Turkish Journal of Medical Sciences

Volume 39 | Number 2 Article 15

1-1-2009

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ERYILMAZ, MEHMET; DURUSU, MURAT; MENTEŞ, ÖNER; ÖZER, TAHİR; KILIÇ, SELİM; ERSOY, GÜRKAN; ALTINEL, ÖZCAN; KALEMOĞLU, MURAT; and TÖRER, NURKAN (2009) "Comparison of Trauma Scores for Adults Who Fell From Height as Survival Predictivity," *Turkish Journal of Medical Sciences*: Vol. 39: No. 2, Article 15. https://doi.org/10.3906/sag-0804-18
Available at: https://journals.tubitak.gov.tr/medical/vol39/iss2/15

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This article is available in Turkish Journal of Medical Sciences: https://journals.tubitak.gov.tr/medical/vol39/iss2/15

TÜBİTAK

ORIGINAL ARTICLE

Turk J Med Sci
2009; 39 (2): 247-252
© TÜBİTAK
E-mail: medsci@tubitak.gov.tr
doi:10.3906/sag-0804-18

Comparison of Trauma Scores for Adults Who Fell From Height as Survival Predictivity

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Aim: Falls from a height and their subsequent injuries and traumas can cause morbidity and death. In the present study, ISS, NISS, RTS, and TRISS values were analyzed to assess mortality probabilities of patients who fell from a height.

Materials and Methods: Patients' age, gender, height of falls (0-2 m, 3-5 m, and 6 m and above), organ pathologies, and ISS, NISS, RTS, and TRISS scores were evaluated in terms of mortality.

Results: Regarding the survival rate, no statistically significant difference was found between age and gender ($P > 0.05$). We determined that all trauma scores were correlated with mortality, and that as Injury Severity Score (ISS), New Injury Severity Score (NISS), and Trauma and Injury Severity Score (TRISS) values increased, and as Revised Trauma Score (RTS) values decreased, the mortality rate tended to increase. The area under the curve in the Receiver Operating Characteristic (ROC) analysis was 0.991 for TRISS, 0.910 for ISS, and 0.915 for NISS ($P > 0.001$). The most satisfactory cut-off point for TRISS was 73.5 and at that point, we found the best sensitivity, specificity, and positive and negative predictive values.

Conclusions: In conclusion, the data showed that TRISS values can be used with high reliability when this value is over 73.5 and any score above it has high specificity and mortality.

Key Words: Trauma Scores, Fall from a height, Mortality

Sağkalım Göstergesi Olarak Erişkin Yüksekten Düşme Olgularına Ait Travma Skorlarının Karşılaştırılması

Amaç: Yüksekten düşmeler (YD) travmalara bağlı morbidite ve mortaliteler içinde önemli yer tutar. Olguların mortalite öngörüsü genellikle travma skorları aracılığıyla yapılır. Çalışmamızda yüksekten düşen olgulara ait mortalite olasılıklarını değerlendirmede kullandığımız ISS, NISS, RTS ve TRISS değerleri analiz edildi.

Yöntem ve Gereç: Kasım 1997-Ekim 2007 tarihleri arasında Ankara GATA acil servisine müracaat eden 87 yüksekten düşme olgusuna ait kayıtlar geriye dönük olarak değerlendirildi. Olgular yaş, cins, düşme yükseklikleri(0-2 m, 3-5 m ve 6 m-üstü), gelişen organ patolojileri, ISS, NISS, RTS ve TRISS gibi skorlar ile mortalite açısından değerlendirildi.

Bulgular: Olguların yaş ortancası 25 (17-61) idi. % 33 oranında kadın idi. Sağ kalım oranları açısından yaş ve cinse göre istatistiksel anlam bulunamadı ($P < 0.05$). Düşme yüksekliği arttıkça organ patolojisi sıklığı arttı ($P < 0.001$). Tüm travma skorlarının mortalite ile ilişkili olduğu, ISS, NISS ve TRISS'nin arttıkça, RTS değerinin ise azaldıkça mortalite oranlarının arttığı saptandı. ROC analizinde eğrinin altındaki alan TRISS için 0.991, ISS için 0.910 ve NISS için 0.915 olarak bulundu (her biri için $P > 0.001$). TRISS için kesim değeri 73.5 olarak alındığında en iyi duyarlılık, özgüllük, pozitif ve negatif öngörü değerlerine sahip olduğu saptandı.

Sonuç: Yüksekten düşen erişkin olgularımıza ait travma skorları geriye dönük olarak değerlendirildiği çalışmamızda TRISS değerinin yüksek özgüllük ve mortalite için 73.5 kesim değerinin üzerinde yüksek güvenirlikte kullanılabileceği doğrultusunda veri elde edilmiştir.

Anahtar Sözcükler: Travma Skorları, Yüksekten Düşme, Mortalite

Received: April 04, 2008
Accepted: November 13, 2008

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Introduction

Falls from a height are the main reason for mortality and morbidity among children of all ages (1). In the USA mortality rate of falls from a height is the second most frequent cause of death after motorcycle accidents (2). In trauma health-care centers, it has been found that accidents, homicides, and suicide events are often connected to falls from a height. In general, these cases generate complicated and multiple organ injuries (1). The height fallen, the body part that hit the ground, and the structure of the ground

have been demonstrated to play a characteristic role in the mortality risk (3). Determining the possibility of mortality in these cases is often accomplished by indicators related to the trauma score (4). However, the literature indicates that there is no consensus of opinion concerning which score would be more convenient when evaluating cases and when determining the needed medical treatment. In this study, to predict whether a patient would survive the fall, patients who fell from a height were assessed according to various trauma scores. Our goal was to evaluate the performance of various trauma scores related to mortality together with the findings in the literature.

Material and Method

Retrospective files and radiological results of the patients referred to the Emergency Department of our hospital between November 1997 and September 2007 were included in this study. The study was approved by the hospital Ethics Committee. Patients with incomplete information, who were below 16 years of age, who had fallen from chairs or while walking, or had incurred small scratches, abrasions, lacerations, contusions, hematomas, and soft tissue traumas were excluded from the study. As our medical center is a tertiary-level hospital, patients that were referred from other medical centers for further care and follow-up were also not included in the study. The height fallen was classified into 3 groups as seen in the literature, 0-2 m, 3-5 m and, 6 m above (5). Falls from a one-flat building and a bunk-bed were assessed respectively as 3 m and 2 m. Patients were evaluated according to age, gender, height of fall, organ pathologies, trauma scores, and mortality rate. The Abbreviated Injury Scale (AIS) (6) was applied based on organ injuries. The calculation of trauma scores was carried out according to the Injury Severity Score (ISS) (7), New Injury Severity Score (NISS) (8), Revised Trauma Score (RTS) (9), and Trauma and Injury Severity Score (TRISS) (10), all of which were obtained from the first intervention data obtained from patient records. As an indicator of survival, statistical significance according to the ISS, NISS, RTS, and TRISS values and the degree of relationship with mortality were analyzed and assessed.

Analyses were carried out with SPSS for Windows 10.0 (Chi, Il., USA) statistic package program. Continuous variables were presented as means ± SEM and were compared using Mann-Whitney *U* test. Categorical values were analyzed using Chi-square test. $P < 0.05$ was considered as statistically significant.

Discrimination was measured by the receiver operating characteristic (ROC) curves. "Discrimination" refers to the ability of a model to distinguish patients who experienced an event from those who did not. The area under the curve (AUC) represents the probability that a patient who experienced the event had a higher predicted probability of having that event than a patient who did not. The higher the true-positive rate is relative to the false-positive rate, the greater the AUC is. An AUC of 0.5 indicates that the model does not predict better than chance. The discrimination power of a model is considered perfect if AUC = 1, good if AUC > 0.8, moderate if AUC is between 06 and 0.8, and poor if AUC < 0.6.

Results

The mean age of patients was 25 years (17 – 61). The distribution of patients according to gender based on the mentioned data and the values of trauma score and mortality rate according to the height fallen are presented in Table 1. Respectively, 67% (n = 64) of the patients were male and 33% (n = 23) female.

When the height fallen was considered, no statistically significant difference was observed between the rate of survival, age, and gender ($P > 0.05$). When the trauma scores of the patients fell from different heights were correlated with the rate of survival, we observed that the intensity of organ pathology tended to increase significantly as the height of falls increased ($P < 0.001$).

However, there was no significant difference between dead and living patients and their ages ($P = 0.201$). When the rate of survival were analyzed, it was determined that all types of scores were correlated with mortality ($P < 0.001$). When ISS, NISS, and TRISS values increase and the RTS values decrease, mortality rate increases (Table 1). Scores of all evaluations are shown in Table 2.

An ROC analysis was performed to evaluate the cut-off points of the scoring systems for the mortality risk assessment. The RTS scale was not a valid scale to make

Table 1. Demographic distribution and trauma scores of patients.

Height (m)	n (%)	Age median (min-max)	Trauma Scores median (min-max)				Mortality n(%)	P
			ISS	NISS	RTS	TRISS		
0 - 2m	24(27.58)	24.5(18-52)	9 (3-34)	9 (3-34)	7.84 (5.88-7.84)	0.6 (0.4-56.90)	0	P < *0.001*
03m - 05m	23(26.43)	25(17-46)	27 (9-50)	27 (9-57)	6.61 (0.77-7.84)	7.8 (0.6-83-60)	4(7)	
above 6m	40 (45.97)	22.5(19-61)	34 (22-57)	40 (22-57)	5.29 (0.75-7.84)	44.75 (2.00-99.70)	5(83)	
Gender								
Male	64(67)	25(17-61)	27(3-57)	27(3-57)	6.39(0.755-7.841)	11.4(0.40-99.7)	7(%10.9)	P > *0.05*
Female	23(33)	23(19-52)	27(3-48)	27(6-57)	5.88(0.755-7.841)	9.8(0.40-92.9)	2(%8.7)	
Survival							Height (m)	
Survived	78(88.47)	24.5(17-52)	27(3-48)	27(3-48)	6.613(0.755-7.841)	7.8(0.4-80.9)	4(1-11)	P < *0.001*
Death	9(11.53)	29(21-61)	48(34-57	49(41-57)	2.338(1.314-4.944)	92.9(65.2-99.7)	8 (5-11)	

ISS: Injury Severity Score, NISS: New Injury Severity Score, TRISS: Trauma and Injury Severity Score, RTS: Revised Trauma Score,

Table 2. Mean scores of the systems evaluated in this study.

	All	Survival	Non survival	P
ISS	26.5 ± 14.1	24.3 ± 12.9	45.5 ± 8.6	< 0.001
NISS	26.9 ± 14.5	24.6 ± 13.2	47.1 ± 8.5	< 0.001
RTS	6.2 ± 1.7	6.6 ± 1.1	2.5 ± 1.3	< 0.001
TRISS	27.4 ± 30.8	20.4 ± 23.9	87.9 ± 11.4	< 0.001

ISS: Injury Severity Score, NISS: New Injury Severity Score , TRISS: Trauma and Injury Severity Score, RTS: Revised Trauma Score,

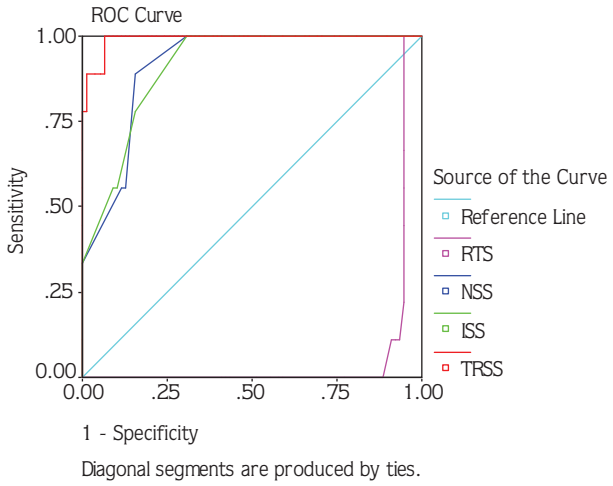
a decision regarding the mortality state of a patient while results obtained from the other 3 scales were found more useful and appropriate. The area under the curve at the ROC analysis was 0.991 for TRISS, 0.910 for ISS, and 0.915 for NISS (P < 0.001 for each). ROC curves of the 4 scoring systems are presented in Figure 1. The best cut-off point for each scoring system was determined and then the sensitivity, specificity, positive predictive value (PPD), and negative predictive values (NPD) were calculated. When a value of 73.5 is accepted as the cut-off point of the TRISS scoring system, this value provided most accurate results in predicting mortality excluding a single incorrect result in 1 out of 2 cases who had died (correct positive) or who were alive (correct negative) (Table 3).

Discussion

The total number of patients served each year in the Emergency Department at our hospital is approximately 120.000. The rate of trauma patients is almost 40% at our center.

Falls from a height are the most frequent cause of death after accidents involving motorized vehicles (2). Industrial accidents and fall from a height related to suicide (11) are encountered more often in adults compared to children (12). All patients in our study were over 16 years of age.

The largest series of study in the literature includes 201 cases and demographic analyses of this 1-year-length study were reported by Ersoy et al. (13). In 180 cases,



ISS: Injury Severity Score, NISS: New Injury Severity Score , TRISS: Trauma and Injury Severity Score, RTS: Revised Trauma Score

Figure 1. ROC analysis for trauma scores on mortality risk.

Agalar et al. (14) investigated the causes that have an impact on mortality due to falls from a height. In our study the number of patients included for assessment was 87. The restrictions of our study were the existence of a retrospective design and conditions of assessing adult age groups. Most of the deaths that occurred due to falls from a height were not referred to our hospital and therefore we assume that the actual number of patients who fell from a height can be more than recorded.

Kennedy et al. (15) state that one of the most frequent types of falling from heights was falls from a low height and that this type of fall was more frequent in women of advanced age. When patients that fell from a height were studied, no publication was found reporting a statistically significant result regarding gender; in our study 33% of the patients were female and 67% male. The rate of mortality in males was 8.7%. However, a significant difference was determined for females. But we assume that this finding shall not possess a scientific continuity.

Kennedy et al. (15) determined that falls from heights less than 2 m commonly were not as severe as expected when compared to falls from a height higher than 2 m. Further, they determined that current associated pathologies were the main cause of increased mortality and morbidity. The investigators also added that spinal injuries were more frequent in falls from a height of 3 m or above, but according to Velhamos et al. (16) this is not an absolute rule. According to the guideline of the Advanced Trauma and Trauma Life Support Course-ATLS (17), 6 m of height is considered a distance that may clinically cause severe major traumas.

Falls from this height can trigger a triage activation mechanism to activate trauma teams in hospitals (4). The correlation between the height that the patient fell and the clinical severity has not yet been scientifically defined (5). However, as reported in the literature, falls that occur from a height of 12 m were fatal 50% of the time while falls from a height higher than 18 m were 100% fatal (18). However, a case was presented in the literature where a patient had fallen from 19 stories (57 m), and eventually survived and managed to stay alive after various medical interventions (19). In many studies, 4.5 m (20,21), 5 m (22), and 6 m (23) of heights were recommended to be considered as limits. In our study, the height of falls was over 6 m in 46% of our patients,

Table 3. Mortality predictive values according to trauma scores.

	Cut Off	Sensitivity	Specificity	PPV	NPV	P	OR	95% CI (min-max)
ISS	31.5.	100	69.2	27.3	100	P = 0.001	1.179	(1.073-1.299)
NISS	31.5.	100	69.2	27.3	100	P = 0.001	1.185	(1.072-1.309)
RTS	1.04.	100	5.1	10.8	100	P < 0.001	0.439	(0.293-0.659)
TRISS	65.2.	100	93.6	64.3	93.6	P = 0.010	1.228	(1.050-1.438)
TRISS	73.5.	88.9	98.7	88.9	98.7			

ISS: Injury Severity Score, TRISS: Trauma and Injury Severity Score, RTS: Revised Trauma Score, PPD: Positive predictive value, NPD: Negative predictive value, CI: Confident Interval

whereas the highest fall occurred at 11 m. In our study, the rate of heights fallen that was 6 m or above was found higher compared to the literature. We assume that this is connected with the fact that our hospital is a medical center that serves a regional hospital, and that attempts of suicide from high buildings and accidents are mostly related with the falls.

The horizontal falls of adults may show differences compared to vertical falls. Parameters affecting survival in falls from a height can display a complex character of numerous physical and bio-mechanical factors. Deaths commonly occur in the early stages of a multiple trauma or a fatal cranial trauma (24,25). Based on the retrospective data obtained in our study, we were concerned only with the data related to age and height fallen. Accordingly, we determined that 83% of the patients who fell from a height of 6 m or over died. The multiplicity of patients with cranial trauma is compatible with the literature (25,26)

The speed with which any fall occurs is dependent on the height fallen; therefore, it can be expected that the extent of injury should increase parallel with the height of a fall (18). In a study including 600 patients, Atanasijevic et al. (27) demonstrated that there was a close correlation between the location of bodily injuries and organs with the height of falls. Regarding seriousness of injuries and probability of mortality, it was determined that the speed of the fall and the first site of impact on the body after the fall were important independent prognostic factors (5,18). On the other hand, Lapostolle et al. stated that the height fallen was an important prognostic factor. In our study, we conclude that the rate of mortality increases as height increases.

Trauma scoring systems are generally used to determine the severity of all types of traumas, and there are lots of controversies regarding the predictive values of these scoring systems. ISS is the most important factor that defines the seriousness of height and age in traumas (14) and an ISS value over 15 is classified as patients with major injuries (5). The literature currently suggests that NISS is better at anatomical scoring.

However, there is no study evaluating the predictivity of these scoring systems for falls from heights. In our study, there was a small difference between ISS and NISS values. We statistically determined that the predictive values on mortality of both scoring systems were not different. Although, it was reported that NISS values were more useful in predicting mortality in trauma patients, we determined that, in predicting the mortality of a patient who fell from a height, there is no statistically significant difference between these 2 scores.

Cut-off values were calculated by ROC analysis for each scoring system. Specificity, PPV, and NPV values of RTS were lower than the other 3 scoring systems, and therefore, we determined that to designate the clinical course of patients that fall from heights was not of much value. Especially, with a specificity of 5.1%, these values were the lowest value when compared to other tests. The threshold value of TRISS was found to be 65.2 and at this point specificity, PPV, and NPV were found 93.6%, 64.3%, and 93.6%, respectively. It was determined that, in patients who fell from a height, the TRISS value could be used with a higher reliability to estimate the mortality rate according to the 3 tests and that the risk of mortality could be higher in patients with a score over 65.2.

No other studies were found in the literature that compared these trauma scores in isolated patients who fell from a height. Fedakar et al. compared trauma scores of 627 judicial trauma patients that occurred for various reasons (28). In their study, to issue a decision related to "injuries that compromise survival", the Glasgow coma score was proved more useful and efficient compared to RTS, TRISS, ISS, and NISS. This result is almost contrary to our findings and may arise from the assessment of trauma cases composed of isolated adult patients who had fallen from a height.

Conclusion

In our study we assessed the trauma scores of adult patients who had fallen from heights and we found that a TRISS value over 73.5 can be used as a predictor with high reliability and high specificity for mortality. We think that prospective studies designed as the model mentioned above may provide a solid contribution in the analysis of our results.

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