



Technical Notes & Surgical Techniques

Assessment of predictors of one-month outcome in head injury in a Nigerian tertiary hospital



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ABSTRACT

Background: Current prognostic models for head injury were developed using data mostly from high income countries. A more useful model may be obtained from predictors designed from data obtained from low and middle income countries where trauma is said to be a neglected endemic condition.

Methods: This prospective study, after ethical and institutional clearance, examined 19 clinical and Computerized Tomographic (CT) scan parameters of all head injured patients who met the study's inclusion criteria. The significance of these parameters in predicting outcomes at 15 and 30 days post-injury using the Glasgow Outcome Scale (GOS) and mortality/survival was statistically determined using Univariate and Multivariate analysis.

Results: One hundred and fifty patients were prospectively recruited. The age range was 0.33 to 82 years. After univariate analysis, the clinical parameters that were significantly predictive of outcomes were pupillary response ($p < 0.0001$, 95% CI = 0.0653–0.3589), Glasgow Coma Score ($p < 0.0001$, 95% CI = 15.3340–199.6713) and Age ($p = 0.008$, 95% CI = 0.0446–0.6142). Among the CT scan parameters, presence of multifocal contusions ($p = 0.000$), intracerebral haematoma (ICH) ($p = 0.01$), intraventricular haematoma (IVH) ($p = 0.000$), effacement of ventricles ($p = 0.004$) and cisterns ($p = 0.000$), midline shift ($p = 0.012$), and crowding of foramen magnum ($p = 0.026$) were found to be significantly associated with poor outcome. Multivariate analysis showed that GCS ($p = 0.006$, OR = 12.8171, 95% CI = 2.1013–78.1779), multifocal contusion ($p = 0.01$, OR = 0.1908, 95% CI = 0.0537–0.6773) and pupillary response ($p = 0.046$, OR = 0.2256, 95% CI = 0.0445–1.1453) were retained as independent predictors associated with overall outcome.

Conclusions: This study suggests that GCS, pupillary response and multifocal contusions may independently predict outcome using GOS in head injury. A prediction model designed on these predictors needs to be considered and evaluated for this environment.

1. Introduction

Head injury affects about 10 million people yearly worldwide and

about 90% of these live in the low and middle-income countries[1–3],

Many clinicians believe that outcome prediction helps clinical triage, resource allocation, diagnostic and therapeutic decisions, and

Abbreviations: MBBS, Bachelor of Surgery, Bachelor of Medicine; MSc, Master of Science; FWACS, Fellow West African College of Surgeon; MHSc, Master of Health Science; FMCPH, Fellow Medical College of Public Health; FRCSC, Fellow Royal College of Surgeon of Canada; FAS, Fellow Academy of Science; MBChB, Bachelor of Medicine, Bachelor of Surgery; FACS, Fellow American College of Surgeon; CT, Computerized Tomography; GOS, Glasgow Outcome Scale; CI, confidence interval; p-Value, Probability Value; ICH, intracerebral haemorrhage; IVH, intraventricular haemorrhage; DRS, Disability Sating scale; NS-SEC, National Statistics Socio-economic Classification; SPSS, Statistical Package for Social Services; SBP, systolic blood pressure; FM, foramen magnum; SAH, Subarachnoid Haemorrhage; SDH, Subdural Haemorrhage; EDH, Extradural haemorrhage; AUC, Area Under Curve; MC, multifocal contusion; ROC, Receiver Operation Curve

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Table 1
Review of predictors of outcome in head injury from previous studies.

Studies	Pupils	Age	Sex	GCS	Cause	CT	TP	SE	BF	AI
Pillai (2003) [7]	–	Sig	NS	Sig	NS	–	–			
Odebode (2004) [29]	Sig	Sig	NS	Sig						
Combes (1996) [30]	Sig	Sig	NS	Sig		NS				
Adeolu (2010) [31]									NS	
Poon (2005) [32]		Sig		Sig						
Signorini (1999) [23]	Sig	Sig	Sig	Sig	NS	NS				
Klauber (1989) [33]	Sig	Sig	NS	Sig	NS					
Morrison (2004) [34]			NS							
Slewa-Younan (2004) [11]			NS	Sig						
Andrews (2002) [35]	Sig	NS		NS						
Schreiber (2002) [36]	Sig	Sig	NS	Sig		Sig				NS
Bahloul (2004) [37]		Sig		Sig		Sig			Sig	
Davis (2005) [38]		Sig	Sig	Sig	Sig					
CRASH (2004) [17]	Sig	Sig		Sig	Sig	Sig		Sig		Sig
Mosenthal (2002) [39]		Sig								
Narayan (1981) [24]		Sig		Sig		Sig				
Van Beek (2007) [40]									Sig	
Jennett (1976) [25]		NS	NS	Sig		Sig				
Overgaard (1973) [41]		Sig		Sig						
Rovellias (2004) [42]	Sig	Sig		Sig		Sig			Sig	
Cassidy (2003) [43]		Sig		Sig						Sig
Lanno (2000) [21]	Sig	Sig		Sig		NS			NS	

“Sig” indicates that the author reported that the predictor was significantly associated with outcome. “NS” means that the author reported that the predictor was not significantly associated with outcomes. TP indicates time before presentation. SE indicates socioeconomic class. BF indicates biochemical features. AI indicates associated injury. CT indicates cranial computed tomographic features.

counseling about outcome and expectation [4–8]. Two surveys of views of neurosurgeons about usefulness of prediction of outcome in head injury were note worthy; Barlow et al. showed that two-third of 59 neurosurgeons opined that computer prediction of outcome/prognostic model would be more reliable than simple clinical judgment of an experienced clinician and Perel et al. reported that 67% of 60 neurosurgeons believed that a more accurate prognostic model would positively change the way they manage patient and counsel relatives about prognosis [5,6].

Age was the most utilized predictor of outcome in head injury by most studies according to the summary of 23 studies on predictors of outcome from our review of literature (Table 1 and Fig. 1). Age appeared to be more predictive of mortality/survival than functional outcome. Most human studies did not find sex to be a good predictor of outcomes as shown in Table 1 unlike reports from animal studies [9–11]. It cannot be over emphasized that Glasgow Coma Score (GCS) and pupillary response were predictors that are almost always significant in most studies. Fig. 1 shows that 100% and 94% of studies that assessed pupillary response and GCS respectively found them to be statistically significant in predicting outcomes. The utility and significance of the common clinical predictors by the studies we reviewed were represented on Table 1 and Fig. 1.

Maas et al. [12,13] reported that some specific CT scan features which include extradura haematoma, subdura haematoma, intracerebral haematoma, ventricular effacement, basal cistern effacement, intraventricular haemorrhage, subarachnoid haemorrhage and midline shift were good predictors of outcome in head injury. They also reported that these CT scan features are superior to Marshall classification if used individually to predict outcome [12,13]. Other CT features reported by other workers include multifocal contusions and

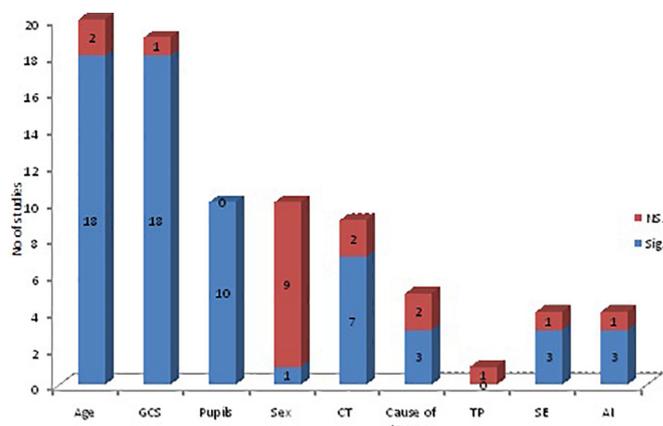


Fig. 1. Pattern of Utility of the predictors and occurrence of predictor significance among 23 studies reviewed in Table 1.

“Sig” indicates that the author reported that the predictor was significantly associated with outcome.

“NS” indicates that the author reported that the predictor was not significantly associated with outcomes.

TP indicates time before presentation.

SE indicates socioeconomic class.

BF indicates biochemical features.

AI indicates associated injury.

CT indicates cranial computed tomographic features.

foramen magnum crowding.

Glasgow Outcome Score (GOS) is the most commonly used outcome scale in head injury. Despite the fact that some workers reported that it has lower sensitivity compare to some scales like Disability Rating Scale (DRS), it is yet to have a replacement in terms of simplicity of use in the clinical setting and investigating early acute predictors of overall outcome [14,15]. It is still more widely used by most existing studies compare to other scales/scores [14].

There is paucity of studies on prediction of outcomes in the low and middle-income countries where head injury is said to be a neglected endemic condition [16–18]. A systemic review by Perel et al. 16 reported that existing prognostic models were found to have been designed from inadequate samples of patients with poor methodological qualities and many were rarely appropriately validated. They were not presented in a user-friendly way and only few were developed from low and middle income countries, where most trauma occurs [16]. This study also found that 93% (n = 95) of studies reviewed were conducted on population from high income countries, 5% (n = 5) included population from middle income countries and only 2% (n = 2) included population from low income countries.

Systematic review and meta-analysis to make a multicentered conclusion on prediction of outcome in head injury that will be applicable in all environments may be impossible if studies are not done in low and middle income countries where trauma is endemic. There are therefore scientific, medical and social needs for further studies of predictors of outcome in head injury in this environment. The purpose of this study is to determine which of the clinical and Computerize Tomography (CT) Scan parameters are good predictors of outcome of head injury at 15 and 30 days using Glasgow Outcome Score and Mortality/Survival as outcome measurements. The clinical parameters include age, sex, socioeconomic status, causes of injury, time before presentation, pupillary response, Glasgow coma score and systolic blood pressure while the CT Scan parameters include multifocal contusions, extradura haematoma, subdura haematoma, intracerebral haematoma, ventricular effacement, basal cistern effacement, foramen magnum crowding, intraventricular haemorrhage, subarachnoid haemorrhage and midline shift.

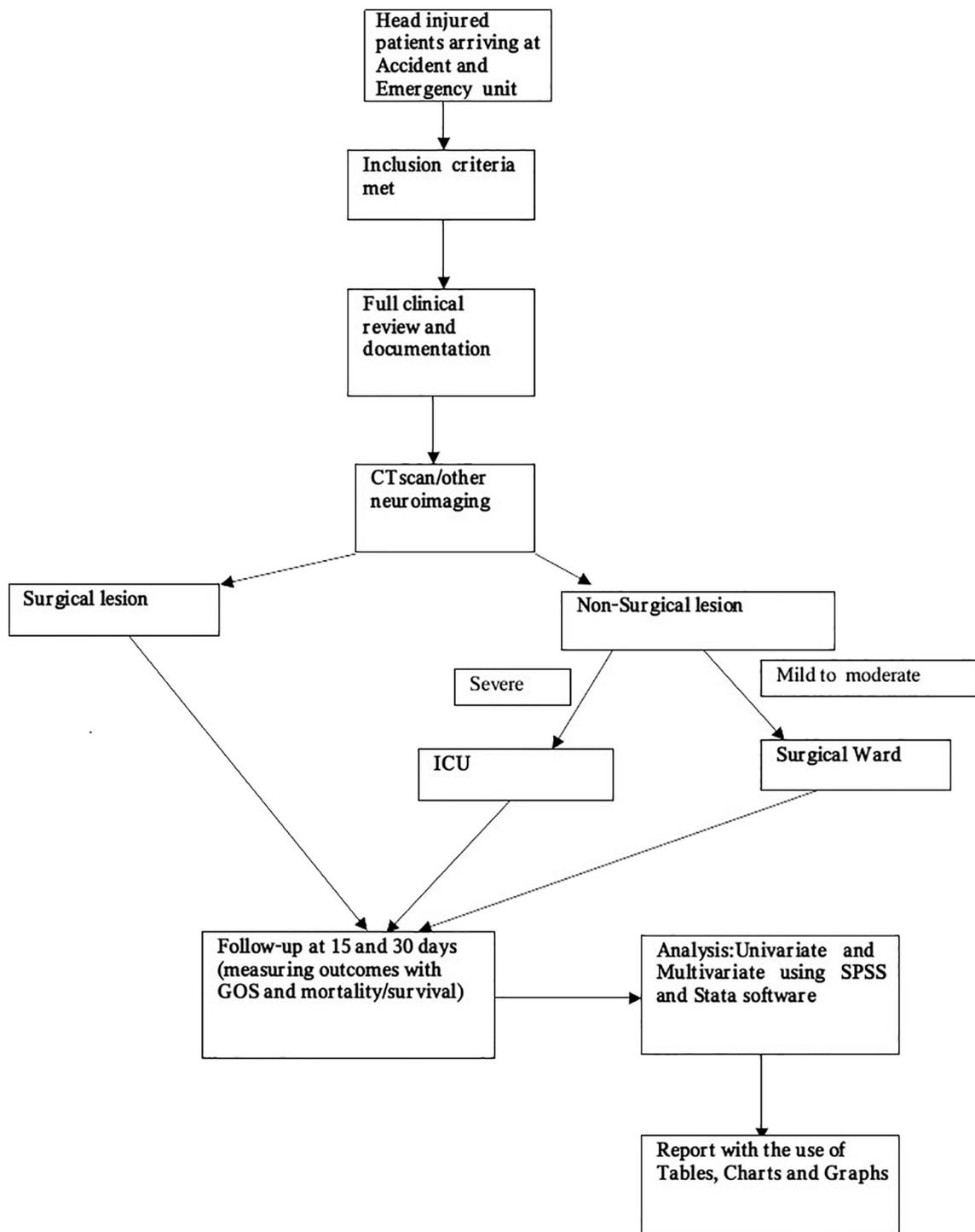


Fig. 2. Flow chart of protocol for managing head injury in this study.

2. Methods

Ethical clearance was obtained from the institutional review board/Ethics committee. The sample size was calculated as appropriate. The patients were recruited from accident and emergency unit of the University College Hospital, Ibadan, Nigeria which is one of the largest centers for neuro-trauma care in Nigeria. These cases were recruited and managed according to the protocol in our department and as shown in the flow chart in Fig. 2. The clinical and CT scan parameters were prospectively extracted from the patients' clinical, biochemical and radiological reports made by the authors of this study.

2.1. Inclusion/exclusion criteria

All patients with traumatic brain injury were included. Exclusion criteria include patients with history of alcohol intoxication, patients who have met criteria for brainstem death after resuscitation and those who survived but were not accessible for evaluation at one month.

2.2. Definition of parameters

The pupillary response was categorized into bilateral reactive pupils and one reactive/no reactive pupil. GCS was categorized into mild (GCS

Table 2
Univariate analysis of Clinical predictors against Glasgow Outcome Score (GOS).

Predictors	At 15 days			At 30 days		
	Poor outcome	Good outcome	p value/OR/95% CI	Poor outcome	Good outcome	p value/OR/95% CI
Age			0.138/0.4882/0.1546–1.5418			0.065/0.3116/0.0961–1.0106
< 39	26(26.8%)	71		18(18.9%)	77(81.1%)	
40–59	6(16.2%)	31(83.8%)		5(13.9%)	31(86.1%)	
≥60	6(42.9%)	8(57.1%)		6(42.9%)	8(57.1%)	
Sex			0.162/0.53/0.1862–1.4924			0.238/0.5661/0.1808–1.7733
Female	5(16.7%)	25(83.3%)		4(13.3%)	26(86.7%)	
Male	33(27.5%)	87(72.5%)		25(21.4%)	92(78.6%)	
Time Before presentation (TBP) ^a			0.123/–/–			0.163/–/–
< 3 h	0(0%)	7(100%)		0(0%)	7(100%)	
> 3 h	30(26.8%)	82(73.2%)		26(23.6%)	84(76.4%)	
Glasgow Coma Score			0.000/55.3333/15.33409–199.6713			0.000/42.5/10.4582–172.7107
≤8	20(76.9%)	6(23.1%)		15(60%)	10(40%)	
9–12	13(36.1%)	23(63.9%)		11(32.4%)	23(67.6%)	
13–15	5(5.7%)	83(94.3%)		3(3.4%)	85(96.6%)	
Pupillary reaction			0.000/0.1531/0.6530–0.3589			0.000/0.1948/0.0802–0.4729
Both reactive	16(15.4%)	88(84.6%)		13(12.7%)	89(817.3%)	
One/none reactive	19(54.3%)	16(45.7%)		15(42.9%)	20(57.1%)	
Cause of injury			0.332/2.077/0.740–5.826			0.082/0.3546/0.1214–1.0357
Motor vehicle accident	13(22.4%)	45(77.6%)		10(17.5%)	47(82.5%)	
Motorcycle accident	13(23.6%)	42(76.4%)		9(16.7%)	45(83.3%)	
Other causes ^b	9(37.5%)	15(62.5%)		9(37.5%)	15(62.5%)	
Socioeconomic Status			0.055/0.25/0.0595–1.0494			0.106/1.7027/0.3150–9.2050
Higher class	3(12.5%)	21(87.5%)		2(8.7%)	21(91.3%)	
Intermediate class	24(33.8%)	47(66.2%)		18(26.1%)	51(73.9%)	
Lower class	8(18.6%)	35(81.4%)		6(14%)	21(91.3%)	
Other Injuries			0.398/0.821/0.361–1.870			0.500/0.363/2.225
Present	16(25.8%)	46(74.2%)		12(19.4%)	50(80.6%)	
Absent	14(22.2%)	49(77.8%)		11(17.7%)	51(82.3%)	
Systolic blood pressure(SBP)			0.018/0.3746/0.1627–0.8625			0.068/0.4521/0.1840–1.1109
Normal	19(21.1%)	71(78.9%)		16(17.8%)	74(82.2%)	
Abnormal (low or high)	15(41.7%)	21(58.3%)		11(32.4%)	23(67.6%)	

The significant predictors and their p-values are in red colour.

^a The odd ratio (OR) and confidence interval (CI) cannot be computed for “time before presentation” because the value of some of the variables is 0.

^b Other causes of head injury include falls, assault and gunshot.

13 to 15), moderate (GCS 9 to 12) and severe (GCS3 to 8). Socioeconomic classification was based on the National Statistics Socioeconomic Classification (NS-SEC rebased on the SOC2010). For the sake of analysis it was categorized into Higher, intermediate and lower class. Higher class was defined as the higher managerial, administrative and professional occupation. Intermediate class was defined as the intermediate occupations and small employers and own account workers. Lower class was defined as the routine/manual occupation and the unemployed [19]. The normal systolic blood pressure was defined as systolic blood pressure between 100 and 140 mmHg while abnormal systolic pressure was defined as systolic blood pressure below 100 mmHg and above 140 mm Hg. Multifocal contusions was defined as the presence of multiple petechial haemorrhages in the brain and this was categorized as present or absent depending on whether it is seen or not seen on CT scan respectively. Intracerebral haematoma (ICH) was defined as the presence of frank haemorrhage in the brain parenchyma and this was categorized as present or absent. Intraventricular haematoma (IVH) was defined as the presence of blood in the ventricular system and this was categorized as present or absent. Midline shift was defined as the migration of the midline to one side and this was categorized as present or absent. Ventricular status was categorized as effaced or not effaced. Ventricular effacement was defined as the obliteration of the lateral ventricle. Basal cistern status was categorized as effaced or not effaced. Basal cistern effacement was defined as the obliteration of the cisterns around the brainstem. Foramen magnum status was categorized as crowded or not crowded depending on whether the anatomical separation of the content of the foramen magnum was distinct or not.

2.3. Outcome measurement/follow-up

The outcome of management was measured at 15 and 30 days after trauma using Glasgow Outcome Scale (GOS) (as the over-all outcome) and mortality/survival (as the other outcome dicotomy). The over-all outcome was categorized into two for the purpose of analysis i.e. **good outcome** {Good recovery (GOS 5) and moderate disability (GOS 4)} and **poor outcome** {Severe disability (GOS 3), persistent vegetative (GOS2) and death (GOS1)}. The follow-up was done at 15 and 30 days after trauma in the hospital ward and the out-patient clinic depending on whether the patient has been discharged at the time follow-up was due or not.

2.4. Data analysis

The data collected from the study was analysed by **Univariate** analysis to estimate the relationship between a single predictor and outcome using odds ratio, confidence interval, Chi2 test and Receiver operative curve (ROC)with level of significance set at $p = 0.05$. The significant predictors from univariate analysis were subjected to **Multivariate** analysis to determine the prognostic value of these predictors after adjusting for confounding effects of other predictors using logistic regression procedure. The analysis was performed with the use of Stata corp. Inc. Version 10 and SPSS Inc. Version 17 as statistical environment.

3. Results

3.1. Demographic characteristic of the study population

A total number of 150 patients were recruited into the study. The age range was 4 months to 85 years (mean \pm SD was 35.54 ± 17.42 years). The male to female ratio was 4:1. More cases of head injury were seen in the intermediate class (51%) and lower class (32%) groups the higher class (17%). There was no case seen in the upper class group. Motor vehicle and motorcycle accidents were the most common causes of head injury in this study with incidence of 38.9% and 34.5% respectively. Most patients (90.3%) presented after 3 h of injury.

3.2. Result of univariate analysis using GOS as measurement of outcome

3.2.1. Clinical predictors

Glasgow coma score ($p = 0.000$), pupillary response ($p = 0.000$), and Systolic Blood Pressure (SBP) ($p = 0.018$) were the clinical parameters associated with 15 day outcome as shown in Table 2 while GCS and pupillary response were associated with 30 day outcome as shown in Table 2. This also means that significantly higher proportion of patients with mild/moderate head injury and presence of bilateral reactive pupils had good outcome while significantly higher proportion of patients with severe head injury and unilateral or bilateral unreactive pupils had poor outcome as shown in Table 2. Higher proportion of patients with normal systolic blood pressure had good outcome while higher proportion of patients with abnormal SBP had poor outcome as shown in Table 2.

3.2.2. Radiological predictors

Multifocal contusions ($p = 0.000$), intracerebral haematoma (ICH) ($p = 0.01$), intraventricular haematoma (IVH) ($p = 0.000$), midline shift ($p = 0.012$), ventricular status ($p = 0.004$), basal cistern status (0.000) and foramen magnum status (FM) ($p = 0.026$) were the radiological predictors which were associated with 15 day outcome as shown in Table 3. These radiological features except ICH and FM were also significantly associated with 30 day outcome as shown in Table 3. This also means that significantly high proportion of patients with the absence of any of IVH, ICH, multifocal contusion, midline shift, effacement of ventricle or cistern and crowded foramen magnum had good outcome while significantly higher proportion of patients with presence of any of these parameters had poor outcome as shown in Table 3. Extradura (EDH), Subdural (SDH) and Subarachnoid (SAH) were not significantly associated with outcome (GOS).

3.3. Results of univariate analysis using survival/mortality as measurement of outcome

GCS ($p = 0.000$), pupillary response ($p = 0.001$), and ventricular status ($p = 0.033$) and basal cistern status ($p = 0.03$) had good correlation with both 15 day mortality/survival while Age ($p = 0.008$), GCS ($p = 0.000$), pupillary response ($p = 0.001$), and Basal cistern status ($p = 0.007$) were associated with 30 day mortality/survival as shown in Table 4.

When age was analysed as a continuous variable using receiver operating curve which is a plot of the sensitivity and 1 minus specificity in an association between increasing age and mortality as shown in Figs. 3 and 4, increasing age was found to have a significant correlation with mortality ($p = 0.044$, 95% CI = 0.533–0.805 at 15th day and $p = 0.027$, 95% CI = 0.548–0.826 at 30th day of follow up). The area under the curve (AUC) was 0.669 for 15 days and 0.687 for 30 days of follow up. The age with the highest sensitivity and specificity most predictive of mortality was approximately 40 years. This was the point at which age discriminated most against mortality.

3.4. Results of multivariate analysis using GOS as measurement of outcome

After multivariate analysis with GOS as outcome measure; GCS, pupillary response and multifocal contusions (MC) retained their high level of significance out of the 10 variables which passed univariate analysis as shown in Table 5.

3.5. Results of multivariate analysis using survival/mortality as measurement of outcome

None of the parameters which were significant associated with outcome following univariate analysis when survival/morbidity was used as an outcome measure was significantly associated with outcome following multivariate analysis. This means that none of the clinical and radiological parameters are independent predictors of mortality/survival.

4. Discussion

The strong association of pupillary response to outcome demonstrated after univariate analysis in this study was similar to what was reported by several authors as shown by our literature review in Table 1. This relationship is graphically demonstrated in Fig. 5. The multivariate analysis also showed that pupillary response can be an independent predictor in this environment. This is like the findings in high income countries as alluded to by Perel et al. In his systemic review of prognostic models in head injury, he reported that pupillary response was the third most commonly used independent predictor (26%) in the 53 prognostic models he reviewed which are mostly from high income countries [16].

GCS was found to be highly correlated with outcome in a similar magnitude to what was reported by authors of previous studies as shown in Table 1. The relationship of GCS to outcomes (GOS) is graphically depicts in Fig. 6. The multivariate analysis showed that GCS can be used as an independent predictor in a prediction model in this environment. GCS has been widely used by most common prognosis model in the high income countries as reported by Perel et al. He reported that GCS was the most commonly used predictors (50%) of the 53 prognostic model he reviewed [16].

CT scan features were found to be as important as the clinical predictors. Univariate analysis showed that **absence** of multifocal contusions, midline shift, basal cistern effacement, ventricular effacement, intraventricular haemorrhage, intracerebral haematoma and crowded foramen magnum were associated with good outcome (GOS). This is consistent with what was reported by Mass et al. and other studies as shown on Table 1 [12,13]. However, out of the aforementioned CT features which passed univariate analysis only multifocal contusion passed multivariate analysis and thus can independently predict outcome (GOS) in this study at both 15th and 30th day of follow up. Fig. 7 shows the relationship of multifocal contusion to outcome (GOS). This is a unique finding because only one study out of the studies reviewed found brain contusion to be significantly associated with outcome and thus included it in constructing a model [20] while most studies found midline shift, status of basal cisterns and presence of mass lesion to be independent predictors [21–23].

Age only showed association with survival/mortality when analysed as a discrete variable with young and middle aged having significant association with survival on univariate analysis similar to some studies carried out in the high income countries as shown in Table 1. This association was retained when age was analysed as a continuous variable using Receiver Operation Characteristic (ROC) curve in a similar manner to previous studies [24–26]. It shows that mortality increases with age and the highest sensitivity and specificity most predictive of mortality was approximately 40 years in our environment as shown in Figs. 3 and 4. This was the point at which age discriminated most against mortality. This shows that patients above 40 years of age have

Table 3
Univariate analysis of Radiological predictors against Glasgow Outcome Score (GOS).

Predictors	At 15 days			At 30 days		
	Poor outcome	Good outcome	p value/OR/95% CI	Poor outcome	Good outcome	p value/OR/95% CI
Multifocal contusions			0.000/0.2006/0.0837–0.4806			0.000/0.1474/0.0532–0.4080
Present	24(48%)	26(52%)		20(41.7%)	28(58.3%)	
Absent	10(15.6%)	54(84.4%)		6(9.5%)	57(90.5%)	
Haemorrhagic mass						
Extradural haematoma			0.287/0.5652/0.2075–1.5392			0.536/1.1620/0.3492–3.8662
Present	8(40%)	12(60.0%)		4(21.1%)	15(78.9%)	
Absent	26(27.4%)	69(72.6%)		22(23.7%)	71(76.3%)	
Subdural haematoma			0.095/0.3858/0.1407–1.0581			0.123/0.3929/0.1344–1.1484
Present	9(47.4%)	10(52.6%)		7(38.9%)	11(61.1%)	
Absent	25(25.8%)	72(74.2%)		19(20%)	76(80%)	
Intracerebral haematoma			0.010/0.1247/0.0358–0.4338			0.150/0.432/0.127–1.467
Present	10(71.4%)	77(76.2%)		21(21.2%)	78(78.8%)	
Absent	24(23)	4(28.6%)		5(38.5%)	8(61.5%)	
Ventricles status			0.004/0.2857/0.1218–0.6700			0.004/0.2597/0.1036–0.6512
Non-effaced	17(21.3%)	63(78.8%)		12(15.4%)	66(84.6%)	
Effaced	17(48.6%)	18(51.4%)		14(41.2%)	20(58.8%)	
Basal cisterns status			0.000/0.0923/0.0234–0.3629			0.000/0.0921/0.0254–0.3342
Non-effaced	24(23.5%)	78(76.5%)		17(17.2%)	82(82.8%)	
Effaced	10(76.9%)	3(23.1%)		9(69.2%)	4(30.8%)	
Foramen magnum			0.026/0.0938/0.0101–0.8728			0.081/0.1825/0.0288–1.1582
Not crowded	30(27.3%)	80(72.7%)		23(21.5%)	84(78.5%)	
Crowded	4(80%)	1(20%)		3(60%)	2(40%)	
Intraventricular haemorrhage ^a			0.000/–/–			0.000/–/–
Absent	29(26.4%)	81(73.6%)		21(19.6%)	86(80.4%)	
Present	5(100%)	0(0%)		5(100%)	0(0%)	
Subarachnoid haemorrhage			0.249/0.486/0.122–1.943			0.352/0.579/0.134–2.505
Absent	28(28.0%)	72(72.0%)		22(22.4%)	76(77.6%)	
Present	4(44.4%)	5(55.6%)		3(33.3%)	6(66.7%)	
Midline shift			0.012/0.2857/0.1218–0.6700			0.004/0.2359/0.0885–0.6288
Absent	23(24.7%)	70(75.35)		16(17.8%)	74(82.2%)	
Present	12(52.2%)	11(47.85)		11(47.8%)	12(52.2%)	

The significant predictors and their p-values are in red colour.

^a The odd ratio (OR) and confidence interval (CI) cannot be computed for “intraventricular haemorrhage” because the value of some of the variables is 0.

high mortality compared with younger age group. However, age was not found to be significantly associated with functional outcome (GOS) in this study. This was consistent with only one study which is the study by Jennett et al. [23]. Most other studies from high income countries reviewed (89% of the studies reviewed) reported significant association of age to GOS unlike our study and Jennett et al. study [16]. The

systemic review of Perel et al. also showed that age was the second commonest predictor (46%) utilized by the 53 prediction model reviewed [16]. This unique finding in this environment, which means that outcome of head injury based on GOS is not different between the old and the young, may be difficult to discuss. Does this mean that the biological characteristic of the brain of an elderly in this environment is

Table 4
Univariate analysis of all predictors against survival/death.

Variable	At 15 days			At 30 days		
	p value	Odd ratio	95% CI	p value	Odd ratio	95% CI
Age	0.032	0.2247	0.0573–0.8814	0.008	0.1655	0.0446–0.6142
Sex	0.153	0.2610	0.0330–2.0689	0.323	0.5255	0.1127–2.4497
Time before presentation ^a	0.435			0.372		
GCS	0.000	0.052	0.010–0.269	0.000	0.044	0.009–0.223
Pupillary response	0.001	0.1459	0.0450–0.4727	0.001	0.1125	0.0357–0.3543
Systolic blood pressure	0.301	0.5556	0.1822–1.6937	0.713	0.8076	0.2584–2.5241
Cause of injury	0.515	2.120	0.517–8.699	0.317	0.4471	0.1220–1.6379
Socioeconomic class	0.479	2.3590	0.2484–22.4054	0.582	2.8947	0.3175–26.3957
Other injuries	0.382	0.677	0.203–2.261	0.401	0.723	0.235–2.222
Multifocal contusion	0.223	0.5206	0.1548–1.7511	0.298	0.6165	0.1929–1.9706
Midline shift	0.238	0.5089	0.1417–1.8280	0.123	0.4000	0.1197–1.3369
SDH	0.378	2.3023	0.2793–18.9751	0.658	1.0476	0.2118–5.1820
EDH	0.342	2.4881	0.3026–20.4568	0.309	2.6667	0.3256–21.8409
SAH	0.643			0.720	1.116	0.128–9.726
IVH	0.430	0.4444	0.0455–4.3370	0.467	0.5053	0.0521–4.9008
ICH	0.162	0.3587	0.0843–1.5269	0.175	0.3745	0.0882–1.5908
Ventricle	0.033	0.2666	0.0782	0.054	0.3214	0.0991–1.0426
Basal cistern	0.030	0.1915	0.0481–0.7622	0.007	0.1407	0.0372–0.5322
Foramen magnum	0.430	0.4444	0.455–4.3370	0.102	0.1719	0.0258–1.1432

The significant predictors and their p-values are in red colour.

^a The odd ratio (OR) and confidence interval (CI) cannot be computed for “time before presentation and SAH” because the value of some of the variables is 0.

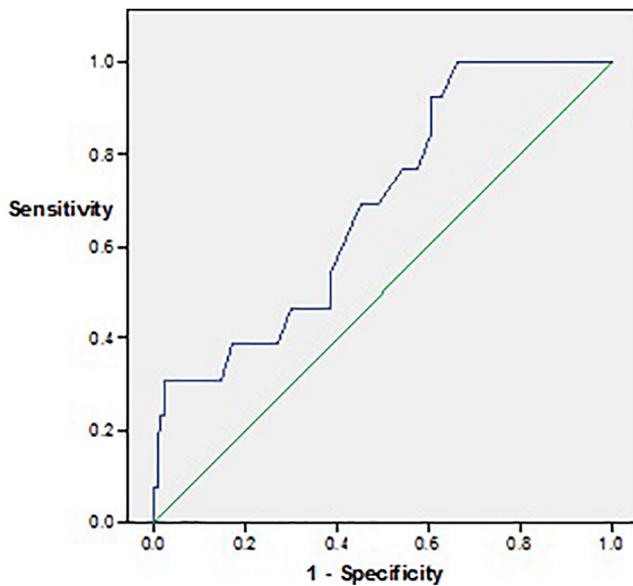


Fig. 3. ROC curve of age vs mortality at 30 days.

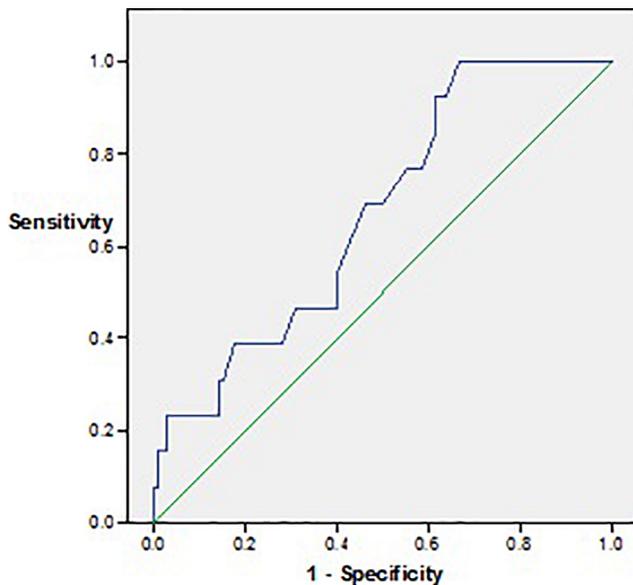


Fig. 4. ROC curve of age vs mortality at 15 days.

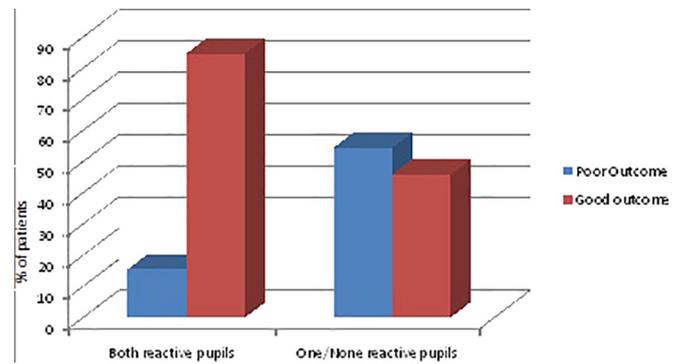


Fig. 5. Relationship of proportion of patients' pupillary response to outcome (GOS).

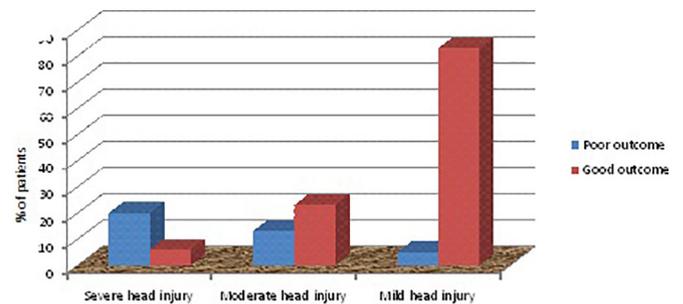


Fig. 6. Relationship of patients' (GCS) to outcome (GOS).

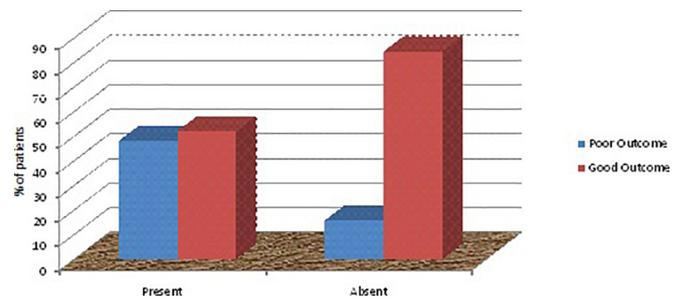


Fig. 7. Relationship of proportion of patients with multifocal contusions to outcome (GOS).

not different from the young? Or can we hypothesized that the previously described changes in intracranial dynamics and biological characteristics thought to have influenced functional outcome is different in the elderly in our environment compared to the developed countries. This finding may need further study to verify the consistency

Table 5
Multivariate analysis (with GOS as measurement of outcome).

Predictors	At 15 days			At 30 days		
	p value	Odd ratio	95% CI	p value	Odd ratio	95% CI
Glasgow coma score	0.002	36.6981	4.0308–334.1155	0.020	12.8171	2.1013–78.1779
Pupillary reaction	0.046	0.2257	0.0444–1.1453	0.174	0.5402	0.1471–1.9831
Systolic blood pressure	0.893	0.6788	0.1742–2.6444	0.065	0.978	0.956–1.001
Multifocal contusion	0.036	0.1744	0.0386–0.7878	0.027	0.1908	0.0537–0.6773
Midline shift	0.844	0.7823	0.0605–10.1123	0.640	1.0442	0.1214–8.9784
Basal cistern status	0.170	0.1522	0.0118–1.9646	0.371	0.2616	0.03160–2.1658
Ventricular status	0.927	0.8781	0.1500–5.1418	0.888	0.7902	0.1414–4.4161
Intraventricular haemorrhage ^a	0.999	–	–	0.999	–	–
Intracerebral haematoma	0.61	0.0457	0.0055–0.3792	0.097	0.298	0.071–1.245
Foramen magnum	0.179	8.6323	0.2596–287.0372	0.275	0.313	0.039–2.518

^a The odd ratio(OR) and confidence interval(CI) cannot be computed for “intraventricular haemorrhage” because the value of some of the variables is 0.

of this unique finding in this environment.

An important observation is the fact that the predictors (Age, GCS, pupillary response, and status of the ventricle and basal cisterns) who passed univariate analysis with survival/death as the outcome measure did not pass multivariate analysis which may suggest that these predictors may not be suitable for use in models design for predicting survival/death.

Other factors like Sex, Time before presentation, Causes of injury, Socioeconomic class and Presence of other associated injuries were found not to be significantly associated with outcomes in this study. 88.9% of the 10 studies reviewed reported that sex was not significantly associated with outcomes in head injury as shown in Table 1 which is consistent with our study. But animal studies have contradictory views. They reported that sex was associated with outcome and that female sex hormones might be neuroprotective [9–11]. It is also against our expectation that “Time to presentation” does not affect outcome despite the fact that there is low emergency preparedness and response in this environment leading to delayed transportation from the accident scene as shown by over 94% of the patients in this study presenting to the hospital > 3 h after injury which is unlikely to happen in the developed world.

4.1. Limitations of the study

Follow up period in this study was 30 days because most patients in this environment do not usually return for follow up beyond this period and there is high financial and logistic implications associated with health practitioners going to their homes for follow up.

5. Conclusion

This study suggests that Glasgow coma score, pupillary response and multifocal contusion which were associated with outcomes like other predictors on univariate analysis were found to be independent predictors of 30 day outcomes on multivariate analysis. These predictors could be useful in prognosis prediction model for our environment. This study also suggests that these independent predictors are better used as predictors of functional outcome rather than survival/death. It appears there is close relationship in the distribution and extent to which these predictors were associated with outcomes between our environment and the high income countries with some few unique findings, however this needs to be subjected to further studies.

Other references on Table 1 [27–42].

Disclosure of conflict

No conflict of interest.

Conflict of interest

Nil.

Scientific conference

Abstract accepted for presentation in 2013 World Federation of Neurological Surgeon (not presented).

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References

- [1] E. Alexander Jr., Global spine and head injury prevention project (SHIP), *Surg. Neurol.* 38 (1992) 478–479.
- [2] K. Hofman, A. Primack, G. Keusch, S. Hrynkow, Addressing the growing burden of trauma and injury in low- and middle-income countries, *Am. J. Public Health* 95 (2005) 13–17.
- [3] A.A. Adeolu, A.O. Malomo, M.T. Shokunbi, E.O. Komolafe, T.C. Abiona, Etiology of head injuries in southwestern Nigeria: a public health perspective, *Int. J. Epidemiol.* 2 (2005) 2.
- [4] L.S. Murray, G.M. Teasdale, G.D. Murray, B. Jennett, J.D. Miller, J.D. Pickard, et al., Does prediction of outcome alter patient management? *Lancet* 341 (1993) 1487–1491.
- [5] P. Barlow, G. Teasdale, Prediction of outcome and the management of severe head injuries: the attitudes of neurosurgeons, *Neurosurgery* 19 (1986) 989–991.
- [6] P. Perel, J. Wasserberg, R.R. Ravi, H. Shakur, P. Edwards, I. Roberts, Prognosis following head injury: a survey of doctors from developing and developed countries, *J. Eval. Clin. Pract.* 13 (2007) 464–465.
- [7] S.V. Pillai, V.R. Kolluri, S.S. Praharaj, Outcome prediction model for severe diffuse brain injuries: development and evaluation, *Neurol. India* 51 (3) (2003) 345–349.
- [8] K.L. Lee, D.B. Pryor, F.E. Harrell Jr. et al., Predicting outcome in coronary disease. Statistical models versus expert clinicians, *Am. J. Med.* 80 (4) (1986) 553–560.
- [9] N.J. Alkayed, I. Harukuni, A.S. Kimes, et al., Gender-linked brain injury in experimental stroke, *Stroke* 29 (1998) 159–165.
- [10] R.L. Roof, R. Duvdevani, D.G. Stein, Gender influences outcome of brain injury: progesterone plays a protective role, *Brain Res.* 607 (1993) 333–336.
- [11] S. Slewa-Younan, A.M. Green, I.J. Baguley, J.A. Gurka, J.E. Marosszeky, Sex differences in injury severity and outcome measures after traumatic brain injury, *Arch. Phys. Med. Rehabil.* 85 (2004) 376–379.
- [12] A.I. Maas, E.W. Steyerberg, I. Butcher, R. Dammers, J. Lu, A. Marmarou, N.A. Mushkudiani, G.S. McHugh, G.D. Murray, Prognostic value of computerized tomography scan characteristics in traumatic brain injury: results from the IMPACT study, *J. Neurotrauma* 24 (2007) 303–314.
- [13] A.I. Maas, C.W. Hukkelhoven, L.F. Marshall, E.W. Steyerberg, Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed tomographic predictors, *Neurosurgery* 57 (6) (2005) 1173–1182.
- [14] K.M. Hall, T. Bushnik, B. Lakisic-Kazacic, J. Wright, A. Cantagallo, Assessing traumatic brain injury outcome measures for long-term follow-up of community-based individuals, *Arch. Phys. Med. Rehabil.* 82 (2001) 367–374.
- [15] D. Cope, J. O’Lear, A clinical and economic perspective on head injury rehabilitation, *J. Head Trauma Rehabil.* 8 (4) (1993) 1–14.
- [16] P. Perel, P. Edwards, R. Wentz, I. Roberts, Systematic review of prognostic models in traumatic brain injury, *BMC Med. Inform. Decis. Mak.* 6 (2006) 38.
- [17] CRASH Trial Collaborators, Effect of intravenous corticosteroids on death within 14 days in 10,008 adults with clinically significant head injury (MRC CRASH trial): randomized placebo-controlled trial, *Lancet* 364 (2004) 1321–1328.
- [18] J. Bruns Jr., W.A. Hauser, The epidemiology of traumatic brain injury: a review, *Epilepsia* 44 (Suppl. 10) (2003) 2–10.
- [19] <http://www.ons.gov.uk/ons/guide-method/classification/current-standard-classification/soc2010-volume-3-ns-sec-rebased-on-soc2010-user-manual/index.html>.
- [20] M. Schaan, H. Jaksche, B. Boszczyk, Predictors of outcome in head injury: proposal of a new scaling system, *J. Trauma* 52 (2002) 667–674.
- [21] D.F. Signorini, P.J. Andrews, P.A. Jones, J.M. Wardlaw, J.D. Miller, Predicting survival using simple clinical variables: a case study in traumatic brain injury, *J. Neurol. Neurosurg. Psychiatry* 66 (1999) 20–25.
- [22] R.K. Narayan, Richard P. Greenberg, J. Douglas Miller, Gregory G. Enas, Sung C. Choi, Pulla R.S. Kishore, John B. Selhorst, Harry A. Lutz I, Donald E. Becker, Improved confidence of outcome prediction in severe head injury. A comparative analysis of the clinical examination, multimodality evoked potentials, ct scanning, and intracranial pressure, *J. Neurosurg.* 54 (1981) 751–762.
- [23] B. Jennett, G. Teasdale, R. Braakman, J. Minderhoud, R. Knill-Jones, Predicting outcome in individual patients after severe head injury, *Lancet* 307 (7968) (1976) 1031–1034.
- [24] B. Ogunbo, V. Kumar, B. Gregson, A.D. Mendelow, Mortality risk after head injury, *J. Am. Coll. Surg.* 198 (5) (2004) 852–853.
- [25] C. Harris, S. Dirusso, T. Sullivan, D. Benzil, Mortality risk after head injury increases at 30 years, *J. Am. Coll. Surg.* 197 (2003) 711–716.
- [26] B.A. Gregson, L. Stobbart, B.I. Ogunbo, et al., Relationships between age and outcome in head injured patients in Newcastle, Abstract Presented at the Euroacademia Multidisciplinaria Neurotraumatica, 8th Congress, Graz, Austria, May 2003.
- [27] T.O. Odebode, A.M. Abubakar, Childhood head injury: causes, outcome and outcome predictors. A Nigerian perspective, *Pediatr. Surg. Int.* 20 (2004) 348–352.
- [28] P. Combes, B. Fauvage, M. Colonna, J.G. Passagia, J.P. Chirossel, C. Jacquot, Severe head injuries: an outcome prediction and survival analysis, *Intensive Care Med.* 22 (1996) 1391–1395.
- [29] A.A. Adeolu, Plasma glucose level in Nigerian Africans with head injury, *J. Clin. Neurosci.* 17 (2010) (325–32.EAD).
- [30] W.S. Poon, X.L. Zhu, S.C. Ng, G.K. Wong, Predicting one year clinical outcome in traumatic brain injury (TBI) at the beginning of rehabilitation, *Acta Neurochir. Suppl.* 93 (2005) 207–208.
- [31] M.R. Klauber, L.F. Marshall, T.G. Luerssen, R. Frankowski, K. Tabaddor, H.M. Eisenberg, Determinants of head injury mortality: importance of the low risk

- patient, *Neurosurgery* 24 (1989) 31–36.
- [32] W.E. Morrison, J.J. Arbelaez, J.C. Fackler, A. De Maio, C.N. Paldas, Gender and age effects on outcome after pediatric traumatic brain injury, *Pediatr. Crit. Care Med.* 5 (2004) 145–151.
- [33] P.J. Andrews, D.H. Sleeman, P.F. Statham, A. McQuatt, V. Corruble, P.A. Jones, T.P. Howells, C.S. Macmillan, Predicting recovery in patients suffering from traumatic brain injury by using admission variables and physiological data: a comparison between decision tree analysis and logistic regression, *J. Neurosurg.* 97 (2) (2002) 326–336.
- [34] M.A. Schreiber, N. Aoki, B.G. Scott, J.R. Beck, Determinants of mortality in patients with severe blunt head injury, *Arch. Surg.* 137 (2002) 285–290.
- [35] M. Bahloul, H. Chelly, M. Ben Hmida, C. Ben Hamida, H. Ksibi, H. Kallel, A. Chaari, M. Kassis, N. Rekik, M. Bouaziz, Prognosis of traumatic head injury in South Tunisia: a multivariate analysis of 437 cases, *J. Trauma* 57 (2004) 255–261.
- [36] D.P. Davis, T.F. Vadeboncoeur, M. Ochs, J.C. Poste, G.M. Vilke, D.B. Hoyt, The association between field Glasgow Coma Scale score and outcome in patients undergoing paramedic rapid sequence intubation, *J. Emerg. Med.* 29 (2005) 391–397.
- [37] A.C. Mosenthal, R.F. Lavery, M. Addis, S. Kau, S. Ross, R. Marburger, E.A. Deitch, D.H. Livingston, Isolated traumatic brain injury: age is an independent predictor of mortality and early outcome, *J. Trauma* 52 (2002) 907–911.
- [38] J.G. Van Beek, N.A. Mushkudiani, E.W. Steyerberg, I. Butcher, G.S. McHugh, J. Lu, A. Marmarou, G.D. Murray, A.I. Maas, Prognostic value of admission laboratory parameters in traumatic brain injury: results from the IMPACT study, *J. Neurotrauma* 24 (2007) 315–328.
- [39] J. Overgaard, O. Hiv-hansen, A. Land, K.K. Pedersen, S. Christensen, J. Haase, O. Hein, W.A. Tweed, Prognosis after head injury based on early clinical examination, *Lancet* 2 (7830) (1973) 631–635.
- [40] A. Rovlias, S. Kotsou, Classification and regression tree for prediction of outcome after severe head injury using simple clinical and laboratory variables, *J. Neurotrauma* 21 (2004) 886–893.
- [41] L.D. Cassidy, D.A. Potoka, P.D. Adelson, H.R. Ford, Development of a novel method to predict disability after head trauma in children, *J. Pediatr. Surg.* 38 (2003) 482–485.
- [42] A.O. Adeleye, K.G. Olowookere, O.O. Olayemi, Clinicoepidemiological profiles and outcomes during first hospital admission of head injury patients in Ikeja, Nigeria, *Neuroepidemiology* 32 (2009) 136–141.