

Original Article

The application of a trauma index to assess injury severity and prognosis in hospitalized patients with acute trauma

Hailin Ruan^{1*}, Wenhan Ge^{2*}, Bing Li³, Yuanqun Zhu⁴, Fan Yang⁵

¹Department of Emergency, Liuzhou Worker's Hospital, The Fourth Affiliated Hospital of Guangxi Medical University, Liuzhou, Guangxi 545005, P.R China; ²Department of Intensive Care Unit, Huaian Hospital Affiliated to Xuzhou Medical College, Huai'an, Jiangshu 223002, P.R China; ³Department of Traumatology, Liuzhou Worker's Hospital, The Fourth Affiliated Hospital of Guangxi Medical University, Liuzhou 545005, P.R China; ⁴Department of Neurology, Liuzhou Worker's Hospital, The Fourth Affiliated Hospital of Guangxi Medical University, Liuzhou, Guangxi 545005, P.R China; ⁵Department of Cardiology, Liuzhou Worker's Hospital, The Fourth Affiliated Hospital of Guangxi Medical University, Liuzhou, Guangxi 545005, P.R China. *Equal contributors.

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Abstract: Objective: The aim of this study was to determine the application value of a trauma index (TI) to assess condition and likelihood of death in hospitalized patients with acute trauma (AT). Methods: Trauma index scores and injury severity scores (ISS) were assessed in 1,802 randomly selected cases of AT-hospitalized patients. The receiver operating characteristic (ROC) curve was used to compare the clinical values of TI and ISS values to predict outcomes in AT-hospitalized patients. Results: The area under the ROC curve for TI scores was 0.896 (95% CI [0.881, 0.909]), while for ISS, it was 0.792 (95% CI [0.773, 0.811]). This difference was not statistically significant ($z = 3.236$, $P = 0.001$). Potentially critical disease conditions in AT-hospitalized patients were best identified when TI scores were ≥ 16 points and ISS values were ≥ 22 points. Conclusions: Trauma Index scores exhibited a higher resolution for outcome prediction in AT-hospitalized patients compared to ISS values. The implementation of this scale was simple, reliable, easy to learn, and could quickly identify disease, which is vital for early detection and treatment of critical trauma patients.

Keywords: Trauma index, trauma, acute, hospitalized patients, injury severity score, prognosis

Introduction

With the rapid development of industry, modern transportation, and urban construction around the world, there has likewise been an increase in industrial accidents and traffic accidents. In addition, the occurrence of natural disasters has increased significantly. Due to the high incidence of trauma, as well as high levels of morbidity and premature mortality associated with trauma, it is an important public health problem. According to the World Health Organization (WHO), over 5 million people worldwide die from traumatic accidents each year, accounting for 9% of total mortality [1]. Trauma is the leading cause of death worldwide among individuals age 1-44, and the fourth most common cause of death for all ages [2]. Traumatic injury frequently leads to infection, sepsis, and multiple organ dysfunction, resulting in high morbidity and mortality

rates [3-5]. This is mainly due to the fact that these complications often occur rapidly and under dangerous conditions and progress so quickly that once a diagnosis is made, it is difficult to curb these processes even with the most advanced treatments.

Research shows that trauma patients in low-mortality hospitals have similar unadjusted rates of major complications associated with traumatic injuries compared to patients in high-mortality hospitals, but patients in low-mortality hospitals have a lower failure-to-rescue rate compared to patients in high-mortality hospitals [6]. In order to achieve this goal, timely assessment and intervention is very important for trauma patients.

The prehospital trauma scoring system is generally used for on-site first aid and injury assessment, but its value in assessing injury severity

Table 1. Comparison of TI and ISS scores between the death group and the survival group ($\bar{x} \pm s$, points)

Groups	N	TI score	ISS score
Survival	2202	10.14 \pm 3.65	8.77 \pm 5.94
Dead	107	18.24 \pm 4.51	21.42 \pm 8.17
<i>t</i>		22.144	15.807
<i>P</i>		< 0.001	< 0.001

in hospitalized patients is poorly understood. In hospital situations, assessing the patient's clinical chief complaints and monitoring vital signs are still very important and cannot be replaced by new medical technologies. To this end, this study examined the value of applying a Trauma Index (TI) to patients hospitalized with acute trauma (AT). The TI scale has the advantage of being simple, rapid, easily repeated, and suitable for assessing dynamic situations, allowing timely awareness of condition changes in critical hospitalized patients, thus providing early warning of changes, enabling early treatment, and reducing mortality in patients hospitalized for acute trauma.

Materials and methods

Subjects

There were 15,074 cases of trauma patients hospitalized at the Fourth Affiliated Hospital of Guangxi Medical University from January 2010 to December 2013. A 20% random sampling was selected using the annual stratification method, which resulted in a total of 3,015 cases with a sampling error of < 5%. These cases were analyzed according to time of first hospital diagnosis, pre-hospital time \leq 24 h, and AIS \geq 3 points, and for evidence of a clear outcome and integral data, yielding 1,802 cases of AT-hospitalized patients for inclusion. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Xuzhou Medical College. Written informed consent was obtained from all participants.

Methods

The Trauma Database System V3.0 (developed by the Trauma Database Research Center, Third Military Medical University of China) was used to record trauma data upon admission

and relevant information during hospitalization, including test results, surgical procedures, and final diagnosis. The software automatically encoded and calculated TI scores and Injury Severity Scores (ISS). The discharge date was set as the end of the observation period, and TI and ISS scores were compared against patient outcomes at that time.

Scoring system

The TI was applied to data upon initial admission using scoring criteria developed in corresponding literature [7]. ISS values were calculated using the internationally recognized AIS-ISS scoring V2005 [8], which was used to assess examination results, surgical records, and final diagnosis.

Statistical methods

Measurement data were expressed as mean \pm standard deviation ($\bar{x} \pm s$). Measurement data were compared using the t-test; counting data were compared using the χ^2 test. The receiver operating characteristic (ROC) curve was used to calculate the area under the curve (AUC_{ROC}), and the difference between ISS and TI AUC_{ROC} values was determined by z-test. All statistical results were calculated using SPSS 17.0, with statistical significance set at $P < 0.05$.

Results

General information

Data were collected from a total of 1,802 hospitalized patients that met the inclusion criteria for acute trauma, with an average hospitalization stay of 26.16 days (\pm 31.45 days). Of these cases, 1,283 were male and 519 were female. Ages ranged from 2 months to 100 years old, and the mean age was 41.11 years old (\pm 22.24 years). Of all 1,802 cases, 104 patients died, yielding a mortality rate of 5.77%.

TI and ISS scores

The TI and ISS scores among patients who died were significantly higher than among the survival group ($P < 0.001$), as shown in **Table 1**.

AUC_{ROC} of TI and ISS scores

The AUC_{ROC} for TI scores was 0.896 (95% CI [0.881, 0.909]), while the AUC_{ROC} for ISS was

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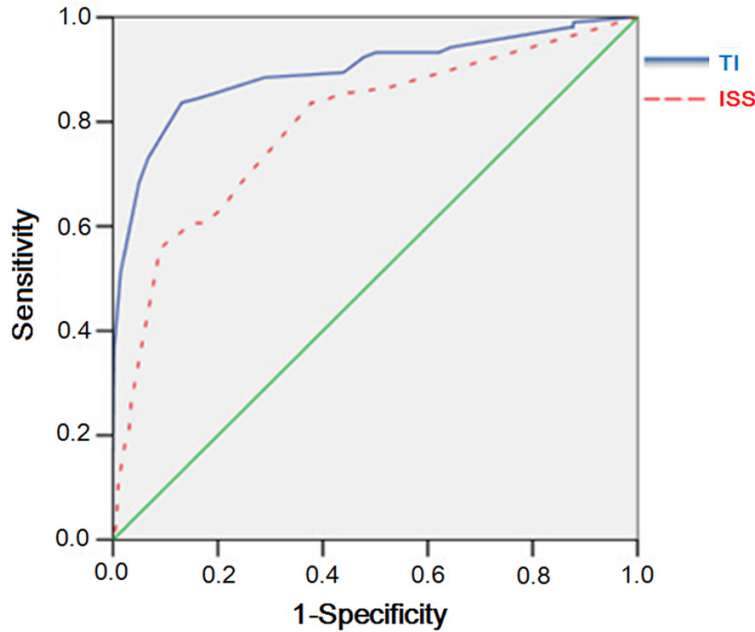


Figure 1. ROC curves of TI score and ISS score of AT hospitalized patients.

0.792 (95% CI [0.773, 0.811]). The difference between these values was not statistically significant ($z = 3.236$). According to the Youden maximum index method, the best cut-off points for determining “potentially critical disease condition” using TI and ISS scores in AT-hospitalized patients were TI scores ≥ 16 points and ISS values ≥ 22 points, respectively (**Figure 1**).

Evaluation indicators of TI and ISS scores

The sensitivity, specificity, accuracy, Youden index, false positive rate, false negative rate, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio of TI and ISS values were calculated according to the best cut-off points for determining potentially critical disease conditions. Trauma Index score was a more sensitive indicator than ISS ($\chi^2 = 16.910$, $P < 0.001$), while the differences in specificity and accuracy were not statistically significant ($\chi^2 = 3.207$, $P = 0.073$; $\chi^2 = 0.120$, $P = 0.729$) (**Table 2**).

TI and ISS values as predictors of mortality

According to the selected optimal cut-off points, cases were classified as mild (TI < 16 points and ISS < 22), or severe (TI ≥ 16 points and ISS

≥ 22 points). The mortality rate in the severe group, as classified by these two scoring methods, was significantly higher than in the mild group ($P < 0.001$).

Discussion

The primary task of trauma medicine is to provide effective regulation, to prevent early injury and death, and to facilitate subsequent therapy and organ recovery [9]. The ability to predict outcomes accurately is an important part of early clinical decision making [10], and could help guide clinical decision making and the rational allocation of limited medical resources [11].

Commonly used trauma outcome scales include The Trauma and Injury Severity score (TRISS) and Injury Severity Characteristic score (ASCOT), among others. Because there is a significant difference between domestic and foreign injuries, response times, pre-hospital rescue methods, medical treatment capabilities, pre-injury lesions, and many other factors, outcome prediction must be specific to the situation. A national trauma database has not been established in China, so the data currently available are neither complete nor accurate enough for true outcome prediction. As a result, direct application of TRISS and ASCOT weighting coefficients in China for intranasocomial scoring and survival prediction is inaccurate and inappropriate [12]; more so, the collection of data and relevant information needed for TRISS and ASCOT scoring requires a lot of time and effort. The Acute Physiology and Condition of Health Evaluation II (APACHE II) is a better measure of severity of trauma in Chinese populations, and this scale is a much more sensitive predictor of mortality [13]. However, there are also some disadvantages to its use: 1) the APACHE scale was specially developed for intensive care unit (ICU) patients, not for the wounded; 2) obtaining some parameters of the scale requires more time, limiting its application in time-sensitive situations; and 3) the

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Table 2. Comparison of commonly used evaluation indicators of TI score and ISS score

Types	Sen (%)	Spe (%)	FPR (%)	FNR (%)	Acc (%)	J	LR (+)	LR (-)	PV+	PV-
TI	83.7*	86.9	13.1	16.3	86.7	0.706	6.398	0.188	0.282	0.989
ISS	57.7	88.9	11.1	42.3	87.1	0.466	5.211	0.476	0.242	0.972

Note: Sen: sensitivity, Spe: specificity, FPR: false positive rate, FNR: false negative rate, Acc: accuracy, J: Youden index, LR (+): positive likelihood ratio, LR (-): negative likelihood ratio, PV+: positive predictive value, PV-: negative predictive value; comparison between TI score and ISS scores: *P < 0.05.

physiological status of a trauma patient is persistently changing, requiring frequent re-application of the APACHE scale. This need for frequent re-evaluation not only increases suffering and economic burden for the patient, but also increases the workload for medical staff, which often affects compliance. In contrast, TI scoring is simple to execute and easy to learn; it also provides accurate predictive information when used in AT-hospitalized patients, and can therefore provide much more useful information about a patient's injuries more quickly, making it a more useful tool for accurate assessment of trauma-related injury.

The closer the ROC curve was to the chance line, namely the closer the AUC_{ROC} value was to 0.5, the weaker the test's ability to distinguish patients from controls, while the closer the AUC_{ROC} value was to 1, the stronger the accuracy of the test. The diagnostic value of the AUC_{ROC} is low for values within 0.5-0.7, moderate for values within 0.7-0.9, and high when values are greater than 0.9 [14]. The AUC_{ROC} of TI and ISS scores were 0.896 and 0.792 respectively, exhibiting no statistically significant difference ($P = 0.073$), indicating that TI and ISS scores have a better predictive value of outcomes in AT-hospitalized patients, and that the resolutions between these two were equal.

This retrospective study analyzed various test results, surgical records, and final diagnoses in 1,802 cases, and demonstrated that ISS values were accurate and reliable predictors of mortality in AT-hospitalized patients. However, the ISS scale had its own drawbacks. First, only one injury can be recorded per region, which does not truly reflect the severity of multiple organ injuries [15, 16]. Second, it is not possible to adequately distinguish injuries throughout complex organs like the liver, pancreas and duodenum, as well as the spleen and small intestine, and the scale is limited to only three parts of the body. Third, it is not possible to reflect the severity of multiple organ injuries.

Fourth, since the ISS includes the thoracolumbar spine as part of the chest and abdomen, and includes the pelvis as part of the lower limbs, it cannot differentiate severity between multiple and single injuries. Fifth, the ISS does not accurately reflect brain injury. Finally, the ISS exhibits an ortho-skewed distribution and does not exhibit a linear relationship with mortality [17]. In addition, the accuracy of the ISS may be affected since some patients require ultrasound and radiology for diagnosis upon admission; more so, some cases of substantial organ damage, blood vessel damage, and nerve damage can only be diagnosed with surgery. In patients with a clear diagnosis, the ISS score was fixed, which does not express the variable physiological dysfunction common after trauma. In addition, each patient exhibits individual differences for trauma tolerance and treatment reactivity, meaning that physiological dysfunction after injury was not consistent with actual anatomic injury severity, resulting in a diversity of clinical manifestations. Despite these shortcomings, the ISS sets clinical criteria for rapid assessment of injury since it was created 40 years ago [16], and ISS values have high predictive value of mortality [18, 19]. The AUC_{ROC} for ISS values in this group was 0.792, which indicates that ISS is a good measure of severity of damage, and it is therefore still important for evaluating injury. The mortality rate for critically wounded patients with $ISS \geq 22$ points was 24.19%, indicating that there exists a high risk of death in such patients, and they need focused care.

The TI score was proposed by Kirkpatrick in 1971 as a simple way to evaluate degree of trauma. It includes five aspects, namely injury site, injury type, circulation, respiration, and consciousness. Higher values are associated with greater injury severity. Values < 9 points indicate minor injury, values between 10-16 points indicate moderate injury, values > 17 points indicate severe injury, while values > 27 points are associated with significantly inc-

reased mortality [20]. When TI scores were applied to AT-hospitalized patients, the established best cut-off point was not consistent with pre-hospital values. In this study, cases with a TI ≥ 16 were classified as "severe" with an associated mortality rate of 28.16%. These individuals needed active rescue, as well as damage control surgery to stabilize their injuries before receiving further treatment. Patients with a TI < 16 points were classified as "mild" and required active observation for dynamic changes in TI, thus helping medical staff in the timely assessment of injuries and in making any necessary adjustments to the treatment plan to protect damaged organ function. Comparison of these two scores revealed that the specificity and accuracy of TI scores and ISS values were similar, while TI sensitivity was better, and the misdiagnosis rate was lower, making TI scores suitable for initial screening of critically ill trauma patients. The TI scale was easy to use, and it utilizes objective indicators with no need for precise instruments. It can be calculated quickly, and it is especially useful when AT-hospitalized patients are transported to and from the operating room where monitoring by large, mechanical equipment and necessary life support systems are temporarily unavailable. During these times, TI scores help medical staff observe and manage dynamic changes to patient condition, enhance the rapid response capability of the emergency team, and enable health care providers to perform early interventions in critically ill patients, thereby directly affecting the patient's prognosis.

The TI scale is simple, includes objective indicators, does not require precise instruments, is easy to master, and is applicable in a wide range of settings. It reflects changing conditions quickly and reliably, is suitable for dynamic comparison, and exhibits a high resolution of outcome prediction for AT-hospitalized patients, thus enabling healthcare providers to promptly recognize changes in injury status, thereby enhancing the rapid response capabilities of the emergency team. The TI scale has unique advantages in outcome prediction for AT-hospitalized patients, and could complement other hospital trauma scoring systems. The selection of the best cut-off point was related to regional traumatic epidemiology, hospital admission standards, and hospital trauma rescue levels, and it should be combined with regional char-

acteristics relative to specific settings. In the future, a more accurate grasp of the dynamic and evolving nature of injuries could be ascertained through prospective studies that examine TI scores both inside and outside of hospital situations and that continuously assess TI scores in patients before admission, while in the emergency room, and after hospitalization, thus allowing for the creation of TI score time charts, giving a dynamic view of changes in TI scores.

Disclosure of conflict of interest

None.

Address correspondence to: Bing Li, Department of Traumatology, Liuzhou Worker's Hospital, The Fourth Affiliated Hospital of Guangxi Medical University, No. 1 Liushi Road, Liuzhou 545005, P.R China. Tel: +86 13978027516; Fax: +86 772 3813836; E-mail: wenhange@126.com

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