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Comparison of Glasgow Coma Scale with Physiologic Scoring Scales in Prediction of In-Hospital Outcome of Trauma Patients; a Diagnostic Accuracy Study

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Abstract

Introduction: Limitations of Glasgow coma scale (GCS) led the researchers to designing new physiologic scoring systems such as revised trauma score (RTS), rapid acute physiology score (RAPS) and rapid emergency medicine score (REMS), and worthing physiological scoring system (WPSS). However, it is not yet known whether these models have any advantage over GCS.

Objective: The present study attempted to compare the values of 4 physiologic scoring systems including RTS, RAPS, REMS and WPSS with GCS in predicting in-hospital mortality of trauma patients.

Methods: The present diagnostic accuracy study was performed on trauma patients presenting to emergency departments of 4 hospitals in Iran throughout 2017. Patients were clinically evaluated and were followed until discharge from hospital. Finally, the status of patients regarding mortality and poor outcome (death, vegetative status, severe disability, and moderate disability) was recorded and predictive value of GCS was compared with physiologic scales.

Results: Area under the ROC curve of GCS in prediction of in-hospital mortality was not significantly different from that of REMS (0.89 vs. 0.91; p=0.298), RAPS (0.89 vs. 0.88; p=0.657), and WPSS (0.89 vs 0.91; p=0.168) but was significantly more than RTS (0.89 vs. 0.85; p=0.002). In addition, area under the ROC curves of GCS, REMS, RAPS, WPSS and RTS in prediction of poor outcome were 0.89, 0.88, 0.88, 0.91, and 0.81, respectively. Area under the ROC curve of GCS in prediction of poor outcome did not differ from area under the ROC curves of REMS (0.89 vs. 0.88; p=0.887), RAPS (0.89 vs. 0.88; p=0.601) and WPSS (0.89 vs. 0.91; p=0.113) but was significantly higher than RTS (0.89 vs. 0.81; p<0.0001).

Conclusions: Findings of the present study indicated that GCS is still the best method for evaluating injury severity and trauma patients' outcome in the emergency department; because it is easier to calculate and assess than many physiologic scales and it has a better performance in predicting in-hospital mortality and poor outcome compared to RTS.

Key words: Decision Support Techniques; Glasgow Coma Scale; Multiple Trauma; Patient Outcome Assessment

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INTRODUCTION

Glasgow coma scale (GCS) is the most important and most common method for evaluation of injury severity and level of consciousness in emergency departments. This scoring system is easily applicable and has acceptable accuracy in evaluating patients' consciousness level and high precision in predicting the outcome of patients (1-4). GCS has the ability to classify head injury severity where a score of 13 – 15 shows mild injury, 9 – 12 indicates moderate injury, and a score less than 9 is indicative of severe brain damage/head injury. Yet, along with all of the advantages of this scoring system, it has disadvantages such as low efficiency in intubated patients, poor application in

cases of language differences and inability to evaluate the reflexes of the brain stem (5, 6).

These limitations led the researchers to designing new scoring systems and newer models such as physiologic scoring systems were introduced, among which revised trauma score (RTS), rapid acute physiology score (RAPS) and rapid emergency medicine score (REMS), and Worthing Physiological Scoring System (WPSS) can be named (7-10). Recent consideration of physiologic scoring systems by healthcare departments led to significant advances in the design of these systems (11-15). In almost all of these systems, GCS is the main part that evaluates injury severity. In these scoring systems, in addition to GCS, physiologic scales such as body temperature, respiratory rate, blood pressure and heart rate are used for determining injury severity. However, a question that has not been answered yet is that does adding these physiologic scales to GCS lead to a sufficiently and significantly better and more accurate diagnosis of the injury severity and outcome or not. To answer this question, the present study attempted to compare the values of 4 physiologic scoring systems including RTS, RAPS, REMS and WPSS with GCS in predicting in-hospital mortality of trauma patients.

Methods

Study design and setting

The present diagnostic accuracy study is a multicenter research carried out in 4 hospitals located in Tehran, Tabriz, and Mashhad in 2017. In each hospital, an emergency medicine physician was in charge of gathering data. Before the initiation of the study, a checklist was prepared and sufficient explanation was given to the emergency medicine specialists regarding the method of data gathering. In each month, 10 checklists were randomly selected from each hospital and evaluated to ensure that they are correctly filled out. Before the initiation of the study, an informed consent was obtained from either the patient or their relative. Throughout the study, the researchers adhered to the declaration of Helsinki. The present study was approved by the ethics committee of Shahid Beheshti University of Medical Sciences (code: IR.SBMU.REC.1396.237).

Study population

The study population consisted of trauma patients over 18 years of age presenting to emergency departments. Exclusion criteria were age less than 18 years, pregnancy, rapid disposition of the patient to the operating room, and discharge against medical advice. Sampling was performed using convenience method. To determine sample size, the study by Hajian-Tilaki et al. was used (16). Based on that study, considering the 5.2% prevalence of in-hospital mortality in trauma patients (17) and area under the curve of GCS in predicting in-hospital mortality being 0.88 (18) and marginal error of 0.05, the minimum required sample size was calculated to be 347 patients. Finally, the data of 1702 patients was evaluated.

Data gathering

In each center, the researcher evaluated the demographic data (age, sex), trauma mechanism, clinical findings of each patient in a prospective manner and recorded them in the data gathering form. The variables of the 4 physiologic models were also evaluated. These variables included age, mean arterial blood pressure, heart rate, respiratory rate, O2 saturation level, body temperature, and consciousness level of the patients. The measures for all of these factors were evaluated on admission. Patients were followed as long as they were hospitalized.

Outcome

In-hospital outcome was evaluated based on Glasgow outcome scale. The living status of the patient (dead or alive) was recorded at the time of discharge from hospital. Poor outcome included mortality, vegetative state, and severe and disability. Good outcome was considered good recovery and mild disability.

Statistical analyses

Analyses were performed using STATA 14.0 statistical software. Based on their final outcome, the patients were divided into 2 groups of dead and alive. Then area under the receiver operating characteristics (ROC) curve as well as sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values with 95% confidence interval were calculated for each of GCS, RTS, RAPS, REMS and WPSS models. Area under the curves of all 4 models were compared with GCS.

Results

Baseline characteristics

Finally, the data of 1702 patients with the mean age of 33.7 ± 15.0 years were included in the study (76.9% male). The most important mechanisms of injury were motorcycle (28.4%) and car (26.3%) accidents. According to GCS, brain injury was mild in 88 (5.4%) patients, moderate in 28 (1.7%), and severe in 87 (5.3%) cases. Mean GCS score in the studied patients was 14.3±2.4. Mean vital sign measures of the patients on admission have been reported in table 1.

Table 1: Baseline characteristics of included patients

Variable	Value
Age (mean±SD; year)	37.7±15.0
Gender (n, %)	
Men	1259 (76.9)
Women	378 (23.1)
Mechanism (n, %)	
Motor vehicle accident	895 (52.7)
Pedestrian car accident	275 (16.8)
Fall (more than 1 meter)	106 (6.5)
Fall (less than 1 meter)	109 (6.7)
Bicycle running accidents	151 (9.2)
Other	101 (6.2)
Glasgow coma scale (n, %)	
15	1434 (87.6)
13-14	88 (5.4)
9-12	28 (1.71)
3-8	87 (5.31)
Vital sign (mean±SD)	
Heart rate (beat/min)	87.5±15.2
Body temperature (Celsius)	36.8±0.9
Systolic blood pressure (mmHg)	117.2±15.6
Diastolic blood pressure (mmHg)	74.4±9.9
Respiratory rate (n/min)	16.2±5.7
PCO2 (%)	94.5±6.4
Outcome (n, %)	
Death	111 (6.8)
Vegetative	0 (0.0)
Severe disability	42 (2.6)
Moderate disability	244 (14.9)
Good recovery	1240 (75.8)

The rate of in-hospital mortality was 111 (6.8%) cases. 42 (2.6%) patients had been discharged from the hospital with severe disability and 244 (14.9%) were discharged with moderate disability. In addition, 1240 (75.8%) patients were discharged from the hospital with good recovery. Considering the definitions of the present study, poor outcome was observed in 153 (9.4%) cases.

Performance of evaluated scales in prediction of in-hospital mortality

Table 2 shows the screening performance characteristics of physiologic scoring systems and Glasgow coma scale in prediction of in-hospital mortality. Area under the ROC curve of GCS in prediction of in-hospital mortality was 0.89 (95% CI: 0.85 to 0.93). In addition, area under the ROC curves for REMS, RAPS, WPSS and RTS were 0.91 (95% CI: 0.88 to 0.94), 0.88 (95% CI: 0.84 to 0.92), 0.91 (95% CI: 0.87 to 0.94), and 0.85 (0.80 to 0.89), respectively. Area under the ROC curve of GCS in prediction of in-hospital mortality was not significantly different from those of REMS (p=0.298), RAPS (p=0.657), and WPSS (p=0.168). However, area under the ROC curve of GCS in prediction of in-hospital mortality was significantly more than RTS (p=0.002) (figure 1). Sensitivity of GCS at the cut-point of 14 in prediction of in-hospital mortality was calculated to be 81.1%. Sensitivities of REMS, RAPS, WPSS and RTS were found to be 91.0%, 81.1%, 90.1 and 68.5%, respectively. In addition, specificity of GCS in prediction of in-hospital mortality was 92.6%. Specificities of REMS, RAPS, WPSS and RTS were 76.1%, 84.5%, 83.9 and 97.1, respectively.

Performance of evaluated scales in prediction of in-hospital poor outcome

Table 2: Performance of physiologic scoring systems and Glasgow coma scale in prediction of in-hospital mortality

	REMS	RAPS	WPSS	RTS	GCS
Cut-offs	**≥3**	**≥2**	**≥4**	**≤7**	**≤14**
True positive	101	90	100	76	90
True negative	1161	1295	1281	1482	1413
False positive	365	231	245	44	113
False negative	10	21	11	35	21
Screening performance					
Sensitivity	91.0 (83.7-95.4)	81.1 (72.3-87.6)	90.1 (82.6-94.7)	68.5 (58.9-76.8)	81.1 (72.3-87.6)
Specificity	76.1 (73.8-78.2)	84.5 (82.9-86.6)	83.9 (82.0-85.7)	97.1 (96.1-97.9)	92.6 (91.1-93.8)
PPV	21.7 (18.1-25.8)	28.0 (23.2-33.4)	29.0 (24.3-34.1)	63.3 (53.4-71.8)	44.3 (37.4-51.4)
NPV	99.1 (98.4-99.6)	98.4 (97.5-99.0)	99.1 (98.4-99.6)	97.7 (96.8-98.4)	98.5 (97.7-99.1)
Positive LR	3.8 (3.4-4.2)	5.4 (4.6-6.2)	5.6 (4.9-6.4)	23.7 (17.3-32.6)	10.9 (9.0-13.4)
Negative LR	0.12 (0.06-0.21)	0.22 (0.15-0.33)	0.12 (0.07-0.21)	0.32 (0.24-0.43)	0.20 (0.14-0.30)

Data are presented with 95% confidence interval; GCS: Glasgow coma scale; LR: Likelihood ratio; NPV: Negative predictive value; PPV: Positive predictive value; RAPS: Rapid acute physiology score; REMS: Rapid emergency medicine score; RTS: Revised trauma score; WPSS: Worthing physiology scoring system.

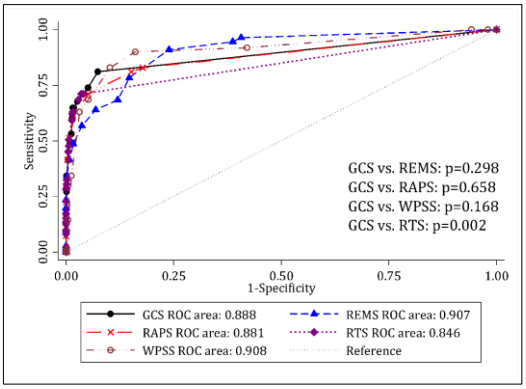

Figure 1: Comparison of area under the receiver characteristics (ROC) curve of assessed scoring systems in prediction of in-hospital mortality of trauma patients.

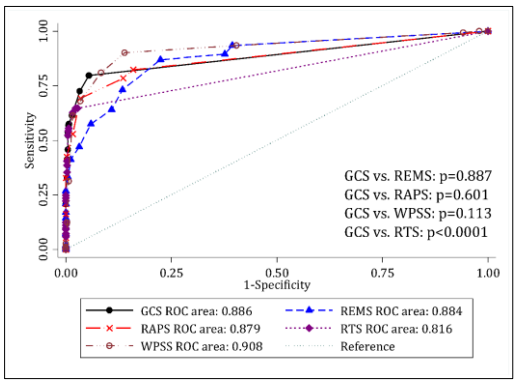

Figure 2: Comparison of area under the receiver characteristics (ROC) curve of assessed scoring systems in prediction of in-hospital poor outcome of trauma patients.

Table 3 shows the screening performance characteristics of physiologic scoring systems and Glasgow coma scale in prediction of in-hospital poor outcome. Area under the ROC curve of GCS in prediction of in-hospital poor outcome was 0.89 (95% CI: 0.85 to 0.91). In addition, area under the ROC curves of REMS, RAPS, WPSS and RTS were 0.88 (95% CI: 0.85 to 0.81), 0.88 (95% CI: 0.84 to 0.91), 0.91 (95% CI: 0.88 to 0.94), and 0.81 (0.78 to 0.86), respectively. Area under the ROC curve of GCS in prediction of poor outcome was not different from area under the ROC curves of REMS (p=0.887), RAPS (p=0.601) and WPSS (p=0.113). However, area under the ROC curve of GCS in prediction of in-hospital poor outcome was significantly higher than RTS (p<0.0001) (figure 2). Sensitivity of GCS at the cut-point of 14 in prediction of in-hospital poor outcome was 79.7%. Sensitivities of REMS, RAPS, WPSS and RTS were 86.9%, 78.4%, 84.3 and 62.7%, respectively. Additionally, specificity of GCS in prediction of in-hospital poor outcome was 94.5%. Specificities of REMS, RAPS, WPSS and RTS were 77.6%, 86.4%, 86.0 and 98.4, respectively.

Discussion

Findings of the present study showed that using physiology scoring systems for predicting the outcome of trauma patients is not superior to using GCS. Although sensitivity of REMS and WPSS in prediction of patients' outcome was higher than GCS, evaluation of area under the ROC curve of the mentioned models showed that their screening

Table 3: Performance of physiologic scoring systems and Glasgow coma scale in prediction of in-hospital poor outcome

	REMS	RAPS	WPSS	RTS	GCS
Cut-offs	**≥3**	**≥2**	**≥4**	**≤7**	**≤14**
True positive	133	120	129	96	122
True negative	1151	1283	1277	1460	1403
False positive	333	201	207	24	81
False negative	20	33	24	57	31
Screening performance					
Sensitivity	86.9 (80.3-91.6)	78.4 (70.9-84.5)	84.3 (77.4-89.5)	62.7 (54.5-70.3)	79.7 (72.3-85.6)
Specificity	77.6 (75.3-79.6)	86.4 (84.6-88.1)	86.0 (84.2-87.8)	98.4 (97.6-98.9)	94.5 (93.2-956)
PPV	28.5 (24.5-32.9)	37.4 (32.1-43.0)	38.4 (33.2-43.8)	80.0 (71.5-86.5)	60.1 (53.6-66.8)
NPV	98.2 (97.3-98.9)	97.5 (96.4-98.2)	98.2 (97.2-98.8)	96.2 (95.1-97.1)	97.8 (96.9-98.5)
Positive LR	3.9 (3.5-4.3)	5.8 (5.0-6.7)	6.0 (5.2-7.0)	38.8 (25.6-58.8)	14.6 (11.6-18.3)
Negative LR	0.17 (0.11-0.25)	0.25 (0.18-0.34)	0.18 (0.13-0.26)	0.38 (0.31-0.46)	0.21 (0.16-0.29)

Data are presented with 95% confidence interval; GCS: Glasgow coma scale; LR: Likelihood ratio; NPV: Negative predictive value; PPV: Positive predictive value; RAPS: Rapid acute physiology score; REMS: Rapid emergency medicine score; RTS: Revised trauma score; WPSS: Worthing physiology scoring system.

performances were not different. More importantly, performance of GCS in prediction of mortality and poor outcome was even better than RTS. In determining the outcome of a disease, both sensitivity and specificity of a model are important (19).

Findings of the present study showed that both sensitivities and specificities of REMS, RAPS, WPSS, and GCS in prediction of mortality and poor outcome of the patients were similar. Meanwhile, sensitivity of RTS in prediction of mortality (68.5%) and poor outcome (62.7%) was lower than other models. Therefore, it seems that adding parameters such as blood pressure, heart rate, respiratory rate, arterial blood O_2 level and body temperature to the level of consciousness, usually evaluated using GCS, does not increase the efficiency of GCS in predicting the outcome of patients; it might even decrease its efficiency in some cases (such as RTS).

In the present study, clinical evaluation has been performed and consciousness level of the patients presenting to the emergency department has been measured on admission. The reason that adding physiologic parameters did not improve the performance of GCS could be that blood pressure, heart rate, respiratory rate and consequently arterial blood O_2 level might have changed due to the stress caused by the accident and instability of the patient and not because of the severity of the patient's injury (20). Therefore, the injury severity might have not been that high but due to stress and other confounding factors such as the condition of patient's transfer to emergency department, physiologic parameters might have changed significantly, which is not a real indication of injury severity. Overall, it seems that in emergency settings, it is better to use GCS for determining injury severity and predicting the outcome of the patients instead of physiologic scoring models.

Limitations

Convenience sampling could be pointed out as a limitation of the present study. This type of sampling increases the probability of selection bias. However, since the number of participants in the present study was more than 4 times the estimated required sample size at the beginning of the study, the researchers believe that the probability of selection bias is low in the present study. Moreover, in calculating the physiologic scores, skill of the physician or the treatment staff is very important since their calculation formula is a little complicated. Overcrowding of the emergency department may also affect the precision of calculations of physiologic scoring scales.

CONCLUSIONS

Findings of the present study indicated that GCS is still the best method for evaluating injury severity and trauma patients' outcome in the emergency department. Because it is easier to calculate and assess than many physiologic scales and has a better performance in predicting in-hospital mortality and poor outcome compared to RTS.

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AUTHORS' CONTRIBUTION

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

CONFLICT OF INTEREST

None declared.

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None declared.

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