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ORIGINAL RESEARCH

Glasgow Coma Scale Versus Physiologic Scoring Systems in Predicting the Outcome of ICU admitted Trauma Patients; a Diagnostic Accuracy Study

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Abstract: **Introduction:** There is no consensus on the performance of decision rules in predicting the prognosis of trauma patients. Therefore, the present study aimed to compare the value of Glasgow coma scale (GCS) and physiologic scoring systems in predicting mortality and poor outcome of trauma patients. **Methods:** This diagnostic accuracy study was conducted on multiple trauma patients admitted to the intensive care units of two hospitals in Tehran, Iran, from 21 November 2020 to 22 May 2021. The patients' demographic characteristics, length of stay in the intensive care unit (ICU), the vital signs, and the GCS on admission were recorded. Finally, the mortality, disability, and complete recovery of patients at the time of discharge were evaluated and receiver operating characteristics (ROC) curve analysis was used to compare the performance of physiologic scoring systems with GCS. **Results:** 200 trauma patients with the mean age of 43.53±19.84 years were evaluated (74% male). The area under the ROC curve for New Trauma Score (NTS), Revised Trauma Score (RTS), Worthing Physiological Scoring System (WPSS), Rapid Acute Physiology Score (RAPS), Rapid Emergency Medicine Score (REMS), Modified Early Warning Score (MEWS), National Early Warning Score (NEWS), Glasgow Coma Scale, Age, and Systolic Blood Pressure score (GAPS) ,Glasgow coma scale (GCS) in prediction of mortality were 0.95, 0.95, 0.83, 0.89, 0.91, 0.84, 0.77, 0.97, and 0.98 respectively. The performance of GCS was statistically superior to RTS (P=0.005), WPSS (P=0.0001), RAPS (P=0.0002), REMS (P=0.002), MEWS (P<0.0001), and NEWS (P<0.0001). However, the performance of GCS, NTS (P=0.146), and GAPS (P=0.513) were not significantly different. Also, in prediction of poor outcomes, the AUC of GCS (0.98) was significantly higher than RTS (0.95), RAPS (0.85), REMS (0.85), MEWS (0.84), NEWS (0.77), and WPSS (0.75). **Conclusion:** The GCS score seems to be a better instrument to predict mortality and poor outcome in trauma patients compared to other tools due to its high accuracy, wide application, and easy calculation.

Keywords: Wounds and Injuries; Clinical Decision Rules; Patient outcome assessment; Glasgow coma scale; Intensive care units

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1. Introduction

Trauma is one of the most well-known external injuries that remain a worldwide public health concern. According to statistics, 16% of the global burden of diseases is related to injuries, and approximately 4.5 million deaths are caused by traumatic injuries annually (1, 2). Furthermore, lower-middle-income countries sustain 90% of injury-related deaths (2). Based on the WHO reports, the common causes of traumas are traffic accidents, falling from a height,

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occupational injuries, and personal accidents. Road traffic accidents will be the fifth major cause of death globally by 2030 (3, 4). Traumatic injuries are the first reason for losing years of potential life and one of the four leading causes of mortality in developing countries (5). The consequences of traumatic injuries are affected by the trauma severity, the physiological reserve, the on-time revival, and appropriate treatment (6).
Patients with severe trauma need hospitalization in the Intensive Care Unit (ICU). Trauma-related death in patients admitted to the ICU is caused by severe brain injury and multiple organ failure (7). Management, timely post-traumatic care, and creating specific care systems at trauma centers are vital for reducing the mortality rate, disability risk, and long-term pain in traumatic patients (8, 9). With the increase in health care costs and the shortage of beds in intensive care units, patients should be appropriately triaged to avoid unnecessary costs and the use of beds (10).
In recent years, several scoring systems have been designed to assess injury severity and determine which patients need observation, treatment, and allocation of health care resources (11, 12). Although improvements have been made to multiple scoring systems, each system still has its limitations and shortcomings, including many variables in the model, failure to evaluate them in different clinical settings, and complex calculations required to conclude (11, 13). The physiological scoring systems are helpful for treatment staff to recognize the severity of trauma and decide the period of trauma management (9). In all of these scoring systems, in addition to the level of consciousness, physiological criteria such as respiration rate, body temperature, heart rate, and blood pressure are used to determine the severity of trauma injury (14). New Trauma Score (NTS), Revised Trauma Score (RTS), Worthing Physiological Scoring System (WPSS), Rapid Acute Physiology Score (RAPS), Rapid Emergency Medicine Score (REMS), Modified Early Warning Score (MEWS), National Early Warning Score (NEWS), Glasgow Coma Scale, Age, and Systolic Blood Pressure (GAPS) are some of these scoring systems. Glasgow coma scale (GCS) is a valuable, rapid, and accurate method to determine patients' injury severity, consciousness level, and outcome, especially in those with a head injury, and has remained an important method for assessing critically injured patients in the Middle East region and Iran (5-9, 14, 15).
There are conflicting results from comparing GCS with scoring systems in predicting patient outcomes. The existence of contradictions indicates the need for more studies. Accordingly, this study was designed to compare the performance values of eight physiologic scoring systems including NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS, with GCS in predicting poor outcome and mortality of trauma patients admitted in ICU.

2. Methods

2.1. Study design and setting

This prospective diagnostic accuracy study was carried out between 21 November 2020 and 22 May 2021 at ICUs of two hospitals in Tehran, Iran. The present study obtained ethical approval from Shahid Beheshti University of Medical Sciences (IR.SBMU.PHARMACY.REC.1399.243). The researchers adhered to the declaration of Helsinki regarding the ethical issues and confidentiality of patients' information.

2.2. Participants

The population study included 200 trauma patients admitted to the intensive care units (ICUs). The researcher selected patients using the convenience sampling method. The inclusion criteria were admission to ICU due to traumatic injuries and age over 18 years. The exclusion criteria included pregnancy and transferring patients to other centers.

2.3. Data gathering

The researcher filled out the pre-prepared checklist in each hospital on admission, including age, gender, trauma mechanism, co-morbidities, vital signs on admission, Alert, Voice, Pain, Unresponsive (AVPU) scale, and Glasgow Coma Scale. Vital signs for each patient were as follows: heart rate, respiratory rate, temperature, systolic blood pressure, diastolic blood pressure, mean arterial pressure, oxygen saturation. The variables such as age, mean arterial pressure, heart rate, respiratory rate, temperature, and oxygen saturation were used to evaluate the eight values of physiologic models. The Glasgow Coma Scale (GCS) is the sum of the three tests of the patient's eye-opening, verbal, and motor responses with a minimum score of 3 and a maximum of 15 (16).
The National Early Warning Score (NEWS) is based on seven simple physiological variables (systolic blood pressure, body temperature, respiration rate, oxygen saturation, heart rate, level of consciousness, and supplemental oxygen). The scoring is from 0-20 (17).
The Modified Early Warning Score (MEWS) includes five variables: systolic blood pressure, heart rate, body temperature, respiration rate, and level of consciousness. The score ranges from 0 to a maximum of 14 (12).
The Rapid Emergency Medicine Score (REMS) is determined using age and five physiological variables including heart rate, mean blood pressure, respiration rate, oxygen saturation, and Glasgow Coma Scale. The highest score is 26 (12).
The Rapid Acute Physiology Score (RAPS) consists of heart rate, respiration rate, blood pressure, and Glasgow Coma Scale. Its scoring range is 0 (normal) to 16 (acute) (13, 18).
The Worthing Physiological Scoring System (WPSS) consists of six parameters: systolic blood pressure, heart rate, respira-

Table 1: Comparing the baseline characteristics of included patients based on their survival status and outcome

Variables	Survival		P	Outcome		P
	Yes (n=163)	No (n=37)		Good(n=125)	Poor(n=75)	
Age (year)	41.28±18.72	53.40±21.80	<0.0001	41.33±18.59	47.18±21.39	0.043
Gender						
Male	120 (73.6)	28 (75.7)	0.797	91 (72.8)	57 (76.0)	0.617
Female	43 (26.4)	9 (24.3)		34 (27.2)	18 (24.0)	
Trauma mechanism						
Motorcycle	49 (30.1)	10 (27.0)	0.766	36 (28.8)	23 (30.7)	0.341
Car accident	35 (21.5)	8 (21.6)		27 (21.6)	16 (21.3)	
Bicycle	5 (3.1)	0 (0.0)		5 (4.0)	0 (0.0)	
Pedestrian	27 (26.5)	4 (10.8)		23 (18.4)	8 (10.7)	
Fall >3m	6 (16.2)	20 (12.3)		13 (10.4)	13 (17.3)	
Fall <3m	27 (16.6)	9 (24.3)		21 (16.8)	15 (20.0)	
Co-morbidities						
Hypertension	44 (27.0)	14 (37.8)	0.189	34 (27.2)	24 (32.0)	0.619
Diabetes	34 (20.9)	7 (18.9)	0.792	27 (21.6)	14 (18.7)	0.469
CVD	8 (21.6)	25 (12.5)	0.063	15 (12.0)	10 (13.3)	0.783
PD	25 (15.3)	8 (21.6)	0.353	19 (15.2)	14 (18.7)	0.523
Other	19 (11.7)	5 (13.5)	0.754	16 (12.8)	8 (10.7)	0.653
Glasgow coma scale						
3-8	24 (14.7)	37 (100.0)	<0.0001	1 (0.8)	60 (80.0)	<0.0001
9-12	38 (23.0)	0 (0.0)		24 (19.2)	14 (18.7)	
13-15	101 (62.0)	0 (0.0)		100 (80.0)	1 (1.3)	
Vital signs on admission						
HR (/min)	99.46±21.34	86.40±28.95	<0.0001	99.05±21.04	93.70±26.72	0.118
RR (/ min)	19.20±4.37	17.67±4.03	0.052	19.49±4.39	17.97±4.12	0.016
T (°C)	36.71±2.43	36.82±0.70	0.781	36.69±2.76	36.79±0.63	0.749
SBP (mmHg)	124.09±22.50	105.32±26.88	<0.0001	125.76±21.18	112.05±27.07	<0.0001
DBP (mmHg)	78.86±17.71	64.05±14.18	<0.0001	79.68±17.38	70.2±17.63	<0.0001
MAP (mmHg)	91.46±19.40	77.11±17.93	<0.0001	92.73±19.60	82.25±18.75	<0.0001
SaO2 (%)	96.20±7.17	95.32±4.75	0.479	95.90±8.07	96.26±3.81	0.715
Length of stay in ICU (days)						
Mean ± SD	5.77±5.30	7.56±7.30	0.086	4.59±3.14	8.62±7.87	<0.0001

Data are presented as mean ± standard deviation (SD) or number (%). These data were evaluated at the time of admission to intensive care unit (ICU). The outcome variables were patient survival status (survived, died), good outcome (complete recovery), and poor outcome (mortality, disability). CVD: cardiovascular disease; PD: pulmonary disease; HR: heart rate; RR: respiratoty rate; t: temperature; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; SaO2: saturation O2.

tion, body temperature, level of consciousness, and oxygen saturation. Its maximum score is 14 (19, 20).

The Revised Trauma Score (RTS) includes the systolic blood pressure, Glasgow Coma Scale, and respiration. The final score of this tool is in the range of 0-12 (21).

The New Trauma Score (NTS) system is a new physiological scoring tool, it is a modified version of the Revised Trauma Score (RTS). This scoring system includes physiological variables (Glasgow coma scale, systolic blood pressure, and oxygen saturation level). The scoring method is that the Glasgow Coma Scale (GCS) score is added to the scores of the other two parameters, and the total score ranges from 3 to 23 (22).

The Glasgow Coma Scale, Age, and Systolic Blood Pressure score (GAPS) is a physiological scoring system with a small number of parameters: Glasgow Coma Scale, blood pressure, and age. Its score varies from 3-24 (23).

2.4. Outcomes

The researcher recorded the patient's status at the time of discharge from ICU as an outcome assessment. The outcome variables were patient survival status (survived, died), good outcome (complete recovery), and poor outcome (mortality, disability).

2.5. Statistical analysis

We assessed the normality assumption of data based on the histograms and Kolmogorov–Smirnov test. Descriptive statistics were means ± SDs for continuous variables and frequency (percentage) for categorical variables. The independent sample t-test and Fisher's exact test were conducted to compare the variables between survivors and non-survivors. Then, the receiver operating characteristic (ROC) curve anal-

Table 2: Performance of physiologic scoring systems and Glasgow coma scale in prediction of mortality in intensive care unit (ICU) admitted trauma patients

Score	CP	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	PLR	NLR
GCS	9	37	133	30	0	100(90.5-100)	81.6(74.8-7.2)	55.2(42.6-67.4)	100(97.3-100)	5.43(3.9-7.5)	0
GAPS	18	35	147	16	2	94.6(81.8-99.3)	90.2(84.5-94.3)	68.6(54.1-80.9)	98.7(95.2-99.8)	9.64(6.01-15.4)	0.06(0.02-0.2)
NTS	14	36	145	18	1	97.3(85.8-99.9)	89.0(83.1-93.3)	66.7(52.5-78.9)	99.3(96.2-100)	8.81(5.7-13.7)	0.03(0.0-0.2)
RTS	7	37	131	32	0	100(90.5-100)	80.4(73.4-86.2)	53.6(41.2-65.7)	100(97.2-100)	5.09(3.7-6.9)	0
MEWS	4	35	84	79	2	94.6(81.8-99.3)	51.5(43.6-59.4)	30.7(22.4-40.0)	97.7(91.9-99.7)	1.95(1.6-2.3)	0.10(0.03-0.4)
NEWS	5	36	48	115	1	97.3(85.8-99.9)	29.4(22.6-37.1)	23.8(17.3-31.4)	98.0(89.1-99.9)	1.38(1.2-1.5)	0.09(0.01-0.6)
WPSS	4	31	100	63	6	83.8(68.0-93.8)	61.3(53.4-68.9)	33.0(23.6-43.4)	94.3(88.1-97.9)	2.17(1.7-2.7)	0.26(0.1-0.5)
REMS	6	31	132	31	6	83.8(68.0-93.8)	81.0(74.1-86.7)	50.0(37.0-63.0)	95.7(90.8-98.4)	4.41(3.1-6.2)	0.20(0.10-0.4)
RAPS	4	32	123	40	5	86.5(71.2-95.5)	75.5(68.1-81.9)	44.4(32.7-56.6)	96.1(91.1-98.7)	3.52(2.6-4.7)	0.18(0.08-0.4)

Data are presented with 95% confidence interval. CP: Cut off point; TP: True positive; TN: True negative; FP: False positive; FN: False negative; PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio; GCS: Glasgow coma scale; GAPS: Glasgow Coma Scale, Age, and Systolic Blood Pressure score; NTS: New trauma score; RTS: Revised trauma score; MEWS: Modified Early Warning Score; NEWS: National Early Warning Score; WPSS: Worthing physiological scoring system; REMS: Rapid emergency medicine score; RAPS: Rapid acute physiology score.

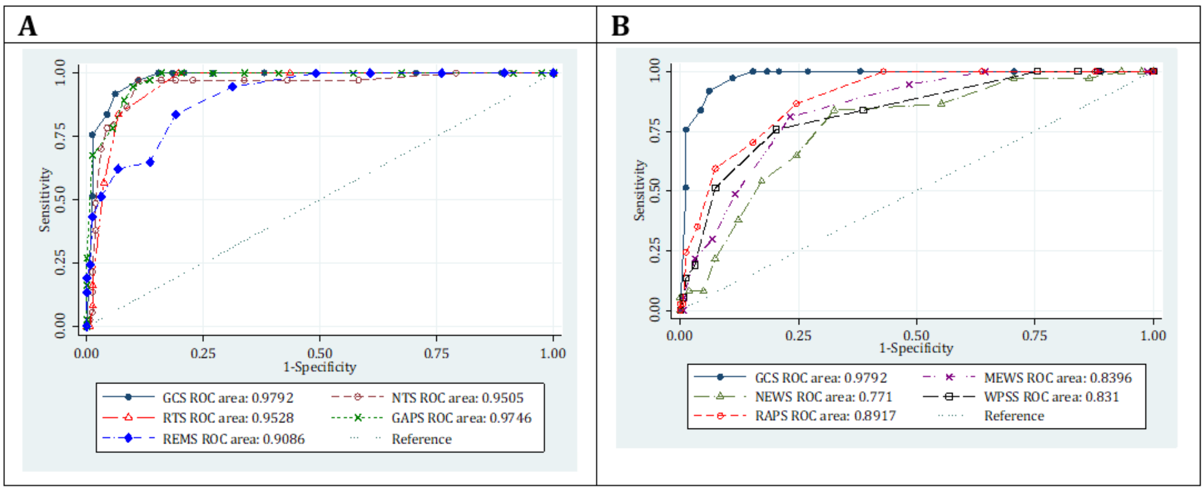

Figure 1: Comparison of area under the receiver characteristics curve (AUC) between assessed scoring systems in prediction of intensive care unit (ICU) mortality. A) Demonstration of the prediction rules with excellent performance (AUC >0.90); B) Demonstration of the prediction rules with good performance (AUC between 0.70 and 0.90).

ysis was used to estimate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (+LR), and negative likelihood ratio (-LR) for each of GCS, NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS models. Finally, the area under the curves (AUCs) of all eight models were compared with GCS. The differences were considered statistically significant at p values < 0.05. Analyses were performed using STATA 14.0 software. The best cut-off point in each scoring system was determined using the Youden index and similar studies (20, 24-26) .

3. Results

3.1. Baseline characteristics of studied cases

A total of 200 trauma patients with the mean age of 43.53±19.84 years were included in the study (74% male). The percentage of the non-survivors among trauma patients in ICU was 18.5% (n=37). The most common trauma mechanisms were motorcycle accidents (29.5%) and car accidents (21.5%). 29% of the patients had hypertension. The average length of stay in ICU was 6.10±5.75 days. The significantly different vital signs between the two groups (survivors, non-survivors) were heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure (P<0.0001). The mean values of these vital signs in survivors were significantly higher than non-survivors. The percentage

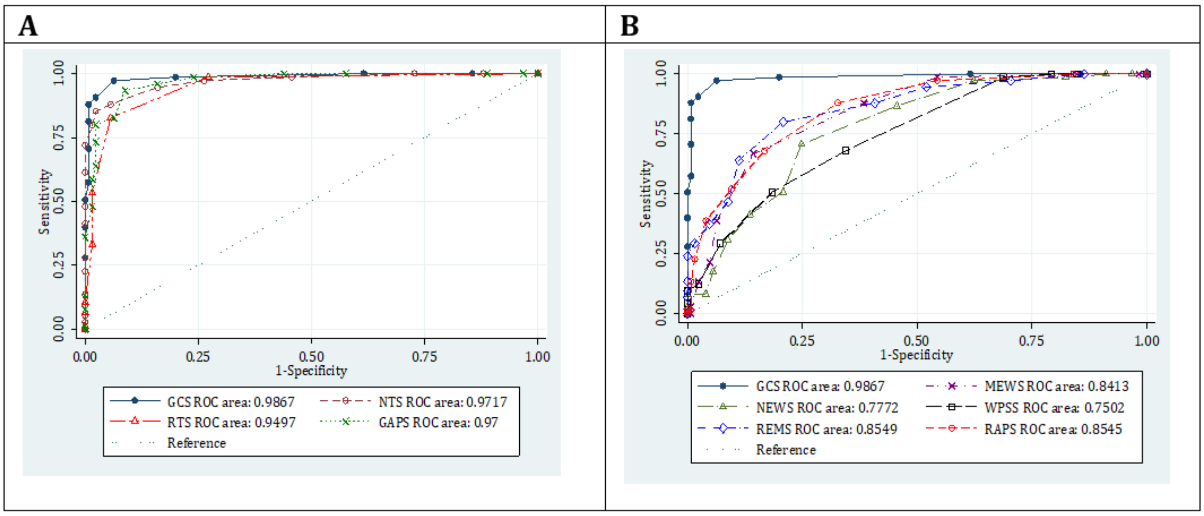

Figure 2: Comparison of area under the receiver characteristics curve (AUC) between assessed scoring systems in prediction of intensive care unit (ICU) poor outcome (mortality or disability). A) Demonstration of the prediction rules with excellent performance (AUC >0.90); B) Demonstration of the prediction rules with good performance (AUC between 0.70 and 0.90).

Table 3: Performance of physiologic scoring systems and Glasgow coma scale in prediction of poor outcome in intensive care unit (ICU) admitted trauma patients

Score	CP	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	PLR	NLR
GCS	9	66	124	1	9	88.0(78.4-94.4)	99.2(95.6-100)	98.5(92.0-100)	93.2(87.5-96.9)	110.00(15.6-776.2)	0.12(0.07-0.2)
GAPS	18	48	122	3	27	64(52.1-74.8)	97.6(93.1-99.5)	94.1(83.8-98.8)	81.9(74.7-87.7)	26.67(8.6-82.6)	0.37(0.3-0.5)
NTS	14	54	125	0	21	72.0(60.4-81.8)	100.0(97.1-100.0)	100.0(93.4-100.0)	85.6(78.9-90.9)	0	0.28(0.2-0.4)
RTS	7	62	118	7	13	82.7(72.2-90.4)	94.4(88.8-97.7)	89.9(80.2-95.8)	90.1(83.6-94.6)	14.76(7.1-30.5)	0.18(0.1-0.3)
MEWS	4	66	77	48	9	88.0(78.4-94.4)	61.6(52.5-70.2)	57.9(48.3-67.1)	89.5(81.1-95.1)	2.29(1.8-2.9)	0.19(0.1-0.4)
NEWS	5	73	47	78	2	97.3(90.7-99.7)	37.6(29.1-46.7)	48.3(40.1-56.6)	95.9(86.0-99.5)	1.56(1.3-1.8)	0.07(0.02-0.3)
WPSS	4	51	82	43	24	68.0(56.2-78.3)	65.6(56.6-73.9)	54.3(43.7-64.6)	77.4(68.2-84.9)	1.98(1.5-2.6)	0.49(0.3-0.7)
REMS	6	48	111	14	27	64.0(52.1-74.8)	88.8(81.9-93.7)	77.4(65.0-87.1)	80.4(72.8-86.7)	5.71(3.4-9.6)	0.41(0.3-0.5)
RAPS	4	51	104	21	24	68.0(56.2-78.3)	83.2(75.5-89.3)	70.8(58.9-81.0)	81.3(73.4-87.6)	4.05(2.6-6.1)	0.38(0.3-0.5)

Data are presented with 95% confidence interval. CP: Cut off point; TP: True positive; TN: True negative; FP: False positive; FN: False negative; PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive likelihood ratio; NLR: Negative likelihood ratio; GCS: Glasgow coma scale; GAPS: Glasgow Coma Scale, Age, and Systolic Blood Pressure score; NTS: New trauma score; RTS: Revised trauma score; MEWS: Modified Early Warning Score; NEWS: National Early Warning Score; WPSS: Worthing physiological scoring system; REMS: Rapid emergency medicine score; RAPS: Rapid acute physiology score.

of poor outcomes was 37.5% (n=75). The mean values of vital signs, including respiratory rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure, were significantly higher in the good outcome group compared to the poor outcome group (P<0.0001). The mean length of stay in ICU in the poor outcome group was higher than the good outcome (P<0.0001) (Table1).

3.2. Accuracy of physiologic scoring systems in mortality prediction

Table 2 displays the ROC curve analyses of the eight physiologic scoring systems and GCS. The sensitivity value of GCS was 100%. However, the sensitivity values of physiologic scoring systems, including NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS, were 97.3%, 100%, 83.8%, 86.5%, 83.8%, 94.6%, 97.3%, and 94.6%, respectively. Also, the specificity value of GCS was 81.6%, and the specificity values of NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS were 89%, 80.4%, 61.3%, 75.5%, 81%, 51.5%, 29.4%, 90.2%, respectively (Table 2).

Figure1 shows the AUC values of physiologic scoring systems. The AUC value for GCS was 0.98 (95% CI: 0.96 - 0.99). The AUC values of NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS were 0.95 (95% CI: 0.92 - 0.98), 0.95 (95% CI: 0.92 - 0.98), 0.83 (95% CI: 0.76 - 0.90), 0.89 (95% CI: 0.84 - 0.94), 0.91 (95% CI: 0.86 - 0.95), 0.84 (95% CI: 0.78 - 0.90), 0.77 (95% CI: 0.69 - 0.85), and 0.97 (95% CI: 0.95 - 0.99), respectively. The AUC of GCS was significantly higher than those of RTS (P=0.005), WPSS (P=0.0001), RAPS (P=0.0002), REMS (P=0.002), MEWS (P=0.0001), and NEWS (P=0.0001). However, the AUC of GCS was not significantly different from NTS (P=0.146) and GAPS (P=0.513).

3.3. Accuracy of physiologic scoring systems in poor outcome prediction

Table 3 represents the results of ROC curve analysis for the eight physiologic scoring systems and Glasgow coma scale. The sensitivity value of GCS was 88%. The sensitivity values of the eight physiologic scoring systems, including NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS, were 72%, 82.7%, 68%, 68%, 64%, 88%, 97.3%, and 64%, respectively. The specificity value for GCS was 99.2% and for NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS, values were 100%, 94.4%, 65.6%, 83.2%, 88.8%, 61.6%, 37.6%, and 97.6%, respectively (Table3).

Figure 2 shows the AUC values for all of the physiologic scoring systems. The AUC value for GCS was 0.98 (95% CI: 0.97 - 1.00). The AUC values of NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS, were 0.97 (95% CI: 0.95 - 0.99), 0.95 (95% CI: 0.92 - 0.98), 0.75 (95% CI: 0.68 - 0.81), 0.85 (95% CI: 0.80 - 0.90), 0.85 (95% CI: 0.80 - 0.91), 0.84 (95% CI: 0.79 - 0.89), 0.77 (95% CI: 0.71 - 0.84), and 0.97 (95% CI: 0.95 - 0.99), respectively. The AUC for GCS was not significantly different from NTS (P=0.182) and GAPS (P=0.089), but the AUC of GCS was considerably higher than those of RTS (P=0.001), WPSS (P<0.001), RAPS (P<0.001), REMS (P<0.001), MEWS (P<0.001), and NEWS (P<0.001).

4. Discussion

This study illustrated the performance of physiologic scoring systems including NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, GAPS, and GCS in predicting traumatic patient mortality and poor outcomes in ICU using the ROC curve. Accordingly, NTS, RTS, WPSS, RAPS, REMS, MEWS, NEWS, and GAPS performed well. However, compared to GCS, the scoring systems of RTS, WPSS, RAPS, REMS, and MEWS had poorer performance and NTS, and GAPS were not significantly different from GCS. Moreover, the sensitivity of GCS was higher than NTS and GAPS in predicting the mortality of patients.

In this regard, different studies have been conducted, which had results consistent or inconsistent with the present study. In a cross-sectional study conducted on 125 traumatic brain injury patients admitted in ICU, the efficacy of GCS and APACHE II score were compared. The values of ROC curve analysis for GCS (AUC=0.81, PPV=69.2, sensitivity=61.4) and APACHE II (AUC=0.83, PPV=80.6, sensitivity=56.9) were acceptable, and they had no significant difference. However, for the initial evaluation, GCS was suggested because of its simplicity and quickness (5). In a diagnostic accuracy study with 1702 trauma patients in emergency departments of four hospitals, the performance of RTS, RAPS, REMS, and WPSS was compared with GCS in predicting in-hospital deaths and poor outcomes. The results demonstrated that the AUC value of GCS was not significantly different from that of RAPS, REMS, and WPSS. However, GCS performed significantly better than RTS in prediction of in-hospital deaths. In addition, this conclusion was also proper for predicting poor outcomes in the emergency department such as mortality, vegetative state, and disability (14). Another prospective observational study was conducted to evaluate the power of scoring systems including GCS, APACHE-II, RAPS, and REMS in predicting the need for mechanical ventilation in patients with drug overdose. The ROC curve analysis showed that there were no significant differences between them. However, it seemed that the utilization of the combination of GCS >8 (NPV=100%) and REMS was beneficial in excluding patients without the need for ventilator support (27). A prospective diagnostic study was conducted to compare the accuracy of GCS and KTS in prediciting in-hospital mortality. The AUC for the GCS value on admission (0.91) and after 24 hours (0.96) was significantly higher than KTS on admission (0.82) and 24 hours later (0.85). Also, the GCS was more precise than KTS in diagnosis of head injury patients (28). A diagnostic accuracy study on 1861 trauma patients assessed scoring systems including GAP, MGAP, ISS, and GCS. The AUC values of GAP, MGAP, ISS, and GCS were 0.91 (sensitivity=72.99, specificity=95.52), 0.90 (sensitivity=81.04, specificity=87.70), 0.80 (sensitivity=89.10, specificity=61.11), and 0.88 (sensitivity=81.52, specificity=92.00), respectively.

Therefore, it seemed that both GAP and MGAP scoring systems could predict mortality (8). On the other hand, a retrospective study was performed to assess the accuracy of scoring systems such as GCS, ISS, and RTS in predicting outcomes in young children with traumatic injuries. The results demonstrated that the AUC of ISS in predicting mortality was higher than GCS and RTS. Also, worse trauma scores of ISS, GCS, and RTS correlated with more deaths (29). A retrospective study was conducted to determine the predictors of trauma patients' deaths in ICU. The AUC values of scoring systems including GCS, ISS, NISS, RTS, TRIS, RISC II, APACHE II, SAPS II, and SOFA were 0.69, 0.82, 0.90, 0.74, 0.86, 0.88, 0.69, 0.67, and 0.69, respectively; so the NISS and RISC II were more accurate in prediction of short-term mortality of patients with severe trauma (7). In a recent diagnostic accuracy study with 754 patients, the results indicated that the performance of REMS was more precise than GCS, ISS, and MEWS for prediction of in-hospital mortality rate of multiple trauma patients ≥ 24 hours after admission, and the AUC value of REMS (0.94) was significantly higher than GCS (0.85; P=0.035) (12).

The differences between the results of this study and others may be related to considering different cut-off values, patient settings, and demographic characteristics. As an illustration, consider Heydari et al.'s study with traumatic patients in the emergency department, in which 90% of patients had GCS≥13 (12). However, the present study was conducted in the ICU and about half of the patients had GCS<13. In addition, Heydari's study is one of the few studies in which the sensitivity of GCS is found to be low (12), while most of the previous studies reported a high sensitivity for GCS (8, 14, 27, 28).

5. Limitations

A limitation of this study was the relative small sample size. A larger sample size and examining the patient at different time points provide more valuable and reliable results. Convenience sampling was another shortcoming of the present diagnostic accuracy study.

6. Conclusion

According to this study, GCS has excellent accuracy in prediction of in-hospital outcome of trauma patients. Since it is easy to use and calculate, GCS can be considered as the optimum predictive instrument in trauma patients. GCS is more practical and simple than physiological scoring systems, which are complex and time-consuming to measure.

7. Declarations

7.1. Acknowledgments

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7.2. Authors' contributions

Study design: SK, MZ, MY; Data gathering: SK; Analysis and interpretation of results: MY, MZ Drafting: SK; Critically revised the paper: MZ and MY. All authors read and approved the final draft of manuscript and are responsible for all parts of study.

7.3. Funding

Shahid Beheshti University of Medical Sciences financially contributed to this study.

7.4. Conflict of interest

The authors declare that they have no conflict of interest.

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