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Full Length Research Paper

The Glasgow coma scale and brainstem signs score: which is a better predictor of coma outcome in acute stroke?

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Coma due to acute stroke is a medical emergency requiring reliable tool(s) for prediction of its outcome. The limitations of the universally adopted Glasgow Coma Scale/Score (GCS) have prompted the development of other coma scales by neuroscientists and critical care workers. This study seeks to compare the predictive values of the GCS and a newly developed Brainstem Signs Score (BSS) to the outcome of coma in acute stroke patients. The depth and severity of coma in 66 acute stroke patients was scored simultaneously at presentation and then daily for a maximum of 28 days with both the GCS and BSS. The predictive score of each scoring system was determined by Wilcoxon Rank Sum/Mann – Whitney-U test. Predictive values of each system were then compared. The BSS had negative predictive values (NPVs) of 100% on initial evaluation up to the 28th day, and positive predictive values (PPVs) of 100% from the first to the 7th day, while the GCS produced NPVs of 100% from the 7th to the 28th days, and a PPV of 100% on the 7th day only. Its negative and positive values on initial evaluations were less than 80%. The BSS had both higher negative and positive predictive values than the GCS and, therefore, appears to be better in predicting outcome of coma in acute stroke patients.

Keywords: Glasgow Coma Scale, Brainstem Sign Score, negative predictive value, positive predictive value, coma outcome, acute stroke.

INTRODUCTION

Many systems have been developed for the assessment and/or prediction of outcome for both traumatic and non-traumatic coma .These systems include the Glasgow Coma Scale (GCS) (Teasdale and Jennett,1974), Glasgow Outcome Scale (Jennett and Bond, 1975), Innsbruck Coma Scale (Benzer et al, 1991), the brainstem reflexes (Snyder et al.,1981), Clinical Sickness Score for the critically ill (Watters et al.,1989; Kollef et al., 1994; Hammed et al., 1995), the Acute Physiology, Age and Chronic Health Evaluation (APACHE) (Knaus et al.,1991) and the FOUR score (Wijdicks, 2006; Wolf et al., 2007). Among these scoring systems, the GCS is the most widely used to predict outcome of traumatic and non-traumatic coma, because it is said to be simple and reproducible and can be used by less skilled hospital staff with little inter-observer variability (Jennett and Bond,1975; Bates et al., 1977; Teasdale et al.,1978; Rwiza and McLarty 1987).

However, the GCS is limited in the assessment of eye opening in severe orbital trauma; or the verbal response in intubated patients; or motor function in brainstem and/or spinal cord injury (Teasdale et al, 1983). Also, its inability to test brainstem reflexes and hence depth of unconsciousness in locked-in syndrome are short-comings (Teasdale et al., 1979). In addition, the GCS has limited utility in children, particularly those less than 36 months. Conditions such as shock, hypoxemia, drug use, alcohol intoxication and metabolic disturbances which alter levels of consciousness may interfere with GCS's ability to accurately reflect the severity of a brain injury (Wolf et al., 2007).

On the other hand, although brainstem reflexes are mainly used as criteria in defining brain death, they have been used to evaluate and monitor severity and outcome, either alone (Snyder et al., 1981) or in conjunction with

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Table 1. Two by two contingency table

GCS	BSS	Predictive value	
3	≤13	Death [True positive (a)]	Survival [False positive(b)]
> 3	>13	Survival [True negative (c)]	Death [False negative (d)]

the GCS (Bates et al., 1977, Levy et al., 1981, 1985, Wijdicks 2006) in traumatic coma. However, studies using a scoring system based on the brainstem reflexes have not been well documented in nontraumatic coma (Snyder et al., 1981, Wijdicks 2006). More uncommon are studies comparing the predictive values of brainstem reflexes with the GCS. Therefore, a scale based on brainstem function should be available if clinicians must have an accurate method for predicting the outcome of nontraumatic coma. This study compared the coma outcome predictiveness of the brainstem signs score (BSS) and the GCS in acute stroke patients.

PATIENTS AND METHODS

Sixty-six consecutive unconscious patients (aged ≥16 years) with a diagnosis of acute stroke who presented to the medical emergency unit of the University College Hospital (U.C.H) Ibadan from August 2004 to March 2005 were studied after obtaining institutional ethical clearance and relatives' consent. Acute stroke patients were defined as those presenting for medical care within 7 days of ictus (Ogun, 2002).

Exclusion criteria were: patients aged below 16 years; patients with clear or altered sensorium and GCS score 9 and above; patients with traumatic coma and other forms of coma unrelated to acute stroke and those presenting for medical care after 7 days of ictus.

Each patient was initially evaluated and subsequently monitored daily for a maximum of 28 days with both the GCS and BSS applied simultaneously. The GCS was as described by Teasdale G, and Jennet B, 1974, while the BSS was modified from the Innsbruck Coma Scale (Benzer et al., 1991).

Standard methods of assessment as described by Bates et al., 1977, Snyder et al., 1981 and Denison 2007 were used to evaluate brainstem reflexes with scores ranging from zero (worst score) to 25 (best score) (Appendix 1). Normal pupil size was recorded as 5 mm and abnormal pupil sizes were either greater than or less than 5 mm. The pupillary light reflexes were recorded as direct or consensual constriction of the pupil to a bright flashlight beam. If either pupil reacted briskly, the light reflex was said to be intact. Sluggish pupillary response or no response to light attracted a lower score or no score respectively. Corneal reflexes were recorded as present if either eye had a definite response .Ocular movements were recorded as orienting and therefore volitional if the patient was looking about and fixating (in at least one visual field).Other forms of spontaneous eye movements were regarded as non volitional and recorded lower scores accordingly. Oculocephalic responses were considered normal when brisk and complete conjugate deviation of the eyes occurred in the opposite direction of head turning. Minimal response recorded a lower score and absent response received no score.

Oculovestibular testing was not performed on this category of patients because of denial of consent. Body posturing to painful stimuli was recorded as normal if the patient withdrew from pain and showed no evidence of the flexor or extensor response. Decorticate posturing was recorded when there was extensor rigidity in the legs and moderate flexion in the arms. It attracted a higher score than decerebrate posturing which was extensor rigidity of all four limbs. Flaccid or no response to pain attracted no score. Normal respiratory pattern and rate attracted a maximum score of four while other forms of abnormal respiratory patterns and rates attracted lower scores (Caronna, 1975).

Statistical Analysis

The lowest predictive scores of 3 and 13 were derived for the GCS and BSS respectively through the Wilcoxon Rank Sum/Mann – Whitney-U test, and based on these, patients were categorized into:-

i. Those with GCS of 3 and > 3 respectively.
ii. Those with BSS of ≤13 and >13 respectively

The positive predictive value (PPV) which is the percentage prediction of death was calculated from the formula, {true positive (a)/ true positive (a) + false positive (b) X 100%} and the negative predictive value (NPV) which is the percentage prediction of survival was derived from the formula, {true negative (d)/ true negative (d) + false negative (c) X 100%}, using the 2 by 2 contingency table (Table 1). Since patients with lowest predictive scores of 3 (GCS) and ≤ 13 (BSS) were generally expected not to survive, the system with higher PPVs was assumed to have better positive predictive value. Conversely, patients with scores higher than the respective scores of 3 (GCS) and ≤ 13 (BSS) were expected to survive. Therefore the system with higher NPVs was also assumed to have better negative predictive value. Cross tabulation of GCS and BSS against outcome in terms of death and survival was also performed.

A frequency table of (i) and (ii), outcome (in terms of survival and death) and the respective positive and negative predictive values of each scoring system is shown in Table 2.

RESULTS

Male gender and the age group 20-59 years constituted 76% and 80 % of the study population respectively. 55 of the 66 patients died giving a mortality rate of 83.3% with respective sex specific mortality rates of 68.2% and 15.1% for the males and females, and the age specific mortality rates of 68.2% and 15.1% for patients below and above 60 years respectively.

The BSS produced NPVs of 100% from the first day up to the 28th day of evaluation, as well as PPVs of 90-100% up to the 7th day (figure 1). This is because while none of the patients with BSS of > 13 died, all the patients with BSS of ≤13 died (Table 2). Evaluation with the GCS did not follow the above trend. For instance, while on the first day, 10 out of 46 patients with GCS of 3 survived, 8 out of 20 patients with GCS of > 3 died, thus giving a PPV of 78.3% and NPV of 60% respectively.

Table 2. Positive and negative predictive values of each scoring system

Day of evaluation	GCS	Outcome		PPV (%)	NPV (%)
		Death	Survival		
1	3	36	10	78.3	60
	>3	8	12		
2	3	5	3	62.5	64.3
	>3	5	9		
7	3	1	0	100	100
	>3	0	11		
14	3	0	0	0	100
	>3	0	11		
28	3	0	0	0	100
	>3	0	11		
Day of evaluation	BSS	Death	Survival	PPV (%)	NPV (%)
1	≤13	44	0	100	100
	>13	0	22		
2	≤13	10	1	90.9	100
	>13	0	11		
7	≤13	1	0	100	100
	>13	0	11		
14	≤13	0	0	0	100
	>13	0	11		
28	≤13	0	0	0	100
	>13	0	11		

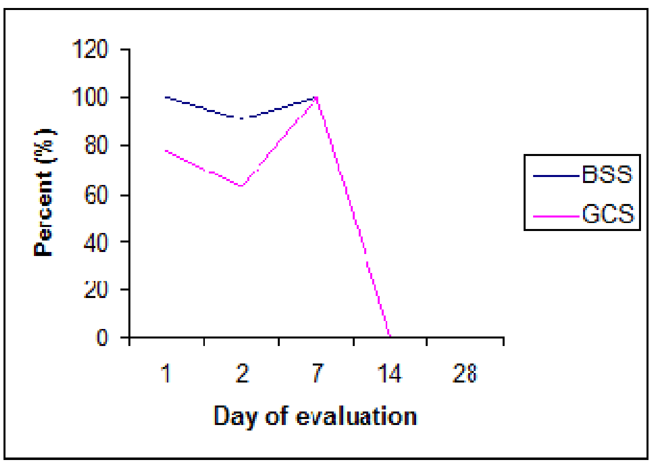

Figure 1. Comparison of Positive predictive value (PPV) between Brainstem Signs Score and Glasgow Coma Score

Also, on the 2nd day, 3 of 8 patients with GCS of 3 survived, 5 of 14 patients with GCS of > 3 died, yielding a PPV of 63% and a NPV of 64.3%. On the 7th day, both PPV and NPV increased to 100% because the only patient with GCS of 13 died while all the 11 patients with GCS of > 3 survived. However, between the 14th and 28th days, the PPV dropped to zero while the NPV remained at 100% because the GCS of all the 11 survivors remained above 3. The details are shown in table 2 and illustrated in figure 2.

Bivariate analysis showed that BSS of ≤13 and GCS of 3 were significantly associated with non-survival (chi square 2.7473; $p < 0.0001$ {BSS} and 2.2691; $p < 0.001$ {GCS}) after adjusting for age of patients ($p < 0.01$).

DISCUSSION

The result of this study has shown that the brainstem signs score (BSS) produced higher predictive values for both death and survival than the Glasgow coma score (GCS). The strong predictive ability of BSS in this study has been corroborated by many earlier studies. Snyder et al, 1981 in their study of 63 consecutively evaluated patients with global ischemic cerebral injury resulting

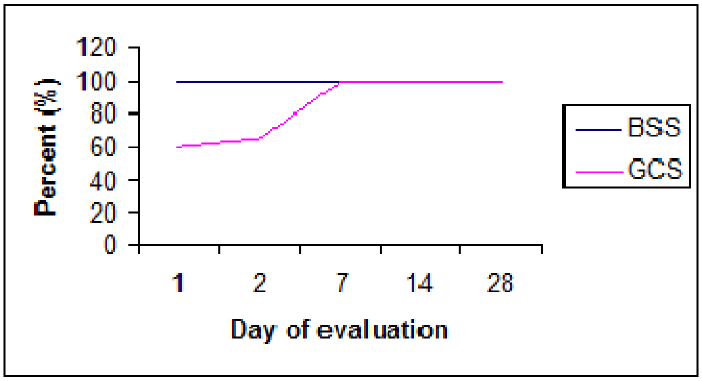

Figure 2. Comparison of Negative predictive value (NPV) between Brainstem Signs Score and Glasgow Coma Score

from cardiopulmonary arrest, reported that no patient with three brainstem reflex abnormalities survived, while all the patients with normal brainstem reflexes survived. They also reported that higher number of brainstem reflex dysfunctions were significantly associated with non-survival. Bates et al, 1977 in a prospective study of 310 non-traumatic coma patients observed that moderate disability or good recovery was rarely attained in patients who were admitted with a combination of ocular abnormalities (i.e., non-reactive pupils, absent oculocephalic or corneal responses) reflecting brainstem dysfunction. In their study they also noted that although these ocular signs were strong predictors when taken separately, they became even more powerful when combined. However, the slight decline in the PPVs after the 1st day in this study may reflect a reduction both in the frequency of brainstem reflex abnormalities or/and the number of patients as they either died or improved over time, as was observed by Edgren et al, 1994 who noted that the predictive accuracy of some neurological signs in the Glasgow-Pittsburgh coma scale improved with time, usually after third day of admission.

The GCS in this study was found to produce NPVs and PPVs which were lower than those of the BSS from the initial examination up to the 7th day. However, its predictive ability became stronger from the 7th day, especially more for survival than death, which may reflect a general tendency for condition of patients to improve with treatment after this period. This result was similar to that obtained by Bates D et al, 1977 in which they stated that identification of patients destined for a good recovery or moderate disability became easier after 24 hours of admission.

The ability to predict death or survival, even before initial treatment, should be an important attribute of a scale used for first assessment of coma, so that the physician can identify and treat patients who may benefit from vigorous intervention. The usefulness of systematic and repeated clinical observations in coma is borne out by the association of different signs with good and poor outcomes. The combination of these signs have been shown to yield better correlation with outcome, as it suggests that relatively independent data reflecting different aspects and levels of brain function were being assessed (Teasdale G. and Jennett B 1974, Caronna 1975, Snyder et al 1981, Levy et al 1985). Favourable signs generally indicate preservation of some forebrain and brainstem functions and unfavourable signs indicate impairment of brainstem functions. Therefore, before acting on such unfavourable signs, the physician must exclude depressant drugs (sedatives, hypnotics, anticonvulsants) as contributors to the clinical picture.

CONCLUSION

The result of this study has demonstrated the potential value of the brainstem signs score in the initial clinical evaluation and subsequent monitoring of acute stroke patients, especially when used in conjunction with the Glasgow coma scale. It is easy to administer and does not require expensive equipment and, would most certainly be of value to practice in developing countries.

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Appendix 1. Brainstem signs score

S.No	BRAINSTEM SIGNS	SCORE
1	*PUPILLARY SIZE(Normal=5 mm)*	-
	Normal in both eyes	6
	Decreased in both eyes	4
	Normal in one eye only	3
	Decreased in one eye only	2
	Increased in both eyes	2
	Increased in one eye only	1
	Completely dilated in both eyes	0
2	*PUPILLARY LIGHT RESPONSES (DIRECT AND CONSENSUAL CONSTRICTION OF PUPILS)*	-
	Brisk in both eyes (Normal)	4
	Brisk in one eye and slow in the other eye	3
	Slow in both eyes	2
	Slow in one eye only	1
	No response (dilated and fixed)	0
3	*CORNEAL REFLEXES*	-
	Present in both eyes	2
	Present in one eye only	1
	Absent	0
4	*OCULOCEPHALIC REFLEXES[Doll's eye movement]*	-
	Full	2
	Minimal	1
	None (eyes are fixed)	0
5	*EYE MOVEMENTS*	-
	Orienting (volitional)	4
	Roving conjugate	3
	Roving dysconjugate (divergent)	2
	Other abnormal movements	1
	None, immobile or fixed	0
6	*MOTOR POSTURING TO PAINFUL STIMULI*	-
	Normal	3
	Decorticate	2
	Decerebrate	1
	Flaccid or no response	0
7	*RESPIRATION PATTERN*	-
	Regular, normal rate	4
	Regular, but hyperapneic / tachyapneic	3
	Chyne- Stokes	2
	Irregular and ataxic	1
	Hypo-/ apneic	0
Total = [6 +4 + 2 +2 + 4 + 3 + 4]= 25		