Shock index and lactate level as prognostic factors of 24-hour mortality in polytraumatized patients in the emergency service of regional hospital

César Rodríguez García M.D.
Adan Pacifuentes Orozco M.D.
David Alejandro Rodríguez Herrera M.D.
Laura Yuritzi Barroso Barrera M.D.
José Fernando Montiel Castañeda M.D.
Raul Manuel Cota García M.D.
Inti Valle Bracamontes M.D.
Mariana Jimena Adame Chavez M.D.
Carlos Ignacio García Castañeda M.D.

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Background
Patients with polytrauma have a high rate of mortality rate in emergency services, it is important to detect early the prognostic factors that may influence as predictors; they have been useful as markers of mortality; shock index and the lactate level; those that must be detected in a timely manner for their management, rule out patients with lower risk, prevent complications and thus reduce the mortality rate.
Objective. To determine the shock index and lactate level as prognostic factors for 24hr mortality in polytraumatized patients in the emergency department of the regional hospital number 1 in Charo, Michoacán.
Material and methods. Observational, analytical, retrospective and cross-sectional study carried out in the emergency department of HGR1 Charo, Michoacán from May 2022 to April 2023. The results of the gasometric study on admission with lactate measurement were evaluated; and calculation of the shock index, clinical information was recorded, and its progression to mortality.
Results: A total of 108 patients with a diagnosis of polytrauma were recorded, of wich 13(12%) presented mortality, demonstrating a direct relationship between a shock index greater than 0.9 and lactate levels > 2mmol/lt. Of the total number of patients, 82 presented a shock index of less than 0.9, that is, 75.9%, and 26 equal to or greater than 0.9, that is, 24.1%. 65 patients presented a lactate level less than 2mmol/lt, that is, 60.2% and 43 a lactate level greater than or equal to 2mmol/lt, 39.8%.
Conclusions: An initial index score greater than 0.9 and lactate levels > 2mmol/lt on admission of a polytrauma patient to the ED at HGR No 1 IMSS Charo, is directly associated with higher mortality independent of other biochemical and sociodemographic factors.

Keywords. Shock index, lactate, mortality, polytrauma.

At the end of the 18th century, the surgeon John Hunter suggested that the biological response to an organic lesion has a beneficial objective, postulating that during trauma a response occurs that does not correspond to the damage but to compensatory mechanisms in an attempt to heal (10).

Recently, the validity of the *Advanced Trauma Life Support* (ATLS) clinical classification of hypovolemic shock has been questioned (9, 11), so vital signs such as heart rate, blood pressure, respiratory rate, and other biochemical markers have been used by different trauma groups to detect abnormalities related to shock and/or trauma status (2).

Several studies have used the shock index to identify states of hypovolemia (9, 12, 13), since the clinical manifestations of hypovolemia do not appear until there is a volume loss greater than 30-40% (4, 14).

Another useful biomarker in shock states is base deficit as it is present in patients in whom aerobic metabolisms are impaired and anaerobic metabolism is utilized. The term base deficit was introduced by Ole Siggard-Andersen, it is an indicator of volume deficit; the base deficit as well as the lactate level reflect the degree of anaerobiosis. Its values allow assessing the hemodynamic status of the patient, as well as his response to treatment (13, 11).

Injuries are the most frequent cause of death in children under 45 years of age in most countries, as well as a major cause of disability, suffering and consumption of economic resources, ranking eighth in years of life lost, according to WHO statistics, with 1.3 million deaths per year due to traffic accidents (3, 15, 16). Due to its diversity of presentation it represents a diagnostic challenge for the clinician (3).

After trauma, the primary injury is volume loss with a deficient oxygen supply

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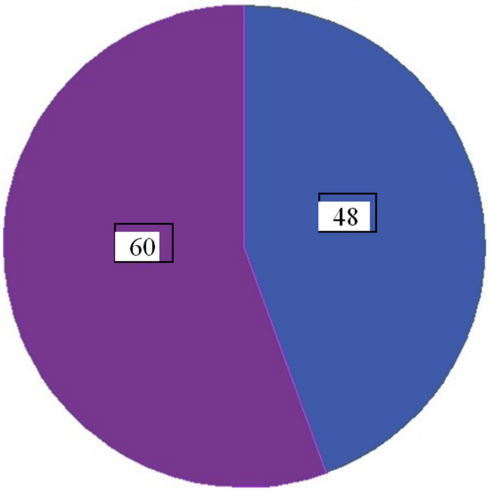

Figure 1. Gender of patients with polytrauma of HGR No 1 Charo, Michoacán from May 2022 to April 2023.
The ages of patients who presented with a diagnosis of polytrauma in HGR No 1 Charo, in the period from May 2022 to April 2023 were from 18 to 65 years with a mean of 44 years, and a standard deviation for patients who presented with mortality of 51 years and those who presented with survival of 43 years.

leading to the utilization of anaerobic metabolism; multiple organ failure may follow.

Shock is the clinical expression of the inability to meet the metabolic needs of the cell, with circulatory failure culminating in the inadequate utilization of oxygen, due to a decrease in its availability (6, 17). Immediate identification of the cause and hemodynamic support of the patient in shock is crucial to prevent worsening of the condition (6, 18).

Hypovolemic shock is due to reduced intravascular volume (i.e., reduced preload), which, in turn, reduces blood supply. Hypovolemic shock can be divided into two categories: hemorrhagic and nonhemorrhagic (17). The current ATLS system was designed to standardize the initial management of severely injured trauma patients and became the unofficial gold standard worldwide. A key aspect of initial management is the early recognition and treatment of hypovolemic shock (21). For the purposes of the present investigation we will then proceed to describe pathophysiologically the body's response to trauma, classification and identification.

Shock index

The normal ratio of HR to SBP is generally <0.7. This ratio is elevated in the setting of acute hypovolemia and circulatory failure and is known as the shock index (27).

Shock index (CI), defined as the ratio of heart rate (HR) divided by systolic blood pressure

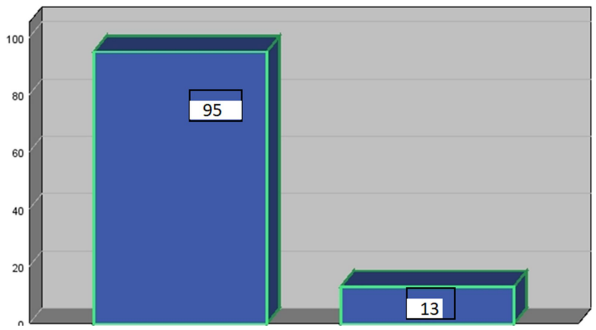

Figure 2. Mortality of patients with a diagnosis of polytrauma admitted to the ED of HGR No 1 Charo in the period from May 2022 to April 2023.

(SBP) (13, 28, 29), was first presented by Allgöwer and Burri in 1967 and in healthy adults ranges from 0.5 to 0.7 (30, 8).

An increase in HF means decreased left ventricular output and acute circulatory failure. Persistent increases in HF are associated with increased mortality (8, 13, 27).

It is an early indicator of hypovolemia and could be an early marker of sepsis and septic shock (6). The Shock Index has been suggested as a useful clinical indicator for acute hypovolemia, especially in patients presenting with HR and SBP within normal ranges (11), making it a widely used tool that identifies acutely ill patients at risk of circulatory collapse in the emergency department (31). One of the advantages of using the shock index is that it is a minimally invasive monitoring (6, 7, 33).

Since this index could be useful in predicting the severity of hypovolemic shock, (8) recently, a group (*The Trauma Register TGU* of the German Trauma Society) has developed a new reliable clinical classification of hypovolemic shock based on four classes of worsening shock index (CI):

- Group I (CI <0.6, without shock)
- Group II (CI ≥0.6 to <1.0, mild shock)
- Group III (CI ≥1.0 to <1.4, moderate
- shock)
- Group IV (CI ≥1.4, severe shock) (11)

Serum lactate

For more than 30 years lactate has been recognized as a marker of hypoperfusion and inadequate oxygen delivery to tissues; there is a resurgence of lactate today thanks to technological advances that allow serum samples to be analyzed in less than 2 minutes with a faster clinical interpretation, an automatic blood gas test and arterial blood sampling, which could be considered invasive and costly in patients with normal vital signs (34).

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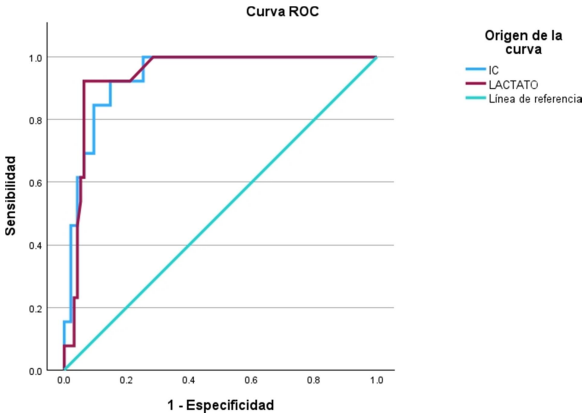

Figure 3. Comparison of ROC curves showing an area of 0.939 for the lactate curve and 0.937 for the shock index curve, which are considered a very good test since they are in the range 0.9-0.97, with an AUC of 0.90.

Serum lactate has value as a marker in states of shock, where the failure of oxygen delivery to the tissues produces a compensatory mechanism that increases the rate of oxygen extraction, which is only useful if accompanied by an adequate minimum of oxygen to avoid anaerobic metabolism and lactate production (35). It has been further identified that the decrease in lactate is a surrogate marker for adequate tissue perfusion after ROSC and potentially serves as an end point for resuscitation (36).

In recent years, the potential value of lactate on admission for predicting survival has been studied. However, the variable results of such studies mean that it is still difficult to make definitive decisions (37), mainly because the evidence generated is of low level and based mainly on small retrospective studies, determining that larger and better controlled studies are needed to assess the value of lactate as a prognostic marker in the trauma patient (38).

Methods

They were taken from the clinical record and clinical constants were recorded: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), temperature and respiratory rate.

Clinical and analytical data were also collected at admission: 24-hour evolutionary data at the end of the present investigation: water therapy, blood product transfusions, PaCO2, PaO2 and serum lactate.

Finally, the information was entered into an Excel database for statistical analysis.

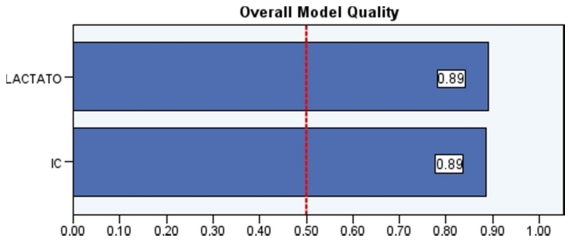

Figure 4. Reports the diagnostic yield of the tests finding an area under the curve with adequate yield for both lactate and shock index; a good model has a value greater than 0.5.

Statistical analysis

Results collected from the observation units were captured in a Microsoft Office 2019 for Windows Excel electronic collection sheet (spreadsheet(s)) to develop a database.

For the descriptive statistical analysis, measures of dispersion (range, standard deviation) were used for quantitative variables, or measures of central tendency (mode, percentage), in the case of qualitative variables. The corresponding statistical analysis was performed for a sample (Chi-2 test, binomial test, Kolmogórov-Smirnov test, as appropriate) and the analysis was based on these using descriptive statistics according to the objectives of this research work. Statistical significance of the asymptotic variables was assigned according to a critical point value (p-value) of <0.05.

The analysis of the data obtained was performed using dispersion measures (mean, median, mode, range, standard deviation, etc., depending on whether the variables were parametric or nonparametric); complementing the analysis with relevant descriptive statistics in order to identify whether in the study population the shock index and lactate are related to 24-hour mortality based on frequency, percentages and temporality of the events. The research group intends to develop the evaluation of the comparative ROC with a cut-off at 24 hours after the beginning of the observation.

The statistical analysis used the IBM SPSS Statistics 29 package in its Spanish version. The presentation of the data is through tables and graphs at the discretion of the researcher, and tools generated by means of Microsoft Office Excel 2019 for Windows were also used in order to provide the most appropriate explanation for the reader to whom this study is addressed.

Results

A total of 108 patients were analyzed who were admitted to the emergency department of HGR No 1 IMSS, Charo, with a diagnosis of

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polytrauma, of which 60 were men (55.6%) and 48 were women (44.4%) (Figure 1), in the period from May 2022 to April 2023; obtaining from them on their admission a record in the unit's laboratory of serum lactate levels, as well as vital signs (SBP and HR) that would allow us to determine the shock index.

Discussion

In the study of shock and lactate index as a prognostic factor for mortality in patients with polytrauma admitted to the ED of HGR No. 1, IMSS Charo; of the 108 patients in this study 82 had a shock index of less than 0.9, that is 75.9%, and 26 equal or greater than 0.9, that is 24.1%. Likewise, 65 patients presented a lactate level lower than 2mmol/Lt or 60.2% and 43 presented a lactate level higher or equal to 2mmol/Lt or 39.8%, 12% presented mortality. In addition, it was observed that the initial lactate levels presented significant differences between mortality and survival; and patients with an initial lactate level > 2mmol/Lt showed a higher mortality, which is mentioned in the results of previous studies although there are studies that mention figures above 3.5mmol/Lt; such as Jansen et al. who suggest that lactate above 3.5 mmol/Lt is associated with higher mortality when compared to lactate levels below 3.5 mmol/Lt in polytraumatized patients at the time of hospital admission.(36).

Regarding the shock index, a study carried out in a university hospital in Colombia by Charry J, and collaborators mentioned the shock index as a prognostic factor for mortality in patients with penetrating chest trauma where 170 patients were analyzed. 75.9% presented a shock index lower than 0.9 (group A) and 24.1%, higher than 0.9 (group B); mortality at 24 hours after the injury was 13.2% for those in group A, and in group B, 60.9%. (1) In comparison with the results of our study carried out in our environment, the same relationship with a higher incidence of mortality is demonstrated in patients admitted to the emergency department with a diagnosis of polytrauma and a shock index greater than 0.9 on admission, which implies a worse prognosis at 24 hours after the injury.

Trauma continues to be a public health problem for the world population that, according to international protocols for the management of trauma patients, such as the Advanced Trauma Life Support (ATLS) course, which requires little or no resources in the hospital setting and in initial emergency care, would not be limited in developingcountries such as ours.

As studies of these characteristics are carried out, favorable results can be observed to identify the serious patient from the Triage in the emergency services; based on this study among many others, it is observed that the male sex is a risk factor for suffering some type of trauma since a higher prevalence is observed, being 55.6% men and 44.4%women.

Another marker or predictor of mortality that is important is lactate which is mentioned in multiple studies that correlates with the presence of a shock index greater than 0.9, which the aim of this study is to have the knowledge that a shock index greater than 0.9,i.e. class II hypovolemic shock, can be a prognostic factor for mortality at 24 hours.9, i.e. class II hypovolemic shock, can be a prognostic factor for mortality at 24 hours, together with a lactate greater than 2.2 mmol/Lt, in our institution a statistically significant figure was observed tied for the shock and lactate index (p=0.001). The normal lactate value is between 0.5 to 2.2mmol/Lt, when a critically ill patient reaches twice the normal maximum value i.e. 4.4mmol/Lt the probability of death is higher. Different publications support the objective of the present study, so so far we consider both the shock index and the initial lactate value that have a useful relationship in daily practice and determine the usefulness of lactate as a marker of tissue hypoperfusion and are statistically significant as predictors of mortality in patients with a diagnosis of polytrauma admitted to the emergency department of the HGR No 1 IMSS, Charo.

Conclusion

In conclusion, through this study conducted at the Hospital General Regional No 1 IMSS, Charo, it was determined that the shock index and lactate level are prognostic factors or predictors of mortality in patients admitted with a diagnosis of polytrauma; regardless of the different variables that were considered in this study, when they present a lactate level greater than 2.0mmol/Lt and a shock index greater than 0, they have a direct impact on the incidence of mortality.9 have a direct impact on the incidence of mortality; in addition to this we mention that the shock index is a mathematical calculation that can be used quickly and easily without requiring a financial resource in all trauma patients at risk of hypovolemic shock; hence the importance of making a timely clinical diagnosis associated with early lactate measurement and early calculation of the shock index; in order to prevent the progression of possible complications of trauma patients and thus reduce the incidence of mortality in the HGR No 1 IMSS, Charo, Michoacan.

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Conflicts of interests

The authors declare no conflict of interest.

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César Rodríguez García
Hospital General Número 1.
Instituto Mexicano del Seguro Social
Michoacán, México.

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