ORIGINAL ARTICLE

The usefulness of trauma scores in determining the life threatening condition of trauma victims for writing medical-legal reports

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Emerg Med J 2005;22:783–787. doi: 10.1136/emj.2004.019711

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Accepted for publication 18 December 2004

Objectives: In the Turkish legal system the severity of the victim's injury determines the severity of the criminal penalty, and the life threatening condition stated in the medical-legal report is one of the main determinants for injury severity. The aim of this study is to investigate the effectiveness and usefulness of the trauma scores in determining the life threatening condition of trauma victims from the forensic aspect in order to write accurate medical-legal reports.

Methods: Data of 296 forensic cases with blunt and penetrating trauma were obtained. The life threatening condition of patients stated in the medical-legal reports according to the criteria based on traditional forensic opinion were examined. For each case, Injury Severity Score (ISS), Revised Trauma Score (RTS), and Trauma and Injury Severity Score (TRISS) were calculated. The ROC curve analysis was used to investigate the success of the trauma scores in distinguishing patients with/without life threatening conditions. Logistic regression analysis was performed to measure the association between trauma scores and life threatening conditions.

Results: The relations between all scores and groups (with and without life threatening risk) were found statistically significant. ISS was the most successful method in distinguishing traumatised patients both in a life threatening or non life threatening condition.

Conclusions: Trauma scores can be used for making more objective, standardised, and accurate judgement on whether the injury was a life threatening one or not. These advantages of using trauma scores in such situations will also be helpful for the conclusion of the lawsuits shortly, but further studies are needed to confirm these findings.

In Turkey, all of the traumatic injuries are defined as forensic cases; medical-legal reports for these cases that do not result in death are written to state the severity of the victim's injury according to the Turkish Penalty Code, section 456. These reports are very important and are the basis of the forensic judgment.^{1–3}

As mentioned in section 456 of the Turkish Penalty Code, the severity of the victim's injury, which determines the severity of the criminal penalty, is divided into four parts. Turkish Penal Code, section 456, part 1 and 4 covers minor and simple injuries that result in a sentence ranging from 2 months to 1 year in prison, whereas part 2 and 3 covers major and severe injuries that result in a sentence ranging from 2–10 years in prison.^{1–2}

According to the Turkish Penal Code, a life threatening condition is one of the main determinants of injury severity, and all of the injuries that are described in section 456, part 2 and 3, endanger life.

Life threatening injury means injury involving a substantial risk of death that results in loss or substantial impairment of the function of a bodily member or organ. The criteria (gold standards), based on traditional forensic opinion for decision making on the injury, is a life threatening one and depends on the presence of one or more of the following:^{1–2}

- Skull fractures, skull cracks, and all intracranial injuries.
- Red blood or cerebrospinal fluid dripping from the nose, mouth, and ear.
- Spinal cord injuries after vertebral fractures.

- Vertebral fractures involving bone body only above C3 vertebrae.
- Injuries that lead to impairment of the integrity of internal organs and/or body cavities.
- Injuries that lead to impairment of the integrity of major blood vessels and nerves.
- Second degree burns in >30% of body surface area, third degree burns in >10% of body surface area.
- Amputation of the glans penis or the body, to the end of the penis just under the glans.
- Poisonings that affect the respiratory and circulatory systems.

Trauma scoring systems have been developed to evaluate the trauma severity, the degree of the harm in the human body, the prognosis after traumatic injury, and the improvements in trauma care quality.^{4–12}

The Injury Severity Score (ISS) is the most widely used anatomical scoring system for assessing the combined effect of multiple injuries, and it consists of the squared and summed Abbreviated Injury Scale (AIS) scores of the three most severely injured body regions. The ISS score ranges from 1–75 and its value correlates with the risk of mortality.^{3–8,9,11,13–16}

Abbreviations: AIS, Abbreviated Injury Scale; FN, negative fraction; FP, positive fraction; ISS, Injury Severity Score; NPV, negative predictive value; PPV, positive predictive value; RTS, Revised Trauma Score; TIS, Turkish Injury Scale; TRISS, Trauma and Injury Severity Score

Revised Trauma Score (RTS) is a physiological scoring system, with high inter-rater reliability and demonstrated accuracy in predicting death, and consists of Glasgow coma scale, systolic blood pressure, and respiratory rate to provide a general assessment of physiological derangement. Values for RTS range from 0–7.8408. A higher score indicates a better prognosis.^{8 9 13 17–19}

Trauma and Injury Severity Score (TRISS) is the most widely used combined scoring system in the world, which combines the RTS, ISS, patient age, and mechanism of injury (blunt or penetrating) to estimate survival probability. The TRISS method offers a standard approach for evaluating outcome of trauma care and it is also a very useful tool for making predictions of risk adjusted hospital mortality.^{6 8 9 12 20–22}

In this study, we investigated the effectiveness and usefulness of the trauma scores in determining the life threatening condition of trauma victims for writing accurate medical-legal reports, and to compare its accuracy to the traditional forensic method.

METHOD

This study included all forensic cases of blunt and penetrating trauma that were admitted to the emergency department of Mersin University Medical Faculty Hospital during the 2 year period (from 2001 through 2003).

Data of the cases were obtained from the patient medical files and medical-legal reports written by the department of forensic medicine. The traumas were analysed according to their demographical characteristics, injury types, and main diagnosis. The diagnoses in the hospital records were coded according to the AIS-85.^{15 23}

The life threatening condition of patients as stated in the medical-legal reports according to the criteria based on traditional forensic opinion was examined. For each case, ISS, RTS, and TRISS were also calculated,²⁴ from information on injuries sustained, recorded in the patient medical files and medical-legal reports, for making a comparison in order to investigate whether trauma scoring systems were as good as traditional methods.

Programme SPSS 9.0 for Windows was used for statistical interpretation. Type I error probability was accepted 0.05.

The ROC curve analysis was used to investigate the success of the trauma scores in distinguishing patients with and without life threatening conditions. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using standard formulas for each trauma score for determining their successes in distinguishing life threatening conditions from non life threatening conditions. Logistic regression analysis was performed to measure the association between trauma scores and life threatening conditions.

RESULTS

Altogether, 296 traumatised patients with blunt/penetrating injury were enrolled in the study. The majority of the patients were male (62.8%) and the mean age was 36.66 ± 16.05 years. The highest number of injuries occurred in the age group 15–25 years. Blunt injury accounted for the majority of traumas (81.1%, 240 cases), which most commonly resulted from falls (50.83%) and motor vehicle accidents (37.91%). The remaining was penetrating injury (18.9%, 56 cases); stab wounds (76.78%) were the cause of most penetrating injuries followed by gun shot wounds (23.22%) (table 1).

By investigating medical-legal reports of the cases, it was found that 88.2% ($n = 261$) of the patients did not have life threatening injuries whereas the remaining 11.8% ($n = 35$) did.

Of total patients, 95% ($n = 284$) were discharged home, and 1.7% ($n = 5$) discharged themselves as they did not accept admission to hospital. There were seven (2.4%) deaths, and of these deaths five were from blunt injury and two were from penetrating injury.

The relations between all scores and groups (with and without life threatening risk) were found statistically significant. Area under the ROC curve of each score was calculated (figs 1a–c) and they are shown in table 2.

For interpretation, we examined the odds ratio as risk coefficient by using binary logistic regression model. When ISS score increases by one unit the predicted odds change by a multiplicative factor of 1.64. This indicates that for an increase of 1 score in ISS, the risk of life threatening increases 1.64 times, and an increase of 1 score in RTS, the risk of life threatening increases 0.23 times. In addition, for an increase

Table 1 Demographical data and the relation between the life threatening conditions and trauma score values

		Total patients	% patients
Age mean $\pm$ SD	36.66 ± 16.05		
Age	15–25 years	96	32.4%
	26–35 years	60	20.3%
	36–45 years	62	20.9%
	46–55 years	34	11.5%
	56 $\uparrow$ years	44	14.9%
Gender	Female	103	36.3%
	Male	181	63.7%
Trauma type	Blunt	240	81.1%
	Penetrating	56	18.9%
Life threatening condition	Present	35	11.8%
	Not present	261	88.2%
Outcomes	Discharge	284	95%
	Death	7	2.4%
	Discharged themselves	5	1.7%
ISS mean $\pm$ SD	Life threatening condition present	30.37 ± 13.81	
	Life threatening condition not present	7 ± 3.97	
RTS mean $\pm$ SD	Life threatening condition present	5.903 ± 1.267	
	Life threatening condition not present	6.87 ± 0.623	
TRISS blunt	Life threatening condition present	66.556 ± 31.67	
	Life threatening condition not present	96.442 ± 9.303	
TRISS penetrating	Life threatening condition present	79.029 ± 25.326	
	Life threatening condition not present	95.531 ± 4.175	

ISS, Injury Severity Score; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

Table 2 Area under the ROC curve for each score (area $\pm$ SE) and the odds ratio (OR) as risk coefficient for the trauma scores and life threatening conditions

	Area under ROC curve (AUC)	SE*	p†	OR	95% confidence interval for OR
ISS	0.992	0.004	0.0001	1.64	1.3718–1.9477
RTS	0.756	0.053	0.0001	0.23	0.13–0.39
TRISS blunt traumas	0.951	0.018	0.0001	0.94	0.91–0.96
TRISS penetrating traumas	0.768	0.071	0.0001	0.88	0.78–0.99

AUC, area under the curve (ROC); ISS, Injury Severity Score; OR, odds ratio; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

*SE, standard error of area; †p, type I error probability of area.

Table 3 The correct and misclassification error probabilities (%) of trauma scores at optimal cut off values

		Specificity (%)	Sensitivity (%)	False + False – (%)	PPV (%)	NPV (%)	Cut off value
ISS*		99.2	85.7	14.3	93.8	98.1	19
RTS†		74.3	54.8	45.2	25.7	94.1	18,1
TRISS†	Blunt	72.2	95.6	4.4	27.8	97.8	56,5
	Penetrating	70.6	68.8	31.3	29.4	81,5	54,5

NPV, negative predictive value; PPV, positive predictive value.

*The success of the Injury Severity Score (ISS) in distinguishing patients with life threatening risk is defined as sensitivity and its success in distinguishing patients without life threatening risk is defined as specificity.

†The successes of Revised Trauma Score (RTS) and Trauma and Injury Severity Score (TRISS) scores in distinguishing patients without life threatening risk is defined as sensitivity and their successes in distinguishing patients with life threatening risk is defined as specificity.

of 1 score in TRISS for blunt trauma, the risk of life threatening increases 0.94 times. Lastly, for an increase of 1 score in TRISS for penetrating trauma, the risk of life threatening increases 0.88 times.

The better the performance of the scores in distinguishing injuries with life threatening risk from the injuries without life threatening risk in terms of sensitivity and specificity, the higher the ROC curve of the scores above the diagonal line. In other words, when we accept the success of ISS score in distinguishing patients with life threatening risk or the successes of RTS and TRISS scores in distinguishing patients without life threatening risk as sensitivity, the ROC curves of these scores will be present above the diagonal lines. In this situation, the success of the ISS score in distinguishing patients with life threatening risk is defined as sensitivity and its success in distinguishing patients without life threatening risk is defined as specificity. In contrast, the successes of RTS and TRISS scores in distinguishing patients without life threatening risk is defined as sensitivity and their successes in distinguishing patients with life threatening risk is defined as specificity.

Sensitivity value of ISS is 85.7% and specificity value is 99.2% when cut off value of ISS was accepted 19. In addition, PPV of ISS is 93.8% and NPV of ISS is 98.1% for this condition. Specificity value of RTS is 74.3% and sensitivity value is 54.8% when cut off value of RTS was accepted 6.6. In addition, PPV of RTS is 94.1% and NPV of RTS is 18.1% for this condition. Specificity value of TRISS for blunt trauma is 72.2% and sensitivity value is 95.6% when cut off value of TRISS for blunt trauma was accepted 89.75%. In addition, PPV of TRISS for blunt trauma is 97.8% and NPV of TRISS for blunt trauma is 56.5% for this condition. Lastly, specificity value of TRISS for penetrating trauma is 70.6% and sensitivity value is 68.8% when cut off value of TRISS for penetrating trauma was accepted 92.2%. In addition, PPV of TRISS for penetrating trauma is 81.5% and NPV of TRISS for penetrating trauma is 54.5% for this condition (table 3).

In calculations, we investigated two types of errors of trauma scores. These are false positive fraction (FP) and false

negative fraction (FN). FP is defined that some cases without life threatening risk will be classified as with life threatening risk. On the other hand, FN is defined that some cases with the life threatening risk will be classified as without life threatening risk. FP of ISS is 14.3% and FN of this score is 0.8%. FP and FN values of the other three scores are shown in table 3.

When we compare the areas under the ROC curve of trauma scores, there is a significant difference between the areas of ISS and RTS. In this condition, it can be said that ISS can more successfully distinguish injuries with life threatening risk from the injuries without life threatening risk than RTS. As a statistically significant difference was found between the areas of penetrating trauma and blunt trauma, it can be said that TRISS can more successfully distinguish life threatening risk in blunt traumas than penetrating traumas.

DISCUSSION

Trauma scoring systems are designed to quantify the severity of an injury, estimate the probability of survival, facilitate pre-hospital triage, allow accurate comparison of different trauma populations, evaluate trauma care, compare trauma patient outcomes among hospitals, and organise and improve trauma systems.^{4-7 10-13 17 20-22}

Numerous studies focussing on sociodemographic characteristics of traumatic injuries determined by trauma scoring systems were found in the literature. Previous studies reported that the majority of traumatic injuries occurred more frequently in the 34–39 year age group, most cases were male patients, and most injuries were related to blunt trauma.^{4 5 7 10 17 21} Our result is concordant with these results.

As according to the Turkish Penalty Code, the severity of the victim's injury determines the severity of the criminal penalty and medical-legal reports that state the severity of injury must be written for all traumatic injuries. For determining the injury severity, the inability period of the victim to follow his ordinary pursuits and the presence of the life threatening or non life threatening condition must be

Figure 1 Area under the ROC curve for (A) Injury Severity Score (ISS), (B) Revised Trauma Score (RTS) and Trauma and Injury Severity Score (TRISS) for the blunt traumas, and (C) TRISS for the penetration traumas

clarified in these reports.^{1,2} No study was found on the usage of trauma scores in identifying the life threatening condition in traumatic injuries from the forensic aspect after doing a literature search. A previous Turkish study by Günay *et al*³ investigated medical-legal reports to compare modified Abbreviated Injury Scale (AIS) and Turkish Injury Scale (TIS) in the evaluation of injuries that causes the sufferer to be unable to follow his ordinary pursuits in order to point out some similarities and differences between these two scoring systems. They stated that AIS was an anatomic ISS that only scored injuries but not the consequences of injuries, and it was insufficient for coding some lesions as the calculation of

the AIS based at most one injury per body region. They also concluded that further studies would be conducted comparing all types of lesions coded in the AIS with the TIS, and, in the same way, comparing all types of lesions coded in the TIS with the AIS.

Various limitations of ISS were reported.^{5,10-14,25} First, the ISS often leaves some injuries out of the scoring process altogether, such as when a patient sustains multiple injuries to a single body region, as it considers at most one injury per body region. Second, it takes no account of physiological variables, such as alcohol and drug consumption, pregnancy, and systemic diseases.

In our study, the mean value of ISS was observed as 30.37 ± 13.81 in the trauma victims suffering from life threatening injuries and 7 ± 3.97 in the traumatised patients having non life threatening injuries (cut off value: 19). The success of ISS in distinguishing patients in a life threatening condition was found to be 85.7% and its success in distinguishing patients in a non life threatening condition was found to be 99.2%. It was determined that 1 point increase in the ISS value would result in 1.64 times increase in the life threatening risk of the trauma victim.

Consistent with our results, previous studies have reported that there was a positive correlation between the ISS value increase and the mortality rate of traumatised patients.^{11,15,25,26}

In the Turkish legal system, the main concern is the potential harm and life threatening condition that will be caused if treatment were not provided at all.³ As ISS is the most widely used highly sensitive and specific measure of injury severity in patients with trauma, and life threatening manner is related to the severity of the injury, ISS can be used for making judgement as to whether the traumatic injury was a life threatening one or not.²

Recent studies have demonstrated that RTS and TRISS were effective in assessing the anatomical and physiological severity of injury, estimating survival probability, evaluating trauma care, and improving the care of injured patients. A positive correlation has also been established between these measures and death.^{4,7,10,12,14,18,20,21}

In our study, when cut off value was taken 6.60, the success of RTS in distinguishing traumatised patients in a life threatening condition (specificity) was found 74.3% and its success in distinguishing traumatised patients in a non-life threatening condition (sensitivity) was found 54.8%. As RTS was found to have fair sensitivity but good specificity, it would be more appropriate to use RTS for distinguishing life threatening injuries.

It was determined that 1 point increase in the RTS value would result in 0.23 times decrease in the life threatening risk of the traumatised patient by examining the odds ratio as risk coefficient. These findings support a negative correlation between the RTS value and the life threatening risk of traumatised patients.

In the present study, the success of TRISS in distinguishing blunt trauma victims in a non life threatening condition and its success in distinguishing penetrating trauma victims in a life threatening condition were found statistically significantly higher. It was determined that 1 point increase in the TRISS value would result in 0.94 times decrease in the life threatening risk of the patients with the blunt trauma and 0.88 times decrease for the patients with the penetrating trauma by examining the odds ratio as risk coefficient.

The results of our study showed that among these trauma score systems, ISS was the most successful method in distinguishing traumatised patients both in a life threatening or non life threatening condition and RTS was found to be the least successful method in trauma scores distinguishing traumatized patients in a non life threatening condition. In

the Turkish legal system, the severity of the victim's injury determines the severity of the criminal penalty and the life threatening condition stated in the medical-legal report is the one of the main determinants for determining the injury severity of the trauma victim.^{1,3}

To our knowledge, our study is the first to examine the role of the trauma scores in determining life threatening or non life threatening injuries from the forensic aspect. Based on the findings of this study, it may be said that trauma scores can be used for making more objective, standardised, reliable, and accurate judgement on whether the injury was a life threatening one or not. These advantages of using trauma scores in such situations will also be helpful for the conclusion of the lawsuits in a short time, but further studies are needed to confirm these findings and to make adaptation of trauma scores according to the traditional criteria for decision making on whether the injury is a life threatening one.

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Competing interests: none declared

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