

Prediction of Discharge Outcome with the Full Outline of Unresponsiveness (FOUR) Score in Neurosurgical Patients

Phuping Akavipat^{a*}, Pimwan Sookplung^a, Pranee Kaewsingha^b, and Patcharin Maunsaiyat^b

Departments of ^aAnesthesiology, and ^bAcademic Service, Prasat Neurological Institute, Bangkok 10400, Thailand

To identify the diagnostic properties of the Full Outline of Unresponsiveness (FOUR) score and the discharge outcome, 318 patients were studied. The evaluators rated the patients on admission or when they had mental status alteration with the FOUR score. The course of treatment was determined based on the clinical. The mortality rate and Glasgow Outcome Scale were recorded. Adjusted regression models and prognostic performance were tested by calculation of the receiver operating characteristic curve. One-hundred and twenty-two patients (40.1%) had a poor outcome defined as a Glasgow Outcome Scale score from 3-5, and 38 patients (12.5%) died. The area under the characteristic curve (AUC) for poor outcome and in-hospital mortality were 0.88 (95% CI, 0.83-0.92) and 0.92 (95% CI, 0.87-0.97). The cut-off point of 14 showed sensitivity and specificity of the total FOUR score predicting poor outcomes at 0.77 (95% CI, 0.69-0.84) and 0.95 (95% CI, 0.90-0.97), while the cut-off point of 10 showed the values for in-hospital mortality at 0.71 (95% CI, 0.55-0.83) and 0.93 (95% CI, 0.90-0.96). The total FOUR score showed satisfactory prognostic value for predicting outcome. The cut-off points for the poor outcome and in-hospital mortality are 14 and 10, respectively.

Key words: consciousness, evaluation, mortality, outcome, Full Outline of Unresponsiveness (FOUR)

Outcome assessment in neurosurgical patients is imperative for determining when hospital discharge can take place, for predicting mortality, and for appropriate resource administration by hospital providers. For these purposes, many different scoring systems have been described, but the neurological assessment or coma scale has been accepted as the most practical outcome indicator for neurological and neurosurgical patients [1, 2].

Wijdicks *et al.* have validated a new coma scale, the FOUR (Full Outline of Unresponsiveness) score which is composed of 4 testable components *i.e.*, eye response, motor response, brainstem reflexes and respiration, each with a scale of 0-4 (0 = worst; 4 =

best) as demonstrated in Table 1 [3]. The FOUR score is uncomplicated, specifically distinguishes certain unconsciousness states, provides important details such as brainstem reflexes, and includes the minimal necessities of neurological testing in impaired consciousness [3]. All patients could be assessed for alertness using the FOUR score in contrast with an all inclusive score like the Glasgow Coma Scale (GCS; as demonstrated in Table 2), which was less useful in a number of patients because they were intubated. Furthermore, it recognizes uncal herniation, a locked-in syndrome, and the beginning of a vegetative state, which the GCS does not do [4]. Establishing the validity and reliability of this scale among users would be important for establishing the viability of scores using this scale, but no attempts have been made to do so. [3-6].

The affiliation between the neurological assessment

Table 1 The Full Outline of Unresponsiveness (FOUR) score

FOUR Score	
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
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
Brainstem reflexes	
	4 = papillary and corneal reflexes present
	3 = one pupil wide and fixed
	2 = papillary or corneal reflexes absent
	1 = papillary and corneal reflexes absent
	0 = absent papillary, corneal, and cough reflex
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

Table 2 Glasgow Coma Scale (GCS) Score

Glasgow Coma Scale	
Eye opening	
	4 = spontaneous
	3 = to speech
	2 = to pain
	1 = no response
Best motor response	
	6 = obeys
	5 = localizes
	4 = withdraws
	3 = abnormal flexion
	2 = extends
	1 = no response
Best verbal response	
	5 = oriented
	4 = confused conversation
	3 = inappropriate words
	2 = incomprehensible sounds
	1 = no response

score, particularly the GCS, and subsequent clinical outcome has been demonstrated. However, few researchers have investigated the affiliation between the neurological assessment score and the FOUR score in neurosurgical patients [7–9]. Thus, the principal reason the authors performed this study was to identify the diagnostic properties of the FOUR score and the discharge outcome in neurosurgical patients whether the score is feasible for clinicians to use.

Materials and Methods

After approval from the Institutional Ethical Committee, patients over 15 years old who were newly admitted to the neurosurgical unit at Prasat Neurological Institute, a tertiary neurological health care center, or had an alteration in mental status during admission were recruited. Patients who had received anesthesia, a sedative, or neuromuscular blockers within the past 24h were excluded. To assess the properties of the score over all types of patient, all 4 categories were studied: awake, drowsy, stuporous, or comatose using the definitions previously described [10]. All categories were comprised of a proportionate number of patients according to the in-hospital distribution and randomly selected by the screening physician who was not involved in the score assessment during the time period [11]. The sample size was calculated with nQuery Advisor software version 6 [3] based on Wijdicks's study in neuro-medical patients at the total FOUR score cut-off point of 9. When the sample size was 289, a two-sided 95.0% confidence interval for a single proportion using the large sample normal approximation would extend 0.050 from the observed proportion for an expected proportion of 0.750. With the expected 10% drop out, the sample was comprised of 318 patients enrolled in this study: 129 awake, 140 drowsy, 28 in a stupor and 21 in a coma.

The FOUR score was assessed by clinicians and registered nurses who had approved kappa inter-rater reliability value of over 0.9. Prior to examining the patients, all raters were re-educated in the FOUR scoring process using 4 lived assembly demonstrations of each consciousness level. The raters were also provided a handout with written descriptions specifying the stimuli to be used and the order in which

observations were taken. The assessment was done within 30min after the screening clinician rated the patient's consciousness level. During the patient evaluation, each rater had to follow the instructions and complete the scoring sheet. The course of treatment was observed naturally. Ultimately, the mortality rate and Glasgow Outcome Scale were recorded on the date of discharge. Prognostic performance was tested by calculation of the receiver operating characteristic curve and displayed in the area under the curve (AUC). The appropriated cut-off values for the aforementioned scores were calculated by the best Youden index (sensitivity + specificity-1). Additionally, adjusted regression models were computed in order to control possible confounders. The odds ratio and 95% confidence interval (95% CI) were demonstrated. Data were analyzed using SPSS for Windows version 11.5.

Results

A total of 304 patients were available for final analysis. The mean age of the study sample was 53.2 ± 15.8 years with a range of 15-89 years. One-hundred and sixty-three were female (53.6%) and 141 were male (46.4%). The distributions of the patients' diagnoses were brain tumour (56.6%), intracranial hemorrhage (21.1%), intracranial aneurysm (15.1%), intracranial infection (2.3%), hydrocephalus (2.0%), pneumocephalus (1.3%) and skull defect (1.7%). The patients were categorized into 4 stages of consciousness as follows: 42.1% awake, 43.1% drowsy, 8.6% stupor, and 6.3% coma.

One-hundred and twenty-two patients (40.1%) had a poor outcome, defined as a Glasgow Outcome Scale score from 3-5 and 38 patients (12.5%) died. The predictive performances overall were quite good for the total FOUR score both for the Glasgow Outcome Scale score from 3-5 at discharge; AUC 0.88 (95% CI, 0.83-0.92), and for in-hospital mortality: AUC 0.92 (95% CI, 0.87-0.97), as shown in Fig. 1 and 2.

The total FOUR score values with the highest Youden index which served as cut-off points were 14 and 10, demonstrating the increasing probability of poor outcomes and in-hospital death accordingly. The best Youden index, sensitivity, specificity and other features of the validity test of the total FOUR score values predicting poor outcomes and in-hospital mortality are demonstrated in Table 3.

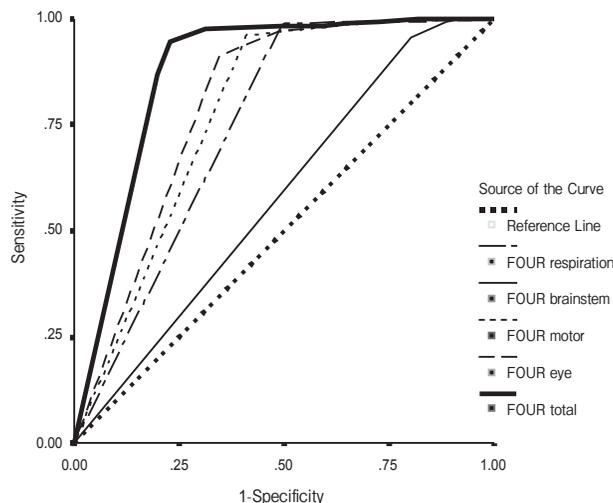


Fig. 1 The receiver operating characteristic curve for Glasgow outcome scale scores from 3-5 at date of discharge evaluated by the total FOUR score and its subscores.

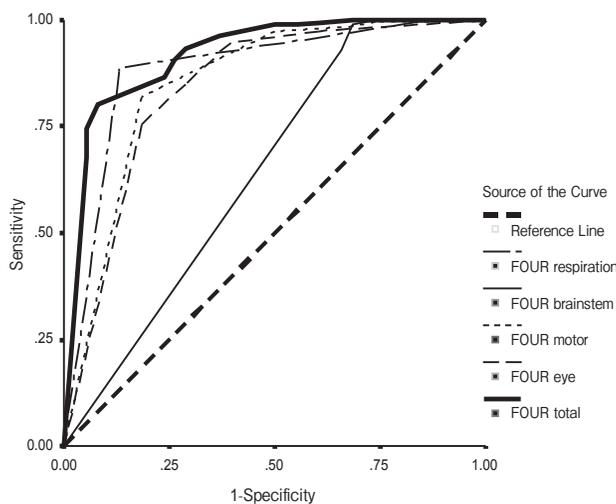


Fig. 2 The receiver operating characteristic curve for In-hospital mortality evaluated by the total FOUR score and its subscores.

Considering the total FOUR score, a 1 step increase in value categorized by each cut-off point (*i.e.* from below or equal 14 to over 14 for poor outcomes or from below or equal 10 to over 10 for in-hospital death) was associated with a 7.85 reduction in the risk of a poor discharge outcome and a 3.92 reduction in the risk of in-hospital mortality. The odds ratio after adjusting for age, sex and consciousness were 10.14; 95% CI, 3.65-28.11 in the Glasgow Outcome scale score 3-5 and 3.94; 95% CI, 0.71-21.98 in death.

The frequency of patient discharge outcomes cat-

egorized by the total FOUR score and total GCS score is shown in Fig. 3, while the sensitivity, specificity, positive predictive value and negative predictive value were 0.58 (95% CI, 0.51–0.64), 0.93 (95% CI, 8.86–0.95), 0.54 (95% CI, 0.47–0.62) and 0.94 (95% CI, 0.88–0.97) in order to predict in-hospital mortality at the cut-off point of 8.

Discussion

A definitive neurological assessment, which was

Table 3 The characteristics of the FOUR score validation for the particular discharge outcomes

	Glasgow Outcome Scale score 3–5	In-hospital mortality
The Youden index	0.72	0.64
Sensitivity	0.77 (0.69–0.84)	0.71 (0.55–0.83)
Specificity	0.95 (0.90–0.97)	0.93 (0.90–0.96)
Positive predictive value	0.90 (0.82–0.95)	0.60 (0.56–0.65)
Negative predictive value	0.86 (0.82–0.91)	0.96 (0.94–0.98)
A likelihood ratio for a positive test	14.02 (7.62–25.82)	10.50 (6.43–17.14)
A likelihood ratio for a negative test	0.24 (0.18–0.34)	0.31 (0.19–0.51)

previously only a part of the predictive scoring for critical patients, is now being utilized to assess instead of the full score. The validity of a variety of scoring systems has been verified, and their convenience, ease of administration, and costs analyzed are mentioned [7, 12, 13]. The FOUR score is a new scale deliberated for this beneficial fulfillment.

The AUC of the total FOUR score to predict discharge outcomes was satisfied, even though it was less accurate than the expectation of mortality similar to the result of Wijdick’s study [3]. The total FOUR score at both cut-off points has comparable sensitivity and specificity. The extremely high specificity value of the FOUR score in clinical practice makes it easier for patients, relatives and healthcare providers to adjust the modalities of treatment and monitor a patient’s condition.

Ninety-six percent of patients will survive up to the date of discharge if the total FOUR score is over 10, and patients with this score can receive clinical information and counseling. Obviously, the likelihood ratio of a positive test is tremendously elevated at both cut-

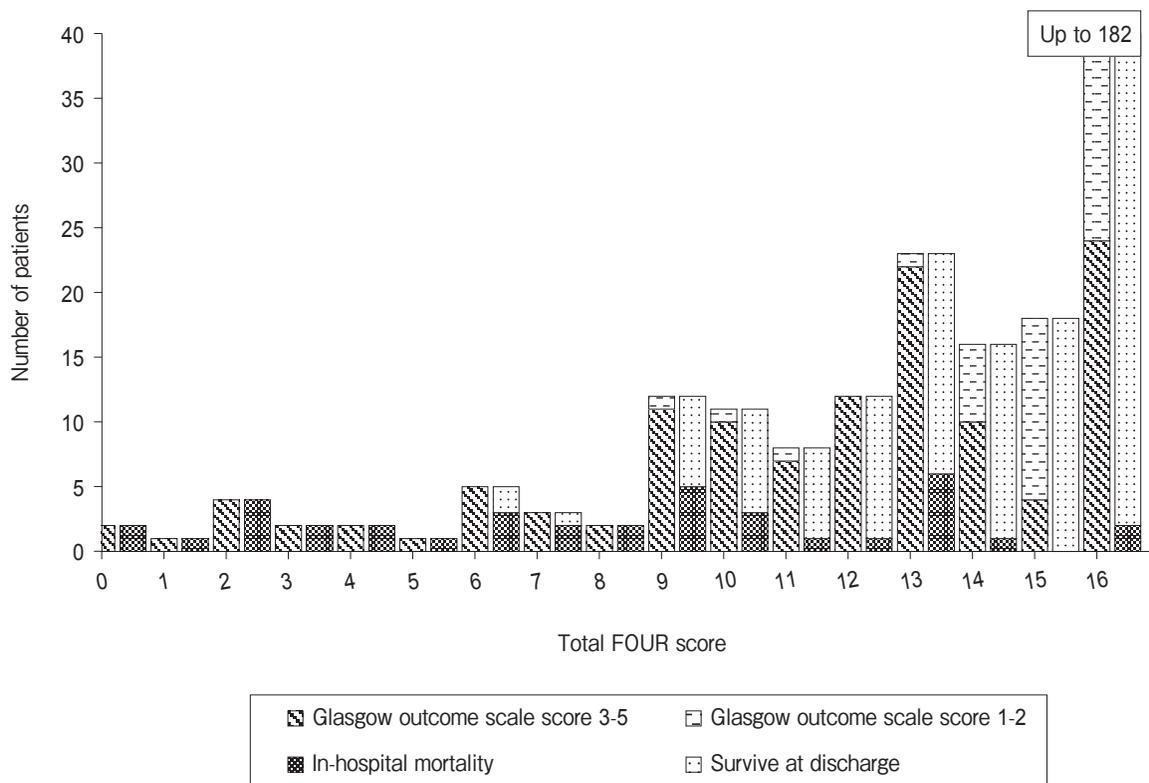


Fig. 3A The frequency of patient discharge outcomes. Categorized by the total FOUR score.

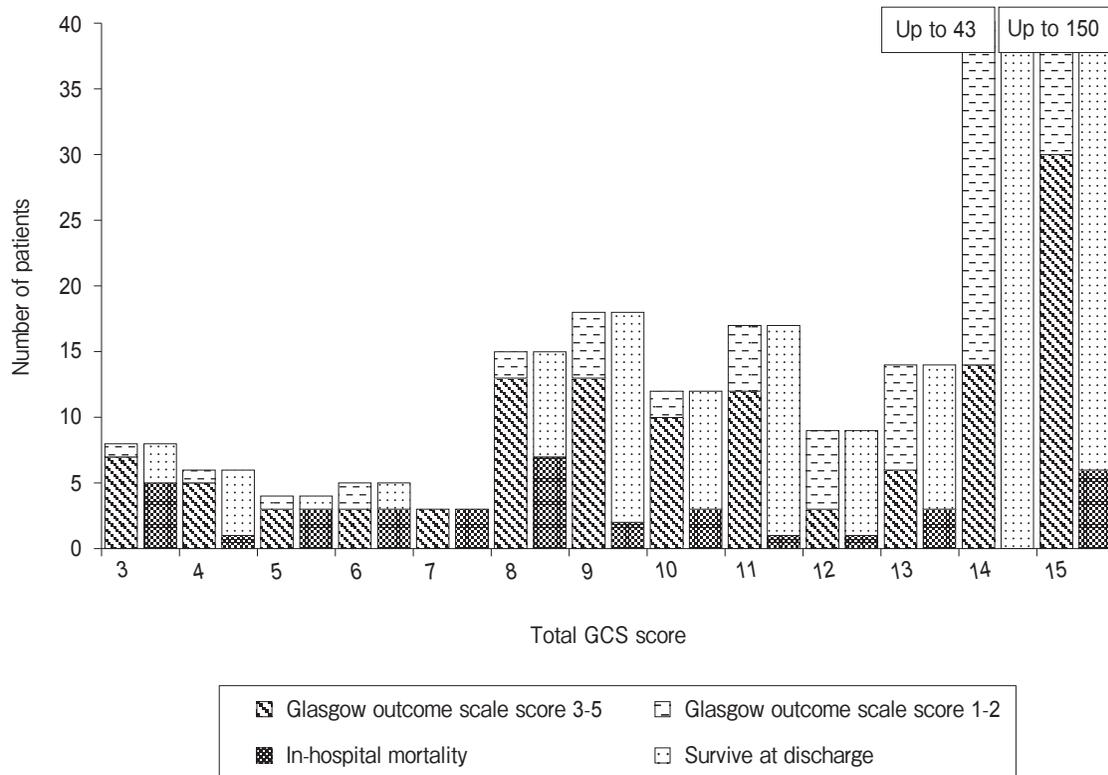


Fig. 3B The frequency of patient discharge outcomes. Categorized by the total GCS score.

off points. With this finding, the FOUR score would have great value for outcomes prediction in any prevalence diversity because it can generate a significant change in post test probability. Nevertheless, the variation among the institutional population should be recognized [14].

Even though the Modified Rankin Scale [3], or Health-related Quality of Life [15] are more accepted by their clinicians to evaluate neurosurgical patients but in this study, the authors discerningly applied the Glasgow Outcome Scale because the objective was focused on the mortality at discharge. Furthermore, we conducted and continued the evaluation until the date of discharge not the 3 month or 6 month mortality, in order to control for possible factors affecting the outcomes, such as physical rehabilitation, alternative treatment, and other modalities.

The originator of the FOUR score validated the cut-off point of 9 for mortality at discharge, while we validated a cut-off point of 10 [3]. We had a disproportionate distribution in our sample among the consciousness levels. However, the allocation of the

neurosurgical patients in this study was based on the actual patients, and those in the alert and drowsy categories were the vast majority. A practical assessment on stuporous or comatose patients should be considered. Further study on these particular patients is needed.

In conclusion, the total FOUR score, which is a new coma scale, has satisfactory prognostic value for predicting outcome on the day of discharge, exclusively shown as sensitivity and specificity. The cut-off points for a poor outcome and in-hospital mortality are 14 and 10, respectively. The authors recommend that the FOUR score be a part of scoring for neurosurgical patients on the day of admission or when the patients have an alteration in mental status.

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