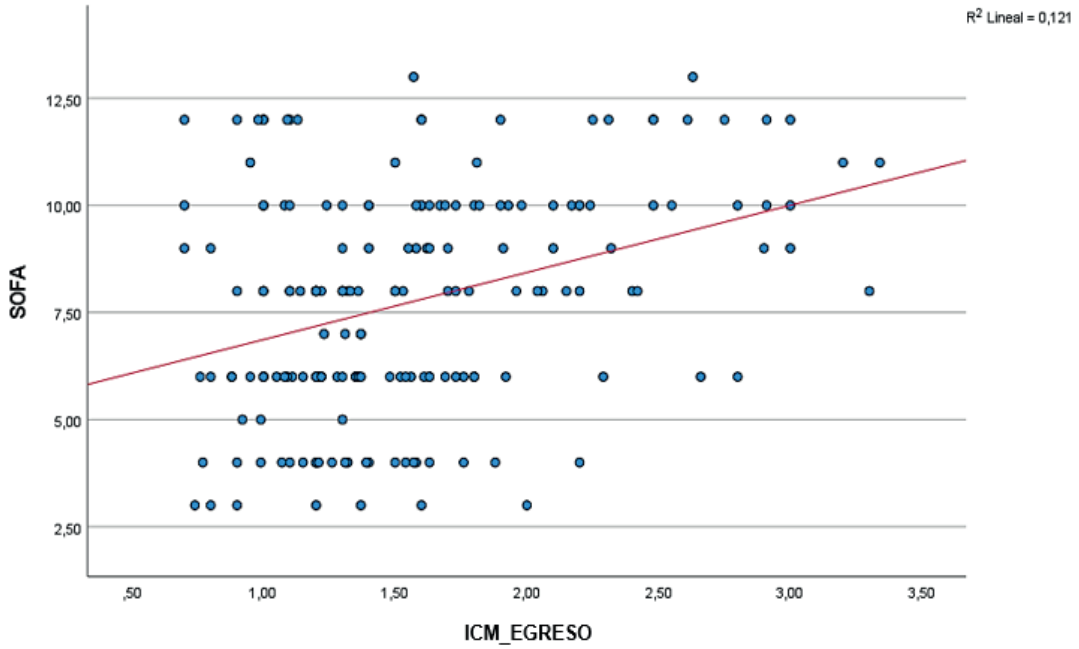

Figure 6. Correlation of modified shock index with SOFA score at discharge

In our study, a CI greater than or equal to 1,65 was observed in patients who died, with a confidence level of 95 %. For the MCI, a value greater than or equal to 2,64 died, with a confidence level of 95 %, in patients with septic shock. In addition, in patients receiving vasopressors, noradrenaline at a dose of 0,70 µg/kg/min was associated with more mortality, with a 95 % confidence level (table 2).

Table 2. Description of the degree of association of HF, MCI, vasoactive and mortality

Variables	Deceased IC/ICM; IC 95 %
IC income	1,15; (1,07 - 1,22)
IC egress	1,65; (1,51 - 1,78)
ICM income	1,75; (1,63 - 1,87)
ICM egress	2,64; (2,41 – 2,86)
Noradrenaline	0,70 µg/kg/min; (0,63 – 0,77)

Notes: CI: shock index, MCI: modified shock index; 95 % CI (95 % confidence interval) µg: gamma, kg: kilogram, min: minute.

DISCUSSION

Despite advances in emergency care, sepsis continues to represent a considerable burden with high hospital costs. Each year, sepsis causes more than 6 million deaths worldwide. Sepsis is a risk factor in elderly patients with severe comorbidities and functional impairment.[15,22] A systematic review led by Devendra Prasad K. et al. shows that HF has been studied in patients with septic shock in recent years, demonstrating a potential predictive value for mortality and the need for fluid management.[20]

Wira et al., in 2014, demonstrated in a retrospective observational study of 295 patients that a sustained elevation of CI > 0,8 during at least 80 % of vital sign measurements on emergency admission during the first 72 hours of management was associated with 4,4 times more requirement for vasopressor support, increased organ dysfunction and mortality compared with patients without this sustained elevation; mortality between the two groups was 19,3 % compared with 13,3 % (p = 0,109). (26) In our study, vasoactive (noradrenaline) use in patients with septic shock was associated with higher mortality in those using noradrenaline greater than 0,29 µg/kg/min.

The ICM was studied using heart rate with mean arterial pressure (MAP), as it better represents the state of tissue perfusion. It is evident that the DBP of a critically ill patient decreases before the SBP; in short, the MAP is an accurate predictor of disease severity;[15,25,26] on the other hand, Liu et al. conducted a retrospective review of 22,161 patients admitted to the Emergency Department of Peking Union Medical College Hospital in 2012, with results reflecting an MCI > 1,3, with a higher probability of ICU admission and death; in our case, an MCI at discharge > 2,6 was reflected with higher mortality and associated with more extended hospitalization and shorter survival.[27]

MAP is the recommended indicator for deciding fluid resuscitation and vasopressor titration, as it is considered a better marker of organ perfusion; a high MCI value indicates that systolic volume and systemic vascular resistance (SVR) are low, reflecting a hyperdynamic type of circulation; this could indicate that the patient is in a compensatory phase and that decompensation may occur rapidly; thus we could indicate that high values of MCI at discharge, as happened in our study, may denote evident decompensation. It may denote obvious decompensation in these patients.[15]

Liu et al. found that MCI performed better than CI in predicting mortality in patients admitted to emergency;[27] Singh et al., in their prospective study, found that MCI scores below 0,7 and above 1,3 were associated with a significant mortality rate, as in our case where values above 2,6 reflected more mortality relative to CI. From another perspective, the available literature shows that between 54 % and 65 % of all patients with sepsis have comorbidities that worsen outcomes;[15,27] in our study, the MCI with a cut-off point of > 1,7,[2,6] with a sensitivity of 87 % (95 % CI: 0,722-0,874; p=0,0001), showed higher mortality in patients over 60 years of age, and it was also observed that the deceased were male, 66 patients out of 108. There was no relevance in mortality of underlying pathologies such as systemic arterial hypertension and type 2 diabetes mellitus.

The most common cause of sepsis is community-acquired pneumonia (CAP), with a high shock index predicting mortality. There are two extensive studies.

Finally, the studies above agree with the results obtained in our study, which shows that the CI and MCI are tools that are easy to calculate and control vital signs on admission in patients with septic shock admitted to the intensive care unit to predict mortality.

CONCLUSIONS

The shock index and modified shock index are moderately accurate predictors of mortality in septic shock patients admitted to the critical care unit, which could be helpful as a reference tool to identify high-risk patients. Their simplicity and calculation speed are advantageous over existing sepsis scoring systems, especially in resource-limited hospitals.

In our study, a cut-off point was taken for CI > 1,1 and MCI > 1,7, where mortality is evident, which had a high sensitivity. It also shows that the modified shock index is a good predictor of mortality in patients with a diagnosis of septic shock admitted to the intensive care unit.

Future research should focus on integrating the shock index into current tools as a predictor of mortality in patients with septic shock.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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