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Research Article

Shock Index and its Variations for Blood Loss Assessment in Polytrauma

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Abstract

Among the main causes of morbimortality of polytrauma as a result of blood loss, is hemorrhagic shock, being equivalent to almost 50% of deaths in the first 24 hours after injury. It is a type of hypovolemic shock resulting from the loss of more than 20% of the body's blood, which can result in organ failure and death. With reduced tissue perfusion and irreversible cellular injury, there is the possibility of circulatory system failure, so that the shock once started, is prone to become worse. In this context, the aim of this study was to analyze the use of the shock index and its variations on the assessment of blood loss in polytrauma patients. Nineteen articles targeting the review theme were selected, which were analyzed and studied to address the outcome of the subject addressed. The results indicated that the Shock Index (SI), portrayed by the relationship between heart rate and systolic blood pressure is a reliable and efficient predictor in the purpose of assessing the need for blood transfusion and intensive interventions. Applying this scoring system in conditions of shock resulting from trauma, together with the education of health professionals on it, will cause a decrease in risk and a better outcome.

Keywords: Shock; Shock index; Hemorrhage; Blood loss

Introduction

Hemorrhagic shock is the leading cause of preventable mortality in polytrauma patients. To avoid this event, it is necessary to adopt measures aimed at early recognition of shock for treatment and stabilization of the patient. However, its initial identification remains a challenge both in and out of the hospital, a fact that results in poor diagnosis and inappropriate transfer of patients.

The shock index (SI) is used as the basis for this identification and is defined as Heart Rate (HR) divided by Systolic Blood Pressure (SBP). In order to try to fill the gap in the use of measurements for the recognition of this state, some modifications of this indicator have emerged. Thus, scientific research has begun to analyze the efficiency of these parameters in the identification of hemorrhagic shock, so that it is possible to achieve a faster stabilization and initiation of early treatment, avoiding the mortality of polytrauma patients.

Hemorrhagic shock is the leading cause of avoidable mortality in polytrauma patients, being responsible for 50% of deaths within 24 hours of admission to a trauma center* [1].

To avoid it, it is necessary to adopt measures aimed at its early recognition to stabilize and treat the patient. However, its initial identification* remains a challenge in both the pre-hospital and in-hospital settings, since there is the compensatory phase of shock, in which the patient still remains with his or her normal vital signs even with significant blood loss, a fact that results in poor diagnosis, inappropriate patient transfer, misuse of hospital resources, and higher mortality. (Whatever else results).

The Shock Index (SI), created in 1967 by Allgöwer and Burri with the goal of establishing hemodynamic status based on simple vital sign measurements [2], is used as the basis for this identification. In order to try to fill the gap in the use of these measurements for the recognition of shock state, there has been the emergence of some modifications of this indicator. Some evidence establishes that the currently acceptable value is between 0.5 and 0.7, although other evidence suggests that values up to 0.9 are also admissible. It is postulated that values very close to 1 are indicative of clinical worsening and that increasing SI has been related to a decrease in left ventricular end-diastolic volume pressures and circulatory volume [3].

Some studies have been developed to analyze and compare the efficiency of these parameters in the identification of hemorrhagic shock, so that health professionals can ensure early stabilization and treatment of the condition, better use hospital resources for such and thus decrease the mortality of polytrauma patients.

Methods

This work is a systematic literature review, with a qualitative approach, which aims to analyze the use of the shock index and its value variations to assess blood loss in polytrauma patients in the adult population. Moreover, the nature of this research fits as a basic and comprehensive research of data collection in original studies, presentation of results and confrontation with the current literature, according to the authors.

At first, a search for descriptors related to the theme was performed, which were identified using the DeCS (Descriptors in Health Science), thus the following terms were used for research: “shock index”, “reverse shock index”, “adjusted shock index”, “trauma score”, “trauma index”, and exclusion of the terms “pediatrics” and “geriatrics” that allowed the formulation of the following search formula, considering the use of the terms in the title or abstract of the works: “(shock index[Title/Abstract] OR reverse shock index[Title/Abstract] OR adjusted shock index)[Title/Abstract] AND (trauma scores[Title/Abstract] OR trauma index) NOT (pediatric[Title/Abstract] OR geriatric)[Title/Abstract]”.

Then, a PubMed search was performed, and a total of 367 articles were found. After searching for the articles that met the pre-established criteria, the first step was to analyze the title and abstract of the articles, which was performed by two researchers, and then only the articles that were agreed upon by both were selected, as can be seen in (Figure 1).

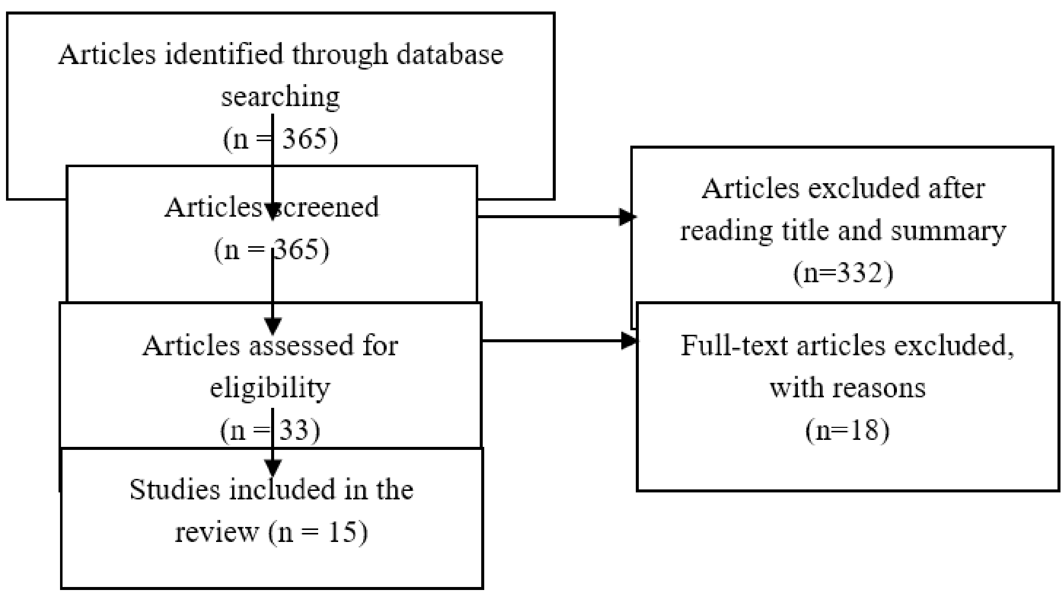

Figure 1: Flow diagram of the included articles.

The inclusion criteria were: articles in English, Portuguese and Spanish, articles that aimed the review theme, that is, the use of the shock index and its several variations to assess blood loss in polytrauma patients. Moreover, it was used as exclusion criteria: articles that did not meet the research objective, main focus on other indexes with simple citation of the shock index, as not having such indexes being used for purposes other than to assess blood loss in polytrauma, pediatric population, geriatric and pregnant women, articles with unavailable reading and letters to the reader.

Finally, 15 articles were chosen, which would be studied and analyzed, with the objective of explaining the outcome of the theme addressed. It is worth pointing out that the research does not have a practical nature, which exempts, therefore, the need for submission to the Research Ethics Committee (CEP) (Table 1).

Results

Author/year	Sample	Study type	Intervention	Results
Cheng-Shyuan Rau et. al, 2016	N = 2490	Retrospective study	From data obtained, from the Trauma Record System, of a regional center of level 1 trauma, of trauma patients upon arrival at the hospital, the use of parameters, as Shock Index, Modified Shock Index and Shock Index by Age, to predict the need of massive transfusion	The Shock Index is more reliable in predict the need of MT than the others parameters, as Systolic Blood Pressure (SBP) or Heart Rate (HR). With a SPB of 120,5 mmHg, a SI of 0,95 and a MSI of 1,15 was identified as the cut-off point for the requirement of MT, as a AUC (Area Under the graph Curve) of 0,716, (sensitivity: 0,725 and specifity: 0,636), 0,760, (sensitivity: 0,563 and specifity: 0,876) and 0,756, (sensitivity: 0,615 and specifity: 0,823), respectively. But, this predict power may be committed with comorbidities.
L.J. Terceros-Almanza et. al, 2016	N = 287	Retrospective study	With system data, of a tertiary hospital, patients admitted to the trauma room, over 14 years old, trauma victims, was observed a capacity of SI and MSI to predict severe **bleeding** and, consequently, define the ideal cut-off point to massive transfusion in patients that suffered severe trauma.	As Much the Shock Index (SI) as the Modified Shock Index (MSI) offers a good capacity of predict massive **bleeding**. To the Shock Index obtained AUROC 0.89 (confidence interval of 95%: 0.84---0.94), with a ideal cut-off point in 1.11, sensibility 91.3% (95% CI: 73.2---97.58) sensitivity 79.69% (95% CI: 74.34---84.16). To the Modified Shock Index obtained AUROC 0.90 (95% CI: 0.86---0.95), with a ideal cut-off point of 1.46, sensitivity 95.65% (95% CI: 79.01---99.23) specificity 75.78% (95% CI: 70.18-80.62). And, the obtained results are comparable to those of Other studies that describe SI and MSI as potentially useful to the identification of hemorrhagic shock as inside as outside the hospital.

Julien Pottecher, et. al 2016	N = 2557	Retrospective study	The study evaluated the precision of the SI pre-hospital and the hemodynamic index (pulse pressure/heart rate) to predict often MT, using the gray zone approach, from collected data from a Trauma Record (TRENAU), that campares the combined screening scheme with the patient gravity and the hospital facilities.	As the SI as the PP/HR were moderately effective on the prediction of MT in trauma patients. In the entire population, the relation PP/HR and moderate SI and similarly preview to MT (área under the receiver operating characteristic curve 0,77 [confidence interval of 95% {CI}, 0,70-0,84]. The proportion of patients in the gray zone to the relation PP/HR and SI were 61% versus 40%, respectively, to predict the massive tranfusion type 1 (≥10 units of red blood cells [RBC] for 24 hours) (p<0,001) and 62% versus 71%, respectively, to predict the massive tranfusion type 2 (transfusion of 3 RBC's or more during the first hour of admission) (p <0,001). In the less severe patient, both index had a reasonable precision to predict MT1 (0,91 [IC of 95%, 0,82-1,00] vs. 0,87 [IC of 95%, 0,79-1,00]; p=0,683), and the relation PP/HR overcame SI to predict MT2 (0,72 [IC of 95%, 0,59-0,84] vs. 0,54 [95% CI, 0,33-0,74]; p <0,015).
Young Tark Lee et. al, 2020	N = 1627	Retrospective study	Shock Index scale capacity X Glasgow coma scale to predict MT in trauma patients, from na observational study in a level 1 trauma center.	The Shock Index X Glasglow Coma Scale (rSIG) score is a useful, fast, and accurate predictor for MT, coagulopathy, in-hospital mortality, and hourly mortality in trauma patients. rSIG showed the highest area under the receiver operating characteristic curve (AUROC) (0.842; confidence interval of 95% [CI], 0.806-0.878) for predicting MT. rSIG also showed the highest AUROC for predicting coagulopathy (0.769; 95% CI, 0.728-0.809), in-hospital mortality (AUROC 0.812; 95% CI, 0.772-0.852), and 24-hour mortality (AUROC 0.826; 95%, 0.789-0.864).
Andrea Campos-Serra et. al, 2018	N = 1402	Analytical study	The study evaluated a cut-off point greater than or equal to 0.8 is more sensitive to detect occult bleeding, allowing the initiation of previous therapeutic maneuvers, based on the relationship of the shock index with 5 variables (need for MT, angiographic embolization, surgical control of bleeding, hypovolemic shock, and active bleeding), with data obtained from a third-level hospital.	The SI with a cut-off point greater than or equal to 0.8 is more sensitive than a cut-off point greater than or equal to 0.9 and allows the initiation of resuscitation maneuvers in patients with occult bleeding. The mean injury severity score was 20.9. There was a 10% mortality. The mean SI was 0.73 (DP 0.29). In total, 18.7% of patients had "active bleeding". The mean SI in patients with "active bleeding" was 0.87, while vital signs were within the normal range. The area under the SI ROC curve for "active bleeding" was 0.749.

II-Jae Wang et al, 2019	N=1007	Retrospective observational study	They evaluated if pre-hospital MSI is more accurate than pre-hospital SI in predicting massive transfusion and mortality in trauma patients, thus calculating the cut-off values of the **scores** by the ROC curve and, to calculate the predictive value, they calculated the areas below the curve and defined cut-off points with high, moderate and low accuracy.	Pre MSI is not superior to pre SI in predicting massive transfusion (AUROC pre SI [0.773 (95% CI, 0.746–0.798] and pre MSI [95% CI, 0.738–0.791]) and hospital mortality, both of which are moderately accurate (AUROC between 0. 7-0.9) Also, pre SI can be more useful as it is easier to calculate.
Alexander Olaussen et al, 2015	N=5619	Retrospective observational study	To evaluated if the combination of the first pre-hospital SI value and the first trauma center SI value can increase MT prediction.	The initial pre-hospital SI is associated with in-hospital massive transfusion, but pre-hospital objective measures of hemorrhagic shock did not clinically increase the massive transfusion decision when combined with in-hospital values.
Faisal Jehan et al, 2019	N=144951	Retrospective observational study	A 2-year retrospective analysis to evaluate if SI can predict transfusion requirements, hospital resource utilization, and mortality. Selected patients were divided into two groups (SI ≤ 1 and SI > 1), based on the cut-off of SI > 1 (demonstrated with greater sensitivity and specificity of ROC curve analysis).	Patients with pre-hospital SI > 1 had a greater need for blood products in the first 4 hours as well as the first 24 hours of resuscitation compared with patients with pre-hospital SI ≤ 1. SI > 1 had a higher probability of massive transfusion (25% vs. 0.012%, p < 0.02) compared with SI ≤ 1. SI > 1 had higher adjusted blood product requirements in patients with penetrating trauma.
Darcy L. Day et al, 2016	N=116	Retrospective case series study	Retrospective analysis of the association of pre-hospital IS and universal donor transfusion with multiple transfusions in patients who received a transfusion of ≥1 RBCs during the first 6 hours after arrival at the trauma bay.	A prehospital SI of 0.98 is associated with transfusion of uncrossed RBCs in the trauma bay. An SI ≥ 1 (p=.02) and not compared RBC transfusion is significantly associated with MULT for trauma patients.
Manianne J. Vandromme et al, 2011	N=8111	cohort, prospective	Patients were categorized according to SI based on pre-hospital vital signs, being considered relatively normotensive (SBP >90mmHg). Relative risk (RR) and confidence interval (CI) for massive transfusion requirement (> 10 units less than 24 hours of admission) were calculated using SI between 0.5-0.7 (normal range) as reference for all comparisons.	There was an increased risk of need for massive transfusion in patients with an SI >0.9, and patients with an SI between 0.9 and 1.1 had a 1.5 times increase in risk (RR, 1.61; 95% CI, 1.13–2.31), SI between 1.1 and 1.3 of 5 times (RR, 5.57; 95% CI, 3.74 – 8.30) and >0.3 of 8 times (RR, 8.13; 95% CI, 4.60 –14.36).

Schroll Rebecca, et al, 2017	N=645	cohort, prospective	The SI and ABC score were calculated for each patient included in the study, then sensitivity, specificity and AUROC were analyzed to assess these **scores** and determine which best predicts the need for early MTP activation.	SI is a more sensitive predictor, being 67.7% (95% CI 49.5% to 82.6%) compared to the ABC score with 47% (95% CI 29.8% to 64.9%) sensitivity and requires less technical skill to calculate than ABC score, in need of early MT.
Ayman El-Menyar, et. al, 2019	N = 572	Retrospective study.	Evaluate the usefulness of the SI for predicting the need for a massive transfusion protocol (MTP) in patients with solid organ injury (SOI) in a level 1 trauma center.	In patients with SOI, SI is a simple bedside predictor for BT and MTP activation. In multivariable regression analysis using 9 relevant variables (age, sex, ISS, ED GCS, serum lactate, hematocrit, abdomen AIS, and focused assessment with ultrasound in trauma (FAST) and SI), SI ≥ 0.8 was a predictor. independent of BT (OR 2.80; 95% CI 1.56–4.95) and MTP (OR 2.81; 95% CI 1.09–7.21).
Manuel Mutschler, et. al, 2013	N = 21.853	Retrospective study.	Correlate classification group developed a new reliable clinical classification of hypovolemic shock based on four classes of worsening base deficit (BD) to the corresponding strata of the SI for fast assessment of trauma patients in the absence of laboratory parameters.	The SI at ED arrival can be considered a clinical indicator of hypovolemic shock with respect to transfusion requirements, hemostatic resuscitation, and mortality. The four SI groups proved to be equal to our recently suggested BD-based classification. The overall accuracy for predicting transfusion need was similar for both parameters, as reflected by an area under the receiving operating characteristics curve of 0.711 (0.703 to 0.720) for BD and 0.719 (0.710 to 0.728) for SI, respectively (P = not significant) In daily clinical practice, the SI can be used to assess the presence of hypovolemic shock if laboratory technology or POCT is not available.
Christopher W. Marenco, et. al, 2020	N = 4008	Retrospective study.	It is hypothesized that SI can reliably identify combat trauma patients who will require MT and ESP when applied to the resource-limited combat environment.	SI is a significant predictor of the need for MT and ESPs in the military trauma population, representing a simple and potentially potent tool for sorting and predicting resource consumption in a rigid environment with limited resources. The sensitivity of the chosen cut-off value of SI 0.8 for predicting the need for MT was 87%, the specificity was 78%, and the negative predictive value (NPV) was 99.6%, with a YI of 0 .66. The sensitivity and specificity of this threshold to pre-dict the need for ESP were less robust at 59% and 81.5%, respectively, but NPV remained high at 93.5% with a YI of 0.41.

Ayman El-Menyar, et. al, 2018	N = 8710	Retrospective study.	Evaluate the clinical utility of the IS for assessing the need for blood transfusion and predicting trauma results.	The post-injury SI can be used early to predict the need for MTF and laparotomy and mortality. It correlates with other physiological and anatomical variables. However, their cut-off values for risk stratification and prognosis need further evaluation. After adjusting for age and sex, ISS, and Glasgow Coma Scale in two multivariate analyses, high SI was found to be an independent predictor for mortality (odd proportion, 2.553; 95% confidence intervals: 1.604-4.062) and blood transfusion. (odd ratio, 3.57; 95% confidence intervals: 3.012-4.239). The SI cut-off point for predicting MTP is 0.81 (sensitivity, 85%; specificity, 64%; positive predictive value, 16%; and negative predictive value, 98%).

Table 1: 15 articles were chosen, which would be studied and analyzed.

Fifteen articles were analyzed whose main characteristic was original studies, of which 80% correspond to retrospective studies (N=12), with the largest fraction of this study, 13.33% of the cohort type (N=2) and 6.66 % of analytical type (N=1).

The sample size of the studies ranged from 116 to 144951 participants (mean=) and the epidemiological profile showed that there was a higher prevalence in males (ranging from 61 to 97.9%), mean age ranging from 25.5 to 53 years, according to the population studied and the most common injury pattern was blunt injury, evidenced in 14 studies, reaching ≥84.7% of injuries in 10 studies.

There were 5 studies that evaluated pre-hospital SI values for blood transfusion requirements. One of these studies demonstrated that patients who received a universal donor transfusion at the trauma center had a higher mean pre-hospital SI (0.98 ± 0.28) than those who did not (mean = 0.82) and, in addition, those who received multiple transfusions, defined as ≥6 units of blood transfused in the first 6 hours, had an even higher mean pre-hospital SI (mean =1.0 ± 0.33) [1].

Another study evaluated its usefulness in relatively normotensive patients (considered to have SPB >90mmHg) who required MT (>10 blood bags in 24 hours) and divided the sample into 6 groups based on prehospital SI. It demonstrated that there was a significant increase in the risk of MT in those with SI > 0.9, with an RR of 8 times in those with SI > 1.3 [4].

The study that evaluated whether an association between pre-hospital IS and in-hospital IS increases the prediction of massive transfusion need (≥5 units of blood in the first 4 hours), showed that pre-hospital IS can predict need for transfusion, but the association does not increase the prediction [5].

Thus, it was also evidenced in another study, which divided two groups of pre-hospital SI (one group with SI ≤1 and the other SI >1), that those with a cut-off point >1, have a predictive value for hospital resource use, such as blood transfusion (p<0.001) [6]

In another study, it was evaluated if pre-hospital IS and pulse pressure (being the difference between systolic pressure and diastolic pressure), divided by heart rate, are good predictors of massive transfusion. Both have been shown to be moderately effective in predicting both critical MT (≥ 3 RBC units in the first hour of admission), having a PP/HR AUC-ROC curve of 0.71 (95% CI, 0.67–0.76) and pre-hospital 0.72 (95%CI, 0.68–0.77), and classic MT (≥ 10 red blood cell units in the first 24 hours) [7]

Two studies compared SI and MSI. One of them compared their pre-hospital values, and demonstrated that the pre-hospital MSI did not have greater predictive power for massive transfusion than the pre-hospital SI, with AUROC being 0.765 (95% CI, 0.738–0.791) and 0.773 (95% CI). CI, 0.746–0.798), respectively [8]. The other study compared their in-hospital values, and showed that both have good values for predicting massive transfusion and consequently determining massive bleeding, having an SI AUROC of 0.89 (95% CI 0.84-0.94), with an ideal cut-off point at 1.11 and MSI AUROC of 0.90 (95% CI: 0.86-0.95), with an ideal cut-off point of 1.46 [9].

One study compared SI with other variations, such as MSI, ASI (age shock index) and showed that only SI and MSI had moderate discriminatory power (defined as AUC >0.7 and <0.9), with the cut-off point for each one was 0.95 (AUC of 0.760) and 1.15 (AUC of 0.756), respectively [10]

One study compared the ability of reverse SI multiplied by the Glasgow Coma Scale (rSIG) with the variables SI, SAI and qSOFA in predicting massive transfusion, and demonstrated that rSIG had the highest AUROC in predicting MT (0.842 [95% CI, 0.806–0.878]), followed by the SI of 0.796 (95% CI, 0.748–0.844) [11].

One study was military, and evaluated SI as a predictor of MT on the battlefield and demonstrated that SI ≥ 0.8 is a reliable and accurate predictor to determine the need for MT, having a sensitivity of 87% and specificity of 78%. [12]. One study evaluated if SI is a good predictor of MT in solid organ trauma patients with blunt abdominal trauma and concluded that SI ≥ 0.8 has greater sensitivity (85%) and negative predictive value (96%) than SI ≥ 0, 9 and ≥1.0 in predicting MT [13].

Three studies evaluated which SI cut-off points are most useful for determining massive transfusion. One evaluated and divided SI into two groups, and demonstrated that those with an SI ≥0.8 had a greater need for transfusion than those with an SI <0.8 and that an SI of 0.82 is more likely to receive massive transfusion (sensitivity 85 %, specificity 64%) [14]. Another study divided SI into 4 groups (group I SI <0.6; group II SI ≥0.6 to <1.0; group III SI ≥1.0 to <1.4; and group IV SI ≥1.4) and concluded that the increase in the SI value it also increases the need for transfusion, especially for groups III and IV [15]. In addition, a study sought to assess whether SI ≥0.8 is more sensitive than SI≥0.9 in the assessment of occult hemorrhage and concluded that it has greater sensitivity, being 59.2% and 46.2%, respectively [16].

Discussion

In a polytrauma scenario, the risks of blood loss become significant and, as a consequence, there is a high rate of associated morbidity and mortality. Among the main causes, hemorrhagic shock is the most frequent, therefore, massive hemorrhage is the main cause of pre-hospital deaths in severe trauma, corresponding to almost half of the deaths that occur in the first 24 hours after the injury [9].

Given the seriousness of the situation to which polytraumatized patients are exposed, it is essential that the team in the pre-hospital environment is able to recognize severe cases and then make decisions related to both field interventions and the transfer of patients to services prepared, as the accurate transfer of information to the hospital team can ensure better preparation, reception and care for that patient, allowing to achieve optimal results with better recovery rates after trauma [5,6,8].

In order for the sorting of polytraumatized patients in need of blood transfusion to be carried out in the best possible way, covering the real cases, there are scores that have been developed and are constantly evolving. These scores aim to guarantee an excellent positive predictive value, in order to become effective for the recognition of these situations. One of the most relevant aspects is that the tool developed is easy to apply by the team and is based on the use of objective data available quickly in the scenario itself, given the importance of being carried out at the exact moment in the pre-hospital environment, in which there is no there is access to a lot of information [6]

Therefore, one of the main tools currently used is the Shock Index (SI), which corresponds to the ratio between heart rate (HR) and systolic blood pressure (SBP), and detects acute hypovolemia and circulatory collapse [4, 15]. In addition, it presents the main characteristics mentioned, such as being easy to apply by the team, using readily available data and being specific in the recognition of cases that require blood transfusion, preventing blood products from being prepared and wasted, and finally, it allows communication with the hospital environment so that the transfusion is performed in a timely manner to prevent and treat acute traumatic coagulopathy, reducing the rates of premature death after trauma [5,6]. Thus, early activation of the massive transfusion protocol has the dual benefit of improving patient outcome and limiting the use of blood components, decreasing complications [7].

As an example, a patient with pre-hospital HR = 100 bpm and pre-hospital SBP = 110 mm Hg (and, therefore, an SI of 0.91) has more than 1.5 times the risk of receiving massive blood transfusions (MT) compared to normal SI; a patient with pre-hospital HR = 120 bpm and pre-hospital SBP = 105 mm Hg (SI, 1.14), the risk of MT is five times increased [4]. In addition, there are some variants of the SI and other scores with the same purpose, but most of them have some disadvantages, such as being difficult to apply or requiring laboratory tests, send others [12].

SIs Cut-Off Values

As mentioned, the SI is the most widely used score, and currently, its cut-off value has been discussed, with the aim of standardizing a more reliable value with the patient's real situation and needs, in addition to being easy to apply.

There are still some divergences regarding the cut-off point, as some studies defend an SI value ≥ 0.8 [12, 13, 14, 16] others with SI ≥ 0.9, and finally some with SI ≥ 1.0 [6, 10]

The lower the cut-off point, the higher the sensitivity and lower the specificity of detecting critical post-trauma bleeding and hypotension, which can lead to erroneous activation of the protocol, in addition to unnecessary expenses, but allows avoiding the loss of patients potentially with apparently normal vital signs [16]. On the other hand, the higher the cut-off point, the lower the sensitivity and the higher the specificity, which means that most patients with this value actually need the MT, in addition to the fact that it facilitates the calculation by professionals in the prehospital environment and spend less time to do so, because when the SBP of the trauma patient is numerically lower than their HR, it already corresponds to an SI ≥ 1.0 [6,10]. In another view, another study delimited that an increase>0.3 is associated with a 22% increase in mortality, suggesting that the change in itself over time can also have clinical value [6].

However, in general, the applicability of the SI is extremely relevant because, regardless of the cut-off value, a high SI corresponds to a high probability of bleeding. In addition, it is important to emphasize that the parameters of vital signs may be within the normal range, but if the SI is above the cut-off point, there is considerable risk [16].

In view of multiple trauma in the elderly, some studies consider the applicability of the IS in this population to be fundamental, as vital signs may appear normal when the patient is in a situation of hemorrhagic shock. With senescence, there are several changes in the functionality of the human body, one of which is the reduction of the maximum capacity of the heart rate, reflecting, therefore, in a lower capacity of tachycardia in response to critical and intense post-trauma bleeding, and the other, systolic blood pressure, which tends to be higher. Thus, it is evident that vital signs in the geriatric population are not so reliable, and therefore, the use of the IS in the face of multiple trauma should be performed, regardless of the numbers of vital signs, as the IS can early identify the need for MT [16].

Furthermore, the Age SI was developed particularly for geriatric patients, with an age adjustment to increase the SI's discriminating ability [10]

Comparison SI Pre-Hospital and Trauma Center

The use of IS in the pre-hospital environment is considered fundamental, as it guarantees the so-called "golden hour", where the optimization of time and resources provides greater patient survival, reducing risks and morbidity and mortality rates [8]

In the pre-hospital environment, the SI and the modified shock index (MSI) are the best scores to use, as they are simpler and faster to calculate [8]. In addition, the incorporation of pre-hospital SI has brought significant improvements in the correct and effective prediction of MT [5].

On the other hand, at hospital evaluate and trauma center, the IS assessment may not be so reliable, as the data may have been influenced by actions performed in pre-hospital care, such as administration of intravenous fluids, sedation and/or use of vasopressors, and therefore, it may not reflect the patient's actual situation [13, 15].

Comparison SI and MSI

The MSI is based on the SI, but corresponds to the ratio between HR and mean arterial pressure (MAP), the latter being the result of [SBP + (DBP x 2)] / 3 [10]. With this MAP calculation formula, the prediction of the current tissue perfusion situation is more reliable and compatible with the patient's condition, thus, theoretically, the MSI can more realistically predict the severity and need for MT in critically ill patients [7].

When the SI is compared with the MSI at the hospital level, the MSI presents more faithful results, however, at the pre-hospital level, where the applicability guarantees greater life support to the patient, the MSI is not superior to the SI. Therefore, currently, the pre-hospital SI is still the most recommended, because in addition to not being inferior to the MSI, it allows a faster and more effective calculation by the emergency team, predicting the need for MT [8,10]. However, with the advent of technology, and the development of hemodynamic monitors available in the pre-hospital environment, the MSI calculation can be used in a complementary way in the prediction of MT in the field [7].

Comparison SI and other Scores

Comparison SI and Score ABC

The ABC **score** assesses four variables, namely SBP (≤ 90 mmHg), HR (≥ 120 bpm), FAST (positive) and the type of trauma, with a score ≥ 2 corresponding to the need to activate the MT protocol.

Regarding the comparison between the SI and the ABC **score**, the SI ≥ 1 showed a greater ability to predict the need for MT than the ABC **score**, being therefore more useful, as it reduces the risk of false negatives and waste of inputs and expenses. In addition to greater sensitivity, the SI requires less technical skill, fewer resources and less time spent on calculation [13].

Furthermore, another study showed that neither the penetrating mechanism of injury nor a positive FAST test significantly predicted the need for MT, but traditional vital signs of HR and SBP predicted it.

Comparision SI and Score Trash (Trauma Associated Severe Hemorrhage)

The TASH score encompasses gender, SBP, hemoglobin, pulse, base excess, FAST, unstable pelvic fracture and open femoral fracture, with a score < 9 corresponding to < 5% of MT need, and a score > 24 corresponding to > 85 % of MT need.

The TASH score is one of the best when performed in a hospital environment, as it does not require computer assistance as a technology, but has the disadvantage of being time-consuming to calculate, since it depends on laboratory and imaging resources. In addition, this score cannot be used in the pre-hospital environment, due to the variables it uses, such as hemoglobin, base excess, and others [5]. Thus, the SI remains the recommendation when compared to the TASH score.

Comparison of SI and ISS (Injury Severity Score)

The ISS evaluates the lesion in different segments of the body, evaluating six regions that are, skull and neck, face, chest, abdomen and pelvis, skeletal and general, and its score can vary from 1 to 75, and the higher the value, the greater the value the greater the severity of the trauma.

Studies show a correlation between ISS (Injury Severity Score) and SI, with the higher the SI, the more severe the injury, as well as the ISS. In addition, higher values increase the likelihood of surgical interventions, mechanical ventilation, prolonged ICU stay and longer hospital stay [14, 15].

Use of the SI and Relationship with Commodities

The rate of comorbidities in the general population is very high, the main ones being Systemic Arterial Hypertension (SAH), Diabetes Mellitus (DM), Coronary Artery Disease (CAD), and others. In view of these comorbidities, unlike what happens in healthy people, the systemic and dynamic response of the human body, such as HR and SBP, in the face of trauma, can be compromised, consequently leading to an interference in the IS. One method used to minimize this change is to calculate the SI serially, and therefore, use the average of the SI measurements in the pre-hospital environment, adding more value to the result and being able to predict if there is critical bleeding and the real need of MT [10].

Relationship of Pre-Hospital SI and Use of Hospital Resources

The relationship between the pre-hospital SI and the need to use resources on arrival at the hospital environment is proportional to the SI value, and, in general, SI ≥ 1.0 can predict greater use of equipment and longer recovery time. Patients with prehospital SI ≥ 1.0 are more likely to need surgery, ICU and for a longer period of time, prolonged hospitalization, blood products in the first 4 hours and during the 24-hour resuscitation period. In addition, it was observed that these patients had higher rates of complications such as acute renal failure, deep vein thrombosis, pneumonia, and even death [9].

Conclusion

In conclusion, the Shock Index (SI) is a reliable and effective predictor for determining the need for blood transfusion and intensive interventions, and it's easy calculation makes it practical to apply. Based on the data brought by the articles included here, it was not possible to determine a best SI reference value that should be applied by professionals. However, it is worth noting that higher SI values increase the likelihood of longer hospital/ICU stays, mechanical ventilation and surgical interventions. Moreover, it is valid to point out that changing the cutoff point of the SI value can change its specificity and sensitivity. Therefore, it is necessary to apply this scoring system in trauma and shock situations associated with the education of health professionals, so that they can apply it quickly and interpret it adequately to provide patients with the best possible therapeutic approach, aiming to reduce the risks arising from the incident and improve the outcome of the situation.

References

1. Darcy L Day , Kathleen M Anzelon, Franscisco A Conde (2016) Association of prehospital shock index and trauma bay uncrossmatched red blood cell transfusion with multiple transfusion. Journal of Trauma Nursing. 23: 89–95.
2. Allgöwer M, Burri C (1967) Schockindex. Deutsche Medizinische Wochenschrift. 92: 1947 1950.
3. Erica Koch, Shannon Lovett, Trac Nghiem, Robert A Riggs, Megan A Rech (2019) Shock index in the emergency department: Utility and limitations. Open Access Emergency Medicine. 11: 179–199.
4. Marianne J Vandromme, Russell L Griffin, Jeffrey D Kerby, Gerald McGwin Jr, Loring W Rue 3rd, et. al (2011) Identifying risk for massive transfusion in the relatively normotensive patient: Utility of the prehospital shock index. Journal of Trauma - Injury, Infection and Critical Care. 70: 384–390.
5. Alexander Olaussen, Evan L Peterson, Biswadev Mitra, Gerard O'Reilly, Paul A Jennings. et al. (2015) Massive transfusion prediction with inclusion of the pre-hospital Shock Index. Injury. 46: 822–826.
6. Faisal Jehan, Jorge Con, Matthew McIntyre, Muhammad Khan, Asad Azim, et al. (2019) Pre-hospital shock index correlates with transfusion, resource utilization and mortality; The role of patient first vitals. American Journal of Surgery. 218: 1169–1174.
7. Julien Pottecher, François-Xavier Ageron, Clémence Fauché, Denis Chemla, Eric Noll, et al.(2016) Pre hospital shock index and pulse pressure/heart rate ratio to predict massive transfusion after severe trauma: Retrospective analysis of a large regional trauma database. Journal of Trauma and Acute Care Surgery. 81: 713 722.
8. Il-Jae Wang, Byung-Kwan Bae, Sung-Wook Park, Young-Mo Cho, Dae-Sup Lee et al. (2019) Pre-hospital modified shock index for prediction of massive transfusion and mortality in trauma patients. American Journal of Emergency Medicine. 38: 187-190.
9. L J Terceros-Almanza, C García-Fuentes, S Bermejo-Aznárez, I J Prieto-Del Portillo, C Mudarra-Reche. et al. (2017) Prediction of massive bleeding. Shock index and modified shock index. Medicina Intensiva. 41: 532–538.
10. Cheng-Shyuan Rau, Shao-Chun Wu, Spencer C. H. Kuo, Kuo Pao-Jen, Hsu Shiun-Yuan et al. (2016) Prediction of massive transfusion in trauma patients with shock index, modified shock index, and age shock index. International Journal of Environmental Research and Public Health. 13: 683.
11. Young Tark Lee, Byung Kwan Bae, Young Mo Cho, Soon Chang Park, Chang Ho Jeon. et al. 2020 Reverse shock index multiplied by Glasgow coma scale as a predictor of massive transfusion in trauma. American Journal of Emergency Medicine. 46: 404-409.
12. Christopher W Marenco, Daniel T Lammers, Kaitlin R Morte, Jason R Bingham, Matthew J Martin. et al. (2020) Shock Index as a Predictor of Massive Transfusion and Emergent Surgery on the Modern Battlefield. Journal of Surgical Research. 256: 112–118.
13. Ayman El-Menyar, Gaby Jabbour, Mohammad Asim, Husham Abdelrahman, Ismail Mahmood. et al. (2019) Shock index in patients with traumatic solid organ injury as a predictor of massive blood transfusion protocol activation. Injury Epidemiology. 6: 41.
14. Ayman El-Menyar, Priya Goyal, Elizabeth Tilley, Rifat Latifi et al. (2018) The clinical utility of shock index to predict the need for blood transfusion and outcomes in trauma. Journal of Surgical Research. 227: 52–59.

15. Manuel Mutschler, Ulrike Nienaber, Matthias Münzberg, Christoph Wölfl, Herbert Schoechl, et al. (2016) The Shock Index revisited - a fast guide to transfusion requirement? A retrospective analysis on 21,853 patients derived from the TraumaRegister DGU®. Critical Care. 17: R172.

16. Andrea Campos-Serra, Sandra Montmany-Vioque, Pere Rebasa-Cladera, Heura Llaquet-Bayo, Raquel Gràcia-Roman, et al. (2018) The use of the Shock Index as a predictor of active bleeding in trauma patients. Cirugia Espanola. 96: 494–500.