A comparison of "Life threatening injury" concept in the Turkish Penal Code and trauma scoring systems

Türk Ceza Kanunu'ndaki "yaşamı tehlikeye sokan yaralanma" kavramı ile travma skor sistemlerinin karşılaştırılması

Recep FEDAKAR,[1] Ahmet Hüsamettin AYDINER,[1] İlker ERCAN[2]

BACKGROUND

To compare accuracy and to check the suitability of the Glasgow Coma Scale (GCS), the Revised Trauma Score (RTS), the Injury Severity Score (ISS), the New Injury Severity Score (NISS) and the Trauma and Injury Severity Score (TRISS), the scoring systems widely used in international trauma studies, in the evaluation of the "life threatening injury" concept established by the Turkish Penal Code.

METHODS

The age, sex, type of trauma, type and localizations of wounds, GCS, RTS, ISS, NISS and TRISS values, the decision of life threatening injury of 627 trauma patients admitted to Emergency Department of the Uludag University Medical School Hospital in year 2003 were examined.

RESULTS

A life-threatening injury was present in 35.2% of the cases examined. GCS, RTS, ISS, NISS and TRISS confirmed the decision of life threatening injury with percentages of 74.8%, 76.9%, 88.7%, 86.6% and 68.6%, respectively. The best cut-off point 14 was determined in the ISS system with 79.6% sensitivity and 93.6% specificity. All of the cases with sole linear skull fracture officially decided as life threatening injury had an ISS of 5, a NISS of 6 and the best scores of GCS (15), RTS (7.8408) and TRISS (100%).

CONCLUSION

ISS and NISS appeared to be the best trauma scoring systems that can be used for the decision of life threatening injury, compared with GCS, RTS and TRISS. Thus, ISS and NISS can be acceptable for using the evaluation of the life threatening injury concept established by the Turkish Penal Code.

Key Words: Forensic medicine; medico-legal report; Turkish Penal Code; life threatening injury; trauma scoring.

AMAÇ

Bu yazıda Türk Ceza Kanunu'nda tanımlanan "Yaşamı tehlikeye sokan yaralanma" kavramının değerlendirilmesinde uluslararası travma çalışmalarında kullanılan, GCS (Glasgow Coma Scale), RTS (Revised Trauma Score), ISS (Injury Severity Score), NISS (New Injury Severity Score) ve TRISS (Trauma and Injury Severity Score) skorlama sistemlerinin doğruluğunun karşılaştırılması ve kullanılabilirliğinin kontrol edilmesi amaçlandı.

GEREÇ VE YÖNTEM

2003 yılı boyunca, Uludağ Üniversitesi Tıp Fakültesi Hastanesi Acil Servisi'ne kabul edilen 627 travma hastasının, yaş, cinsiyet, travma tipi, yaralanma tipi ve lokalizasyonu, GCS, RTS, ISS, NISS ve TRISS değerleri ile yaşamı tehlikeye sokan yaralanma olup olmadığı incelendi.

BULGULAR

Olguların %35,2'sinde yaşamı tehlikeye sokan yaralanma saptandı. GCS, RTS, ISS, NISS ve TRISS değerlerinin, yaşamı tehlikeye sokan yaralanma kararı verilen hastalara uygunluğu sırasıyla, %74,8, %76,9, %88,7, %86,6, %68,6 saptandı. En iyi uygunluk 'cut-off' noktası 14, sensitivite %79,6, spesifite %93,6 ile ISS sisteminde idi. Resmi olarak yaşamı tehlikeye sokan yaralanma olduğuna karar verilen, izole kafatasında lineer kırık bulunan tüm olgularda ISS 5, NISS 6 ve GCS (15), RTS (7,8408) ve TRISS (%100) sisteminde en iyi değerleri olan skorlar saptandı.

SONUÇ

GCS, RTS ve TRISS ile karşılaştırıldığında, yaşamı tehlikeye sokan yaralanma kararının verilmesinde ISS ve NISS en uygun travma skorlama sistemleri olarak görülmektedir. Bu skorlar Türk Ceza Kanunu'ndaki yaşamı tehlikeye sokan yaralanma kararının değerlendirilmesinde kullanılabilecek, kabul edilebilir skorlar olabilir.

Anahtar Sözcükler: Adli tıp; adli rapor; Türk Ceza Kanunu; yaşamı tehlikeye sokan yaralanma; travma skoru.

Departments of [1]Forensic Medicine and [2]Biostatistics, Uludag University Medical Faculty, Bursa, Turkey.

Uludağ Üniversitesi Tıp Fakültesi, [1]Adli Tıp Anabilim Dalı, [2]Biyoistatistik Anabilim Dalı, Bursa

Correspondence *(İletişim)*: Recep Fedakar, M.D. Uludağ Üniversitesi Tıp Fakültesi Adli Tıp Anabilim Dalı, Görükle, 16059 Bursa, Turkey.
Tel: +90 - 224 - 295 36 12 Fax *(Faks)*: +90 - 224 - 442 80 38 e-mail *(e-posta)*: fedakar@uludag.edu.tr

The concept of "wound" was adopted instead of "battery" in articles 86, 87, 88 and 89 of the renewed Turkish Penal Code[1] to cover sentences in cases of injuries that do not result in death. All behaviours causing pain in the body, perceptional disorders, or injuries to physical health are accepted as wound. The crime of intentional wound requires imprisonment from one year to three years according to the article 86, paragraph 1.[1] It is a reason for increased punishment, when an intentionally applied wound threatens one's life to danger and the sentence for imprisonment shall be increased by one fold according to the article 87, paragraph 1.[1]

The "life threatening injury", in article 87, paragraph 1,[1] is a legal concept, medically determined and reported by specialists of forensic medicine. According to the interpretations of Turkish Council of Forensic Medicine, the lesions that threaten one's life to danger are as follows: 1) linear or depressed skull fractures, 2) fractures of the atlas, axis and third cervical vertebra, 3) penetrating injury of the head, thorax and abdominal cavities, 4) visceral organ injuries, 5) major vascular injuries, 6) spinal cord injuries, 7) second-degree burns covering more than 20%, or third-degree burns covering more than 10% of the body area, 8) intoxications that cause severe clinical presentation, 9) intracerebral haemorrhage, contusion or laceration, 10) clinically presented cerebral edema, 11) clinical symptoms seen with more then 20% of blood loss caused by extensive ecchymosis, hematoma and lacerations without large vessel or visseral organ damage, 12) the bites from animals that infected by rabies, 13) electrocution (The evidence of the entry lesion and/or the exit lesion or verification of the clinical signs resulted by electrical energy passing through the body).

In order to refine attitudes towards traumatized patients, an established system of anatomical and physiological trauma scoring exists in many countries. The criteria used in these systems should always be quantifiable and objective, since they assist in providing a description of a patient's status and treatment outcome.[2-5] Similarly, objective criteria are required for the penal code in order to be able to provide exact descriptions of the detriment caused to the victim and to ensure a fair penal system.

The most widely used scoring systems in international studies are the Glasgow Coma Scale (GCS),[3,4] the Revised Trauma Score (RTS),[3,4] the Injury Severity Score (ISS),[3-5] the New Injury Severity Score (NISS)[6] and the Trauma and Injury Severity Score (TRISS).[3,4] The GCS is the most widely preferred scoring system used in quantifying level of consciousness following traumatic brain injury and it correlates well with the outcome following severe brain injury. The RTS is a physiological scoring system, with high inter-observer reliability and demonstrates accuracy in predicting death and correlates with the probability of survival. The ISS and NISS are the anatomical scoring systems that provide an overall score for patients with multiple injuries and correlates linearly with mortality, morbidity, hospital stay and other measures of severity. The TRISS determines the probability of survival of a patient from the data derived using ISS, RTS, age index and coefficients of blunt and penetrating trauma.

The present study aims to compare accuracy and check the suitability of GCS, RTS, ISS, NISS and TRISS, the scoring systems widely used in international trauma studies, and of "life threatening injury" concept established by the Turkish Penal Code.

MATERIALS AND METHODS

Study setting and population

This study was performed as a retrospective research project, examining suitability of trauma scoring systems for "life threatening injury" existing in Turkish Penal Code among trauma patients, admitted to the Emergency Department of the Uludag University Medical School Hospital that serves a predominantly trauma patients as a 3rd step healthcare unit in southern Marmara region of Turkey. Eligibility criteria for inclusion were defined as being an adult and a trauma patient. Patients admitted to hospital as dead and patients with incomplete records of trauma files were excluded from the study.

Data collection procedures

The records of the trauma files of the injured patients admitted to hospital in year 2003 were reviewed. The trauma files have included information on the patient's age, sex, type of trauma, findings of the primary (in the first ten minutes) and secondary (after the first ten minutes) examinations, both including physical examination reports, laboratory and radiological analysis reports, the Glasgow

Coma Scale (GKS), the Revised Trauma Score (RTS), diagnosis according to ICD-9[7] and treatments.

Trauma files were evaluated by a research assistant of forensic medicine with three years of experience and an assistant professor of forensic medicine with nine years of experience sequentially. The interval between the first and second physician's examination ranged between 10 minutes to one hour. Before the study began, the two physicians agreed on a standardized examination technique and if any discordance in information occurred, they reviewed and concluded on the trauma file together.

Trauma files of 627 adult patients were examined in this study. Information about patient's age, sex, type of trauma, type and localizations of wounds, GCS, RTS were recorded to a registration form and the Injury Severity Score (ISS), the New Injury Severity Score (NISS) and the Trauma and Injury Severity Score (TRISS) were then calculated. The presence of life threatening injury was decided with respect to the lesions of the patients following the interpretations of Turkish Council of Forensic Medicine.

Trauma scoring systems

The GCS, which is composed of three parameters: best eye response, best verbal response and best motor response, is scored between 3 and 15, 3 being the worst and 15 the best.[2,4]

The RTS is scored from the first set of data obtained from the patient and consists of Glasgow Coma Scale, systolic blood pressure and respiratory rate. Values for the RTS are in the range 0 (worst) to 7.8408 (best). RTS is calculated from: RTS=0.9368 value of GCS + 0.7326 value of systolic blood pressure + 0.2908 value of respiratory rate.[8]

The ISS is scored for patients with multiple injuries. Each injury is assigned to an Abbreviated Injury Scale score and is allocated to one of six body regions (Head, Face, Chest, Abdomen, Extremities (including Pelvis), External). Only the highest Abbreviated Injury Scale score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS score. The ISS score takes values from 0 (best) to 75 (unsurvivable injury).[5] The NISS is computed as the simple sum of squares of the three most severe Abbreviated Injury Scale injuries, regardless of body region. Therefore, the NISS will be equal to or higher than the ISS.[6]

TRISS determines the probability of survival (Ps) of a patient from the ISS and RTS using the following formulas: Ps=1 / (1+e-b), where "b" is calculated from: b=b0 + b1 (RTS) + b2 (ISS) + b3 (age index). The coefficients b0 - b3 are derived from multiple regression analysis of the Major Trauma Outcome Study database. Age index is 0 if the patient is below 54 years of age or 1 if 55 years and over. b0 to b3 are coefficients which are different for blunt and penetrating trauma.[3]

Statistical analysis

Data were transferred into SPSS statistical package, Version 11.5.1 for Windows (2002, SPSS Inc., Chicago, IL, USA) was used and statistical analysis was performed. Shapiro-Wilk and Kolmogorov-Smirnov one-sample test was used to test whether the samples of the random variables belong to predefined distribution or not. The comparisons of the means were done by the t test, while the categorical data was analysed using χ^2 and Fisher's exact tests. Continuous variables not normally distributed were analysed non-parametrically by using the Mann-Whitney U-test to compare groups. Probability values of <0.05 were considered significant.

Receiver operating characteristic (ROC) curves were generated for each of the variable by plotting the sensitivity against 1-specificity using the MedCalc statistical package, Version 7.2.1 (2003, MedCalc Software, Mariakerke, Belgium). This program generates ROC curves using continuous data points. The area under the curve with 95% confidence interval was calculated by the software using methods described by Hanley and McNeil.[9] Optimum *cut-off* points for each variable were established by selecting the points of values that provided the greatest sum of sensitivity and specificity - that is, the point closest to the top left hand corner on the ROC curve. Comparison of ROC curves to test the statistical significance of the difference between the trauma scoring systems was done by using the MedCalc statistical package.

Positive likelihood ratios were calculated for the optimum *cut-off* points of the variables. Positive likelihood ratio is the likelihood that the test would be positive in a patient with life threatening injury that

Table 1. Distribution of the life threatening injury with respect to the type of trauma

Type of trauma	No. (%) of life threatening injuries		*Total*
	Not present	Present	
Motor vehicle crash	243 (76.4)	75 (23.6)	318
Fall	59 (54.6)	49 (45.4)	108
Vehicle-pedestrian crash	43 (55.1)	35 (44.9)	78
Industrial accident	17 (43.6)	22 (56.4)	39
Firearm injury	16 (50)	16 (50)	32
Knife injury	15 (46.9)	17 (53.1)	32
Blunt trauma	10 (62.5)	6 (37.5)	16
Burn	3 (75)	1 (25)	4
Total	406 (64.8)	221 (35.2)	627

the same result would be expected in a patient without life threatening injury. The higher the likelihood ratio, the better is the test discriminating between those with and without life threatening injury.

RESULTS

Description of cases

Of the 627 cases, 170 (17.1%) were females and 457 (72.9%) were males. The age was ranged from 19 to 87 years. The mean (±standard deviation) age of women and men were 40±16.52 and 38±13.38, respectively (t=-1.408, df=255, p=0.160). A life threatening injury was present in 122 women (71.8%) and 284 men (62.1%) (χ^2=5.024, df=1, p=0.025). There was a significant difference between the mean ages of the groups with (35.2%, n=221, mean: 41.4±14.78) and without (64.8%, n=406, mean: 37±13.83) a life threatening injury (t=-3.632, df=427, p<0.001).

The distribution of the life threatening injury with respect to the type of trauma is shown in Table 1. The most common type of trauma was motor vehicle crashes followed by free-fall injuries (318 and 108, respectively, in a total of 627 cases). Out of the 627 cases 64.8% did not have a life threatening injury. The three highest percentage of presence of life threatening injury was seen in industrial accidents (56.4%), knife injuries (53.1%) and firearm injuries (50%).

The relationship between the phrase of life threatening injury and trauma scoring systems

A significant difference was observed between all trauma scoring systems and the presence of life threatening injury. ISS and NISS were found as the two best-related trauma scoring systems with the decision of life threatening injury with the Z value of -17.810 and -17.540, respectively (Table 2).

Table 2. The relationship between the phrase of life threatening injury and trauma scoring systems assessed in 627 adult trauma patients

Life threatening injury	Score* obtained by scale				
	GCS	RTS	ISS	NISS	TRISS
Not present (n=406)	15 (15-15)	7.8408 (7.8408-7.8408)	4 (1-10)	4 (1-10)	99.76 (99.63-99.81)
Present (n=221)	15 (11.5-15)	7.8408 (6.3756-7.8408)	21 (14-27)	24 (17-33)	98.38 (87.64-99.49)
Z value†	-10.836	-12.211	-17.810	-17.540	-15.136
p	<0.001	<0.001	<0.001	<0.001	<0.001

*Median (lower quartile-upper quartile); †Mann-Whitney U-test. GCS: Glasgow Coma Scale; RTS: Revised Trauma Score; ISS: Injury Severity Score; NISS: New Injury Severity Score; TRISS: Trauma and Injury Severity Score.

Table 3. *Cut-off* points established according to the use of a ROC curve in 627 adult trauma patients

Descriptive parameters of ROC curve	Findings for the scale				
	GCS	RTS	ISS	NISS	TRISS
Cut-off point	≤14	≤7.2592	> 13	> 13	≤99.52
Area under the ROC curve (%)	67.6	69.5	92.6	92.0	86.4
(95% confidence interval)	(63.8-71.2)	(65.8-73.1)	(90.2-94.5)	(89.6-94.0)	(83.4-88.9)
Sensitivity (%)	39.8	42.1	79.6	82.8	76.9
(95% confidence interval)	(33.3-46.6)	(35.5-48.9)	(73.7-84.7)	(77.2-87.5)	(70.8-82.3)
Specificity (%)	93.6	95.8	93.6	88.7	80.0
(95% confidence interval)	(90.8-95.8)	(93.4-97.5)	(90.8-95.8)	(85.2-91.6)	(75.8-83.8)
Positive likelihood ratio	3.06	3.41	8.22	8.36	4.99
p	<0.001	<0.001	<0.001	<0.001	<0.001

GCS: Glasgow Coma Scale; RTS: Revised Trauma Score; ISS: Injury Severity Score; NISS: New Injury Severity Score; TRISS: Trauma and Injury Severity Score.

Sensitivity and specificity of trauma scoring systems

GCS, RTS, ISS, NISS and TRISS confirmed the decision of life threatening injury with a percentage of 74.8%, 76.9%, 88.7%, 86.6% and 68.6%, respectively. Descriptive parameters of ROC curves for each scoring system are shown in Table 3. The pairwise comparisons of ROC curves for different scoring systems denoted a significant difference between the scoring systems at the level of p<0.001, apart from the comparisons between GCS and RTS (p=0.427) and ISS and NISS (p=0.226).

With the specificity level of 84.2%, TRISS had a significant association with the decision of life threatening injury. The GCS and the RTS were well-related with the decision of life threatening injury. The *cut-off* point for GCS was 14 (39.8% sensitivity, 93.6% specificity, Table 3), where its range is accepted to be between 3-15 worst to best and the score under 8 is considered as serious brain damage, while 9-12 as moderate and over 13 as reversible brain damage.[4] When *cut-off* point of 12 points was chosen, sensitivity became 28.1% and specificity 99.8%. The best *cut-off* point for RTS was found to be 7.2592 (42.1% sensitivity, 95.8% specificity, Table 3), where RTS value ranges zero (worst) to 7.8408 (best). A threshold of RTS <4 has been proposed to identify those patients who should be treated in a trauma centre.[4] When *cut-off* point of 4 was applied, sensitivity became 8.6% and specificity 100%.

The best association of the decision of life threatening injury was determined with ISS and NISS. ISS and NISS had the two highest likelihood ratios, so they were more accurate than the other in making decision of life threatening injury. The *cut-off* points for ISS and NISS 14 or over were associated with the decision of life threatening injury with a sensitivity of 79.6% and 82.8% and specificity 93.6% and 88.7%, respectively. ISS values ranged from zero (best) to 75 (worst) according to the severity of trauma, an ISS value over 16 was referred as severe.[5] When *cut-off* point was taken as 16 for ISS, sensitivity became 61.1% and specificity 97.8%.

DISCUSSION

In the present study, analysis of the scoring systems suggested that ISS and NISS, the anatomical scores, were more likely associated with the decision of life threatening injury compared with other scoring systems and exerted higher impact compared with physiological scores, since the *cut-off* points of ISS and NISS appeared to be compatible with the values that indicated the severity of trauma and thus had the highest ability to predict the life threatening injury. The best *cut-off* points of alternative scoring systems such as GCS, RTS and TRISS were not compatible with the values that indicated severity of trauma. Furthermore, some limitations for these scoring systems have been described in previous studies. Scores for specific subgroups of patients like GCS for assessment of consciousness in head injuries can not be applicable to a general

adult trauma population.[3] The RTS by itself has a modest predictive value for survival[10] and the power of RTS is further limited the efforts of emergency medical service personnel trying to stabilize the patient's haemodynamic condition and by the dependence of time until presentation for GCS.[11] Cayten et al.[12] identified three limitations of TRISS: inability of TRISS to account for multiple severe injuries to a single body part, inability to predict survival in low falls and the lack of distinction between gunshot wounds and knife injuries. Moreover, Demetriades et al.[13] showed that TRISS performed well in predicting the survival among mildly injured patients but not for the moderately and severely injured patients. Although preliminary studies suggest that the NISS is a more accurate predictor of trauma mortality than the ISS and the NISS is superior to the ISS as a measure of tissue injury,[8,14,15] Tay et al.[16] reported that the NISS should not replace the ISS, as they share similar accuracy and calibration. In our study we also did not find any statistical difference in making decision of life threatening injury. Although ISS appeared as the one of the most appropriate scoring system in the present study, it has certain limitations. Firstly, it has been suggested that ISS has a nonlinear increment in injury severity and overemphasizes small injuries.[17] Secondly and perhaps more importantly, it would not be sufficient in the determination of some life threatening traumas such as poisonings, since it bases on an anatomical approach rather than a physiological one. It should be emphasized that no poisoning case was include in the present study. However, in a study performed in Turkey it has been suggested that GCS could be used to determine the brain functions and to make a life threat decision in poisoning cases.[18] It was reported that when GCS cut-off value was taken as 8, there was an association with life threat with sensitivity of 81% and specificity 94% in these cases.[18]

As far as the authors are aware, there are no first step healthcare units in Turkey which are currently using the trauma score systems to systematically score for injuries, although some second step health care units are using them. Therefore, this limitation is appeared to be the major obstacle for using a score system for evaluation of the life threatening injury and thus trauma scoring systems that serve the purposes of triage, trauma care management and trauma epidemiology may not only help the forensic medicine specialists in objective decision making of circumstances such as life threatening injury, but may also extended into a widespread clinical usage.

Another observation arising from this study was the expediency of the scoring systems to penal systems. The phrase of life threatening injury is a legal concept exists in the article 87, paragraph 1 of the Turkish Penal Code. Although in the Turkish Penal Code there is no exact definition for this concept, forensic medicine specialists generally use a set of anatomical criteria which define the lesions that threaten one's life, which are explained in detail in the introduction of this study. However, although the decision of a life threatening injury in traumatic cases can be decided objectively in patients with traumatic focal lesions of brain, visceral organs and major vascular injuries, extensive burns and conditions similar to these, there may be conflictions in making an objective decision in some other life threatening conditions. For example, while linear fractures of the skull are accepted as life threatening injury officially, some experts in the forensic medicine strongly suggest that the presence of intra-cranial haemorrhage is a prerequisite to accept the linear fractures as life threatening injury. Therefore, the criteria used in this definition of life threatening injury require being quantifiable and objective in order to be able to give an exact description of the detriment caused to the victim and to ensure a fair penal system. In this study, all nine isolated linear skull fracture cases' GCS were 15, RTS 7.8408, ISS 5, NISS 6 and TRISS 100% (best scores for these scoring systems). Therefore, these findings clearly suggest that the latter opinion should be assumed as officially in use. In future, an objective scoring system would be used by forensic medicine specialists in Turkey in the evaluation of life threatening injury concept, in order to be able to provide exact descriptions of the detriment caused to the victim and to ensure a fair penal system.

In conclusion, ISS and NISS were appeared as the best trauma scoring systems that can be used for the decision of life threatening injury, compared to GCS, RTS and TRISS. Thus, ISS and NISS can be acceptable for using the evaluation of the life threatening injury concept established by the Turkish Penal Code, bearing in mind that decision for individual case should never be based solely on a statistically derived injury severity score.

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