ORIGINAL ARTICLE

The Prognostic Value of Early Follow-up Computerized Tomography of the Brain in Adult Traumatic Brain Injury

A Kiflie, MMed*, N A Alias, MMed*, M M Abdul Kareem, PMRD*, W Mar, MMed*, J Abdullah PHd,** , N N Naing, MMed (Stats)***

*Department of Radiology, **Department of Neurosciences, ***Biostatistics and Research Methodology Unit, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

Summary

A total of 31 adult patients with moderate and severe head injury were assessed clinically on admission for Glasgow Coma Scale (GCS) and short test of mental status (STMS) on follow-up and compared to their initial and follow up CT scan. Good predictors were admission GCS, midline shift, volume of subdural haemorrhage in the initial CT scan of the brain as well as the presence of post-traumatic hydrocephalus, gliosis and site of gliosis in the follow-up CT scan. There was no direct correlation between the significant predictors on the first CT scan and the follow-up CT scan of the brain.

Key Words: Prognosis, CT scan, Adult, Traumatic brain injury, Cognitive rehabilitation, Developing countries

Introduction

The lack of professional rehabilitation in South East Asian developing countries like Malaysia for traumatic brain injuries requires recognition from both physicians and the public. In Malaysia, nearly every town has a Computer Tomographic (CT) scan of the brain and a general radiologist who can report them but most neurological or neurosurgical services and rehabilitation centers are based in University Hospitals as well as larger government or private hospitals. The need to correlate abnormal follow up CT scan findings with the need for cognitive rehabilitation is very important in this country with low human resources in subspecialized care. The objective of this study was to predict the outcome in patients with moderate and severe head injury following motor vehicle accident (MVA) using the initial and mainly the follow-up CT scan of brain parameters and correlating them with a brief cognitive test using the Short Test of Mental Status (STMS).

Materials and Methods

A cross sectional study was conducted amongst all adults with moderate and severe head injury following MVA who had initial and follow-up CT scan of brain. Ethical approval was given to conduct this study for 28 months from June 2000. The exclusion criterias were those aged 12 years and below, patients with significant head injury due to non-MVA, speech difficulties, other causes within the period of study from the day of injury till the day of the assessment of outcome that might change the CT scan appearance of the study group, patients who has incomplete data available for the

This article was accepted: 19 July 2006
Corresponding Author: Jafri Malin Abdullah, Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

study, patients who were fixed and dilated and those with extracranial injuries that may have caused hypoxic or hypotensive damage to the brain. Patients with mild head injury and Glasgow Outcome Score (GOS) of two were excluded from this study.

On admission, all patients involved in MVA were assessed clinically and categorized to moderate and severe head injury by using Glasgow Coma Scale[1]. All patients who were categorized into moderate and severe head injury, had a CT scan of brain. A patient, who had a repeat CT scan of the brain for clinical deterioration or after underwent surgical intervention for the head injury such as evacuation of blood clot during first admission, was assessed in terms of severity. If the CT scan findings was worst than the first CT scan, this CT scan of brain parameters were considered as the initial CT scan in the study instead of the first CT scan of brain parameters. The intention was to use the worst findings of CT scan of brain during the admission period as a predictor for outcome. For statistical analysis, the CT worst scan of brain was known as 'initial CT scan of brain' (Group A).

All these patients who had a follow-up CT scan of brain at about six weeks from the initial scan was included for further statistical analysis to determine the factors that could predict the cognitive outcome of the patient. As for statistical analysis, these CT scan of brain was known as 'follow-up CT scan of brain' and was grouped into Group B. Two senior radiologist who was blinded to the history and outcome of the patients would review both the CT scan films and radiological analysis was done according to Marshall classification[2] and Lobato et al description for gliosis and atrophy and ventriculomegaly[3].

All demographic data, level of consciousness and cognitive assessment were recorded by the corresponding author and the CT scan findings by the first author. The Short Term of Mental Status (STMS) was used instead of the Mini-Mental State Examination due to its sensitivity to the problem of learning and mental agility for use in brain injuries[4-5]. The Glasgow Outcome Scale (GOS) was not used in this study as comparison because of the modest association with cognitive[7] and thus the STMS was done as a quick cognitive analysis. In all our patients, there was direct correlation between the severity grade of the GOS and the STMS.

For the purpose of statistical analysis, the STMS analysis was further grouped into good and poor. Good outcome includes Group 1 and 2 of the STMS (0-4 errors) and poor outcome included Group 3, 4 (5-8 errors) respectively.

The definitions of intracranial pathology on CT scan was defined according to Lane et al, 1992, Orrison and Levine 1996, Hijdra et al 1990, Zimmerman et al 1978 and Kido et al 1992[8-12].

The data entry and statistical analysis were done using SPSS software version 10.0. The sociodemographic data was analyzed using descriptive analysis. The associations between the clinical parameters, initial and follow-up CT scan of brain parameters and the outcome of the patients were determined. Analysis was done by using Pearson Chi-square test. The p value of less than 0.05 was taken as the significant level.

Results

Twenty one who patients were diagnosed as moderate and severe head injury cases secondary to motor vehicle accident had a complete set of initial CT scan of brain as well as follow-up CT scan of brain six weeks later. The cognitive outcome of the patients was reviewed at six weeks follow-up at the same time of the CT scan. Out of 31 patients, 21 (67.7%) patients were males and 10 (32.3%) patients were females. Twenty-nine (93.5%) patients were Malays and only two patients were Chinese. The age of patients ranges from 13 years to 81 years. The mean age was 30.52 years. Young adults contribute most of the cases with 71.0% who were below 30 years old.

The most severe score of GCS on admission was four and maximum score was 12 (Table I). The mean GCS was 9.48. Most patient presented with GCS score of 12 in this study, which was 12 (38.7%) of 31 patients. The rest were 2 (6.5%), 3 (9.7%), 3 (9.7%), 2 (6.5%), 4 (12.9%) and 1 (3.2%) presented with GCS 4,6,7,8,9,10 and 11 respectively. Out of 31 cases, 21 patients (67.7%) were having moderate head injury and ten patients (32.3%) were having severe head injury.

All types of intracranial haemorrhage, midline shift and hydrocephalus on the initial CT scan of brain were taken as the parameters for assessment. In this study, most of the patients presented with intraparenchymal haemorrhage 15 (48.4%) and followed by subarachnoid haemorrhage 12 (38.9%). Eleven patients were having midline shifted to the contra-lateral side of the lesions causing mass effect. Only one patient presented with acute hydrocephalus. The rest were 11 (35.5%) had subdural haemorrhage, 9 (29.0%) had extradural haemorrhage, 8 (25.8%) had haemorrhagic contusion and 2 (6.5%) had intraventricular haemorrhage.

The sites of bleeding in all type of intracranial haemorrhage were analyzed. In intraparenchymal haemorrhage, the commonest site was the parietal lobe with 10 (66.7%) and followed by temporal region with 9 (60.0%). The others were frontal 5 (33.3%) and basal ganglia 1 (6.7%). The lesions are either single or multiple. Similar observations were seen in both extradural and subdural haemorrhage. For extradural haemorrhage, 55.6% were seen in parietal lobe and 33.3% in temporal lobe. Subdural haemorrhage occurred in parietal lobe for 81.8% and 63.6% in temporal lobe. There was no intraparenchymal, extradural or subdural haemorrhage seen in the cerebellar region.

For subarachnoid haemorrhage, 75.0% were seen in the sylvian fissure and 66.7% in the sulci. Out of 31 patients, only two patients (6.5%) presented with intraventricular haemorrhage, one in the temporal horn and the other in occipital horn of the lateral ventricle. Haemorrhagic contusions were observed with the dominant (left) temporal lobe being the commonest site 6 (46.2%) followed by frontal lobe 4 (30.8%) and parietal 3 (23.0%).

Out of 31 patients, 11 (35.5%) had midline shift. Out of these 11 patients, six patients had less than 5mm of midline shift and another five patients had 5mm and more. The rest of the patients did not have midline shift.

Volumes of the intraparenchymal, extradural and subdural haemorrhage were also calculated using a method proposed by Kido et al, 1992[9]. The volume of a similar type of bleed was added together if the lesions were multiple. The volume of the lesions were further classified into two groups. The first group consisted of volume less than 25 mm^3 and the second group consisted of volume of 25 mm^3 or more.

Only five patients (16.1%) had repeat CT scan of brain during the first admission. These were due to deterioration of clinical assessment and post-operative CT scan of brain. These CT scans were assessed for severity of CT scan findings and included as initial CT scan. Out of five patients, two patients had new intraparenchymal haemorrhage, two patients with new contusion and subdural haemorrhage each and one patient had no additional CT findings.

Follow-up CT scan of brain were done six weeks after the initial CT scan focussing on parameters which included residual intracranial haemorrhage, post-traumatic hydrocephalus, midline shift, presence and site as well as volume of gliosis and brain atrophy. However, none of these patients had residual intracranial haemorrhage, midline shift and brain atrophy on the follow-up CT scan. Out of 31 patients, only three patients (9.7%) had post-traumatic hydrocephalus and 18 patients (58.1%) were noted to have gliosis.

In this study, the sites of gliosis being either single or multiple were assessed together with its volume. The mean and the standard deviation of volume gliosis were reported as 72 ± 52 mm^3. Parietal lobe (11) was the most common site of gliosis followed by temporal lobe (10), frontal (8), occipital (1) and basal ganglia (1). The volume of gliosis was calculated by using the similar method and was grouped into two categories for the statistical analysis; group A (volume of less than 25 mm^3) and group B (volume of 25 mm^3 and more). Group A was found in 11 patients (61.1%) and the group B was seven patients (38.9%). For multiple areas of gliosis, the volumes were added together.

In this study age and gender of the patients were not statistically significant, however the score of Glasgow Coma Scale on admission was statistically significant as one of the predictors of outcome ($p = 0.014$). Other significant predictors were the presence of midline shift ($p = 0.035$) during the injury and presence of post-traumatic hydrocephalus ($p = 0.022$) on follow-up CT scan.

Generally, in this study all types of intracranial haemorrhage were not statistically significant predictors if taken as a whole. However, univariate analysis by using chi-square test on severity of GCS, site and volume of haemorrhages of selected intracranial haemorrhages showed few parameters, which were significant statistically. Those parameters are severity of GCS in patients with intraparenchymal haemorrhage ($p = 0.029$), subdural haemorrhage ($p = 0.036$) and subarachnoid haemorrhage ($p = 0.030$). Volume of bleeding site in patients with subdural haemorrhage was also statistically significant ($p= 0.036$). All 31 patients were further grouped by using Traumatic

Coma Data Bank classification and statistical analysis showed significant (p= 0.047) to predict the outcome. Another significant outcome predictor in those patients was gliosis (p=0.040) especially the presence of dominant temporal lobe gliosis (p= 0.020) and hydrocephalus (p=0.022) (Table I). Other variables (age, gender and site of intraparenchymal haemorrhage and volume of gliosis) were not statistically significantly associated with the outcome.

Table I: The significance of CT scan of Brain on initial follow-up and after six weeks with STMS

Variable	STMS Outcome		°p-value
	Poor n (%)	Good n (χ)	
GCS on admission (n=31)			
Moderate	5 (23.8)	16 (76.2)	0.014
Severe	7 (70.0)	3 (30.0)	
Mid-line shift during injury on initial CT scan (n=31)			
Yes	7 (63.6)	4 (36.4)	0.035
No	5 (25.0)	15 (75.0)	
Intraparenchymal haemorrhage on initial CT scan (n=15)			
Moderate Head Injury	4 (36.4)	7 (63.6)	0.029
Severe Head Injury	4 (100.0)	0 (0.0)	
Subdural haemorrhage on initial CT scan (n=11)			
Moderate Head Injury	1 (16.7)	5 (83.3)	0.035
Severe Head Injury	4 (80.0)	1 (20.0)	
Subarachnoid haemorrhage on initial CT scan (n=12)			
Moderate Head Injury	1 (12.5)	7 (87.5)	0.030
Severe Head Injury	3 (75.0)	1 (25.0)	
Volume of bleeding site with subdural haemorrhage on initial CT scan (n=11)			
Moderate Head Injury	1 (16.7)	5 (83.5)	0.036
Severe Head Injury	4 (80.0)	1 (20.0)	
Traumatic coma data bank classification on initial CT scan (n=31)			
Diffuse injury I	0 (0.0)	0 (0.0)	0.047
Diffuse injury II	2 (13.3)	13 (86.7)	
Diffuse injury III	1 (33.3)	2 (66.7)	
Diffuse injury IV	4 (80.0)	1 (20.0)	
Evacuated mass	2 (66.7)	1 (33.3)	
Non-evacuated mass	4 (80.0)	1 (20.0)	
Presence of post-traumatic hydrocephalus on follow-up CT scan (n=31)			
Yes	3 (100.0)	0 (0.0)	0.022
No	9 (32.1)	19 (67.9)	
Gliosis on follow-up CT scan (n=18)			
Single	4 (36.4)	7 (63.6)	0.040
Multiple	6 (85.7)	1 (14.3)	
Dominant temporal lobe gliosis on follow-up CT scan (n=18)			
Yes	8 (80.0)	2 (20.0)	0.020
No	2 (25.0)	6 (75.0)	

Discussion

In general, increasing age was associated with poorer outcome in adults. In this study, age of the patients was of no significance in determining the outcome following head injury secondary to motor vehicle accident. This was also noted in a study done by van der Naalt et al, 1999[13]. However, some study observed differently whereby there was a strong correlation existing between age and outcome[14-15]. Kishore et al, 1981 found that the average of 32 patients with normal CT and intracranial pressure and a good outcome was 22 years, compared to 39.5 years in the patients with poor prognosis[11].

Although male patients made the majority of the cases studied that was 67.7% of the 31 patients, this did not contribute to the significant factors of outcome. A study performed by Jeret et al, 1993 also did not observe any difference in the incidence of abnormal CT findings between the sexes[16].

In this study, 67.7% of 31 patients had moderate head injury and 76% had good outcome. The GCS score was found to be statistically significance in predicting the outcome of patients (p= 0.014). However, on certain type of intracranial haemorrhages, GCS was not statistically significant predictor. These were noted in patients who had extradural haemorrhage, intraventricular haemorrhage and haemorrhagic contusion. On the other hand, GSC was statistically significance in patients with intraparenchymal haemorrhage (p= 0.029), subdural haemorrhage (p value = 0.036), subarachnoid haemorrhage (p= 0.030) and gliosis (p= 0.040).

This study indicated that all type of intracranial haemorrhages without including the site, multiplicity and volume, were not considered a significant predictors. However, some of the intracranial haemorrhages were statistically significant when assessing the GCS and volume of the lesions as well as when using the Traumatic Coma Data Bank classification. The GCS score of patients with intraparenchymal, subdural and subarachnoid haemorrhages showed significant p value as predictors of outcome. Midline shift, as one of the initial CT scan parameter in this study was also statistically significance in predicting the outcome.

In assessing the patients with intraparenchymal haemorrhage, only when combined with GCS, this parameter was significant. In contrast to other studies, volume of the lesions also had a high predictive value for mortality in patients with intraparenchymal haemorrhage as noted by Tuhrim et al, 1988[17] and Choksey et al, 1993[18]. However, this was not observed in the study.

In patients with subdural haemorrhage, the authors found that there was statistically significant p value noted in the volume of lesions and GCS group in correlation with the outcome of the patients. In a study done by Benedict M. Selladurai et al, 1992, acute subdural haemorrhage was proved to be the focal lesion with the greatest potential for a poor outcome[15]. Massaro et al, 1996 also found that subdural haemorrhage in head injury patients as well as GCS were the most important prognostic variable[19].

None of the parameters in nine patients with extradural haemorrhage (EDH) were significant in predicting the outcome of the patient with moderate and severe head injury in this study. In contrast with other study, Cook et al, 1988 noted that there was an accuracy of 88% using the EDH in predicting the outcome[20]. Servadei et al, 1997 showed that volume of the lesion was a significant parameter in terms of prognosis[21].

GCS in patients with subarachnoid haemorrhage (SAH) had significant predictive value in this study. However, the rest of the parameters in SAH were not statistically significant. A study done by Yusukawa et al, 1988 found that cases with prepontine and /or interpeduncular subarachnoid haemorrhage had a poor prognosis as compared to those haemorrhages confined to the ambient cistern, quadrigerminal cistern and/or sylvian fissure which has a better prognosis[22]. Bernedict M. Selladurai et al, 1992 stated that the presence of subarachnoid haemorrhage was also significantly correlated with poor outcome where by the risk of poor outcome is doubled in the presence of SAH[15].

In the analysis of haemorrhagic contusion, again the authors did not find any parameters those were statistically significant in predicting the outcome. In contrast, a study by Bernedict M. Selladurai et al, 1992 showed that the outcome was only slightly better in patients with single intrinsic haemorrhagic contusion as compared to those with multiple lesions[15]. Kunishio et al, 1992 noted that 66.7% of his subjects with haemorrhagic contusion had good outcome[23].

In our study, only two patients had intraventricular haemorrhage that had poor prognosis. Nineteen out of

29 patients with no intraventricular haemorrhage had good outcome. However, statistical analysis showed no significant p value in predicting the outcome. A study done by Fearnside et al, 1993 revealed that the presence of intraventricular haemorrhage was highly significant predictor in mortality[24]. Young et al, 1990 found that the volume of intraventricular haemorrhage was a determinant of prognosis[25]. However, the author did not study the volume since only two patients presented with intraventricular haemorrhage.

This study showed that midline shift was one of significant predictor with the p value of 0.035. Patients with no midline shift had a better prognosis as compared to those with midline shift. Bernedict M. Selladurai et al, 1992 showed that 76% patients with midline shift of >10mm had poor outcome[15]. Fearnside et al, 1993 also noted that mortality increased with degree of midline shift[24]. Some study revealed differently that the degree of midline shift did not have the predictive significance[15,26].

As mentioned earlier, the goal of follow-up CT scan of brain is to detect any new and to monitor existent lesions. It was believed that the brain injury and its complication evolve with time. Jannet et al suggested that 60% already had reached it status of certain by three months, while 90% had reached that status by six months[27]. Hence the ideal follow-up CT scan should be done three months after the initial CT scan. In our study, the follow-up CT scan was done as early as six weeks post-trauma. There was no direct correlation between the significant predictors in the first CT scan and the follow-up CT scan of the brain which tallied with one other similar publication[28]. A few parameters were assessed such as residual of haemorrhage, midline shift, brain atrophy, post-traumatic hydrocephalus and gliosis. However, only post-traumatic hydrocephalus and gliosis were found in all 31 patients.

Three out of 31 patients were diagnosed to have post-traumatic hydrocephalus whom all of them had poor prognosis. The statistical analysis showed a significant p value of 0.022 in predicting the outcome of patients in this study. Kishore et al, 1978 showed that 29 out of 100 patients developed ventriculomegaly in the first year and out of this, 27 patients had developed it in the first two weeks post-injury[14]. Two other studies had shown the relationship of ventriculomegaly with cognitive dysfunction[29-31].

Another common sequelae in head injury patient was gliosis. It is defined as an area of low density on CT due to proliferation of glial tissue that replaces the myelin resulting in relatively increased water. Focal area of gliosis with atrophy was found to be related to poor outcome in developed countries[32-35]. Atrophy at the frontotemporal region was especially related to poor outcome[36]. In this study, the presence of gliosis was the only significant p value in predicting poor cognitive outcome especially if the gliosis was located in the dominant temporal region. The rest of the regions were not statistically significant.

Conclusion

This study was design to predict the group of patients that may need cognitive rehabilitation with moderate and severe head injury patients by using initial and especially follow-up CT scan of brain parameters. Physicians in developing countries with lack of specialized rehabilitation centers must note that the presence of post-traumatic hydrocephalus as well as gliosis would increase the possibility of having poor cognitive function especially when the dominant temporal lobe is involved. These patients would need to be referred to a center with rehabilitation facilities as soon as possible or as early as six weeks.

References

1. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974; 13; 2(7872): 81-84.
2. Marshall LF, Eisenberg HM, Jane JA, Luerssen TG, Marmarou A, Foulkes M. A new classification of head injury based on computerized Tomography. J. Neurosurg 1991; 75: S14-S20.
3. Lobato RD, Gomez PA, Alday R et al. Sequential Computerized Tomography Changes and related final outcome in severe head injury patients. Acta Neurochi (Wien) 1997; 139: 385-91.
4. Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficits in eldery patients. J American Geriartrics Society 1975; 23: 433-41.
5. Tang-Wai DF, Knopman DS, Geda YE, et el. Comparison of short term of mental status and the mini mental status examination in mild cognitive impairment. Arch Neurol. 2003; 60 (12): 1777-81.
6. Perea MV, Ladera V, Morales F. Predictive value of rapid tests of cognitive condition in traumatic head injury. Rev Neurol. 1999; 29: 1099-03.
7. Wilson JT, Peltigrew LE, Teasdale GM. Emotional and cognitive consequences of head injury in relation to the Glasgow coma scale. J Neurol Neurosurg Psychiatry 2000; 69: 204-9.
8. Lane B, Moseley IF, Theron J. Cranial and intracranial pathology. In: Grainger RG, Allison DJ (eds) Diagnostic radiology. Churchill Livingstone, New York, 1999; 2001-26.
9. Orrison Jr WW, Lewine JD. Neuroimaging in closed head injury. In : Rizzo M, Tranel D (eds) Head injury and post-concussive syndrome. Churchill Livingstone, New York, 1996; 2001-26.
10. Hijdra A, Brouwers PJ, Vermeulen M, van Gijn J. Grading the amount of blood on computed tomograms after subarachnoid hemorrhage. Stroke 1990; 21 (8): 1150-55.
11. Zimmerman RA, Bilaniuk LT. Computer tomography of traumatic intracerebral hemorrhagic lesions: the change in density and mass effect with time. Neuroradiology 1978; 16: 320-21.
12. Kido DK, Cox C, Hamill RW, Rothernberg BM, Woolf PD. Traumatic brain injuries: Predictive usefulness of CT. Radiology 1992; 182: 777-81.
13. van der Naalt J, Hew JM, van Zommeran AH, Sluiter WJ, Minderhoud JM. Computed Tomography and Magnetic Resonance Imaging in mild to moderate head injury: Early and Late imaging related to outcome. Ann. Neurol 1999; 46: 70-80.
14. Kishore PRS, Lipper MH, Becker DP, Domingues da Silva AA, Narayan RK. Significance of Ct in head injury: correlation with intracranial pressure. Am. J. Roentology 1981; 137: 827-33.
15. Selladurai BM, Jayakumar R, Tan YY, Low HC. Outcome prediction in early management of severe head injury: and experience in Malaysia. Br J Neurosurg 1992; 6(6): 549-57.
16. Jeret JS, Mandell, M. Anziska, B. Lipitz M., Vilceus, AP, Ware, JA, Zesiewicz, TA. Clinical predictors of abnormality disclosed by computed Tomography after mild head trauma. Neurosurgery 1993; 32(1): 9-16.
17. Tuhrim S., Danbrosia JM, Price TR. et al. Prediction of intracerebral haemorrhage survival. Ann. Neurol. 1988; 24: 258-63.
18. Choksey M, Crockard HA, Sandilands M. Acute traumatic intracerebral hematomas: determinants of outcome in retrospective series of 202 cases. Br J Neurosurg 1993; 7(6): 611-22.
19. Massaro F, Lanotte M, Faccani G, Triolo C. One hundred and twenty seven cases of acute subdural hematoma operated on. Correlation between CT scans findings and outcome. Acta neurochir (Wien) 1996; 138(2): 185-91.
20. Cook RJ, Dorsch NW, Fearnside MR, Chaseling R. Outcome prediction in extradural hematomas. Acta Neurochir (Wien) 1988; 95 (3-4): 90-94.
21. Servadei F. Prognostic factors in severely head injured adult patients with epidural hematoma's. Acta Neurochir (Wien) 1997; 139(4): 272-78.
22. Yusukawa K, Shigeta H, Momose G, Kobayashi S, Miyatake M. Traumatic subarachnoid haemorrhage – clinical study of 16 cases. No Shinkei Geka 1988; 16(5 Suppl): 482-86.
23. Kunisho K, Shinohara C, Tokunaga K, Matsuhisa, et el. Analysis of long term social rehabilitation of brain contusion. No Shinkei Geka 1992; 20(9): 959-63.
24. Fearnside MR, Cook RJ, McDougall P, McNeil RJ. The Wesmead Head Injury Project outcome in severe head

injury. A comparative analysis of pre-hospital, clinical and CT variables. Br J Neurosurg 1993; 7(30): 267-79.

25. Young WB, Lee KP, Pessin MS, et al. Prognostic significance of ventricular blood in supratentorial haemorrhage: a volumetric study. Neurology 1990; 40: 616-19.

26. Lipper KH, Kishore, PR.S, Enas GG, Domingues da Silva, AA., Choi, SC, Becker, DP. Computed Tomography in prediction of outcome in head injury. J. Neurosurg 1985; 75: S28-S36.

27. Jannet B. Outcome after severe head injury : definitions and predictions. Med J Aust 1976; 25: 2(13): 475-77.

28. Lobato RD, Sarabia R, rivas JJ, et al. Normal Computerized Tomography scans in sever head injury. J. Neurosurg 1986; 65: 784-89.

29. Ariza M, Mataro M, Poca MA, Junque C, Garnacho A, Amoros S, Sahuquillo J. Influence of extraneurological insults on ventricular enlargement and neuropsychological functioning after moderate and severe head injury. J Neurotrauma 2004; 21: 864-76.

30. Matara M, Poca MA, Sahuquillo J, Pediaza S, Ariza M, Amoros JC. Neuropsychological outcome in relation to the traumatic coma data bank classification of computed tomographic imaging. J Neurotrauma 2001; 18: 869-79.

31. Wilson JT, Wiedmann KD, Hadley DM, Condom B, Teasdale G, Brooks DN. Early and late magnetic resonance imaging and neuropsychological outcome after brain injury. J Neurol Neurosurg Psychiatry 1988; 51: 391-96.

32. van der Naalt J, Hew JM, van Zommeran AH, Sluiter WJ, Minderhoud, JM (1999). One year outcome in mild to moderate head injury: the predictive value of acute injury characteristics related to complaints and return to work. J Neurol Neurosurg Psychiatry 1999; 66: 207-13.

33. Van der Naalt J, Van Zomeren AH, Skiter WJ, Minderhoud JM. Acute behavioural disturbances related to imaging studies and outcome in mild-to-moderate head injury. Brain Inj 2000; 14; 781-88.

34. Reider-Grosswasser, Cohen M, Costeff H, Grosswasser Z. Late CT findings in Brain Trauma: Relationship to Cognitive and Behavioural Sequelae and to Vocational Outcome. American Journal of Roentology 1993; 160: 147-52.

35. Terayama Y, Meyer JS, Kawamura J, Weathers S. Role of thalamus and white matter in cognitive outcome after head injury. J Cereb Blood Flow Metab. 1991; 11: 852-60.

36. Maler C. Correlation of computer tomographic findings and psychological result in patients with craniocerebral injury. Fortschr Neuro Psychiatr 1984; 52: 346-51.