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The Most Common Tools to Measure Trauma Severity: A review Study

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ABSTRACT

Introduction: Due to the increasing mortality rate from trauma, determining the severity of injury has a very important role in the prognosis of the injured person. On the other hand, the quality of medical care provided to the casualties is evaluated using the Trauma Scoring System. Various scales were used to determine the trauma severity of injured. In this study, the most commonly used tools are investigated.

Methods: This review was conducted by searching throughout the Persian data bases of Magiran, Barakat, SID and English databases of Scopus, Web of sciences, PubMed, and Google scholar. To conduct the search, the following keywords were used: "Severity of Trauma", "Trauma scoring", and "Trauma Scoring System" without considering any time intervals. Our early search resulted in 2125 articles. Finally, 17 articles were analyzed and different functions of traumatic assessment tools were compared and studied.

Results: Traumatic assessment methods vary based on the anatomical and physiological parameters and composition of these two methods. In this study, the Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), and New Injury Severity Score (NISS) were considered as anatomical parameters; Revised Trauma Score (RTS) as physiological parameters; Trauma Score Injury Severity Score (TRISS) and A Severity Characterization of Trauma (ASCOST) were mentioned as a hybrid ranking system.

Conclusion: Application of accurate scientific evaluations in trauma severity assessment methods and application of each method in its appropriate position would result in appropriate improvements in the development of trauma care. In addition, these systems can play an important role in providing care to patients with traumatic injuries in the present and future.

Keywords: Trauma scoring system; Trauma; Severity of trauma
Abbreviations: AIS (Abbreviated Injury Scale), ISS (Injury Severity Score), NISS(New ISS), RTS (Revised Trauma Score), TRISS (Trauma Score Injury Severity Score (ASCOST A Severity Characterization of Trauma)

Introduction

Trauma is the first cause of mortality and one of the main causes of disability and disorder among active population in the developing countries (1). Any injury, lesion, shock, harm, or

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accident that happen to human body is considered as a trauma in the medical sciences, provided that it was entered from the outside and no internal factor caused the injury (2). Management of the traumatic injuries is a major issue in medical science. In the management of traumatic patients, two important challenges exist that include delivering the injured person to the closer and more appropriate traumatic center and estimating the severity of the trauma. Due to an increase in the mortality rate caused by trauma, determining the casualty's severity of injury has a very vital role for prognosis of the injured person. Furthermore, this kind of assessments can be applied to evaluate the quality of medical care provided for casualties (3). Evaluating the trauma scores are necessary to perform any research, accurate assessment of injuries, compilation of preventive programs, quality of care improvement, assessment of the trauma centers' results and triage activities, and a quantitative measurable scale (4).

The trauma scoring system has different functions; provides accurate, reliable and demonstrable description about the injuries, and predicts mortality in all circumstances (5). In fact, these systems provide databases that include injured and severity scores, which can assess the quality of care and management of trauma. Furthermore, it estimates the mortality rate, predicts the length of hospital admission, and provides a criterion to monitor trauma centers (3).

Since several years ago, various scales have been used to determine the severity of trauma in casualties; some countries are using these scales currently. These scales use anatomical and physiological criteria as well as combination of them to determine the trauma severity (6). Different studies have provided a review and research of various methods for assessing the severity of trauma and the advantages and disadvantages of the methods. In this study, we tried to explain the calculation method of each case, summarizing the advantages and disadvantages of each process (7-9).

In the present study, we evaluated the methods of measurement, and function of six most commonly used trauma scoring systems (10), including abbreviated injury scale (AIS), injury severity score (ISS), new ISS (NISS) of the anatomical parameters, revised trauma score (RTS) of physiological parameters, trauma score-injury severity score (TRISS), and a severity characterization of trauma (ASCOST), as hybrid ranking systems.

Materials and Methods

This review was conducted by searching the Persian databases including; Danesh Gostar Barakat system, Magiran, SID, and English databases including Scopus, Web of Sciences, PubMed, and the Google scholar using the following keywords: "severity of trauma", "trauma scoring", and "trauma scoring systems" with no time limitation.

Of the total studied databases, 2125 articles were obtained; 1129 Records remained after removing duplicates. Consequently, 1105 articles were excluded after the title and abstract, and 124 full-text articles were analyzed. Furthermore, 14 articles were selected and other articles were excluded due to lack of necessary criteria. Inclusion criteria were studies that indicated one of the six trauma severity assessment methods considered in this study and stated the reason for choosing this method and its computational method. The types of articles (including research, systematic review, etc.) were also included in the study. The included studies' reference lists were investigated and three other articles were included. As a result, a total of 17 related articles were analyzed (Information extracted from each article includes article title, introduced tool, calculation method, application, strengths, weaknesses). The results are shown in Figure 1.

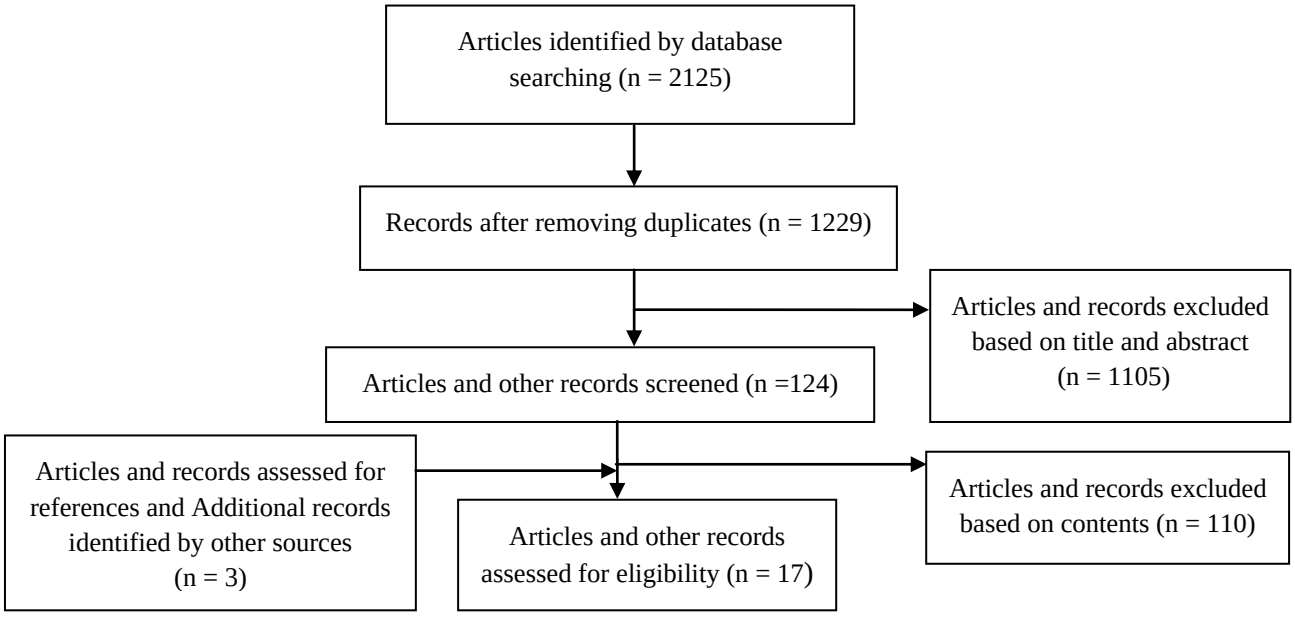

Figure 1. Searching and selecting articles

Results

Initially, each trauma scoring system was explained along with the measurement method; then, the methods were compared based on the functionality and non-functionality **(Table 1)**.

Table 1. Comparison of the trauma scoring system according to studies

Row	Trauma scoring system	Function/non-function
1	Abbreviated Injury Scale (AIS)	The AIS is an appropriate method to determine the severity of injury to parts of the body, but in a simple description, it is not appropriate among patients with multiple injuries (12,13).
2	INJURY SEVERITY SCORE (ISS)	It is often calculated in the initial assessment and recovery in the emergency department. It is difficult to predict results for injured people with severe injury to one part of the body. Generally used to evaluate the epidemiology of trauma (14,15). Major limitations are decreasing the ability to classify the ISS in grades higher than 15 (ISS> 15) and higher ages (3).
3	Trauma Score-Injury Severity Score (TRISS)	Mortality prediction of traumatic brain injuries to evaluate the survival rate of injured patients with regard to their characteristics (13,18,20)
4	Revised Trauma Score (RTS)	It is more worthwhile to identify traumatic injuries (triage) and determine their need to use specific facilities.
5	ASCOST (A Severity Characterization of Trauma)	An appropriate criterion to identify injuries is without problem.
6	NISS (NEW ISS)	It is an edited scoring system of ISS. It has more prediction of complications and mortality than ISS. It is more efficient in severe traumas (25, 26). The limitation includes the lack of discrimination among severity of injury in different areas of the body (3).

1. Abbreviated Injury Scale (AIS)

One of the first methods to measure the severity of trauma was developed by the Committee on Medical Traffic Disaster (USA) in 1971. Since 1985, its penetrating and non-penetrating wounds were determined separately. From 1971, it was

revised in the AIS system six times in different years and the latest change was called AIS-6 (11).

In this method, the amount of injury is investigated in six important parts of the body (head and neck, face, chest, abdomen, limbs, and external surface of the body). The severity of injuries ranges from 1= no injury to 6= fatal injury. Scores one and two are considered as weak to moderate injuries and six is perceived as fatal injuries. The AIS scoring method shows that 1= minor, 2 = moderate, 3 = serious, 4=severe, 5 = critical, and 6 = fatal injury (11).

2. Injury Severity Score (ISS):

Considering that AIS was used to measure the severity of injury in a body organ and was not used for patients with multiple trauma, Baker et al. (1974) invented the ISS system. This system indicates the severity of injury in patients with multiple trauma (9). The ISS is defined as the sum squares of the highest AIS scores in each of the three severely injured physical areas. In the case that there was more than one injury in a particular area of the body, the highest AIS score would be used.

$ISS = a^2 + b^2 + c^2$

In order to calculate the ISS, the AIS score of each injured body organ should be determined. Then, three injuries that get the highest AIS scores will be selected. Later, the ISS is calculated by making the sum scores squared (8).

$ISS = a^2 + b^2 + c^2$

The minimum and maximum ISS rates were three and 75, respectively. It is worth mentioning that if the AIS score of an organ is six (Nonsurvivable), the ISS score will be 75 automatically. In addition, if each of the three scores equals six, the score is calculated as 75 automatically. Since the score of 6 (Nonsurvivable) indicates the importance of having more medical care in life-sustaining, this may mean stopping more care in the patient's preference for a 6 score in each category (10,11).

3. Trauma injury severity score (TRISS):

Trauma injury severity score is a hybrid indicator, in which the patient's age, mechanism of injury, the condition of the symptoms, and vital signs of casualties are considered along with ISS. In order to calculate TRISS, the following equation is used (16, 17).

TRISS = B0 + B1 (RTS) + B2(ISS) + B3(AGE)

In the above-mentioned equation, regression coefficients are calculated using the related coefficients for penetrating and non-penetrating trauma according to the following coefficients.

Table 2. Regression coefficients in TRISS equation

	B3	B2	B1	B0
Non-penetrating trauma	-1,9052	-0,0768	0,9544	-1,2470
Penetrating trauma	-2,6676	-0,1516	1,430	-0,6029

Age was considered as zero for patients less than 55 years and one for older patients (18, 19).

4. Revised Trauma Score (RTS):

According to three Glasgow Coma Scale (GCS *), the systolic blood pressure and respiratory rate are calculated according to the following table.

RTS: GCS + SBP + RR

Table 3. Coded values of RTS calculation variables

Coded values	RR	SBP	GCS
4	10-29	>89	13-15
3	>29	76-89	9-12
2	6-9	50-75	6-8
1	1-5	1-49	4-5
0	0	0	3

* The GCS or Japan Coma Scale (JCS) is a neurological criterion used to determine the depth. In other words, it is used to measure the severity of consciousness decrease among people higher than five years (14, 21).

The GCS consists of three parts. The first part is related to opening of eyes with four scores, the second part is the verbal answer with five scores, and the third part is attributed to motor response with six scores (18).

5. A severity characterization of trauma (ASCOST) :

In 1990, another scale called ASCOST was used for the first time. In this method, the anatomical description of the lesion is performed using the four components A, B, C, and D of the Anatomic Profile (an anatomical method to determine the severity of the trauma). Component A includes all the dangerous injuries (with AIS of more than 2) to the areas of the head, brain, and the spinal cord; component B includes dangerous injuries to the chest and anterior part of the neck; component C includes all harmful injuries (except the follow-ups); and component D includes non-dangerous injuries with AIS of one or two.

In order to calculate the values of each four components, the second root of the AIS total squares is calculated for the injuries related to that organ. The patients 'survival possibility with very appropriate or inappropriate prognoses is already determined (22). This probability is calculated for other patients using this equation:

$$Ps = \frac{1}{1+e^{-K}}$$

Where,

K = K1 + K2G + K3S + K4R + K5A + K6B + K7C + K8 (AGE)

Ki are the regression coefficients considered for each penetrating and non-penetrating injuries with regard to the following table.

Table 4. The regression coefficients in ASCOST calculation

penetrating	Non-penetrating	Variable
-1.1350	-1.1570	constant
-1.0626	0.7705	G
0.3638	0.6583	S
0.3332	0.2810	R
-0.2702	-0.3002	A
-0.2052	-0.1961	B
-0.3188	-0.2086	C
-0.8365	0.6355	Age

Component D is essentially excluded from the above-mentioned equation because it is not an important factor in predicting the mortality of patients. In this regard, R, S, and G indicated the coded GCS values, systolic blood pressure, and respiratory rate on the RTS scale, respectively. The ASCOST method has a more detailed classification than TRISS, which can receive a value in the range of 0-4 for each injured person (23,24).

Table 5. Classification of patients in ASCOST

Age Value	Ages (y)
0	0-54
1	55-64
2	65-74
3	75-84
4	>84

6. NISS (NEW ISS)

The NISS is defined as the sum of the squares of AIS scores for three injured patients. This calculation is more accurate than the ISS, because the location of the injury should not be considered necessarily. The three higher AIS scores are used without considering the location of the injury (7).

Discussion

In the present study, the most commonly used trauma scoring methods were investigated. There were advantages and disadvantages for each method in measuring the trauma severity. Therefore, the efficiency of each method should be considered.

In the study conducted in Tehran hospitals, the calculated difference in Trauma Scoring System by each of the methods (ISS, RTS TRISS, and ASCOST) among the patients who survived and those who died was significant (13). Each different method for measuring the trauma severity had a separate application in different situations. Application of these methods in appropriate situations results in better outcomes.

The first method in this area was the AIS method, which was an appropriate method to determine the severity of injury to different parts of the body, but it was not appropriate among patient with multiple injuries (27). In fact, this indicated a life threat related to harm rather than a comprehensive assessment of the injury severity.

It is important to note that the AIS grade only assesses the threat to life of an isolated injury and not the combined effects of multiple injuries (28).

In general, the ISS system was used to determine the severity of injury among multiple trauma patients, but today it is used for patients with only one injured part (29).

One of the complications of ISS method in evaluating the prognosis of casualties with multiple trauma could be saied that in injuries to different organs, similar ISS scores cannot accurately reflect the similar prognoses. For example, the mortality rates of two traumatic patients, one with an AIS score of five due to liver injury and another with an AIS score of five due to limbs injury would not be equal. The reason is that the death rate from liver injury is higher than the injury to the limbs. Consequently, the TRISS method is more efficient in such cases (30).

In many cases, the ISS is used in the trauma epidemiological study (26). The results of a study by Moradi et al. showed that the most important factor to determine the length of hospital admission and expenses was the anatomical characteristics of the lesion indicated with ISS (10).

New ISS was another method to measure the trauma severity. It improved because of ISS limitations, but its but its application is not as extensive as the ISS. Several articles exist about predicting the mortality of injured individuals using ISS and NISS methods. In addition, NISS was calculated with regard to multiple injuries of one area; however, it does not differentiate between the severity of injuries in different areas. Similarly, NISS is more widely used in special studies such as severe trauma (25). The NISS is proposed as a solution to the obvious underestimation of injury severity when facing multiple injuries to the same body region (28).

The ISS considers only a single injury in each organ. In the case that patients have multiple injuries in the same part, ISS considers the most severe injury in this area. For patients who have multiple injuries in different body organs, the ISS needs to injure another area to measure the amount of injury. For this reason, ISS is not usually successful, because it considers the injuries with less severity than more severe injuries that affect other body parts (15).

The results of a study in Brazil showed higher value for NISS compared to ISS and NISS (15). In another study, no differences were found between the two groups (14). The study by Sullivan et al. showed a similar performance for ISS and NISS in predicting the mortality of children, who were not severely injured, whereas, NISS was more appropriate in predicting mortality among severely injured people (31).

Revised trauma score was more efficient in identifying patients who need triage and determining their needs than specific facilities. In the past years, a

major challenge was observed in calculating RTS; it was difficult to calculate Glasgow Coma Scale (GCS) and Respiratory Rate (RR) due to the increase in the number of endotracheal tubes, relaxation, and muscular paralysis during the pre-hospital care. Eventually, the researchers concluded that TRISS and RTS were not appropriate for the injured patients with intubation. Consequently, they reported that the ISS was not an appropriate method for this purpose. TRISS was an appropriate method to measure the result and outcome for both adults and children (8,14).

In a study, three methods of measuring the trauma severity were evaluated. The researchers conducted their study in ICU among admitted patients with trauma. The findings showed that anatomical traumatic scores (NISS, ISS) predicted the patients admitted to ICU and their needs better. However, TRISS determined the ICU anatomo-physiologic trauma score and mechanical ventilation time (17).

In a study conducted in Tehran's hospitals, ASCOST had an appropriate criterion to identify patients without difficulty and can be very efficient in clinical decision makings (13, 23). ASCOT, however, improved only marginally over TRISS regarding discrimination. Because it is somewhat more complicated to use, its usage has been somewhat limited (28).

Strengths and weaknesses

The current study had some limitations, such as lack of access to the full text of some articles and the variety of methods to measure the trauma severity, which made the selection difficult. However, we classified the studies to overcome the problem and deal with the most common methods. With regard to the strengths, this study provided an accurate calculation and appropriate functions of these methods; such a comprehensive comparison among the methods was not observed in any other studies.

Conclusion

Trauma scoring systems and their distinct ways of showing severity of injury are steadily growing. They have become increasingly complicated in recent years. The scoring system is a critical component of trauma care systems. In fact, these methods are designed to facilitate triage before the hospital and provide an opportunity to compare different trauma populations accurately and to organize and improve the trauma systems.

Trauma scoring systems are critical for the scientific study of epidemiology and the treatment of trauma. They also may be used to define and provide resources in the future. The trauma systems that measure the results with regard to mortality and survival rates were considered as the best tools. Therefore, if we conduct accurate scientific evaluations about the trauma severity methods and apply each method in appropriate situation, improvements will be observed in the development of traumatic care.

An ideal method for evaluating outcomes should include both objective and subjective evaluations and still be simple, fast, reliable, reproducible and cost effective. In general, there is no such tool. There is no agreement on the best scale or score that accurately describes (or eliminates) health and is appropriate to all circumstances. Therefore, several methods are useful in estimating trauma severity.

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Conflict of interest

The authors declare no conflict of interests regarding this study.

Authors' contribution

In this paper, AE and SM contributed in writing the manuscript and searching the articles from the databases, AD and KhN screened the

manuscript, and MHM and MM extracted the necessary results from the papers. Finally, AE and SM contributed in writing this manuscript.

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