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The Role of Computed Tomography in Predicting the Outcome of Traumatic Brain Injury Patients

Authors
Nandhini S[1], Sudhakaran S[2], Beena Sebastian[3]
[1]Senior Resident, Department of Radiodiagnosis, Govt Medical College, Kottayam
[2]Former professor, Department of Radiodiagnosis, Govt Medical College, Kottayam
[3]Associate Professor, Department of Radiodiagnosis, Govt Medical College, Kottayam
Corresponding Author
Beena Sebastian
Email: *beenasebastian22@gmail.com*

Abstract
Background: *Traumatic brain injury is the leading cause of mortality, morbidity, disability and socio-economic losses worldwide. The aim of this study was to determine the proportion of poor outcome among the head injury patients with Glasgow coma scale < 12 and to determine the role of initial CT scan in predicting the outcome among them.*
Materials and Methods: *The study was carried out in the department of Radio diagnosis, Medical college, Kottayam for a period of 12 months in patients coming to casualty with features of moderate to severe traumatic head injury (GCS <12) and had taken the initial CT head scan within 24 hours of injury. All CT scans taken in the department were reviewed in digital form. Rotterdam CT scoring and Glasgow outcome score at and after 3 months of discharge were noted.*
Results: *A total of 150 patients were included in the study. 57.3% had moderate head injury and 42.7% had severe head injury. Abnormal CT findings were noted in 95.3% of patients. The incidence of poor outcome was 52.7% in patients with moderate to severe head injury. Statistically significant association with poor outcome was noted in status of basal cistern, midline shift, tSAH, IVH, SDH and contusions. Among these variables, absent basal cistern had the highest PPV of 95.5% and highest odds ratio of 26.011 with 95% confidence interval (7.747 – 85.135). With Rotterdam scoring, the higher the grades, more the probability for poor outcome*
Conclusion: *More than half of the patients with moderate and severe head injury patients had poor outcome. The status of basal cistern was the best predictor among the CT variables. Rotterdam scoring can be used as an objective score to predict the mortality in patients with moderate or severe head injury.*

Introduction

Traumatic brain injury (TBI) is defined as an alteration in brain function or other evidence of brain pathology, caused by an external force. According to Centre of Disease Control and Injury Prevention, approximately 1.7 million people sustain a TBI each year worldwide. The ability to predict outcome early after a severe TBI enables

the treating physicians to approximately advise family members regarding expected duration of treatment, likely short and long term outcomes, future needs for rehabilitation and other clinical, social and financial issues that requires extensive planning. In practice, relatively few features have been found to contain most of the prognostic information. These include the patient's age, clinical indices indicating severity of brain injury (e.g. the depth and duration of coma, Glasgow Coma scale (GCS) score and the neurological deformities) and the results of investigation and imaging studies, particularly intracranial pressure (ICP) and computed tomography (CT) scanning

CT scanning of head is routinely performed in all patients with severe TBI and provides information with important therapeutic implications for operative interventions or indications for intracranial pressure (ICP) monitoring. Individual characteristics are found to be particularly relevant. Status of basal cisterns, traumatic subarachnoid hemorrhage (tSAH), intraventricular hemorrhage, presence and degree of midline shift and presence, type of intracranial hematoma are taken into account. The status of basal cistern is found to be a better predictor in TBI when compared to other CT findings[1]

Mass et al. in 2005 examined the prognostic performance of the Marshall CT classification in comparison with other combinations of CT predictors in TBI, by reevaluating and refining the CT characteristics used to determine this classification and by including additional CT parameters. They developed a simple CT prognostic score (Rotterdam CT Score) that seems to be more closely associated with outcome than the Marshall scheme.

Materials and Methods

A longitudinal study was conducted in 150 patients with GCS score 4-12 i.e. moderate to severe head injury who undergo first CT within 24 hours of event in the Department of Radiodiagnosis, Medical college, Kottayam during the period March 2014 to February 2015. Patients with polytrauma in whom injury elsewhere is expected to have significant influence on outcome and patients who have already undergone any intracranial surgical intervention before first CT study were excluded from the study.

Study Instrument

CT scan were taken using TOSHIBA ASTEION, four slice computed tomography system installed in the Department of Radiodiagnosis. CT were taken in Axial sections with slice thickness of infratentorial 4 mm and supratentorial 8mm, scan time of 20-30 seconds, factors of 120Kv and 100-200 mA, window settings of brain – 120 (width)/ 40(level) and Bone – 2500 (width)/ 450(level).

Study Procedure and Data Collection

After obtaining the ethical clearance from Human Ethical Committee of the institution the study was commenced. Initial Ct was performed in 150 patients and findings were entered in a semi-structured questionnaire. Glascow Coma Scale score as recorded by the attending physician in the casualty was taken.

Table 1: Glasgow outcome score

Death	5
Persistent vegetative state	4
Severe disability (conscious but disable)	3
Moderate disability (disable but independent)	2
Good recovery	1

All CT scans taken in the department were reviewed in digital form. The presence or absence of abnormality, status of basal cisterns, absence and presence of traumatic subarachnoid hemorrhage, Intra ventricular blood, midline shift, intracerebral lesion were noted. tSAH was graded as per Greene grading. Rotterdam CT scoring was done for all patients. Glasgow outcome score at and after 3 months of discharge were noted. Outcome variables will be categorized as Good (GOS 1 and 2) and Poor (GOS 3, 4 and 5)

Follow up of the patients was done through direct examination while coming to the OP for review and through the telephone.

Analysis

Data were entered in Excel and analysis was done using SPSS 16.0 version. Incidence of poor outcome among the head injury patients with Glasgow coma scale <12 was calculated by dividing total number of patients with poor outcome (based on Glasgow outcome score) with total patients under study. Then the association between the initial CT scan findings (basal cistern status, midline shift, SAH, Intraventricular hemorrhage, Intra-parenchymal lesions, epidural mass lesions) with the outcome of patients were measured using chi-square test by univariate analysis. Then the association between initial Rotterdam scoring and outcome were assessed also by using chi-square test. Multivariate logistic regression was done to find out the predictors of outcome.

Results

A total of 150 patients were enrolled in the study and followed up for three months. 57.3% (86) had moderate head injury with GCS score 9 – 12 and 42.7% (64) had severe head injury (GCS < 8). No patient with GCS score of 3 was included in the study as none of them survived to undergo CT scan.

143 (95.3%) patients had abnormalities in the first CT scan. Only 7 patients had normal scan. Most common abnormality found was contusions (73.3%). 98.4% of patients with severe head injury had abnormalities in initial CT.

As per Glasgow Outcome Scale (GOS), 79 patients (52.7%) had poor outcome. After 3 months of follow up, 90 (60%) patients were found to have poor outcome.

Maas et al[2]. in 2005 proposed Rotterdam CT prognostic score. This score gives the probability of mortality in patients with severe or moderate TBI based on CT characteristics. It includes status of basal cisterns (open/compressed/absent), midline shift (< 5mm/ >5mm) presence or absence of EDH and tSAH or IVH. Score of 0, 1 or 2 each are given for the presence or absence of above findings. A score of one is added to the total score in all cases to get a maximum possible total score of six. This is to make the grade numerically consistent for statistical analysis with grading of motor score of GCS and with Marshall CT classification

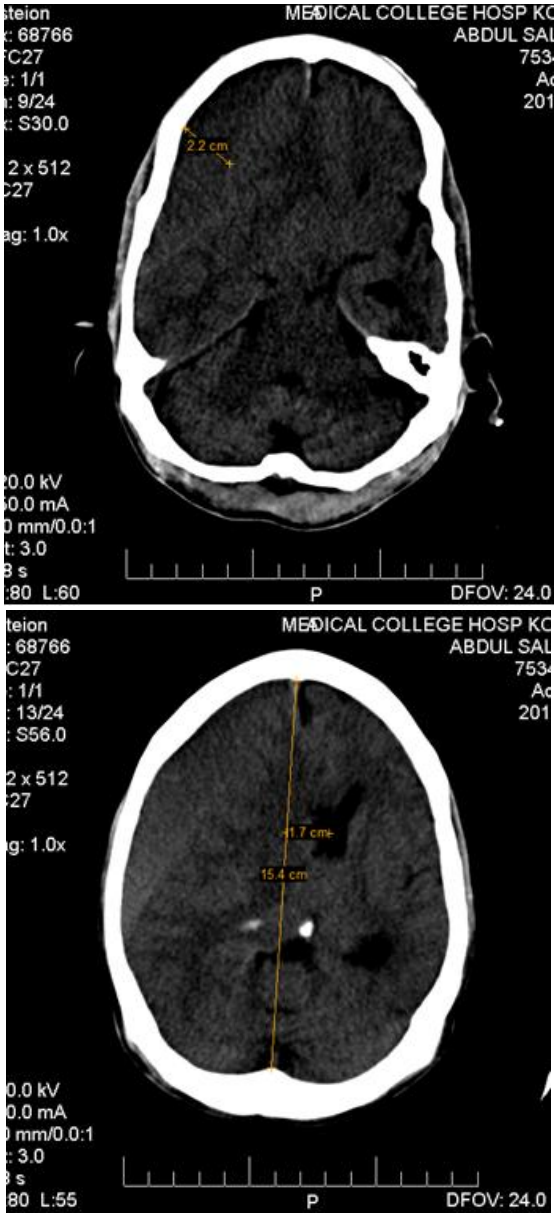

Figure 1: This patient came with GCS score of 8 and underwent initial CT scan within 3-6 hours. CT revealed acute SDH of thickness 22mm in right fronto-parieto-temporal region with midline shift of 17 mm, compressed basal cisterns and 3 tiny contusions in left parietal lobe. Rotterdam score was 4. Patient was discharged in 2 weeks and had poor outcome (severe disability) at the time of discharge and after 3 months follows up.

Rotterdam Ct prognostic score of 3 had the highest incidence (30%) followed by score 4 (27.3%). Absent basal cistern is given the highest priority with the score of 2. Except for EDH, score of 1 is added in the presence of findings. No score is added in the presence of EDH and score of 1 is added in its absence.

Table 2: Distribution of mortality based on Rotterdam Scoring

Rotterdam score	Mortality		
	Present	Absent	Total
Score 1	0	10 (100%)	10 (100%)
Score 2	0	33 (100%)	33 (100%)
Score 3	3 (6.7%)	42 (93.3%)	45 (100%)
Score 4	17 (41.5%)	24 (58.5%)	41 (100%)
Score 5	16 (84.2%)	3 (15.8%)	19 (100%)
Score 6	2 (100%)	0	2 (100%)

Chi-square = 69.233; P value = 0.001

Zero mortality (0/10 and 0/33) was found with sum score of 1and 2 respectively in this study group. Total score of 3 to 6 can be given for varying combinations of findings. Importantly, patients having only tSAH as the finding will have a score of 3. This study shows 6.7% (3/45) mortality with sum score of 3 which had the highest incidence. A sum score of 4 and 5 had higher mortality rates of 41.5% (17/41) and 84.2% (16/19) in this study. 100% (2/2) mortality was found in patients with score of 6. Hence, there is significant association between Rotterdam CT prognostic score and outcome. Higher probability of mortality is expected with higher scores.

Tables 3: Logistic regression

Variables	B	df	Significant level	Odds ratio Exp (B)	95 % C.I. for EXP (B)	
					Lower	Upper
tSAH	2.449	1	0.001	11.578	3.627	36.956
IVH	0.448	1	0.585	1.566	0.313	7.839
Midline shift	1.362	1	0.022	3.903	1.214	12.546
SDH	1.490	1	0.005	4.439	1.569	12.559
EDH	-1.887	1	0.013	0.151	0.034	0.677
Intracerebral lesions	2.310	1	0.009	10.073	1.769	57.341
Basal cistern status	3.799	1	0.001	26.011	7.947	85.135
Constant	-3.799	1	0.001	0.022		

B- Regression coefficient; df- degree of freedom; C.I- confidence interval.

Discussion

In this study, basal cisterns were compressed in 67 (44.7%) patients and absent in 22(14.7%) patients. 95.5% of subjects with absent basal cisterns had poor outcome compared to those with compressed (74.6%) and open (13.1%) basal cisterns. The association was found to be statistically significant. Absent basal cisterns have 95.5% of positive predictive value for poor outcome. 86.9% of patients with open basal cisterns in their first CT after head injury had good outcome at the time of discharge. Cordobes et al.[3] in a selected series of 78 patients with DAI showed a PPV of 84% for unfavourable outcome when the basal cisterns are compressed. Van Dongen et al.[4] showed a 97% positive predictive value for poor outcome when the cisterns are absent.

A positive predictive value of 75% was found in this study when the midline shift is > 5mm. PPV of midline shift was 89.3% at 3 months follow up. The association between midline shift and outcome was statistically significant. Vollmer et al.[5] on analysis of the TCDB, including six month outcome, showed a PPV of 78% for poor outcome in the presence of midline shift of >5mm.

Traumatic intraventricular hemorrhage is a relatively rare finding. Incidence of intraventricular hemorrhage was 17.3% in this group. Atzema Clare et al.[6] had 118 patients with tIVH out of 8374 severe head injury victims and 70% poor outcome was noted in them.

Contusions were the most common lesion with the incidence of 73.3%. SDH was the most common hematoma in this study group with the incidence of 42.7%. PPV of 68.8% noted in patients with SDH in predicting the poor outcome and this association was found to be statistically significant. Overall mortality associated with SDH was 35.9% in this study group. . Marshall et al.[7] showed 50% mortality in patients with SDH.

Factors which were significant in logistic regression were basal cistern status (open/ compressed/absent) with odds ratio of 26.011 (95%C.I.=7.747-85.135) followed by tSAH with odds ratio of 11.578 (95%C.I.= 3.627-36.956), midline shift with odds ratio of 3.903 (95%C.I 1.214=12.546), SDH with odds ratio of 4.439 (95% C.I=1.569-12.559), intracerebral lesions with odds ratio of 10.073 (95% C.I = 1.769-57.349).EDH was found to be protective factor as per logistic regression with odds ratio of 0.151 (<1) and 95% C.I of 0.034-0.677.IVH was not statistically significant as an independent predictor. The Nagelkerke R^2 value of the model was 0.658, i.e. 65.8% variability in the outcome of head injury patients can be explained using these variables.

Conclusion

The incidence of poor outcome in patients with moderate to severe head injury was found to be 52.7% at the time of discharge and 60% at 3 months follow up. The absent basal cistern had the highest positive predictive value in predicting the poor outcome among moderate to severe head injury patients. Among these variables, the highest odds ratio of 26.011 with 95% confidence interval (7.747 – 85.135) was noted with the abnormal basal cistern. Thus the status of basal cisterns was the best predictor of outcome. With Rotterdam scoring, the higher the grades, more the probability for poor outcome.

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