Original Article

Predictive Value of Glasgow Coma Score and Full Outline of Unresponsiveness Score on the Outcome of Multiple Trauma Patients

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Abstract

Introduction: The Full Outline of Unresponsiveness (FOUR) score was developed to compensate for the limitations of Glasgow coma score (GCS) in recent years. This study aimed to assess the predictive value of GCS and FOUR score on the outcome of multiple trauma patients admitted to the emergency department.

Patients and Methods: The present prospective cross-sectional study was conducted on multiple trauma patients admitted to the emergency department. GCS and FOUR scores were evaluated at the time of admission and at the sixth and twelfth hours after admission. Then the receiver operating characteristic (ROC) curve, sensitivity, specificity, as well as positive and negative predictive value of GCS and FOUR score were evaluated to predict patients' outcome. Patients' outcome was divided into discharge with and without a medical injury (motor deficit, coma or death).

Results: Finally, 89 patients were studied. Sensitivity and specificity of GCS in predicting adverse outcome (motor deficit, coma or death) were 84.2% and 88.6% at the time of admission, 89.5% and 95.4% at the sixth hour and 89.5% and 91.5% at the twelfth hour, respectively. These values for the FOUR score were 86.9% and 88.4% at the time of admission, 89.5% and 100% at the sixth hour and 89.5% and 94.4% at the twelfth hour, respectively.

Conclusion: Findings of this study indicate that the predictive value of FOUR score and GCS on the outcome of multiple trauma patients admitted to the emergency department is similar.

Keywords: Consciousness, glasgow coma scale, multiple trauma, patient outcome assessment

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Introduction

Evaluating the level of consciousness is one of the initial, important and basic assessments of patients and it can be challenging even for experienced physicians. Various scoring systems have been defined that can be helpful in predicting patients' outcome by evaluating their level of consciousness. The scales used worldwide to evaluate the patients with a disturbed level of consciousness are: Glasgow Coma Scale, the National Institutes of Health Stroke Scale, the Canadian Neurological Scale, and the Full Outline of Unresponsiveness Score. Glasgow coma scale (GCS) is the most commonly used approach in this regard. However, this scoring system has limitations including the variability of inter-rater reliability, predictive validity, inability to evaluate the verbal part of this measure for endotracheally intubated patients and the inability to detect small changes in neurological condition.[1–4] New scoring systems have been produced in recent years to compensate for these limitations. One of these systems is called Full Outline of Unresponsiveness (FOUR) score which evaluates four components, including visual response, motor response, brainstem reflexes and the respiratory pattern.[5,6] Compared to GCS, the verbal component is removed and evaluation of brainstem reflexes and respiratory pattern are added to FOUR. The designers believe that these changes help monitor and assess neurological changes more accurately. This scale was developed by Wijdicks, et al. to assess non-traumatic patients' level of consciousness in ICU and its efficacy has been evaluated in some studies with similar statistical population.[6–8] In addition, other studies that have investigated this outside of ICU and their results, suggested the high diagnostic accuracy of this method in other clinical conditions, such as in the emergency department.[5,9,10] Then this scale was tried in patients with trauma and the predictive value of FOUR score, and GCS in patients with head trauma indicated its appropriate efficacy.[11] Although the predictive value of this scale has been proven in various studies, there are few articles on multiple trauma patients especially in the emergency department. Therefore, this study aimed to compare the predictive value of GCS and FOUR score on the outcome of patients with multiple trauma admitted to the emergency department.

Patients and Methods

Study design and setting

This cross-sectional prospective study was conducted between May 2014 to October 2014 to compare the predictive value of FOUR score and GCS on the outcome of a convenience sample of multiple trauma patients with decreased level of consciousness admitted to the emergency department of Shohadaye Tajrish Hospital, Tehran, Iran. In this study, an emergency medicine senior

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resident collected the data. The study protocol did not interfere with patients' routine treatments and was approved by the ethics committee of Shahid Beheshti University of Medical Sciences. Researchers adhered to the principles of the Helsinki Convention throughout the study. In addition, the study objectives were explained to patients' or their guardians and the patients entered the study only when consent is obtained.

Patients under study

In the present study, all non-sedated multiple trauma patients with decreased level of consciousness admitted to the emergency department were studied. Patients who had decreased level of consciousness for non-traumatic causes (hypoglycemia, receiving sedative drugs, drug poisoning), who had hemodynamic instability (systolic blood pressure below 90 mmHg), and who died in the emergency department within 12 hours were excluded from the study. Patients' or their guardians' lack of consent to participate in the study was another exclusion criterion. In the present study, there were no limitations in terms of age and gender.

Data collection

Data were collected using a checklist containing demographic information, trauma mechanism, CT scan findings, patient's outcome, and ultimately subunits of GCS and FOUR score. All brain CT scans were interpreted by a certified radiologist. GCS and FOUR score were evaluated at the time of admission, as well as at the sixth and twelfth hours after admission by a resident who conducted the study.

Outcomes under assessment

In-hospital mortality, clinical diagnosis of brain death, motor disability and full recovery without any sequelae at the time of discharge were studied over a month of evaluation.

Definitions

GCS consists of three components: eye, verbal and motor response with the minimum score for each component as 1 and the maximum score as 4 in eye component, 5 in verbal component and 6 in motor component. FOUR score has 4 components, including visual response, motor response, brainstem reflexes and respiratory pattern. The minimum score for each component is zero and the maximum score is 4 (Appendix 1). For intubated patients, a minimum score was considered for the verbal component of GCS. Brain death was confirmed by a team composed of a certified neurologist, certified anesthesiologist and a coroner. Inability was defined as any permanent motor and sensory disability of the patient at the time of discharge.

Statistical analyses

The required number of patients based on 96% sensitivity of FOUR score in predicting the outcome of traumatic brain lesions and by considering 69% incidence of brain lesions in traumatic brain injuries (3), accuracy of 5% and confidence level of 95% equaled 87 patients and finally 89 patients were evaluated. Data were entered into STATA 11 statistical program. Descriptive analyses were presented as mean, standard deviation, frequency, as well as a percentage for qualitative and quantitative variables. To evaluate internal consistency of scoring measures, the Cronbach's alpha coefficient was calculated. In the present study, receiver operating characteristic (ROC) curve and sensitivity, specificity and positive and negative predictive value of GCS and FOUR score were evaluated to predict patients' outcome. The area under the ROC curve (AUC) was used to determine the best cut-off point in predicting the outcomes based on Youden's J statistic. Finally, the AUC of GCS and FOUR scores were compared using the Hosmer-Lemeshow test and the method proposed by Cleve.[12,13] We used "roccomp" module in STATA for comparison between AUCs.

Results

Finally, 89 patients entered the study. The mean and standard deviation of patients' age were 31.9 ± 19.9 years (minimum 1 and maximum 80 years; 83.2% male). The most common chief complaints were moderate head trauma and severe head trauma with

Table 1. The basic variables of patients in the study

Variable	N (%)
Reason of referral	
No-head trauma	3 (3.4)
Minor head trauma	3 (3.4)
Moderate head trauma	43 (48.3)
Severe head trauma	40 (44.9)
Mechanism of trauma	
Pedestrian car accident	29 (32.6)
Motor car accident	16 (18.0)
Falling	16 (18.0)
Pedestrian motor accident	10 (12.4)
Direct trauma	11 (11.2)
Car rollover	4 (4.5)
Car car accident	3 (3.4)
CT scan findings	
Normal	14 (15.7)
Skull fracture	14 (15.7)
Subdural hematoma	12 (13.5)
Subarachnoid hemorrhage	11 (12.4)
Brain contusion	9 (10.1)
Epidural hematoma	7 (7.9)
More than one abnormality	14 (15.7)
Outcome	
Full recovery	38 (46.3)
Hospital mortality	27 (32.9)
Functional outcome in discharge	13 (15.9)
Brain death	4 (4.9)

the frequency of 43 patients (48.3%) and 40 patients (44.9%), respectively. Pedestrians hit by vehicles (32.6%), motorcycle accidents with vehicles (18%) and falling (18%) were the most prevalent mechanisms of injury in this study (Table 1). The results of CT scans are shown in Table 1. Fourteen normal CT scans (15.7%) and 14 skull fractures (15.7%) were the most common findings in the imaging evaluation. Twenty-seven patients (32.9%) died in the hospital. Thirteen patients (15.8%) were discharged from the hospital with motor disability, and 4 patients (4.9%) were brain dead. Thirty-eight patients (46.4%) were fully recovered and discharged from the hospital. LOC assessment of patients based on GCS and FOUR score is presented in Table 2.

The area under the ROC curve of GCS and FOUR score is given in Table 3 and Figures 1 to 3. As observed, assessment of GCS and FOUR score in three separate times has a close relationship with prediction of disease outcome. This relationship is larger in the area under the curve of these measures at the sixth and the twelfth hours. Comparison of AUC of GCS and FOUR score did not show significant differences in time of admission (P = 20), sixth hours (P = 0.16), and the twelfth (P = 0.49). Since the area under the curve of FOUR score and GCS in predicting the presence of a lesion (death or disability) was higher than predicting death alone, the predictive value of these measures was also presented for the prediction of a lesion. Sensitivity and specificity of GCS in predicting adverse outcome (motor deficit, coma or death) were 84.2% and 88.6% at the time of admission, 89.5% and 95.4% at the sixth hour and 89.5% and 91.5% at the twelfth hour, respectively. These values for FOUR score were 86.9% and 88.4% at the time of admission, 89.5% and 100% at the sixth hour and 89.5% and 94.4% at the twelfth hour, respectively (Table 4).

Discussion

The findings indicated that the predictive value of the FOUR score and GCS in predicting the outcome of multiple trauma patients admitted to the emergency department is similar. Although GCS is used to predict patients' outcome and injury severity in many centers, it has limitations such as failure to assess verbal responses in intubated patients. Inability to assess the latter in intubated patients can cause confusion and inaccuracy. This may be due to inter-personal variability, especially when various scores are selected by different individuals for the same patient. The ad-

Table 2. The findings of evaluating GCS in the present study at the time of admission, at the sixth and twelfth hours

	The mean score (standard deviation)		
Measures under evaluation	**The time of admission**	**Sixth hour**	**Twelfth hour (%)**
Glasgow coma score			
Visual assessment	2.4 (1.1)	2.2 (1.3)	2.4 (1.4)
Verbal assessment	2.9 (1.4)	2.6 (1.7)	2.8 (1.8)
Motor assessment	4.4 (1.4)	4.2 (1.7)	4.4 (1.7)
Total score	9.7 (3.6)	8.9 (4.3)	9.6 (4.7)
FOUR coma score			
Visual assessment	1.5 (1.3)	1.4 (1.6)	1.7 (1.8)
Motor assessment	2.8 (1.1)	2.6 (1.3)	2.8 (1.3)
Brainstem assessment	3.3 (1.3)	2.7 (1.5)	2.8 (1.5)
respiratory pattern assessment	3.2 (1.3)	2.4 (1.7)	2.5 (1.7)
Total score	10.9 (4.2)	9.2 (5.6)	9.9 (5.9)

Table 3. The area under the curve (confidence level at 95%) of measures under assessment in predicting outcome of patients at the studied times

The time under study	**The time of admission**	**Sixth hour**	**Twelfth hour**
Death			
Glasgow coma score	0.85 (0.77–0.93)	0.93 (0.88–0.98)	0.95 (0.90–1.0)
FOUR coma score	0.86 (0.79–0.94)	0.93 (0.89–0.98)	0.95 (0.91–0.99)
Death or disability			
Glasgow coma score	0.91 (0.85–0.97)	0.96 (0.91–1.0)	0.95 (0.90–1.0)
FOUR coma score	0.93 (0.87–0.98)	0.96 (0.93–1.0)	0.96 (0.92–1.0)

Table 4. GCS predictive value in predicting disease's outcome

Variable	**The time of admission**	**Sixth hour**	**Twelfth hour**
GCS			
Sensitivity	84.2 (68.1–93.4)	89.5 (74.3–96.6)	89.5 (74.3–96.6)
Specificity	88.6 (74.6–96.0)	95.4 (82.9–99.2)	91.5 (76.4–97.8)
Positive predictive value	86.5 (70.4–94.9)	94.4 (80.0–99.0)	91.9 (77.0–97.9)
Negative predictive value	86.7 (72.5–94.5)	91.1 (77.9–97.1)	89.2 (73.6–96.5)
FOUR coma score			
Sensitivity	86.9 (71.1–95.0)	89.5 (74.26–96.57)	89.5 (74.3–96.6)
Specificity	88.4 (74.6–95.6)	100.0 (89.79–100.0)	94.4 (80.0–99.0)
Positive predictive value	86.8 (71.1–95.0)	100.0 (87.36–100.0)	94.4 (80.0–99.0)
Negative predictive value	88.4 (74.6–95.6)	91.5 (78.73–97.24)	89.5 (74.3–96.6)

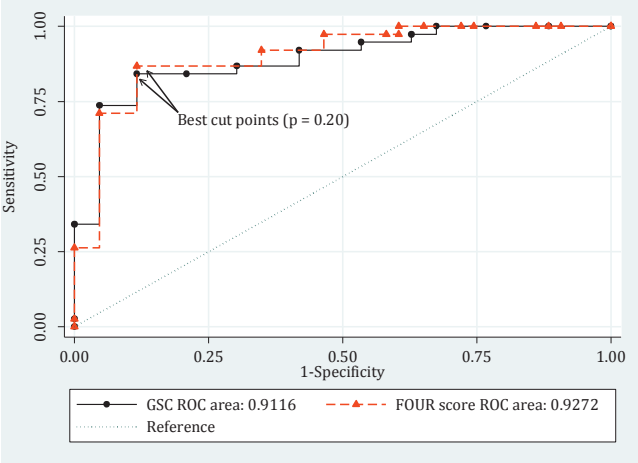

Figure 1. The area under the ROC curve of GCS and FOUR score at the time of admission.

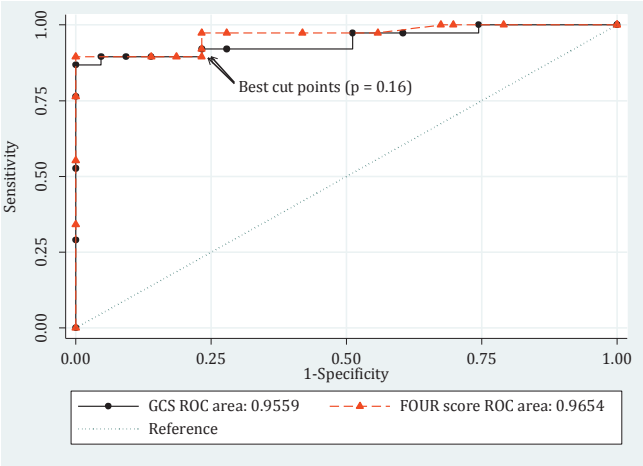

Figure 2. The area under the ROC curve of GCS and FOUR score at six-hour after admission.

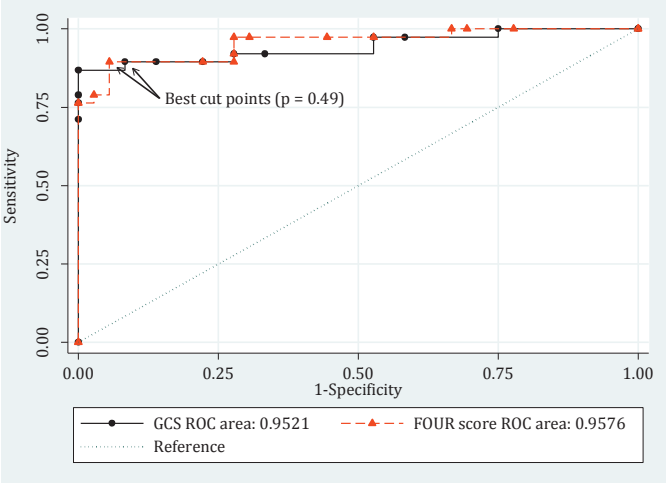

Figure 3. The area under the ROC curve of GCS and FOUR score at twelve-hour after admission.

dition of a letter in place of the verbal component is not validated either and it falls beyond the scope of the validated GCS score. Another important point to consider is the minimal predictive prognostic value of the verbal component in GCS and its influence on the overall score as compared to the known motor component's value in prognostic prediction. These limitations can be overcome through FOUR score. In this study, the area under the FOUR score curve ranged 0.91 – 0.95 in predicting death or permanent injury (depending on the time of assessment). Regardless of the time, the predictive value of this scale for the outcome of multiple trauma patients admitted to the emergency department is at a favorable level. Eken, et al. study showed the area under FOUR score curve was 0.776 in predicting mortality of patients in ICU within 3 months.[11] Bruno, et al. also showed that the area under the FOUR score curve to predict the outcome of patients with coma in ICU was 0.7.[7] Both of these studies suggest that the predictive value of FOUR SCORE is similar to GCS. Although the area under the curve obtained in this study was much higher than that in the mentioned studies, the findings are consistent in these different cohorts of patients. In other words, the present study and studies of Eken, et al. and Bronu, et al. state that the predictive value of FOUR score and GCS are similar. Moreover, similar findings were reported by McNett, et al. These researchers suggest that GCS and FOUR score are similar in evaluation of hospital mortality within 3 months.[14]

In our study, the predictive value of FOUR score and GCS was very high. However, in many similar studies,[14–16] this predictive value has been reported at intermediate level (0.68 – 0.76). The difference can be attributed to many reasons such as using trained (or certified) emergency medicine senior resident in the present study whose evaluation of the consciousness level was somewhat more valid than any other personnel such as general physicians and nurses. In addition, the time to teach physicians how to assess the consciousness level based on FOUR score was about an hour in most studies. However, in our study an emergency medicine resident examined the way of evaluating consciousness level after a two-hour of theory and clinical training, and the study began after ensuring the accuracy of the assessment. Furthermore, our study population consisted of multiple trauma patients admitted to the emergency department, while other studies enrolled patients admitted to the ICU. In addition, we evaluated patients with different levels of consciousness, while for example, in the study of Bronu, et al. only patients with GCS under 8 were investigated.[7]

Appendix 1. Details of calculation of FOUR score and GCS

FOUR Score	Glasgow Coma Scale
Eye response 4 = eyelids open or opened, tracking, or blinking to command 3 = eyelids open but not tracking 2 = eyelids closed but open to loud voice 1 = eyelids closed but open to pain 0 = eyelids remain closed with pain	Eye response 4 = eyes open spontaneously 3 = eye opening to verbal command 2 = eye opening to pain 1 = no eye opening
Motor response 4 = thumbs-up, fist, or peace sign 3 = localizing to pain 2 = flexion response to pain 1 = extension response to pain 0 = no response to pain or generalized myoclonus status	Motor response 6 = obeys commands 5 = localizing pain 4 = withdrawal from pain 3 = flexion response to pain 2 = extension response to pain 1 = no motor response
Brainstem reflexes 4 = pupil and corneal reflexes present 3 = one pupil wide and fixed 2 = pupil or corneal reflexes absent 1 = pupil and corneal reflexes absent 0 = absent pupil, corneal, and cough reflex	Verbal response 5 = oriented 4 = confused 3 = inappropriate words 2 = incomprehensible sounds 1 = no verbal response
Respiration 4 = not intubated, regular breathing pattern 3 = not intubated, Cheyne–Stokes breathing pattern 2 = not intubated, irregular breathing 1 = breathes above ventilator rate 0 = breathes at ventilator rate or apnea	

Limitations

The groups of patients included in this study were victims of multiple traumas. Despite the considered inclusion and exclusion criteria, these are usually a very non-homogeneous group, suffering from different levels of injury. The brain damages in such patients could have been due to direct head trauma, poor brain perfusion, complete or incomplete stroke, temporary or permanent hemodynamic disturbances and several other factors which need stabilization and correction during the pre-ICU period or after reaching ICU facilities. We excluded sedated patients in our study but not intubated ones. Although some of sedative medications can change the depth of brain stem function and reflexes, most usual ones do not. It's one of the most important points of view in the creation of FOUR score by Wijdicks, et al. It also should be mentioned that such sedative agents are almost always have a short half-life and considering this point could would help to solve the related problem. This may prevent the generalizability of the findings, recruiting these patients would have shown the apparent increase in the severity of the injury, which is a greater bias. Another limitation of this study was the small sample size. One of the strengths of FOUR score is its larger potential predictive value in intubated patients than GCS. The small sample size prevented a sufficient number of intubated patients to be included to be able to discuss the accuracy or inaccuracy of this hypothesis. The small sample size also prevented a sufficient number of patients to be included to be able to discuss based on variants of age and imaging findings. It is suggested to use standard scales such as modified Rankin Scale (mRS) to explain the outcome of the cases, while in the hospital or short period after discharge.

In conclusion, the findings indicate that the predictive value of FOUR score and GCS in predicting the outcome of multiple trauma patients admitted to the emergency department is similar. Evaluation of these two methods at the sixth and twelfth hours after admission has a better predictive value of that at the time of admission.

Conflict of Interest

None.

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Authors' Contributions

All authors met FOUR criteria for authorship contribution based on recommendations of the International Committee of Medical Journal Editors.

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