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Original Research Article

Full outline of unresponsiveness versus Glasgow coma scale in predicting mortality in paediatric trauma patients

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ABSTRACT

Background: Many scoring models have been proposed for evaluating level of consciousness in trauma patients. The aim of this study is to compare Glasgow coma scale (GCS) and full outline of unresponsiveness (FOUR) score in predicting the morbidity and mortality of trauma paediatric patients.
Methods: In this diagnostic accuracy study trauma paediatric patients hospitalized in emergency room (ER) of Menoufia University hospital were evaluated. GCS and FOUR score of each patient were simultaneously calculated on admission as well as 6, 12 and 24 hours after that. The predictive values of the two scores and their area under the receiver operating characteristics (ROC) curve were compared.
Results: 100 patients were included in the present study (mean age 7.6±5.1; 77% male). Comparing the area under the ROC curve of GCS and FOUR score showed that these values were not different at any of the evaluated times: on admission (p=0.68), and 6 hours (p=0.13), 12 hours (p=0.18). However, The values of FOUR score was high accuracy than GCS score in predicting mortality in paediatric patients with ROC; 0.97, 0.89 respectively.
Conclusions: The results of our study showed that, GCS and FOUR score have the same value in predicting the mortality of trauma patients in first 24 hours. However, FOUR score has high accuracy than GCS score after 24 hours. Both tools had high predictive power in predicting the outcome at the time of discharge.

Keywords: Glasgow coma scale, Wounds and injuries, Trauma severity indices, Outcome assessment (health care)

INTRODUCTION

Head injury (HI), also termed 'traumatic brain injury' (TBI) forms a major contributor towards trauma related mortality and morbidity all over the world. This is especially significant in developing countries India, where such injuries are progressively increasing due to rapid motorization, alcohol abuse and the general indifference by the public towards safety measures.[1]

In Egypt, it is estimated that nearly 0.5 million people get injured, 100,000 people die and another 300.000 people require rehabilitation services every year due to traumatic brain injury.[2] As per the study undertaken by NIMHANS, it is shown that the incidence, mortality and case fatality rates are 150/100000, 20/100000 and 10%, respectively.[3] The public health burden this causes is not trivial, as most of these patients belong to the young and productive age group.

A head injury survivor has a wide range of brain injuries varying from superficial injuries to a permanent vegetative state. Apart from the physical damage and neurological disabilities of different types, psychosocial problems like depression, anxiety and suffering will affect the individual for a long period even after getting

discharged from the hospital.[4] Adequate initial assessment and early intervention is of paramount importance in treating patients with HI, so as to decrease mortality and also to lessen the long term disabilities. However, assessing a patient's level of consciousness is a complex affair, mostly due to the difficulty in finding appropriate terminologies that are truly objective and user independent. Several scales have evolved over the decades to answer this need.[5]

One of the earliest systems developed was the 'vital sign card' or the Ommaya coma scale, developed by Ommaya, a neurosurgeon at the National Institute of Neurological Diseases and Blindness in Bethesda, Maryland, the USA in 1966.[6] However, the scale never found much use outside of that institution. The Jouvet coma scale, which was published in 1969, evaluates two parameters: perceptivity and reactivity.[7] Another scale, the Moscow coma scale, was developed by the Institute for Research into Neurosurgery at the USSR Academy of Medical Sciences.[8] This scale, which consisted of a quantitative scale for the findings of the neurological examination and a scale for classifying disorders of consciousness, also failed to gain popularity outside the USSR.

The Glasgow coma scale (GCS) was the result of two parallel international studies on coma and prognosis of severe head injuries, which were funded by the National Institutes of Health. In 1974, Teasdale and Jennett published 'assessment of coma and impaired consciousness: a practical scale' 0.6 This coma scale utilized the theoretical model of level of consciousness earlier proposed by Plum and Posner in 1972.[8] This got revised in 1976 with the addition of a sixth point in the motor response subscale for 'withdrawal from painful stimulus'. The scale mainly assessed only motor, verbal, and eye responses. The first version of this scale was called initially as the coma index but soon became known as the GCS, based on the location of the authors' affiliated institution.[9] The GCS was designed mainly to improve the communication between physicians and nurses when describing the state consciousness and to avoid ambiguous terminologies such as "somnolence" and "unresponsiveness".[10]

The GCS was initially developed as an unnumbered system. The assigning of numbers to the responses (using "1" for the lowest score rather than "0") was introduced in a later article that also expanded the motor responses, adding abnormal flexion. Although users of the GCS began creating sum scores for the 3 components (giving a total range between 3 to 15 points), this method was never the primary intention of the originators of the scale. Specific GCS sum scores such as 3, 8, and 15 have acquired immediate familiarity; so much so that use of the sum scores even led to the commonly used directive, "Glasgow 8, intubate."

Many scoring models have been proposed to evaluate level of consciousness in patients who are affected with traumatic brain injuries, the most famous of which is Glasgow coma scale. This scale has some limitations such as its low efficiency in intubated patients, its poor use in cases of language differences, and not being able to evaluate the reflexes of brainstem.[11] In intubated patients, the verbal part is practically non-measurable and therefore, it is possible that the reported level of consciousness in these patients is lower than its real level.[12] Full Outline of UnResponsiveness (FOUR) score is another scale for evaluating level of consciousness, the accuracy and precision of which in critically ill patients has been evaluated in only a few studies.[13] Availability of a scoring system that in addition to accuracy, precision, and easy use, leads to facilitation of the nursing care of trauma patients is a necessity.

By providing an accurate picture of injury severity, such a system would be able to give a reflection of the outcome of the patient to the health care team. Contradicting results exist from comparing GCS and FOUR score in prediction of final outcomes. In a multi-center study, Wijdicks et al showed that FOUR score and GCS do not differ in prediction of inhospital mortality, although they suggested that FOUR score can be a better diagnostic tool for assessing brainstem reflexes and respiratory pattern.[14] However, Jalali and Rezaei showed that FOUR score performs better than GCS in prediction of mortality.[15] Presence of these contradictions shows the need for carrying out more studies. Therefore, the present study was done with the aim of comparing GCS and FOUR score in predicting the mortality of trauma paediatric patients.

METHODS

This is a prospective analysis of collected data from paediatric patients presented with traumatic head injury. Before the beginning of the study, ethics approval was obtained from the Menoufia University Hospital's Review Board and a written informed consent was obtained from all participants prior to subject characterization and sample collections. This comparative study will include 100 patients from all paediatric trauma patients who present to the Emergency department of Menoufia University Hospital from October 2017 to April 2019. All patients will be evaluated using both FOUR score and GCS.

The selection of patients in the emergency unit will be according to following criteria.

Inclusion criteria

All pediatric trauma patients aged below 18 years old presented to our emergency department in Al Menoufia university Hospital.

Exclusion criteria

Patients arrived to our hospital in cardio pulmonary arrest, patients transferred from other hospitals after

performing any medical or surgical procedure or given any sedation, and burn patients.

Table 1: Shows Glascow coma scale and FOUR score.[27]

FOUR score	GCS
Eye response	**Eye response**
One has the following: 4 = eyelids open or opened, tracking, or blinking to command 3 = eyelids open but not to tracking 2 = eyelids closed but open to loud voice 1 = eyelids closed but open to pain 0 = eyelids remaining closed with pain stimuli.	One has the following: 4 = eyes open spontaneously 3 = eye opening to verbal command 2 = eye opening to pain 1 = no eye opening
Motor response	**Motor response**
One has the following: 4 = thumbs up, fist, or peace sign 3 = localizing to pain 2 = flexion response to pain 1 = extension response 0 = no response to pain or generalized myoclonus status.	One has the following 6 = obeying commands 5 = localizing pain 4 = withdrawal from pain 3 = flexion response to pain 2 = extension response to pain 1 = no motor response
Brain stem reflexes	**Verbal response**
One has the following 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, or cough reflex	One has the following 5 = oriented 4 = confused 3 = inappropriate words 2 = incomprehensible sounds 1 = no verbal response.
Respiration	
One has the following: 4 = regular breathing pattern 3 = Cheyne-stokes breathing pattern 2 = irregular breathing 1 = triggering ventilator or breathing above ventilator rate 0 = apnea or breathes at ventilator rate	

Each patient will be subjected to: primary survey (ABCDE) protocol: airway and cervical spine control, breathing, circulation and hemorrhage control, disability and exposure and secondary survey: history of allergies, medications, past illness or pregnancy, last meal and event and environment related to injury with head to toe examination and local examination.

Investigation including CT brain, X-ray (spine, chest and pelvis), abdominal US and additional radiological investigation if needed were done.

Conscious level using GCS which include eye response, verbal response, and motor response was assesed (Table 1). Assessment conscious level using FOUR score which include eye response, motor response, brain stem reflexes and respiratory pattern was done (Table 1). Evaluation using both scores will be carried out during the first 24 hours. Both scores will be recorded in the same setting with no time interval. The outcome of each trauma patient will be recorded. The relation between either FOUR score and GCS and the outcome will be studied.

Demographic data (age, sex), trauma mechanism (pedestrian-car accident, motorcycle accident, falling, pedestrian-motorcycle accident, direct trauma, car rollover, and car-car accident), and length of stay in ICU were gathered. In addition, a checklist consisting of items used for calculating GCS (evaluation of eye, speech, and motor score) and FOUR score (evaluation of eye, motor, brainstem reflexes, and respiratory pattern score) was also used in this study. Data were gathered by 2 trained ICU nurses who were completely familiar with data gathering tools. Before the initiation of the study, in order to approve inter-rater reliability of the 2 nurses in scoring of GCS and FOUR score, a primary study was performed in which both nurses evaluated both scores simultaneously for the same 15 patients. The agreement rate obtained was 91% (κ=0.91).

In the present study, predictive values of GCS and FOUR score in prediction of in-hospital mortality of trauma patients were assessed. The details of scoring methods of the 2 mentioned scores have been reported in previous studies.[19,20] GCS and FOUR score of each patient were simultaneously calculated on admission as well as 6, 12 and 24 hours after that.

Death or survival of the patient at the time of discharge from the hospital was used as the reference test. Patients were followed until their discharge from the hospital and their living status at the time of discharge was evaluated.

Statistical analysis

Area under the curves reported for GCS and FOUR score have been 0.78 and 0.84, respectively in previous study.[21] Therefore, by considering 95% confidence interval (α=5%) and power of 90% (β=10%), sample size is calculated as about 100 patients. Data were analysed using SPSS version 22.0. Descriptive analyses were presented as mean and standard deviation, or frequency

and percentage, for quantitative and qualitative factors, respectively. To compare mean score of GCS and FOUR score in dead and alive patients at the evaluated times, two-way repeated measures ANOVA with Bonferroni posthoc was applied. In addition, the predictive values of GCS and FOUR score were evaluated in predicting the outcome of patients via drawing receiver operating characteristic (ROC) curve. Fitness of the model was evaluated using Hosmer-lemeshow test and in the end, the mentioned values were compared between the 2 models. In this study, $p<0.05$ was considered as level of significance.

RESULTS

In this study, data of 100 trauma paediatric patients presented to ER, Menoufia University Hospitals were evaluated. Mean and standard deviation of patients' age was 7.6±5.1 years (77% male). The most important mechanisms of trauma were Road traffic accidents (65%), and falling from a height more than 3 meters (29%). However, local head trauma (3%) and drowning (3%) resembles the least incidence as a cause of Disturbed Conscious level (Table 2).

Table 2: Demographic and baseline characteristics of the studied patients.

Characters	Value (%)
Age (Mean±SD)	7.6±5.1
Sex	
Male	77
Female	33
Trauma mechanism	
Road traffic accident	65
Falling from height	29
Others	6
Presentation at ER	
Threatened air way	43
Shocked	6
Final destination	
Admitted ICU	50
Admitted ward	33
Undergo operation	11
Died	21

43% of patients presented with threatened air way and 6 patients presented with shock. 50 patients were admitted in ICU, 33 patients were admitted in the ward and 11 patients undergoing operations. Mortality rate was 21% (Table 2). The trend of changes in GCS and FOUR score during 24 hours based on death or survival of the patients is presented in Table 1. Based on these findings mean GCS (df: 1, 10±4.3; F=6.58; p=0.01) and FOUR score (df: 1, 11.2±4.6; F=46.64; p<0.001) were lower in those who died compared to those who survived.

The most frequently seen associated injuries were facial bone fractures and long bone fractures. (25% each among severe head injury patients and 30% and 22% among all subjects respectively). Around 18% of the severe head injury patients and 20% of all subjects had associated injuries to the chest wall like fractured ribs, hemo/pneumo thorax or lung contusions/lacerations. Blunt trauma abdomen was seen in 6% of the severe head injury patients compared to 9% among all subjects. Spine injury was seen in 2 patients one of whom had severe head injury. 18.5% of the subjects had no other injuries.

When the whole of study population is taken, the highest GCS score of 15 was found in 36%, followed by GCS of 3 and GCS of 14 seen in 8%. Among patients with severe head injury, 39% had the lowest possible GCS of 3 at the time of presentation. Most of the patients in the study group had a full FOUR score of 16. Most of the other patients had a FOUR score around 12 to 14. Among severe head injury patients, the FOUR score was found to be distributed in a wider range.

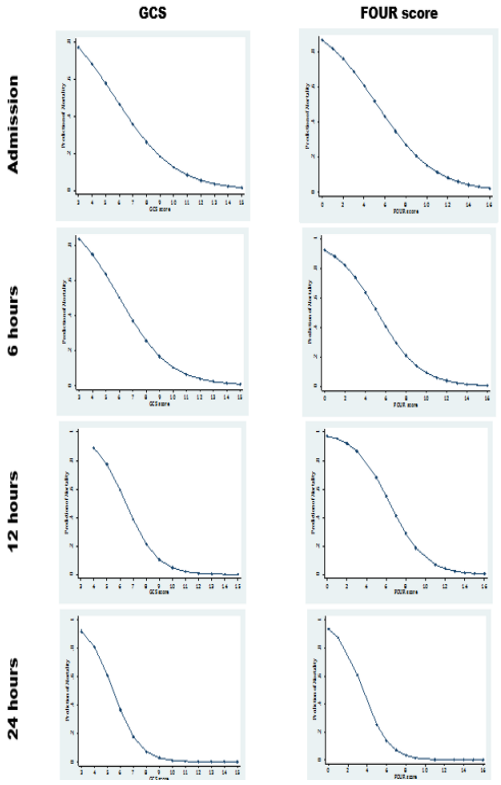

Figure 1: Correlation between GCS, FOUR score and hospital mortality.

Area under the ROC curve calculated for GCS on admission and 6, and 12 were 0.87 (95% CI: 0.77 to 0.98), 0.91 (95% CI: 0.84 to 0.99), 0.95 (95% CI: 0.90 to 0.99) and 0.97 (95% CI: 0.95 to 1.0), respectively. These values were calculated as 0.88 (95% CI: 0.77 to 0.99), 0.96 (95% CI: 0.92 to 1.0), 0.97 (95% CI: 0.92 to 1.0) and 0.99 (95% CI: 0.97 to 1.0), respectively for FOUR score. Comparison of area under the ROC curve of GCS

and FOUR score showed that this value was not different between the 2 systems in any of the evaluated times of on admission (p=0.68), 6 hours (p=0.13), 12 hours (p=0.18). However, the values of FOUR score was high accuracy than GCS score in predicting mortality in paediatric patients with ROC; 0.97, 0.89 respectively (Figure 2).

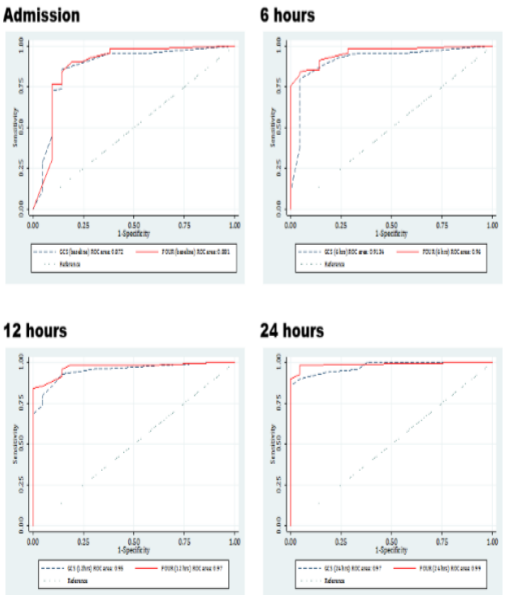

Figure 2: ROC curve of the GCS and FOUR score regarding hospital mortality at different times.

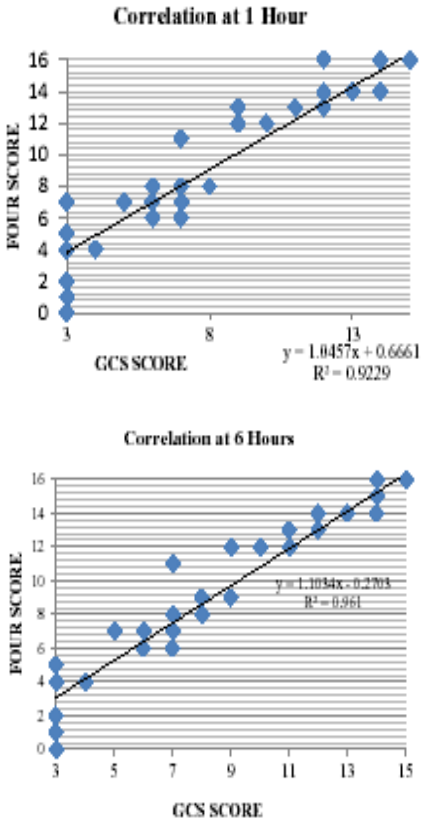

Figure 3: Correlation between GCS and FOUR score at 1 and 6 hours after admission.

The Pearson correlation coefficient between FOUR score and GCS was calculated to be 0.83, 0.78 and 0.91 respectively at the time of presentation, after 1 hour and after 6 hours in patients with severe head injury. The Pearson correlation coefficient between FOUR score and GCS for moderate head injury at presentation was 0.76, at 1 hour 0.85 and 0.98 after 6 hours whereas that between FOUR score and GCS for mild head injury at presentation was 0.80, at 1 hour 0.87 and 0.69 after 6 hours. Overall the Pearson correlation coefficient between FOUR score and GCS for all subjects studied at presentation is 0.94, at 1 hour 0.96 and 0.98 after 6 hour.

DISCUSSION

This was a descriptive study undertaken to find whether FOUR score can be an effective tool in assessing patients with head injury. As per the results of this study, most of the patients presenting with head injury are young, between the age group of between 4-14 years. This might be attributed to the fact that the most common mechanism of injury happens to be motor vehicle accidents, wherein younger people are the ones very often involved. This association of head injuries with motor vehicle accidents might also explains the fact why males outnumber females by a large ratio. In patients with head injuries, the most frequently associated injuries are facial bone fractures and long bone fractures.[16]

The FOUR score hovered around the maximum of 16 in most of the studied patients. Among severe head injury patients, the FOUR score was found to be distributed in a wider range. It was found that higher the consciousness level based on GCS score the higher also the levels obtained by FOUR score and vice versa. When the GCS score improved over a period of time, a similar improvement in FOUR score was also noted. Also, it was quite evident that the FOUR score could furnish out more details about the neurological status of the patients and thus turn out to be more informative.[17]

The correlation between predicted in-hospital mortality and the 2 scales (GCS and FOUR score) was also similar (Figure 2). Findings resulting from multivariate logistic regression showed that with a decrease in scores of GCS and FOUR score, the probability of mortality increases in trauma patients. Range of predicted mortality was similar in both GCS and FOUR score models (Figure 1).

In line with our study, the results of the study by Sahin et al in evaluation of 105 patients also showed that GCS and FOUR score have similar value in prediction of patient mortality and can be used interchangeably.[18] The results of a study by Atahar et al also showed that GCS and FOUR score have the same predictive value in prediction of in-hospital mortality and mortality within 3 months of discharge among children.[19] The findings of Gujjar et al study showed that FOUR score is a better scale compared to GCS for evaluation of changes in level of consciousness in medical wards.[20] One of the reasons for

the dissimilarity of the results of this study with ours might be their different research environment. The research environment in our study was trauma ICU department. In line with our findings, the study by Temiz et al also showed that FOUR score has the same prediction value as GCS in evaluating the level of consciousness and follow-up of patient's status in neurosurgery ICU.[21] In contrast to these findings, the results of the study by Nair et al showed that there is a statistically significant difference between FOUR score and GCS in estimating the severity of injury in head traumas. They reported that FOUR score is a better index for evaluating the level of consciousness in patients with head trauma.[22] The results of Wolf et al. study showed that GCS is one of the proper indices in prediction of mortality in emergency medical admission.[23] In this study we evaluated GCS and FOUR score in 4 points of time: on admission, and 6 hours, 12 hours, and 24 hours after admission. The results showed that the mean and standard deviation of both of these scales were different between those who died and those who survived in the 4 evaluated points of time. In line with these findings were the results of a study by Gujjar et al that evaluated GCS and FOUR score during the initial 3 days of patients' hospitalization and showed that there is no significant difference regarding mean value of these scales on the second and third day between dead and survived patients but there is a significant difference between these mean values on the first day.[20]

FOUR score has four testable components, in contrast with the GCS. The number of components and the maximal grade in each of the categories is four (E4, M4, B4, R4), which is easier to remember than the GCS with its varying number of scores and is reinforced by the acronym. Another study concluded that the FOUR score appears to be an easier tool to use and it provides a more comprehensive neurological assessment.[25] A study on pediatric patients indicated that the FOUR score is more capable than GCS in predicting the mortality and discharge of patients admitted to the PICU.[26] Another study found that the inter-rater agreement of FOUR score results was excellent among medical intensivists.[26] Also, all components of the FOUR score could be rated even when patients were intubated.

This study also had limitations including its small sample size and being performed in 2 trauma centres. Using a larger sample size and designing a multicentre study might provide more valuable and reliable results.

CONCLUSION

The results of our study showed that, GCS and FOUR score have the same value in predicting the mortality of trauma patients in first 24 hours. However, FOUR score has high accuracy than GCS score after 24 hours. Both tools had high predictive power in predicting the outcome at the time of discharge. We also concluded there is high correlation between GCS and FOUR score in predicting in-hospital mortality.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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