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Trauma score

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The Trauma Score (TS), a simple physiological measure of injury severity, is presented as a modification of the previously reported Triage Index by consensus physician peer review. Performance of the Trauma Score is presented as an index of injury severity both alone and in combination with an anatomic index of injury severity, the Injury Severity Score (ISS) and patient age. The application of these tools for field triage and evaluation of care of the trauma victim is proposed.

Injury severity scales of proven reliability and validity are essential for the appropriate allocation of therapeutic resources, for evaluation of changes of status over time, for prediction of outcome, and for evaluation of the quantity and quality of trauma care in differing facilities. The authors[1] previously described research that led to the development of a Triage Score and Triage Index, measures of injury severity that correlate with patient outcome. The value of such tools is clear. Rapid assessment of injury severity is enhanced, and permits not only greater consistency in field triage between various echelons of care, but also informed planning, allocation of therapeutic resources, and system audit.

The previously described Triage Score was modified to include systolic blood pressure and respiratory rate and renamed the Trauma Score (TS) (Table 1). Interval weights were selected by consensus of the participants of a conference on injury severity scoring systems. This paper briefly reports the TS, its correlation with outcome and its performance as an index of severity, when used either alone or in conjunction with an anatomic severity scale and patient age.

METHODOLOGY

A retrospective analysis of the performance of the TS alone and in combination with patient age and the ISS,[2] a quadratic equation derivative of the Abbreviated Injury Scale,[3] was carried out on the computer data bank of over 2000 injured patients. All patient information pertinent to this study had previously been collected, validated for accuracy, and encoded.[1] Autopsy records on all patients who died were provided by the District of Columbia Medical Examiner's office. Patients with penetrating injury were excluded from analysis because a highly detailed anatomical injury coding (PEBL),[4] which is not commonly available is used. Blunt injury was found in nine hundred and forty patients. A subgroup of 249 patients critically injured with blunt trauma were selected for separate analysis. This patient group has been defined in detail previously.[1] The TS and TRISS (the *TR*auma Score, *ISS*, age combination index) were computed for each patient and were used to predict survival probabilities for the two patient sets using a logistic model of the form:

$$P_s\,(X;\,b) = 1/(1 + e{-}^{b})$$

where $P_s\,(X;\,B)$ is the probability of survival and where $b = b_0 + b_1x_1 + \cdots + b_nx_n$. $x_1, x^2, \cdots x_n$ are the numerical codes for each measured variable, and $b_0, b_1, \cdots, b_n$ are weights for each of the variables derived through the use of the Walker-Duncan regression algorithm.[5]
In the first computation,

$$b = b_0 + b_1 \cdot (TS)$$

and in the second computation,

$$b = b_0 + b_1 \cdot (\mathrm{TS}) + b_2 \cdot (\mathrm{ISS}) + b_3 \cdot (\mathrm{age})$$

As a result of a detailed analysis of the information gain for age, this variable was coded as 0 for age less than 60 years, and 1 for 60 years or greater.

The performance of the TS and TRISS as predictors of survival was evaluated using the misclassification rate, information gain, and relative information gain. This methodology is called PER. P is the a priori probability of survival (the survival rate) for all patients in the population being analyzed. The information gain, E for an index is the average improvement (over a priori probability) in the estimation of the probability of survival based on the index. Over the last several years, there has been vacillation between two definitions of E, each of which appealed to some but not to others. The authors believe that both definitions are useful and have included both here.
Definition 1.

$$E = \sum_X /P - P_s\,(X;\,b)/f\,(X)$$

where $P_s\,(X;\,b)$ is the probability of survival given X, and $f(X)$ is the fraction of patients with index value X.

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TABLE 1

Trauma score	Value	Points	Score
A. Respiratory rate	10–24	4	
Number of respirations in 15 sec, multiply by four	25–35	3	
	>35	2	
	<10	1	
	0	0	A.________
B. Respiratory effort			
Shallow—markedly decreased chest movement or air exchange	Normal	1	
Retractive—use of accessory muscles or intercostal retraction	Shallow, or retractive	0	B.________
C. Systolic blood pressure	>90	4	
Systolic cuff pressure—either arm-auscultate or palpate	70–90	3	
	50–69	2	
	<50	1	
No carotid pulse	0	0	C.________
D. Capillary refill			
Normal—forehead, lip mucosa or nail bed color refill in 2 sec	Normal	2	
Delayed—more than 2 sec of capillary refill	Delayed	1	
None—no capillary refill	None	0	D.________
	Total GCS Points	Score	
E. Glasgow coma scale			
1. Eye opening			
Spontaneous ________4	14–15	5	
To Voice ________3	11–13	4	
To Pain ________2	8–10	3	
None ________1	5–7	2	
	3–4	1	E.________
2. Verbal response			
Oriented ________5			
Confused ________4			
Inappropriate words ________3			
Incomprehensible words ________2			
None ________1			
3. Motor response			
Obeys commands ________6			
Purposeful movement (pain) ________5			
Withdraw (pain) ________4			
Flexion (pain) ________3			
Extension (pain) ________2			
None ________1			
	Trauma score________		
Total GCS point (1+2+3)________	(Total points A+B+C+D+E)		

Definition 2.

$$E = 2P(1 - P) - \text{misclassification rate}.$$

The misclassifications are based on a decision rule which predicts a patient will survive if $P_s(X; b) > 0.5$, or will die if $P_s(X; b) \leq 0.5$. Definition 2 is particularly useful when comparing a logistic model obtained in one patient population to another population. Numerical values of E are not directly comparable but can be normalized with respect to a perfect predictor for the same level of P. This value is R in the acronym and is derived from the following expression:

$$R = \frac{E}{2P(1 - P)}$$

TABLE 2. Walker-Duncan Weights for the TS and TRISS for the total patient set and the critical subset

		Total set	Critical subset
Trauma Score	b_0:	−6.9383	−7.0710
	b_1:	0.7124	0.7424
TRISS, (TS, ISS, age combined)	b_0:	−5.9583	−3.5170
	b_1:	1.8384	0.6650
	b_2:	−0.4281	−0.0808
	b_3:	−9.5624	−1.5938

R, or the relative information gain, is a measure of the predictive power of an index. R takes on values from 0 to 1. High R values imply that an index has high predictive power relative to a perfect index.

TABLE 3. PER values for both definitions of E (labeled D_1, D_2), and average probability of survival (P_s) for survivors and nonsurvivors for each patient set

		Total set				Critical subset			
		TS		TRISS		TS		TRISS	
		D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
Probability of survival	P	0.92	0.92	0.92	0.92	0.81	0.81	0.81	0.81
Information gain	E	0.105	0.100	0.131	0.113	0.24	0.23	0.26	0.25
Relative information gain	R	0.73	0.70	0.90	0.77	0.77	0.74	0.86	0.80
Average P_s survivors		0.967		0.985		0.937		0.953	
Average P_s nonsurvivors		0.402		0.309		0.265		0.207	

RESULTS

Table 2 contains the Walker-Duncan weights for the TS and TRISS for each patient set. The weights vary between the total set and the critical subset and, thus, affect the probabilities of survival. The constant b_0 reflects the intercept on the probability of survival axis. The coefficient b_1 reflects the steepness of the probability of survival curve for the TS. Coefficients b_2 and b_3 reflect the impact of ISS and age on the probability of survival curve. The differences in signs of the coefficients show that as age and ISS increase, the probability of survival decreases and that a high TS correlates with a good outcome.

Table 3 gives the PER values for both definitions of *E*, and the average probability of survival in survivors and nonsurvivors for each patient set. The difference between these two values is a good measure of severity index performance.

The difference between the two patient populations under study is shown by the *p* values of 0.81 a priori probability of survival in the critical subset and 0.92 probability of survival for the patient group at large. Both measures (D_1 and D_2) rank TRISS as better than the TS alone for both patient groups. This is shown by the *R* values. The *R* values rate both indices between 0.7 and 0.9 of perfect index performance for these patient groups. The best index performance was shown by TRISS on the total set, which is the type of patient set most likely to be subject to an evaluation of care scrutiny.

Table 4 gives the false positive and false negative prediction rates. A few data items were missing accounting for the slightly differing populations (N_1–N_4). The use of an anatomic index physiological index combination with age, reduces the misclassification rate particularly the false negative predictions.

Table 5 gives the distribution of the TS in the total patient set, together with the probabilities of survival associated with each score.

Several modifications of the TS were analyzed, but did not improve on the results shown here. Of particular note, each state of each variable was coded based on the individually computed probability of survival values. This resulted in minor changes of the assigned scoring system, but improved the *R* value of index performance by less than 0.01.

TABLE 4. False negative rate and false positive rate for the TS and the TRISS for total patient set and critical subset

	False negative rate[a]	False positive rate[b]
TS		
Total set (N_1 = 821)	30/64	5/757
Critical subset (N_2 = 226)	14/43	4/183
TRISS		
Total set (N_3 = 815)	19/64	8/751
Critical subset (N_4 = 224)	9/43	5/181

[a] Number predicted to live but died/total number.
[b] Number predicted to die but lived/total number.

TABLE 5. Probabilities of survival (P_s) for and percentage of patients (%) with each value of the TS

TS	P_s	%
16	0.99	66
15	0.98	14
14	0.95	6.3
13	0.91	3.4
12	0.83	2.8
11	0.71	1.3
10	0.55	1.6
9	0.37	0.49
8	0.22	0.24
7	0.12	0.24
6	0.07	0.49
5	0.04	0.00
4	0.02	0.12
3	0.01	0
2	0	3.2
1	0	0

DISCUSSION

A meaningful measure of injury severity would be a significant step to characterize the trauma patient. In modifying the statistically derived Triage Index, a slightly less powerful measure of injury severity has been produced in the TS. However, in adding the systolic blood pressure and respiratory rate to the scoring system, a higher degree of face validity for the attending physician was obtained.

The probability of survival associated with any value of TS or TRISS can be computed using Table 2. The data indicate that age is a statistically important factor in predicting outcome, but its relative importance diminishes as a certain level of critical illness supervenes. It is also found that for the range of moderately severe injuries, patients with ages of 60 years or more were significantly compromised.

The authors have developed the PER analysis to evaluate the performance of severity indices. Table 3 contains results for both definitions of information gain. The TS has less predictive power than the Triage Index. The two differ in developmental methodology; "consensus expert opinion" versus "statistical." Systolic blood pressure is an important component of clinical trauma evaluation, and respiratory rate has recently been shown again to be a sensitive indicator of respiratory distress.[6] Accurate field measurement of both could be aided by the educational impact of introduction of the TS. When used alone, the TS as evaluated on this data base performs better than any other single index or score with the exception of the Triage Index. Statistically significant separation between survivors and nonsurvivors is evident.

TRISS, despite the aggravating clinically inconsistent elements of the Abbreviated Injury Scale,[3] performs very well as a predictor of outcome. An R value of 0.90 reflects the power of the physiological indicator, anatomical descriptor and age combination in defining injury severity. It is hoped that needed improvement in the Abbreviated Injury Scale will reconcile the clinical pathology of trauma with the descriptive terminology of this scoring system. This could result in both a modest improvement in statistical performance and a wider acceptance of the use of such indices by physicians for evaluation of care.

Table 4 indicates that the direction of error is still towards underprediction of severity. This is reflected by relatively higher rates of false negative predictions (patients predicted to live but died). These errors are reduced when age and the ISS are added to the TS. There are several factors contributing to false negative predictions:

False Predictions from the Anatomical Scale

The Abbreviated Injury Scale does not discriminate between lethal anatomical injury and sublethal injury to the same organs or combinations.

False Predictions from Admission TS

The data base for testing the TS consisted only of measurements obtained on arrival at hospital. A significantly worse set of physiological data, particular coma scores, can sometimes be attained postadmission in spite of optimum early care. For use in care evaluation, the worst TS within 1 h of injury may be a more appropriate measure.

Therapeutic or System Failures

Therapeutic or system failures should be distinguished from the true-false predictions mentioned previously. The latter are unpredicted deaths that could not have been prevented by more appropriate or timely interventions in a given system of trauma care. The former may be failures of the system or of one system component. Clear identification of system failures may enable modification of the system and improvement of care. Clearly age, anatomical injury, and physiological deviation from normal are all essential components in an evaluation of care methodology that includes injury severity.

The TS has a potentially important application in emergency medical service operations as a means of facilitating field triage. Table 3 identifies a good performance in predicting outcome in the potentially critical subset of patients ($R = 0.77$) and a statistically significant separation of the survivors and deaths. Table 5 illustrates that the patients likely to benefit from prompt diagnosis and definitive care at a trauma center are those with a TS of 12 or less. The majority (90%) of patients transported to hospital with injury have scores greater than 12. A clear understanding of this fact may reduce the trepidation with which a regional trauma system is often viewed by hospital administrators and physicians.

Simple decision rules regarding the site and multiplicity of injury can be incorporated with the TS for field triage. Thus, when informed of the mechanism of injury and estimated transport times to various facilities, the physician providing medical control to the field can act with a level of precision which can be reviewed and evaluated in a system audit.

When good medical control for interventions at the scene and prompt rapid transport are available, system, failure in the prehospital phase of care most often results from incorrect triage decisions. Patients with critical injuries not uncommonly languish at the "nearest hospital" in need of definitive diagnosis and therapy. Excluding the dead on arrival and those who die briefly thereafter, it would be fair to judge a regional system of trauma care by the number of deaths occurring in hospitals other than designated trauma centers. There should be no deaths that have occurred as a direct result of injury. Those that do occur have not had the benefit of the correct decision enabling them to reach the appropriate level of care. Likewise, less severely injured patients sometimes transported at great cost by helicopter, can burden the limited resources of a trauma center, deny access for the critically injured and contribute to the already significant cost of regional trauma care. Clearly, efficient and accurate field triage is essential to regional systems of trauma care. The TS, after further empirical testing, may prove to be of some value in defining the crucial components involved in emergency decisions, choices, and patient outcomes.

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