FOUR score versus GCS in patients with traumatic brain injury in the prehospital setting

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Abstract

Objective: The purpose of this study is to compare two coma scales, the GCS (Glasgow Coma Scale) and the FOUR score (Full Outline of UnResponsiveness score).

Design: We performed a prospective observational cohort study over a one-and-a-half-year period. Statistical methods were used, and results of data analysis presented.

Setting: The study was conducted in a prehospital setting.

Patients: We included 200 adults with traumatic brain injury.

Interventions: We evaluated the GCS and FOUR scores at three different prehospital time points, and we reassessed the scores in surviving patients 24 hours, one month and three months after the injury.

Main outcome measures: We aiming to examine which scale is better for predicting mortality outcome in traumatic brain injury patients.

Main result: We introduced and compared different models for the prediction of morality outcome 24 hours after the injury and re-evaluated the predictive ability of the models one and three months after the injury.

The results of our work reveal that FOUR score perform almost identically to GCS in terms of predictive outcome morality.

Conclusions: Despite some promising model scores, the result of our research has shown no statistically significant difference in terms of the correct prediction of mortality outcome between the GCS and FOUR scores 24 hours, one month, and three months after brain injury.

Background

The assessment of the level of consciousness in patients with brain injuries is particularly important and demanding in emergency scenarios outside the hospital. In the last few decades, several different coma score scales have been proposed. In 1974, a new scale, the Glasgow Coma Scale (GCS), was introduced; since then, it has been widely applied and is still largely utilized worldwide [1]. The GCS offers a good tool for assessing the level of consciousness and coma. Many studies have suggested that this scale should be used with other neurological estimations [2-5] and should be administered as soon as possible in emergency situations. Not only, GCS may be repeated at intervals, especially when neurological function fluctuates [6]. The purpose of the GCS is to evaluate patients with TBI (traumatic brain injury) and predict their chances of neurological recovery. However, the GCS presents some weaknesses, such as limited utility in intubated patients as well as an inability to assess brainstem reflexes. Considering such limitations, a new coma score, the Full Outline of UnResponsiveness (FOUR) score, has been developed [7] to overcome these shortcomings. The FOUR score also provide further neurological details that might lead to a better prediction of outcomes in coma patients.

The FOUR score has four components: eye responses, motor responses, brainstem reflexes, and respiration patterns. Each component ranges from a minimal value of 0 to a maximal value of 4 [7]. The total FOUR score ranges from a minimum of 0 to a maximum of 16 [9]. The components and the grading of the FOUR and GCS score are described in Table 1.

Methods

The present study was approved by the National Medical Ethics Committee of the Republic of Slovenia. All declarations were performed in accordance with the relevant guidelines and regulations. We performed a prospective observational cohort study over a one-and-a-half-year period, from March 2012 to September 2013.

We contact prehospital units in large community area in Slovenia by sending an introduction letter to colleagues describing the aim and procedures of the study. Recruitment materials were provided and includes: accurate description of the research purpose, name and address of the investigator, condition under study, plans of the study and researcher checklist, eligibility criteria of the patients, time commitments required, location of the research, written and illustrated material on GCS and FOUR score with links to web access for further explanations (official and dedicated web sites, videos…), sample excel tables to collect study data, medical ethics consent, informed consent, in charge person to contact for further information. We also sent reminder letters to increase response rate among clinicians, using emails and SMS on scheduled time to colleagues, in order to follow-up and re-evaluate patient's outcome.

Our inclusion criteria were minor or moderate-to-severe TBI patients with altered mental status and/or coma who were either polytraumatized or had isolated head injuries. We did not include patients under the age of 18, patients who required CPR or patients who died before arriving at the hospital.

TBI patients were treated and evaluated by emergency prehospital medical unit personnel. The arrival time to the nearest regional hospital was up to 15 minutes. All patients were treated according to the ATLS guidelines.

We evaluated the GCS and FOUR scores in the prehospital setting at three different time points: immediately upon first contact with the patient at the scene, subsequently after the management of the patient by the prehospital medical unit, and for the third time during patient handover by the ambulance staff at the hospital (Table 2). Outcome was assessed after 24 hours, 1 month and 3 months.

We included 200 patients with TBI in our study (133 men and 67 women). The study size was obtained with a power analysis using GPower 3.1.9 software and z test for an a priori power calculation using alpha (α) of 0.05, power of 80% and effect size (d) of 0.8 calculated separately for FOUR and GCS scores. A priori power analysis has shown that for 80% power at least 107 vs. 15 or 27 vs. 27 individuals have to be included for allocation ratio of 0.14 or 1, respectively. Post-hoc statistical power of proportions is presented as sensitivity ($1-\beta$).

An overview of the clinical characteristics of the cohort study is shown in Table 3.

The sensitivity, specificity, correct prediction and Youden's J-statistic (index) [13] were obtained with a two-by-two table. Youden's J-statistic was used to assess the performance of a dichotomous diagnostic test. For each scale and each outcome (dead or alive), all possible cut-off points were constructed by means of two-by-two tables. We calculated the sensitivity (true positive) by choosing survivors with equal or more points according to the selected cut-off point. In addition, we calculated the specificity (true negative), where we chose nonsurvivors with fewer points according to the selected cut-off point. The best cut-off points for each of the outcomes were further assessed and pairwise compared. The percentages of correct predictions of outcomes were obtained according to these cut-off points. For the coordinates of the receiver operating characteristic (ROC) curves, we applied test result variable(s): FOUR 1, GCS 1, FOUR 2, GCS 2, FOUR 3, GCS 3 that has at least one tie between the positive actual state group and the negative actual state group. The smallest cut-off value was the minimum observed test value minus 1, and the largest cut-off value was the maximum observed test value plus 1. All the other cut-off values were the averages of two consecutive ordered observed test values. For each score, ROC curves were obtained. The greater the area under the ROC curve was, the better the scoring system [14-17].

Data were analysed with IBM SPSS Statistics for Windows, version 21.0. Armonk, NY: IBM Corp. The outcome prediction data were compared to the observed data for each of the two following assessment model combinations (F1-F2, F1-F3, F1-G1, F1-G2, F1-G3, F2-F3, F2-G1, F2-G2, F2-G3, F3-G1, F3-G2, F3-G3, G1-G2, G1-G3, G2-G3) where F: FOUR and G: GCS, separately at three fixed time. We use McNemar's test for comparison of paired dichotomous categorical mutually exclusive variables in order to meet the assumptions. A statistically significant test result ($P < 0.05$) shows that there is evidence of a systematic difference from the two models. The absence of a systematic difference implies that there is no bias. Although, a non-significant result indicates only that there is no evidence of a systematic effect. The comparisons of the areas under the ROC curves and the analyses of the differences in the Youden index were performed using the method described by Hanley and McNeil [14-17].

Possible biases that could affect our study:

- In relation to data collection, we spot a potential bias about physicians who may superficially perform GCS and FOUR score because of lack of skills, especially for a FOUR score. We skip that potential unfamiliarity, educating clinicians who performed and interpret the scores, exposing them to the same level of basic knowledge.
- We also detect a possible bias evaluating GCS and FOUR score in intubated and mechanically ventilated patients compared to patients who breath spontaneously. In these study, the amount of intubated and mechanically ventilated patients in the prehospital arena were insufficient to statistically influence the p value of the suggested models in our study.
- GCS and FOUR score were also compared by drawing ROC curves to avoid bias of arbitrary cut-off points. The comparison of the GCS score and the FOUR score at three different time points out of the hospital in patients who survived for 24 hours (A) and for one (B) and three months (C) after the injury in regard to outcomes show no differences in correct prediction (Figure 1).

Results

Within 24 hours after the injury, 6 patients (3%) died. One month after the injury, we registered 23 deceased patients (mortality 11,5%), and three months after the injury, we recorded a cumulative total of 25 deceased patients (mortality 12.5%). Specifically, the mortality rate of severely injured patients was 11%, and for moderate injured patients 1,5%. We do not register fatalities among patient who suffer just mild brain injury.

The prehospital medical unit performed head-to-toe immobilization and fixation and placed an IV line with IV therapy; additional oxygen was administered. Within all patients, 33 out of 200 (16,5%) were ET intubated (with appropriate sedation, analgesia and muscular relaxation), mechanically ventilated and monitored with end-tidal CO_2. No missing data were present in the final dataset.

Table 3 indicate an overview of the clinical characteristics and dataset of the study cohort. Taking into account that both scales are not fully comparable we want to deal with the problem of assessing verbal response on GCS intubated patients. In the Table 3 we introduce extra comparative data obtained from the assessment at first contact with the patient (before the endotracheal intubations were performed when indicated), and match only the two singular components present in both scales: the eye and motor response. Both the eye and motor responses of the two scales were compared to the severity of TBI (mild, moderate, severe and other). Considering the range of value of the eye and motor components of the two scales, we can appreciate that at the first assessment the results of the two scores are comparable. We additionally carried out neurologic sequels three months after brain injury using the Glasgow Outcome Scale Extended (GOS-E) with eight progressive outcome step ranges: from 8 and 7 for good recovery, 6 and 5 for moderate recovery, 4 and 3 for severe disability, 2 for persistent vegetative state and 1 for death. The table clearly reveal that more severe is the brain injury, more likely are the disabilities.

We examine TBI patients using FOUR and GCS scores at three different times out of the hospital.

Table 4 provide data regarding the sensitivity, specificity and correct predictions of outcome 24 hours after the injury for the best cut-off points for the Youden index for all the three different times scenarios.

Upon first contact at the scene, we assessed the FOUR 1 score and the GCS 1 score. The average score upon first contact at the scene for the FOUR 1 model was 14/16 and for the GCS 1 model was 12.6/15. Data analysis shows that the best cut-off points for predicting outcomes within 24 hours after the injury, were 12 for the FOUR 1 model and 8 for the GCS 1 model achieved at the first contact with patient.

After the other two time points out the hospital (afterward the initial management of the patient, and during the patient handover by the ambulance staff at the hospital), we do not observe statistically significant differences between the FOUR and the GCS score within 24 hours following the injury.

According to McNemar's test, inside all possible combinations for each of the two assessment models performed separately at three fixed time, we confirmed that the FOUR 1 model and the GCS 1 model showed slightly better predictive power in terms of patient outcome ($p<0,031$) (Table 4). The best cut-off values for the Youden index after 24 hours were 0.85 for the FOUR 1 model and 0.88 for the GCS 1 model (Table 4). The p value of Youden index for the model FOUR 1 – GCS 1 was $p>0,378$. The area under the ROC curve (area ± standard error) obtained after 24 hours was 0.94 ± 0.02 for FOUR 1 and was almost the same at 0.93 ± 0.02 for GCS 1 (Table 4). The p value of ROC model FOUR 1 - GCS 1 was $p>0,667$. We conclude that no differences in the Youden index or area under the ROC curve 24 hours after the injury were found.

In addition to the 24-hour follow-up outcomes, we also evaluated the GCS and FOUR scores in surviving patients one and three months after the injury.

Within all possible combination of assessment of two models, Table 5 displays analysis performed one month after the injury and revel that the best cut-off point was 8 for the FOUR 2 and FOUR 3 models and 11 for the GCS 3 model. According to McNemar's test, this two pair of models (each model $p<0,021$) had the highest outcome prediction value between all combined models. The cut-off value for the Youden index was the same at 0.81 for the FOUR 2, FOUR 3 and GCS 3 models (Table 5). The p value of Youden index for the model FOUR 2 – GCS 3 and for the model FOUR 3 – GCS 3 was the same $p>0,939$. ROC curve was also the same at 0.91 ± 0.04 for both the FOUR 2 and FOUR 3 models and was 0.95 ± 0.05 for the GCS 3 model (Table 5). The p value of the ROC model FOUR 2 – GCS 3 was $p>0,197$ and for the ROC model FOUR 3 – GCS 3 $p>0,208$. Even after one month from the injury we can conclude that no differences in the Youden index or area under the ROC curve were found.

Data obtained from all the possible combination of assessment of two models, indicate in Table 6 that the analysis performed three months after the injury reflect, that according to McNemar's test, the best three pair of models (each model $p<0,007$) were the FOUR 2 and FOUR 3 (both cut-off values of 12) as well as GCS 1 (cut-off value of 12) and GCS 2 (cut-off value of 9) models (Table 6). The Youden index values were 0.77 for the FOUR 2, FOUR 3 and CGS 2 models and 0.78 for the GCS 1 model (Table 6). The p value of Youden index for the three models FOUR 2 – GCS 1, FOUR 3 – GCS 1 and GCS 1 – GCS 2 was the same $p>0,953$. The ROC was 0.89 ± 0.04 for the FOUR 2 and FOUR 3 models, 0.93 ± 0.02 for the GCS 1 model and 0.95 ± 0.02 for the GCS 2 model (Table 6). The p values of ROC model FOUR 2 – GCS 1 was $p>0,234$; for FOUR 3 – GCS 1 it was $p>0,119$; and for GCS 1 – GCS 2 was $p >0,396$. Yet again, no significant differences in the Youden index or area under the ROC curve were found.

Discussion

Impaired consciousness is present in many injured patients. Efforts directed to evaluate the level of consciousness, proper management and prediction are crucial.

We performed target review of previously published original works that describes the comparison between GCS and the FOUR score in hospital setting.

The goal of the study was to compare the two scores and to verify their ability to predict mortality outcomes in TBI patients outside the hospital field.

Since 1974 [1], when the GCS was introduced, the GCS has been widely used in the prehospital setting. In 2005, the FOUR score [7] was proposed to reduce some limitations of the GCS. Currently, the FOUR score is mostly utilized in hospital environment, specifically in emergency department, intensive and neurological care units.

The advantages of the FOUR score have been assessed by Wijdicks et al. [7], especially in neurologically critically ill patients who are intubated. Intubation is a common procedure after head injury. The FOUR score tests essential brainstem reflexes and provides information about the degree of brainstem injury that is not registered with the GCS. The FOUR score also can distinguish a locked-in syndrome and a possible vegetative state [7] and includes signs suggestive of uncal herniation [7]. The evaluation of respiratory patterns in the FOUR score may also add information about the presence of anomalous breath rhythms and the presence of respiratory drive [7]. No less important was the fact that the in-hospital outcomes between the scales were better for the lowest total FOUR scores than for the GCS scores [7].

What emerges from the analysis of the previous published works and articles is that FOUR score is an accurate predictor of outcome in TBI patients [8], that it has some advantages over the GCS [8] and that it can be performed in a variety of ICU contexts [8]. The FOUR score is easily taught and simple to administer, and it provides essential neurologic information that allows for an accurate assessment of patients with altered consciousness with excellent interrater agreement among medical intensivists [9]. The FOUR score also might be a better prognostic tool for ICU outcomes than the GCS, most likely again, because it integrates brainstem reflexes and respiration [10]. After moderate and severe TBI in patients, FOUR score on admission has predictive value [11] and also the prognostic ability for the primary outcome 2 weeks after injury, was no better than that with the GCS score [11]. For nontraumatic comatose patients, other different parameters as predictors of outcome in the prehospital environment were also studied [12].

Examinations performed between the GCS and FOUR scores in the hospital environment have demonstrated that the GCS is missing the key, that is essential elements of a comprehensive neurological examination for comatose patients [18]. Supplementary originally works have concluded that the FOUR score can be applied as an ideal tool to evaluate consciousness levels and patients' status in patients with traumatic head injury, and that it can be used as the ideal replacement for Glasgow Coma Scale [19].

Other promising studies claim that prospective research with larger cohorts of patients treated in various intensive care units for longer durations are needed to evaluate whether the application of these scales influences functional and cognitive outcomes [20].

Further comparative neurological outcome works showed that the outcome of patients admitted to the ICU was significantly higher when the GCS or the FOUR score was used [21], and the discrimination was fair for both scores, but the FOUR score was superior to the GCS [21]. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were also better for the FOUR score than for the GCS [21]. In this study good correlation was observed between the two scores [21].

A comprehensive overview of the relationship between a patient's FOUR score and outcome is still lacking. A recent study on the FOUR score showed that the FOUR score had a close overall relationship with in-hospital outcomes and poor functional outcomes in patients with impaired consciousness [22], still there was insufficient evidence to determine whether performance was modified in different groups. There was some suggestion that the assessment of brainstem reflexes and respiratory patterns made less of a contribution than eye and motor scores [22].

In a more recent Letter to editor, the authors conclude that the two scoring systems should be complimentary, as one will complement the limit of others [23]. The author states that GCS can be modified to adapt the FOUR score parameters for patients with low GCS and predict in-hospital mortality for critically sick patients. Contrary, GCS can accompaniment the FOUR score to predict critically ill children's outcomes [23].

The approach and choice to evaluate the cohort sample patients with TBI in an out-of-hospital setting is original till now.

Conclusions

The present study involved a comparison between the GCS and FOUR scores in TBI patients in out-of-hospital scenarios at different follow-up times. We introduced and compared different models for the prediction of morality outcome 24 hours after the injury and re-evaluated the predictive ability of the models one and three months after the injury.

The results of our work reveal that FOUR score perform almost identically to GCS in terms of predictive outcome morality 24 hours, one month, and three months after injury.

We agree with some of the conclusions citated and expressed by authors of previous published works, that FOUR score could be regularly performed in patients with low GCS score and predict in-hospital mortality for critically sick patients, especially in intubated patients with brain injuries [23].

According to our research, we ought to obtain a better understanding of the anatomical and pathophysiological pathways that are not evidenced by certain GCS and FOUR scores. Further research should be focused on the comparison between the obtained GCS and FOUR score data and the anatomical substrate changes revealed by diagnostic tools such as head CT scans and brain fMRI. With these data, we could acquire the accurate subanatomical and clinical information needed to perform specific invasive therapy to lead to a far better diagnose, therapy management and finally outcome of patients.

Nevertheless, further research work undertaken out of hospital, engaging extensive cohort of TBI patients with severely impaired level of consciousness, should be performed before we can unanimously accept the FOUR score as gold standard clinical grading scale in prehospital arena.

Abbreviations

FOUR - Full Outline of Unresponsiveness

GCS - Glasgow Coma Scale

TBI - Traumatic Brain Injury

ICU - Intensive Care Unit

ROC - Receiver Operating Characteristic

IV - Intravenous Line

ET - Endotracheal Tube

ATLS - Advanced Trauma Life Support

CT - Computed Tomography

fMRI - functional Magnetic Resonance Imaging

GOS-E Glasgow Outcome Scale Extended

Declarations

Ethics approval and consent to participate

The present study was approved by the National Medical Ethics Committee of the Republic of Slovenia. We recruited only patients who gave signed consent to participate. Informed signed consent was obtained from the patients' or patient's guardian/caregivers.

Consent for publication

Informed signed consent was obtained, and explanations that data may be published in the study were provided.

Availability of data and material

The datasets collected and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MRF contributed to the acquisition and interpretation of the data. MG performed the analysis of the data. JR revised the study. All authors read and approved the final manuscript.

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Tables

Table 1 Description of the FOUR and GCS score components.

Table 2 GCS and FOUR scores in the prehospital setting at three different time points: immediately upon first contact with the patient at the scene (GCS 1/FOUR 1), after the management of the patient by the prehospital medical unit (GCS 2/FOUR 2), and during patient handover by the ambulance staff at the hospital (GCS 3/FOUR 3).

Table 3 Overview of the clinical characteristics of the study cohort.

Table 4 Sensitivity, specificity, ROC area, and correct prediction of outcomes 24 hours after injury for selected cut-off points in the FOUR and GCS models based on the best Youden index. 1: immediately upon first contact at the scene.

Table 5 Sensitivity, specificity, ROC area, and correct prediction of outcomes 1 month after injury for selected cut-off points in the FOUR and GCS models based on the best Youden index. 2: after initial management and intervention of the patient, 3: during patient handover by the ambulance staff at the hospital.

Table 6 Sensitivity, specificity, ROC area, and correct prediction of outcomes 3 months after injury for selected cut-off points in the FOUR and GCS models based on the best Youden index. 1: immediately upon first contact at the scene, 2: after initial management and intervention of the patient, 3: during patient handover by the ambulance staff at the hospital.

Table 1.

Description of the FOUR score components

Eye Response (E)	Brainstem Reflexes (B)	Motor Response (M)	Respiration (R)
4 Eyelids open or opened, tracking or blinking to command	4 Pupil and corneal reflexes present	4 Thumbs up, fist, or peace sign to command	4 Not intubated, regular breathing pattern
3 Eyelids open but not tracking	3 One pupil wide and fixed	3 Localizing to pain	3 Not intubated, Cheyne-Stokes breathing pattern
2 Eyelids closed, open to loud voice, not tracking	2 Pupil or corneal reflexes absent	2 Flexion response to pain	2 Not intubated, irregular breathing pattern
1 Eyelids closed, open to pain, not tracking	1 Pupil and corneal reflexes absent	1 Extensor posturing	1 Breathes above ventilator rate
0 Eyelids remain closed with pain	0 Pupil, corneal, and cough reflex absent	0 No response to pain or generalized myoclonus status epilepticus	0 Breathes at ventilator rate or apnoea

Description of the GCS score components

Eye Response (E)	Best Verbal Response (V)	Best Motor Response (M)
4 Spontaneous	5 Oriented	6 Obeys commands
3 Response to verbal command	4 Confused	5 Localizing response to pain
2 Response to pain	3 Inappropriate words	4 Withdrawal response to pain
1 No eye opening	2 Incomprehensible sounds	3 Flexion to pain
	1 No verbal response	2 Extension to pain
		1 No motor response

Table 2**.** GCS and FOUR in the prehospital setting.

Time point	Variable
Immediate first contact at the scene	GCS 1/FOUR 1
After the management of the patient at the scene	GCS 2/FOUR 2
Patient handover at the hospital	GCS 3/FOUR 3

The three different time points are as follows: immediately at first contact with the patient at the scene (GCS 1/FOUR 1), after the management of the patient by the prehospital medical unit (GCS 2/FOUR 2), and during patient handover by ambulance staff at the hospital (GCS 3/FOUR 3).

Table 3. Overview of the clinical characteristics of the cohort study.

Severity	Sex (M/F)	Age (years±SD)	FOUR Eye Response First assessment (median/IQR[e])	GCS Eye Response First assessment (median/IQR[e])	FOUR Motor Response First assessment (median/IQR[e])	GCS Motor Response First assessment (median/IQR[e])	GOS-E Assessment after three months (median/IQR[e])
Severe [a] (N=35)	23/12	59.0±24.7	1/4	2/3	3/4	4/5	1/3
Moderate [b] (N=29)	24/5	47.9±21.1	3/3.5	3/3	3/2	5/3	7/2
Mild [c] (N=121)	77/44	51.8±24.1	4/0	4/0	4/0	6/0	8/0
Other [d] (N=15)	9/6	49.8±17.3	4/0	4/0	4/1	6/1	8/0

The severity score was classified upon CT (computerized tomography**)** score diagnose.

[a] Head trauma - intracranial haemorrhage, brain oedema, severe loss of consciousness.

[b] Head trauma - concussions with moderate loss of consciousness.

[c] Head trauma without brain damage.

[d] No direct head trauma, but different level of loss of consciousness and syncope due to cardiovascular, neurological or psychogenic nature contemporary to the event.

N: number of patients by severity classification

[e] IQR – inter quartile range

Table 4. Scale metrics at 24 hours after injury.

Scale (N)	Best cut-off point	Sensitivity (%)	Specificity (%)	Correct prediction of outcome (%)	Youden index±SE	ROC area±SE (CI95)
FOUR 1ª (N=200)	12	85	100	85	0.85±0.03	0.94±0.02 (0.89-0.99)
GCS 1ª (N=200)	8	88	100	88	0.88±0.02	0.93±0.02 (0.89-0.98)

ROC: Receiver Operating Characteristic; FOUR: Full Outline of UnResponsiveness; GCS: Glasgow Coma Scale; N: number of patients enrolled in cohort study; SE: standard errors; SE (CI95): standard errors from 95% confidence intervals. 1ª: at immediate first contact at the scene.

According to McNemar's test among all models carried out in three different times out of the hospital, FOUR 1 - GCS 1 model assessed at first contact at the scene, showed slightly better predictive power in terms of patient outcome (p<0,031). The p value of Youden index for the model FOUR 1 – GCS 1 was p>0,378 and the p value of ROC model FOUR 1 - GCS 1 was p>0,667. We conclude that no differences in the Youden index or area under the ROC curve 24 hours after the injury were found.

Table 5. Scale metrics at 1 month after injury.

Scale (N)	Best cut-off point	Sensitivity (%)	Specificity (%)	Correct prediction of outcome (%)	Youden index±SE	ROC area±SE (CI95)
FOUR 2ª (N=200)	8	94	87	94	0.81±0.07	0.91±0.04 (0.83-0.98)
GCS 3 (N=200)	11	89	91	90	0.81±0.06	0.95±0.02 (0.92-0.98)
FOUR 3 (N=200)	8	94	87	94	0.81±0.07	0.91±0.04 (0.83-0.98)
GCS 3 (N=200)	11	89	91	90	0.81±0.06	0.95±0.02 (0.92-0.98)

ROC: Receiver Operating Characteristic; FOUR: Full Outline of UnResponsiveness; GCS: Glasgow Coma Scale; N: number of patients enrolled in cohort study; SE: standard errors; SE (CI95): standard errors from 95% confidence intervals. 2ª: after initial management and intervention on the patient, 3: during the patient handover by ambulance staff at the hospital.

In conformity to McNemar's test, the two pair of models FOUR 2 - GCS 3 and FOUR 3 – GCS 3 had the highest outcome prediction value between all combined models (p<0,021). The p value of Youden index for the model FOUR 2 – GCS 3 and for the model FOUR 3 – GCS 3 was the same p>0,939. The p value of the ROC model FOUR 2 – GCS 3 was p>0,197 and for the ROC model FOUR 3 – GCS 3 p>0,208. Same conclusion here, no differences in the Youden index or area under the ROC curve were found.

Table 6. Scale metrics at 3 months after injury.

Scale (N)	Best cut-off point	Sensitivity (%)	Specificity (%)	Correct prediction of outcome (%)	Youden index±SE	ROC area±SE (CI95)
FOUR 2 (N=200)	12	93	84	92	0.77±0.08	0.89±0.04 (0.81-0.97)
GCS 1ª (N=200)	12	86	92	87	0.78±0.06	0.93±0.02 (0.90-0.97)
FOUR 3 (N=200)	12	93	84	92	0.77±0.08	0.89±0.04 (0.81-0.97)
GCS 1ª (N=200)	12	86	92	87	0.78±0.06	0.93±0.02 (0.90-0.97)
GCS 1ª (N=200)	12	86	92	87	0.78±0.06	0.93±0.02 (0.90-0.97)
GCS 2 (N=200)	9	93	84	92	0.77±0.08	0.95±0.02 (0.92-0.98)

ROC: Receiver Operating Characteristic; FOUR: Full Outline of UnResponsiveness; GCS: Glasgow Coma Scale; N: number of patients enrolled in cohort study; SE: standard errors; SE (CI95): standard errors from 95% confidence intervals. 1ª: at immediate first contact at the scene, 2: after initial management and intervention for the patient, 3: during the patient handover by ambulance staff at the hospital.

Based on McNemar's test, the best three pair of models (each model p<0,007) were the FOUR 2 and FOUR 3 as well as GCS 1 and GCS 2. The p value of Youden index for the three models FOUR 2 – GCS 1, FOUR 3 – GCS 1 and GCS 1 – GCS 2 was the same p>0,953. The p values of ROC model FOUR 2 – GCS 1 was p>0,234; for FOUR 3 – GCS 1 it was p>0,119; and for GCS 1 – GCS 2 was p >0,396. Yet again, no significant differences in the Youden index or area under the ROC curve were found.

Figures

Figure 1

Comparative GCS and FOUR score outcome assessment at three different time points out of the hospital in patients who survived 24 hours (A), one month (B) and three months (C) after the injury.